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Where Is the Essence? Developmental Shifts in Children's Beliefs About Internal Features

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Abstract

The present studies investigated children's and adults' intuitive beliefs about the physical nature of essences. Adults and children (ranging in age from 6 to 10 years old) were asked to reason about 2 different ways of determining an unknown object's category: taking a tiny internal sample from any part of the object (distributed view of essence) or taking a sample from one specific region (localized view of essence). Results from 3 studies indicated that adults strongly endorsed the distributed view, and children showed a developmental shift from a localized to distributed view with increasing age. These results suggest that even children go beyond mere placeholder notions of essence, committing to conceptual frameworks of how essences might be physically instantiated.

Adults and children alike seem to believe that many sorts of things have essences. In its everyday sense, an essence is often thought of as something intrinsic to an entity that causes that entity to be the kind of thing that it is. For example, the essence of a tiger would be some unique characteristic, such as DNA, that is shared by all tigers and causes tigers to have their distinct tiger properties (Sober, 1994). Such beliefs are part of a cognitive bias known as "psychological essentialism" (Medin & Ortony, 1989), a bias that not only embraces the notion of an essence but also the idea that this deep, underlying nature is somehow causally responsible for an entity's category membership and its phenomenal properties (Gelman, 2003).

Much of the support for psychological essentialism comes from studies with young children. For example, children as young as 4 years old appear to understand that internal causes are more to likely determine an objects' behavior and appearance than are external ones (Gelman, 2003; Gottfried & Gelman, 2005; Inagaki & Hatano, 2002; Sobel, Yoachim, Gopnik, Meltzoff, & Blumenthal, 2007), and they are likely to view internal properties as vital to determining an animal's category membership (Gelman & Wellman, 1991; Keil, 1989). Young children will also extend internal, nonvisible features to novel category instances (e.g., Gelman & Coley, 1990; Gelman & Markman, 1987). For example, if children are taught a property about leaf insects, they are likely to generalize that property to similarly named organisms (other insects) instead of similar-looking objects (other leaves), even when surface appearance conflicts with category membership (Gelman & Markman, 1987).

The emergence of such reasoning in young children underscores the strength of essentialist commitments. Yet, the ease with which children seem to reference internal, nonvisible features presents somewhat of a dilemma. As adults, we are at least familiar with the concepts of cells, molecules, and DNA. Thus, there is at least some basis for essentialist beliefs to be grounded in real, physical structures—even if those connections to reality are often inaccurate (Hull, 1965; Keil & Richardson, 1999; Mayr, 1982). But for children as young as 4 or 5, who

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presumably know nothing about such structures, it is unclear what type of representation they are using to guide their inferences about these unseen, internal properties. In other words, in the absence of concrete theories about actual biological mechanisms, what does it mean to take an essentialist stance?

Some researchers have suggested that essences are understood more as causal “placeholders,” rather than as actual physical entities (Gelman, 2003; Medin & Ortony, 1989). Thus, one could believe that there is some underlying property that unites category members, without knowing exactly what that property actually is or where it might be located. It might be that for young children—and for that matter, many adults—psychological essentialism consists of nothing more than the belief that certain kinds of entities, such as animals, have essences, and that those essences are somehow causally responsible for each member of a kind sharing certain properties. In this “barest placeholder” sense, the child is completely agnostic about particular causal relationships or mechanism and believes nothing beyond the very general idea that essences cause surface properties in ways that remain completely mysterious (see Strevens, 2000, for a more detailed account of different notions of psychological essentialism).

An alternative to the barest placeholder account would argue that even though children clearly do not have knowledge about specific biological mechanism such as genes and gene regulation, they still might possess much more abstract hunches about likely causal pathways and patterns through which essences have their effects. There is ample precedent for the idea that young children, even preschoolers, can have abstract expectations about causal patterns in a domain while not having any idea about specific mechanism (Inagaki & Hatano, 2002; Kalish & Gelman, 1992; Simons & Keil, 1995). For example, children expect animals and machines to have different insides even when they lack specific predictions about what those insides should look like (Simons & Keil, 1995). By this account, even if young children obviously do not know anything about DNA or the molecular basis of gene expression, they still might have some skeletal hunches about the ways in which essences are physically manifested.

Moreover, there is evidence to suggest that children may often conceive of essences as “very tiny, internally located” structures. For example, Springer and Keil (1991) found that if young children are asked to describe how various types of properties might be transmitted from parents to offspring, they are likely to endorse “Gemmulic” theories of biological transmission. In these studies, children reported, for example, that when a brown mother dog has a puppy, the puppy is likely to be brown because, “some very tiny brown pieces went from the mother to the puppy, … got into the puppy’s skin, and the puppy turned brown.” Springer and Keil derived the name “gemmules” from early theories in biology that proposed that the fetus inherits tiny pieces or copies of organs emanating from its mother’s body (Appleman, 1979; Mayr, 1982).

The aim of the present studies was to investigate whether children (and adults) may go beyond the barest placeholder sense of essence, to make auxiliary assumptions about the way in which essences are physically realized within an entity. For obvious reasons, it is difficult to directly ask children and adults about the physical nature of essences because people rarely refer to the concept of “essence” per se. Instead, similar to previous work (e.g., Keil, 1989), the present studies used “discovery” scenarios in which the category of an object is unknown, and participants must decide the best way to identify that object’s category. This method assumes that beliefs about the category-identifying feature (a feature that is specific to one particular kind and no other) should map onto beliefs about the essential feature (a feature that causes one kind to be different from all others).

This method is about identifying categories, not individuals. With individuals, idiosyncratic surface features are often paramount. A person’s tattoo, fingerprint, or dental work may be all one needs to confidently identify a person, even though those marks are not at all considered central to the individual. With categories, however, it is far less common to assume that there is some sort of causally irrelevant "accidental" marker of category membership. To be sure, surface traits can indicate category membership, but we assume they work because they are lawful products of internal causes. Hence, the focus on categories in these studies avoids some concerns about idiosyncratic surface properties that might arise for individuals. In addition, by focusing exclusively on internal parts, we are selecting just those properties that prior work has argued as closest to beliefs about internal determinants of kind (e.g., Gelman, 2003; Keil, 1989).

So, what sorts of assumptions might children make about the physical nature of essences? Adults, for instance, tend to believe there are kind-specific microscopic structures (DNA and molecules) that are common to members of naturally occurring categories. For living kinds, such beliefs may actually be inaccurate as the actual genetic basis of a species is always a probabilistic distribution of highly similar but not identical genetic sequences (Hull, 1965; Keil & Richardson, 1999; Mayr, 1982). Moreover, adults often appreciate that the same microstructure is homogeneously distributed throughout an organism—for instance, that the DNA in my finger is the same as the DNA in my stomach—even though they may not fully appreciate how microstructure in these different locations is responsible for morphological differences. One way to characterize such beliefs is that they reflect a "distributed" notion of essential features—that is, that members of a category share a common feature, which is distributed throughout the inside of each category member. Thus, despite the existence of different internal structures within a particular entity (e.g., the heart, the brain, or the lungs), the same essential feature (DNA) is present throughout. In terms of categorization, because the critical feature is distributed, samples from any internal location should be capable of identifying its kind; a sample from one part should be as equally identifying of category membership as a sample from another part.

Assuming that adults' beliefs about the essential features of natural kinds are best characterized as *distributed*—a possibility we explored in the first study—a critical question is, how do beliefs about distributed essence develop? Do children constrain their inferences about essential features in a manner similar to adults?

It may be that for natural kinds, children instead tend to think of the essential feature as a single entity that is located in one special place. This "localist" notion of essential features might be analogous to the idea that there is a "seat of soul" such as the pineal (Bloom, 2004; Descartes, 1985), a highly focal point out of which causal effects emanate. Thus, rather than thinking of essential features as distributed throughout an entity, children may think that there is a single focal place within an object that determines category membership. This view might predict that, unlike the distributed account, there could be only one location where one could look to identify the category of an object. In all the three studies, we contrasted the distributed view against the localized view to determine how children of different ages and adults may think about the physical nature of essences.

If children do make some assumptions about how identifying features are physically realized within an object, a second critical question asks about the domain specificity of those notions. Consider first the contrast between biological kinds and other nonliving natural kinds. There is broad consensus that both are thought to possess essential features (e.g., Ahn et al., 2001; Medin & Ortony, 1989; Putnam, 1975; but also see Malt, 1994; Strevens, 2000 for alternative accounts); but the nature of those features is quite different. Cut a piece of gold into any number of pieces and all pieces are "essentially" the same. Cut a dog into small pieces (only as a thought experiment, please), and it is still clear that most pieces will be very different from each other. Indeed, most nonbiological kinds (e.g., elements such as gold and sulfur, compounds such as water and jade, and mixtures such as dirt and sand) are normally considered to have homogeneous internal structures. Such things are normally substances that take mass nouns—although, not necessarily (e.g., an icicle or a snowflake). In comparison, living kinds are predominately bounded entities with heterogeneous internal structures and take count nouns; only with a layer of more sophisticated biological knowledge, do the deeper commonalities in all biological tissue in an organism become apparent.

Because of this major contrast and because very young children do have a clear sense of count/mass distinctions as well as a some notions about substances (e.g., Au, Romo, & DeWitt, 1999; Dickinson, 1987; Stavy, 1991), our first two studies contrast living and nonliving natural kinds. Because even a modest amount of experience with broken up pieces of rocks or minerals would reveal that nonliving natural kinds are homogeneous, a shift to a distributed view of essences might occur earlier in development for homogenous substances than for living kinds and in fact might be a basis for later emerging analogous notions about living kinds. Using the method outlined above, our first two studies compare beliefs about essential features for living kinds with beliefs about essential features for nonliving natural kinds.

A second major contrast is between all natural kinds and artifacts. It is controversial whether artifacts should even be thought of having essential features anything like those of natural kinds. For example, they have been argued to either have no essences (Sloman & Malt, 2003) or to have essences in the form of the intended category of their creators (Bloom, 2004). Moreover, given sharply divergent intuitions among elementary school children about the relevance of surface properties to category membership of artifacts versus natural kinds (Gelman, 1988; Keil, 1989), the artifact/natural kind divide may reveal contrasting intuitions about distributed versus localized accounts. Our third study explores this contrast while also using a converging method to explore the generality of the first two studies. In particular, we predict that it would be implausible at any age to have a distributed view of artifacts (other than for synthesized substances such as plastics).

In short, these studies use intuitions about features needed for categorization (identifying features) as a way of asking whether young children merely believe in essential features that somehow determine category membership in a completely unspecified manner or whether they also embed their sense of essential features in a more constraining framework that specifies how those features are physically realized within objects. We predict that even young children will show judgments that go beyond barest placeholder notions. We further predict that these intuitions will vary across broad domains such as substances, living kinds, and artifacts, with distributed views emerging first for substances, then for living kinds, and never for artifacts.

Experiment 1

The purpose of Experiment 1 was to determine whether the distinction between the distributed versus the localist accounts was a psychologically useful one, and second, whether adults show any strong endorsement of either view.

Method

Participants—Thirty-one undergraduates participated in exchange for course credit.

Stimulus materials and procedure—In a within-subjects design, participants were given questionnaires that described a situation in which scientists discovered objects whose category was unknown. They read, for example:

> Many years ago, a giant glacier moved across the land and froze some things inside. A group of scientists discover the glacier and they notice that a large animal is frozen inside. They want to know what kind of animal it is. The scientists decide that they

> will take really tiny pieces from the inside of the animal. Each piece will be about the size of a pea, and then the scientists will use all their tools and technology to look at these tiny pieces, and they will be able to see everything that is inside each piece.

Participants were then asked to rate the degree to which they agreed with the each of the following statements:

1. "It doesn't matter where they take the pieces from, any piece will be able to tell them what kind of animal it is" (distributed statement).
2. "There is only one special piece that will tell them what kind of animal it is" (localized statement).

For four different natural objects (a large animal, a small animal, a rock, and a piece of metal), participants rated on a 0 – 9 scale (where higher numbers denoted greater agreement) the degree to which they agreed with the distributed and localized statements. The wording was similar for each item except that the words "small animal," "rock," and "piece of metal" were substituted as appropriate. We created four different versions of the survey that varied the order in which the different scenarios were presented as well as whether the localized or distributed statement appeared first.

Results

The results from Experiment 1 are reported in Table 1. Adult participants were overwhelmingly more likely to agree with the distributed approach, as confirmed by a mixed-model analysis of variance (ANOVA) with statement type (distributed vs. localized) and object type (animal vs. substance) as within-subjects factors. This analysis revealed a significant main effect of statement type on participants' ratings, $F(1, 30) = 128.69$, $p < .001$, partial $\eta^2 = .811$; as predicted, participants were more likely to agree with the distributed statement ($M = 6.93$, $SE = .27$) than with the localized statement ($M = 1.34$, $SE = .26$). We also observed a significant main effect of object type, $F(1, 30) = 10.78$, $p = .003$, partial $\eta^2 = .264$; participants gave higher ratings to substances ($M = 4.41$, $SE = .09$) than to animals ($M = 3.85$, $SE = .17$). We also found a significant interaction between statement type and object type, $F(1, 30) = 6.98$, $p < .05$, partial $\eta^2 = .188$. This interaction was driven by differences in ratings of the distributed statement. Participants were more likely to agree with the distributed statement for substances ($M = 7.59$, $SE = .27$) than for animals ($M = 6.27$, $SE = .40$), $t(30) = 3.22$, $p < .01$. Agreement with the localized statements, however, was not significantly different between items ($p = .62$). We ran an additional ANOVA that included which survey version participants completed (i.e., presentation order) as a between-subjects factor. There were no main effects or interactions of presentation order on participants' ratings ($F < 1$).

Agreement with distributed statements was negatively correlated with agreement with localized statements (for substance items, $r = -.79$, $p < .001$; for animal items, $r = -.52$, $p < .01$).

Discussion

The results indicated that there is strong agreement among adults about the physical nature of essential features. Adults appear to think of such features as distributed throughout the inside of natural kinds and not localized to one particular region or part.

We also observed a significant interaction between statement type and object type. Adults were more likely to agree with distributed statements that referred to substances than distributed statements that referred to animals. One interpretation of this result is that substances are simply known to be more internally homogenous than animals, and the interaction with object type reflected this difference. Another interpretation might be that although adults overwhelmingly endorse distributed views for both animals and substances, they could still think of the essential features of animals as more localized. In other words, though adults have explicitly learned that the internal causal property in animals (DNA) is distributed, perhaps more developmentally primitive ways of viewing these structures (i.e., localist notions) still compete with this view. Therefore, data from children (Experiments 2 and 3) may shed light on this issue, as they provide an important comparison not only for when distributed notions develop but also what types of knowledge might be used to support such beliefs. If, for example, children think of substances as distributed before animals, it may because they use their knowledge about homogeneous substances to support more complicated inferences about the underlying essence of living kinds.

Experiment 2

The purpose of Experiment 2 was to explore when distributed views of essential features develop and any potential differences between substances and animals. We adapted the adult procedure from Experiment 1 to be suitable for elementary school children. We tested elementary school children as a way of dissociating the degree to which notions of distributed microstructure might stem from explicit knowledge about actual microstructure (DNA and molecules) versus more naïve assumptions about the nature of natural kinds. Presumably, all our adult participants (college undergraduates) had been exposed to the concepts of DNA and molecules in some formal sense. However, children are typically not exposed to these concepts in school until sixth-and seventh-grade biology and chemistry, and it is not typically until high school that children learn about the periodic table or biological processes such as cell division, genetic recombination, and so forth. This of course does not rule out the possibility of our participants' learning about DNA from other sources, such as parents, older siblings, or television crime shows. It does, however, limit the degree to which children have formally learned, for instance, that DNA consists of chromosomes and base pairs, which are replicated in every cell in the body. Thus, it is fair to say that children and our sample of college adults were substantially different in terms of their explicit knowledge about actual microscopic bodies.

Method

Participants—Participants were 67 children, including 20 kindergarteners (*M* age = 6.0, range = 5.6 – 6.7), 23 second graders (*M* age = 8.1, range = 7.7 – 8.6 months), and 24 fourth graders (*M* age = 10.2, range = 9.7 – 10.7 months), each of whom was interviewed individually. An additional 9 students were tested but did not complete the session. Altogether there were 36 boys and 31 girls, roughly evenly distributed across grade. Participants were from middle- and upper-middle-class backgrounds and were recruited at public and private elementary schools. Ethnicity breakdowns were as follows: Asian (*n* = 41), Caucasian (*n* = 21), Hispanic (*n* = 4), and African American (*n* = 1). A polling of the teachers confirmed that children were not receiving instruction about DNA or chemical elements in class.

Stimulus materials and procedure—Participants were first shown a picture that depicted a large block of ice with objects frozen inside. The objects were created to loosely resemble four different natural objects (identical to Experiment 1). The experimenter said:

> Many years ago a giant block of ice moved across the land and froze some things inside. A group of scientists discover the block of ice and they want to know what kinds of things are frozen inside.

Participants were then presented with a card that "zoomed in" on one of the objects. The experimenter then said:

> Scientists discover that a large animal is inside the block of ice and they want to know what kind of animal it is. To figure it out, the scientists decide that they will take really tiny pieces from the inside of the animal. Each piece is really, really, tiny. It's about the size of a pea. The scientists will use all their tools and technology to look at these tiny pieces, and they can see everything that is inside each piece.

Participants were then shown two pictures of scientists thinking about the tiny pieces (see Figure 1). The experimenter said:

> There is a disagreement between the two scientists. One scientist thinks that it doesn't matter which piece they look at to figure out what kind of animal it is, because any of the pieces they look at can tell them. But the other scientist thinks that there is only one piece that can tell them about what kind of animal it is, and they must find that one piece to figure it out.

Participants were asked to decide which scientist they thought was correct. After they responded, either verbally or by pointing, they were also asked to explain why they chose that answer. This process was repeated for the remaining three items (a small animal, a rock, and a piece of metal). The protocol was similar for each item, except that the words "small animal," "rock," and "piece of metal" were substituted as appropriate. The order in which the statements were presented was balanced within each participant so that for half of the items, a child was given the distributed statement first (any piece can tell them), whereas for the other half of the items, the localized statement (only one piece can tell them) was presented first. Additionally, two sets of distributed and localized images were created (where we crossed which scientist was pictured with which statement type), so that children did not respond on the basis of which scientist looked more knowledgeable. Materials were presented in one of the four different randomized orders that varied the sequence in which each item occurred.

Participants also completed an item at the end of each session that asked about distributed microstructure more generally. The experimenter said:

> Today in school, Molly and Erica learned about what makes an animal be a certain kind of animal. Their teacher told them about what makes a dog be a dog, a cat be a cat, and a mouse be a mouse. After school, Molly and Erica are trying to remember what they learned. Molly says that what makes an animal be a certain kind of animal is one special piece that is buried deep inside. Erica says that what makes an animal be a certain kind of animal is spread out through the entire body of animal.

Participants were asked to decide which person they thought was correct. The order of the distributed and localized statements, as well as which name was paired with which option, was balanced across participants.

Results

For each item, children's responses were classified as either distributed (i.e., *any location can identify the object*—coded as 1) or localist (i.e., *only one location can identify the object*—coded as 0). This produced five data points for each child (one for each item).

Two separate analyses were performed. We first examined the data nonparametrically. There were significant differences in the pattern of responses between the age groups for the "small animal," $\chi^2(2) = 7.52$, $p < .05$; "rock," $\chi^2(2) = 12.03$, $p < .01$; and "metal," $\chi^2(2) = 10.30$, $p < .01$ items. We then looked at each age group separately. Fourth graders were significantly more likely to choose the distributed option over the localized option for the "metal" and "rock" items ($p < .01$) and showed the same marginally significant pattern for the "large animal" and "kind-identity" items ($p = .06$) via binomial tests (two-tailed). Second graders' responses did not differ from chance (all $p > .38$). Kindergarteners, on the other hand, were more likely to choose the localized option over the distributed option for the "small animal" item ($p < .05$) via a binomial test (two-tailed), but did not show significant differences on any of the other items (all $p > .82$). These results are reported in Table 2.

In a second analysis, we summed the scores from all items to produce a score that ranged from 0 *localist response on all items*) to 5 (*distributed response on all items*); see the Appendix for a distribution of these parametric scores. A one-way ANOVA of this combined score comparing the three age groups revealed a significant main effect of grade on children's responses, $F(2, 64) = 9.86$, $p < .001$. Bonferroni post hoc analyses revealed that fourth graders were significantly more likely to endorse a distributed account ($M = 3.75$, $SE = .23$) than either second graders ($M = 2.43$, $SE = .27$), $p < .001$, or kindergarteners ($M = 2.20$, $SE = .32$), $p < .001$. Second graders and kindergarteners were not significantly different from one another. Comparisons to chance responding ($M = 2.5$), revealed that only fourth graders were significantly different than chance, $t(23) = 5.50$, $p < .001$.

Overall, children's justifications were too infrequent and sporadic to be coded and analyzed. However, only one child (age 10 years 7 months) used DNA to explain their response and a second child (age 10 years 4 months) mentioned cells.

Discussion

Results from Experiment 2 indicate that by at least fourth grade, children, like adults, tend to hold a distributed view of essence. These children reported that the unknown object's category could be determined by looking "anywhere," rather than in one specific location. Moreover, such beliefs do not appear to directly stem from knowledge about DNA or molecules because children hardly ever referred to these concepts. At the same time, fourth graders' responding was not identical across items. Endorsement of the distributed option for substances (rocks and minerals) was robustly above chance responding, whereas endorsement of the distributed option for animal items (small animal and large animal) only trended in that direction or was weakly significant. This pattern is interesting because it dovetails with the patterns observed in adults. Both adults and fourth graders tended to show weaker endorsement of the distributed option for animals compared to substances. As hypothesized before, this could be because a distributed understanding of complex, heterogeneous biological systems, such as animals, stems from a distributed understanding of less complicated, homogeneous structures, such as minerals. We return this issue at greater length in the General Discussion section.

The differences we found between fourth graders and younger children could be interpreted in one of the two ways: It could be that younger children simply do not have reliable intuitions about the physical nature of "very tiny internal pieces"; thus, they were at chance responding throughout. However, it may also be that younger children hold a consistent but competing view that we did not adequately measure with this task—namely, that *there is* one special piece that informs categorical identity better than others. Such an interpretation is at least plausible given that kindergarteners did favor this response at above chance levels for at least one item. Additionally, some of the younger children's justifications for selecting the localized option supported this view as well. For example, a few children spontaneously reported that the scientist would know best by looking "in the middle," whereas others offered structures such as "the blood" or "the heart." It could be that younger children really do tend toward a localist view of identifying internal properties, but the difficulty of the task obscured this pattern. In Experiment 3, we explored this issue further by creating a different scenario that simplified some of the task demands from Experiment 2.

Experiment 3

Results from Experiment 2 clearly suggested a developmental shift in children's endorsement of distributed views of essence. However, on the basis of that study alone, it was unclear exactly why younger children were at chance levels of responding. To address this question in Experiment 3, we employed a different but related measure to probe children's notions about essence. In this study, children were presented with two different kinds of objects that appeared the same on the outside. For example, children saw a picture of two lions that looked identical. However, they were told that one of the animals was a real lion, whereas the other was actually a tiger in a very good lion costume. Children were told that in order to figure out which was the real lion and which was the tiger, scientists looked at tiny pieces taken from the insides of the animals (see studies by Lizotte & Gelman, reported in Gelman, 2003, for a similar task in which children identify "insides" as vital to identifying the proper category). Unlike Experiment 2, however, we specified where the pieces were taken from—for example, from the middle of the animal and from the leg. This task was designed such that a distributed response would be to say that both pieces would tell you the same, whereas a localist response would be to say that a piece from one location might tell you better than a piece from another location. This task was in many ways superior to the task used in Experiment 2 because it eliminated any ambiguity about where the tiny pieces were taken from or how many their were. Moreover, this task better focused children's attention to "unseen," internal differences between the kinds, because the outward appearances of the objects were identical.

In this experiment, we also asked about artifacts to test the degree to which notions of distributed microstructure might be specific to animals and substances. Children saw two artifacts that looked identical on the outside, yet were different on one internal dimension (e.g., a pen and a mechanical pencil). For artifacts, a single functional component may indeed be the critical feature needed for categorization. Most artifacts are constructed of similar materials (e.g., plastics, various metals or alloys, wood, etc.), and rarely is it possible to distinguish an artifact solely on the basis of its *distributed* internal properties. Rather, these identifying markers of kind tend to be single functional units that in some way define or directly support that artifact's unique function. Thus, we predicted that children might have different intuitions about artifacts than animals and substances. For these items, all age groups should report that there is only one part (such as lead or ink) that can identify the object's category.

Method

Participants—A new group of 60 children participated in this study, including 20 kindergarteners (*M* age = 6.5), 20 second graders (*M* age = 8.5), and 20 fourth graders (*M* age = 10.5). Altogether there were 32 boys and 28 girls, roughly evenly distributed across grade. As in the previous study, participants were from middle- and upper-middle-class backgrounds and were recruited at public and private elementary schools. Ethnicity breakdowns were as follows: Caucasian (*n* = 56), Hispanic (*n* = 1), and African American (*n* = 3).

Stimulus materials and procedure—Participants were first shown a picture of two objects that appeared the same on the outside (see Figure 2). The experimenter said:

> Scientists find two animals. They know that one animal is a real lion and they know that the other animal is actually a tiger in a very good lion costume. Someone has played a trick and they have dressed up a tiger in a special skin-tight costume that makes it look just like a lion. The scientists cannot tell which is the real lion just by looking at them because they both look exactly the same on the outside. In order to figure it out, the scientists take really tiny pieces from the insides of the animals. Each piece is really, really, tiny. It is about the size of a pea. They will use all their tools and technology to look at the tiny pieces and they can see everything that is inside

> each piece. The scientists took a tiny piece from here in each of the animals (the middle), and the scientists took a tiny piece from here in each of the animals (the leg).

Participants were then asked:

> Which piece do you think will tell them the most about which is the real lion and which is the tiger? The piece from the middle, the piece from the leg, or will they both tell them the same?

For half of the participants, the middle piece was discussed first and for the other half of the participants, the leg piece was discussed first. This procedure was repeated for five additional pairs of items that consisted of one additional animal item (zebra/horse), two substance items (gold/coal and cement/wood), and two artifacts (pen/pencil and battery-operated watch/wind-up watch). The protocol was identical for each set of items, except for as follows: For substance items, the tiny pieces were taken either from the middle of the object or from a location that was off center. For artifact items, the tiny pieces were taken either from the middle of the object or from a nonfunctional location (the back of the pen or the band of the watch). Materials were presented in one of the four different randomized orders that varied the sequence in which each item was presented as well as which location (i.e., middle or other) was presented first.

Results

Children's responses were classified as either *center* (e.g., "only the piece from the middle can identify the object") *other* (e.g., "only the piece from the inside of the leg can identify the object") or *both* (e.g., "both locations can identify the object"). The *center* and *other* options reflected a localist view of essence, whereas the *both* option reflected a distributed view.

The results from Experiment 3 are reported in Table 3. Consistent with the previous study, we found significant differences in the pattern of responses between age groups. We compared each of the grade levels using a Fisher's exact test and found significant differences between grades for the "gold/coal" ($p < .05$) and "cement/wood" ($p < .01$) items, and the same trend was present for the lion/tiger" item ($p = .12$). There were no differences between grades for either of the artifact items (both $p > .24$). We then looked at each age group separately. Fourth graders were significantly more likely to say that pieces from *both* internal locations could identify "gold/coal," and "cement/wood" items ($p < .05$), and the "lion/tiger" item ($p = .055$) via binomial tests (two-tailed). As predicted, however, fourth graders were significantly more likely to say that pieces from "the center" could identify the "pen/pencil" and "watch" items ($p < .01$) via binomial tests. Additionally, because we predicted differences between natural kinds and artifacts, we compared fourth graders' pattern of responding to each of the natural kinds items against the pattern of response to the two artifact items. Each of these comparisons was statistically significant via Fisher's exact tests (all *p*s < .001).

Second graders' pattern of response did not differ from chance for the natural kind items (all $p > .18$). However, similar to fourth graders, the second graders were significantly more likely to say that pieces from *the center* could identify the "pen/pencil" and "watch" items (*p*s < .01) via binomial tests. We then compared their pattern of response to each of the natural kind items against the artifact items via Fisher's exact tests. Each of these comparisons was statistically significant (all *p*s < .001).

In contrast, kindergarteners showed a very different pattern of response, as they tended to report that only the piece from *the center* could identify the natural kind objects. They were more likely to agree with the center option for the "gold/coal," and "cement/wood" items ($p < .01$), the "lion/tiger" item ($p = .055$), as well as the "watch" item ($p < .01$) via binomial tests (two-tailed). Unlike older children, kindergarteners' pattern of response to each of the natural kind items was not statistically different from the two artifact items, as they tended to endorse the “center” location option throughout.

Discussion

Experiment 3 found a developmental shift in how children think about the physical nature of essential features. Consistent with the previous experiment, fourth graders endorsed a distributed view of essence for animals and substances. In contrast, kindergarteners reported that for both animals and substances, the essence was localized to one specific region. And, second graders appeared to reflect a transition between these two understandings, as their responses were split between distributed and localized responses.

These data also helped resolve unanswered questions from the previous study. A concern from Experiment 2 was whether younger children really do show a preference for the localist view. Indeed, kindergarteners were significantly more likely to report that a “center” location would identify the objects for several of our items, even when given the option of another single, internal location. This pattern preliminarily suggests that kindergarteners actually appear to hold a rather specific belief about the physical nature of essence—namely, that it is located in the center of the object, for both animals and substances.

Data from the artifact items suggest that by at least fourth grade and possibly earlier, children make a sharp distinction between natural kinds and artifacts in terms of how they think essences are physically realized. For natural kinds, older children appreciate that essential features are distributed throughout the entity. However, for artifacts they recognize that there may be only one single location that correctly identifies the object. Kindergarteners, however, did not show this distinction, as they tended to favor a localist view throughout.

Finally, across all items, we tended to find greater agreement with the distributed view for substances than for animals. This result again parallels the results found in both Experiments 1 and 2. The appearance of such a pattern across three experiments is consistent with the interpretation that distributed beliefs about homogenous substances tend to emerge earlier than do distributed beliefs about animals and that such intuitions may, in fact, be used to buttress a distributed understanding of animals.

General Discussion

Children, as young as 6 years old, do not seem to be agnostic about the physical nature of essence. However, these younger children, contrary to adults, favor the view that essences are localized to the center of objects—not only for animals but for minerals as well. Around second grade, children begin shift away from this localist view to recognize that for minerals at least, essential features are distributed throughout. By fourth grade, children, like adults, recognize that for both minerals and animals, essential features are distributed—a view which they apply to natural kinds, but not to artifacts.

This shift from localist to distributed accounts is a developmental pattern that is distinct from what might be predicted by a “barest placeholder” notion of essence. We argue that instead, it may be incoherent to have a notion of essential features without some sense of how those features are physically instantiated. Thus, children and adults tend to constrain their inferences about essential features by making some rudimentary assumptions about where those features may be located: Initially, children seem to think of the essence as a single, localized thing, buried somewhere within the center. However, over time, this view is replaced with the notion that essential features are located throughout.

Not only do these results suggest that children may go beyond the barest placeholder notion of essence, but they also potentially speak to alternative accounts in the literature, which have argued that “blind-faith” essentialism based on barest placeholder notions alone may be implausible. For example, it has been suggested that children represent a few causal laws that link innards and heredity to phenomenal properties and that these laws masquerade as essentialist-like biases (Strevens, 2000). Along with others, we do not agree that such alternatives negate essentialism (see Ahn et al., 2001). Rather, we suggest that the results of the present studies point toward the idea that there is a drive to contextualize essentialism in terms of a more elaborate framework of causal assumptions—a framework that, for example, makes assumptions about how essences are physically instantiated. The critical modification here, however, is that this set of causal assumptions is far different from a detailed mechanistic understanding. It instead seems to consist of a very general sense of how and where causal features are located.

Indeed, the shift to a distributed view seems to occur without the benefit of detailed biological models or adult-like understandings of biology. Only one child in both studies ever mentioned DNA, and traditionally the concept of DNA is not introduced until sixth or seventh grade, at least 2 years older than children in our studies. Thus, even though a distributed view and knowledge about DNA make similar predictions about the location of identifying features (i.e., they can be found anywhere inside an entity), convictions about distributed essence seem to occur at a level of understanding far above that of concrete mechanism. The convictions instead seem to consist of a general sense of a causal pattern and its association with natural kinds. The presence of distributed reasoning in the absence of concrete theories about actual physical structures is additional support for the idea that children go beyond the barest placeholder notion of essence.

One potential limitation to these findings, however, concerns different sizes of microstructure. It is the case that the level of analysis suggested by our stimuli (e.g., pea-sized pieces) is larger than the level at which DNA is normally envisioned. And, for some adults, this may indeed result in different forms of reasoning. For children, however, we doubt that this difference was a factor. Moreover, attempts to realistically describe the appropriate microscopic scale would have not been feasible and well beyond the scope of this set of experiments. Thus, although we do not feel that this limitation prevents interpretation of these studies, it is an interesting question for future work as to how reasoning might vary as a function of the scale of the internal sample.

How might the shift from a localist to a distributed view of essence occur? One possible way may be through analogies to minerals, which seem to be understood as distributed somewhat earlier than living kinds. Experiment 1 found that adults were more likely to endorse the distributed account for minerals than they were for animals. Similarly, Experiments 2 and 3 found that the older children in our samples tended to endorse a distributed account for minerals more often than for animals. This pattern suggests a tendency to think that minerals are more likely to have distributed essential features than animals. We speculate that this contrast might be due to a number of factors. For example, real-world experience with substances such as rocks would reveal that their internal composition is homogenous. It may be that this type of real-world observation directly aided the distributed view in our tasks—for instance, leading children to respond that the scientists could take a piece from “anywhere” on the inside and still be able to identify the object’s category. In turn, a distributed view of animals may occur through analogy to substances. Children may link knowledge about homogeneous distributed structures in substances to unseen distributed structures in animals. At the same time, though the data support the emergence of distributed reasoning for substances before animals, the hypothesis that real-world knowledge about substances actually “launches” later notions about living kinds needs to be confirmed in more focused experimental studies.

Moreover, this explanation does not address why younger children may hold a localized view of essence in the first place. A second, though not mutually exclusive, mechanism may be that the shift from localist to distributed accounts represents a more fundamental change in assumptions about the causal connection between internal causes and category membership. Previous work suggests that adults are often biased to prefer properties as central to categories when they are the single initial element in a causal chain (e.g., Ahn, 1999). It may be that younger children confuse a theoretical preference for a single, initiating cause with the physical existence of centrally located structures. This would be consistent with the finding that although young children insist that there is an identifying feature located in the center of objects, they never specify a particular internal part. It is also consistent with work showing that *what* children actually think the essence of an animal is, may change as a function of that child's particular culture (Waxman, Medin, & Ross, 2007). Moreover, in the case of substances, where young children express the same beliefs about a localized identifying feature, it is even less clear what actual physical structures could guide their intuitions, as there are none. It may be that the idea of a single initiating causal element is so compelling that it overrides considerable experiences with homogeneous substances suggesting otherwise.

We now return to the differences in adults' endorsement of the distributed statements between animals and substances. At the outset, we would have no reason to expect that adults should hold different views about animals and substances. However, we suggested that one explanation for adults' willingness to endorse Distributed views more often for minerals than for animals might be because more developmentally primitive ways of viewing these structures (i.e., localist notions) compete with the explicit knowledge that such features are distributed. To illustrate this point, consider the difficulty of reconciling Fact 1—that there is a single causal element, DNA, that causes biological kinds to be different—with Fact 2—that this same element is equally distributed around the body (represented in all nucleated cells). Although we speculate that most Western adults who have taken at least high school – level biology can confidently produce both of these facts, when it comes to explaining how DNA is then responsible for complex, synchronized developmental changes like growth or puberty, we speculate that most people's explanations will tend to fall flat—or more likely, revert to some sort of localist notion (e.g., that there is one special factor that oversees the process). Of course, this speculation requires empirical investigation, but examples such as this one raise important questions about what happens when even adult folk-biological models have to confront the true complexity of the biological world. We argue that people's lay models may have to be at least "a little localist" at times, simply because often the phenomena in question are so complex that they must be reduced to single-cause frameworks. Similarly, younger children, for reasons that are either specific to their particular theories of biology or constraints on their processing, may also be, in a sense, "required" to take a localist view of essential properties, merely because it represents a simpler causal story.

An additional mechanism that may promote these different views of essence could be some sort of instruction that is particular to a given culture. Would we see the same developmental patterns 150 years ago, before Mendel published his work on genetics—or even 200 years ago, before Brown observed the motion of microscopic particles? Or, would we expect the same patterns cross-culturally, in remote groups that might not be familiar with concepts such as DNA or atoms? Here, it is difficult to speculate, as the answers to these questions largely depend on how one believes children acquire notions of a distributed essence in the first place. On the one hand, if children develop such beliefs either through analogies to substances or a more profound change in their assumptions about underling cause, then we would expect the same types of patterns to occur, regardless of time or place. There is some support for this position, as ideas about atomistic or inherent, unseen causes far predate modern science and are culturally pervasive (Sober, 1994).

On the other hand, it may be that notions of a distributed microstructure reflect, or are in some way aided by our modern, Western scientific view. For example, work by Waxman et al. (2007) finds culturally specific intuitions about the nature of biological causes in children. They presented children from several different cultures with versions of the adoption paradigm in which children were told about a baby pig that was adopted and raised solely by other cows. Children were then asked about many of the pig's properties such as what sorts of things would be "pig like" and what sorts of things would be "cow like." Across all cultures, they found evidence for a strong biological component to children's understanding of property inheritance. Native American children, however, seem to have more firm commitments about the biological mechanism underlying the transmission of properties from parent to offspring. They often reported that the blood was essential, a belief that is widely shared among adults in this culture as well. The authors concluded that "children may be more likely to consider biological than nonbiological processes as candidate essences, and that in identifying candidate biological processes, they are sensitive to community-wide discourse" (p. 306). Thus, it is certainly plausible that children's notions of distributed essence are in some way shaped or buttressed by our modern scientific understanding and language.

In sum, we propose that even quite young children do not simply believe in a completely unspecified, barest placeholder notion of essence. In other words, they are not "blind-faith essentialists." Instead, they seem to embed essentialism into a more complex causal framework that takes into account the way in which essences may be physically instantiated. For natural kinds, children have some notions about the physical nature of essential features and will constrain their decisions about identifying features accordingly. At the same time, children may well be misguided early on, favoring a localized view of identifying features because it fits with a seemingly simpler causal story.

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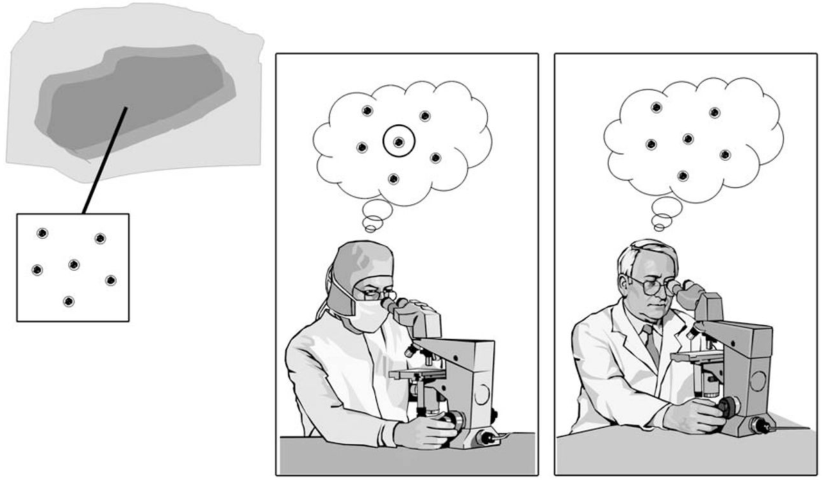


Figure 1.
Sample pictures used in Experiment 2.

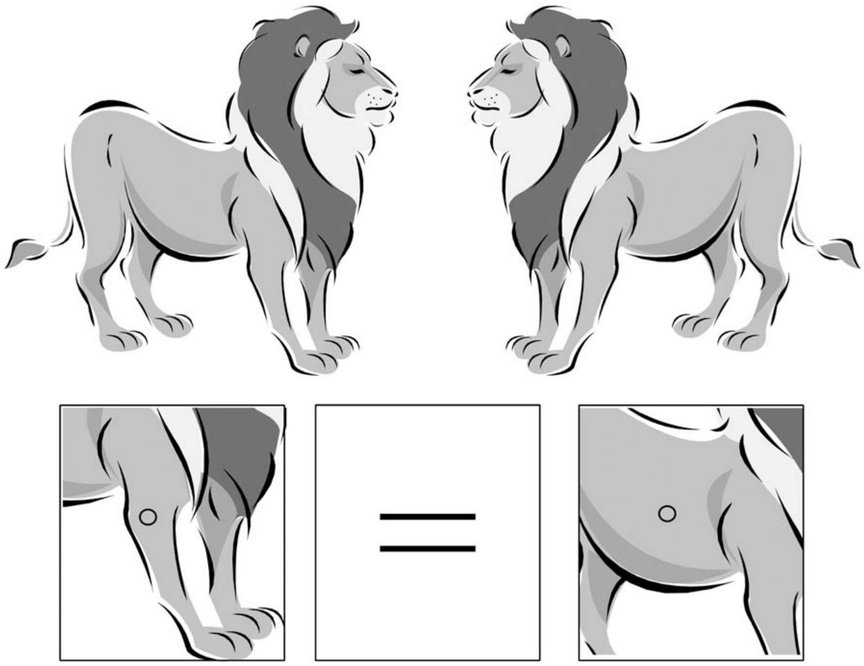
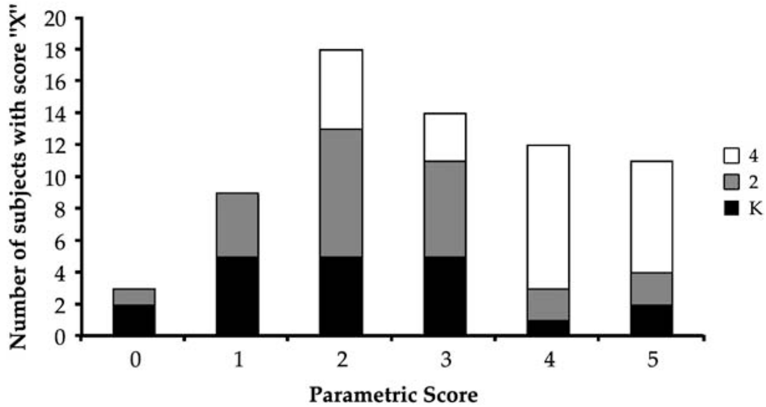


Figure 2.
Sample pictures used in Experiment 3.



Appendix.
Distribution of Parametric Scores in Experiment 2

Table 1

Mean Agreement (Standard Deviation) With Localized and Distributed Statements for Each Item in Experiment 1

Item	Localized	Distributed
Large animal	1.40 (1.61)	6.40 (2.25)
Small animal	1.47 (1.79)	6.15 (2.57)
Rock	1.26 (1.65)	7.19 (2.01)
Metal	1.21 (1.67)	7.98 (1.36)

Note. Judgments were made on a 0 – 9 scale, where higher numbers denoted greater agreement.

Table 2

Proportion of Children in Each Age Group Choosing the Distributed Option in Experiment 2

Item	Kindergarten	Second grade	Fourth grade
Large animal	.55	.57	.71[†]
Small animal	.22[*]	.45	.63
Rock	.55	.39	.88[**]
Metal	.45	.48	.87[**]
Kind Identity	.50	.62	.71[†]

Note. Binomial test results (two-tailed).

[†] $p < .10$.

[*] $p < .05$.

[**] $p < .01$.

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Table 3

Proportion of Children in Each Age Group Choosing *Center*, *Other*, and *Both* Options in Experiment 3

	Kindergarten			Second grade			Fourth grade		
Item	**Center**	**Other**	**Both**	**Center**	**Other**	**Both**	**Center**	**Other**	**Both**
Lion	.55*	.15	.30	.25	.30	.45	.40	.05	.55†
Zebra	.50	.28	.22	.30	.25	.45	.35	.15	.50
Cement	.60*	.20	.20	.40	.10	.50	.25	0	.75**
Gold	.75**	.10	.15	.32	.21	.47	.35	.10	.55*
Pen	.45	.50	.05	.70**	.30	0	.70**	.30	0
Watch	.90**	.10	0	.80**	.10	.10	.95**	0	.05

Note. Exact binomial test results (two-tailed).

† $p < .1$.

* $p < .05$.

** $p < .01$.