Psychological Review

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Online First Publication, December 12, 2024. https://dx.doi.org/10.1037/rev0000527

AMERICAN PSYCHOLOGICAL ASSOCIATION

Psychological Review

ISSN: 0033-295X

https://doi.org/10.1037/rev0000527

The Development of Kind Concepts: Insights From Object Individuation

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Object individuation studies have been a valuable tool in understanding the development of kind concepts. In this article, we review evidence from object individuation paradigms to argue that by their first birthday, infants represent at least three superordinate-level sortal kinds: OBJECT, ANIMATE, and AGENT (possibly also ARTIFACT). These superordinate sortal-kind concepts share key characteristics of adult kind concepts, such as prioritizing causal properties and having inductive potential. We then discuss the implications of this body of research. First, we discuss how the early development of these sortal-kind concepts (i.e., OBJECT, ANIMATE, and AGENT) relate to the two major theories of concepts: core knowledge and psychological essentialism. Second, we suggest that superordinate kind concepts set the stage for later development of basic-level kind concepts and present evidence that human communication, either in the form of language or pedagogical demonstration, plays a key role in constructing basic-level kinds. Third, we compare feature-based versus kind-based object individuation studies and put forth the hypothesis that they may reflect two modes of construal theory. Last, we discuss several open theoretical and empirical questions about sortal-kind concepts and suggest directions for future research. Overall, our review underscores the importance of object individuation methods as a powerful research tool for investigating the development of kind concepts, mechanisms of learning, and the relationship between language and thoughts.

Keywords: object individuation, sortals, kind concepts, psychological essentialism, conceptual development

Kind concepts are pervasive in every day thought and help facilitate common sense reasoning and communication. Even our most ordinary conversations are guided by an intuitive understanding of kinds. For example, when a child points and asks, "What is it?" Their parents might say "It is a dog" but not "It is brown." Why is the first answer satisfactory but not the second? One explanation, according to philosophers and psychologists, is that the word "dog" refers to a kind, whereas the word "brown" does not.[1] A child may also ask, "How many dogs does our neighbor have?" or "Is that the same dog that I saw yesterday in our neighbor's yard?" but certainly not "How many browns does our neighbor have?" nor "Is that the same brown that I saw yesterday in our neighbor's yard?" This is because a subset of kind concepts, namely, sortal-kind concepts, provide principles of individuation (how many) and principles of identity (is it the same as …) which guide the tracking of objects through time and space (Gupta, 1980; Hirsch, 1982; Macnamara, 1987; Wiggins, 1980).

The nature and development of kind representations have been a long-standing area of philosophical and empirical interest—and for good reason. Kind concepts like *dog*, *bee*, *apple*, *water*, and *sand* proliferate human thought and culture. In this review, we primarily concern ourselves with sortal-kind concepts (often referred to as "sortals" in the philosophical literature, especially in logic and formal semantics; Macnamara, 1987; Wiggins, 1980). In natural languages with a count/mass distinction, sortal-kind concepts are lexicalized as count nouns (e.g., *dog, bee, apple*), whereas kind concepts generally can be lexicalized as either count or mass nouns (e.g., *dog, bee, apple, water, sand*). Even in languages that do not mark the count/mass

Elena L. Grigorenko served as action editor.
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The authors thank Susan Gelman for very helpful comments on an earlier version of this article.

Jenna Croteau played a lead role in writing–original draft and an equal role in conceptualization and writing–review and editing. Erik Cheries played a supporting role in writing–review and editing and an equal role in conceptualization. Fei Xu played a supporting role in writing–original draft and an equal role in conceptualization and writing–review and editing.

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[1] It is possible to respond with descriptors other than count nouns in response to "What is it?" (e.g., "It is Fido" or "It's the thing I told you about the other day."). Importantly, the reason we are able to respond with these nonsortal descriptors is because of how discourse semantics operates (i.e., conceptual pacts; Brennan & Clark, 1996). We can only refer to "Fido" or "the thing I told you about the other day" if the object has already been introduced to the discourse context, either via perception of the listener (i.e., responding "Fido" is okay if you know the listener can see the dog and knows it's a dog) or via previous discourse history (i.e., responding "the thing I told you about the other day"). In a recent theoretical proposal, Perner and Doherty argue that children and adults use sortal concepts to track discourse referents, "Certain labels (sortals) individuate the referent under a specific concept. This is particularly important for ostensive reference" (Doherty & Perner, 2020, p. 3). Furthermore, some languages do not make a syntactic distinction between count/mass nouns (e.g., Mandarin Chinese). It is an open question whether in casual conversation one is more likely to answer "It is brown" or "It is running" when asked "What is it" in these linguistic communities compared to English speakers. We thank two anonymous reviewers for pointing out these issues.

distinction grammatically, sortal-kind concepts are lexicalized in some form or another (for a review, see Doetjes, 2017). We use the fact that linguistic distinctions exist between sortals and other concepts in many natural languages as evidence of a conceptual distinction when it comes to kinds. In other words, we are making the general assumption that these linguistic distinctions exist in part because they reflect different cognitive representations of things in the world.

Representations of different kinds license different inferences and predictions. A child who correctly identifies the backyard intruder as a *dog* might intuit that the dog she saw today is the same as the one she saw yesterday. Alternatively, that same child might infer that the neighbor has two pets if she sees a *cat* (a member of a different sortal kind) later in the day. Furthermore, representing a hard to see object as a *bird* might lead us to predict that it will continue to fly forward, whereas representing that same object as a *rock* will mean that it should fall to the ground. Finding a *hammer* in a forest enables us to infer the presence of a person who left it behind, whereas finding a *puddle* leads us to infer that it rained. We also engage with objects very differently by dint of their kind: writing with a *pencil* while sitting on a *chair* but not writing with a *chair* while sitting on a *pencil*. These seemingly trivial examples of inferences invite important developmental questions: How and when do young learners represent sortal-kind concepts? And how and when do young learners use them in common sense reasoning? The goal of this article was to articulate a response to these questions.

The focus of this theoretical review will be on object individuation studies, which have served as a productive research tool in investigating the development of sortal-kind concepts.

The Sortal Concepts and Object Individuation section lays out the theoretical framework on sortal-kind concepts. The Representations of Sortal-Kind Concepts in Infants section reviews empirical studies that use object individuation methods. After nearly 30 years of empirical work, it appears that at least three (possibly four) superordinate-level sortal-kind concepts are in place by 10 months of age: OBJECT, ANIMATE, AGENT, and maybe ARTIFACT. These superordinate sortal-kind concepts share several defining characteristics of adult kind concepts, such as the prioritization of deep causally relevant features. We hypothesize that the subsequent development of basic-level kinds occurs within the domains of these superordinate kinds and that basic-level kinds inherit the causal features from the superordinate kind (e.g., self-propelled motion is inherited for ANIMATES, intentionality is inherited for AGENTS).

In the Theories of Concepts: Sortals, Core Knowledge, and Psychological Essentialism section, we discuss the relationship between sortal-kind concepts and two prominent theories of concepts: core knowledge and psychological essentialism. We describe how findings from object individuation studies provide a more sensitive type of method for investigating the developmental origins of essentialism, moving past the nearly exclusive use of explicit and language-based behavioral tasks. In the Mechanisms of Learning: The Emergence of Basic-Level Sortal-Kinds section, we propose two communicative mechanisms for acquiring basis-level sortal-kind concepts: the role of pedagogy and the role of language. We also review object individuation studies with nonhuman animals and raise questions about whether they represent sortal-kind concepts. The Two Modes of Construal: Sortal-Kind Concepts Versus PR section focuses on reconciling seemingly contradictory findings in object individuation studies, contrasting the development of physical reasoning (PR) and the development of sortal-kind concepts. Finally, in the Future Directions section, we end with open questions and suggestions for future research using object individuation methods.

Sortal Concepts and Object Individuation

Central to the scientific investigation of object individuation is a philosophical concept known as a sortal. Sortals are concepts that provide principles of individuation and identity, and often map onto what we consider basic-level kinds or what we referred to earlier in this article as sortal kinds (Gupta, 1980; Hirsch, 1982; Macnamara, 1987; Wiggins, 1980; Xu, 1997, 2007). According to Macnamara (1987), sortal concepts provide the *principle of individuation* and the *principle of identity*. Sortals provide satisfactory answers to questions such as "How many Xs?" and "Is it the same X?"

A good test for whether a particular concept, considered as a sortal, is to ask, "How many [concept]?" If the question makes sense, then the concept is a sortal. As an illustration, we cannot pose the question "How many waters?" because it is unclear whether we should be counting *molecules*, *droplets*, *puddles*, or *lakes*. Since the concept of water does not provide us clear principles of individuation, *water* is not a sortal. By contrast, we can ask "How many plants?" because the principles of individuation are clear; we should count those living things that are multicellular, photosynthesize, and have cell walls. In other words, the sortal *plant* provides the principles of individuation.

Principles of identity are distinct from the principles of individuation. Consider a dog at t_1 and a dog at t_2. At both time points, we have one dog but there is the further question of deciding whether the dog at t_1 is the same dog at t_2. The sortal *dog* provides us with the criteria for tracking identity in this case. For example, we learn from observing the world that dogs may grow over time, but it is unlikely that they will change their fur color dramatically. When tracking the identity of dogs, we can make the judgment that the brown dog at t_1 is the same as the brown dog at t_2, but we would not say that the black dog at t_1 is the same as the brown dog at t_2. That is, the sortal *dog* provides the criteria for tracking identity over time. Since sortals provide principles of individuation and identity, sortals can be thought of as an abstract conceptual structure that organizes perceptual information into discrete and usable chunks of information. These information chunks facilitate our ability to track objects over time and space, making the philosophical concept of sortals useful for framing empirical investigations on object perception and object individuation.

Decades of research in this tradition have documented that both adults' and children's object-tracking success relies upon the subtle perceptual details that support positive object individuation judgments. This is because humans have evolved to experience a world of discrete and stable physical objects that move between any two points in a continuous manner (e.g., Green & Quilty-Dunn, 2021; Leslie et al., 1998; Scholl, 2001; E. S. Spelke, 1990; E. S. Spelke, Kestenbaum, et al., 1995) and object behaviors that violate these norms can be extremely difficult to track under some conditions because of the way they frustrate individuation and identity judgments. For example, objects that violate cohesion as they move from one location to the next disrupt performance in both adults (VanMarle & Scholl, 2003) and infants (Cheries et al., 2008; Huntley-Fenner et al., 2002). Of course, the most common type of potential individuation disruption during tracking is that of an object completely disappearing, such as when it becomes occluded behind another object. In this way, knowing that an object continues to exist in some fashion is a prerequisite for knowing how many objects exist in an event. Indeed, even very young infants expect an object to continue to exist when out of sight (Aguiar & Baillargeon, 1999; Baillargeon et al., 1985; E. S. Spelke, 1990; Valenza et al., 2006).

Interestingly, the perceptual cues that govern object permanence—that is, whether an object's disappearance is interpreted as going out of sight or going out of existence—are relatively subtle, highly constrained, and operational in both adults (Scholl & Pylyshyn, 1999) and infants (Cheries et al., 2008; Kaufman et al., 2005). This research demonstrates how objects that do not disappear from view in a typical manner (e.g., by deleting along its leading edge) or do not reappear at the right time or location are not easily tracked. In fact, adults can determine the number of hidden objects in an event by explicitly representing and exploiting principles such as spatial continuity (i.e., was it possible for an object to travel from A to B) and temporal continuity (i.e., given an object's current speed, was it possible to travel from A to B in X amount of time; Burt & Sperling, 1981; Scholl, 2001). Furthermore, when it comes to object tracking, these principles of spatiotemporal continuity often take precedence over highly salient featural changes like color, shape, or texture transformations (Burt & Sperling, 1981; Flombaum et al., 2004, 2009).

In addition to spatiotemporal information, we can also successfully individuate objects based on the sortal-kind information. In fact, when spatiotemporal information is ambiguous as to the number of objects involved in an event, sortal-kind information plays a determining role. To illustrate, imagine watching a child pull a *robot* from a toy box without letting you see inside of the box. Now imagine that child returns the *robot* to the box and after a moment retrieves a *truck*. Despite the fact you did not see both toys simultaneously (i.e., ambiguous spatiotemporal information), you would infer the existence of two distinct toys because a *truck* and a *robot* are not the same kind of thing. This type of inference is grounded in the belief that objects are members of sortal kinds and kind memberships are stable over time and space. In simple terms, *robots* do not magically transform into *trucks*.

While principles of individuation can tell us how many objects we are dealing with, principles of identity tell us how to track these objects over time. For example, a person starts out life as a *baby* before becoming a *child*, *teenager*, or *adult*. Because a person's appearance radically changes across the lifespan, reidentifying a person across these stages of life requires overlooking large superficial changes in appearance in favor of more enduring yet less obvious traits such as facial proportions, intonation patterns, or personality and temperament. Relatedly, sometimes we misidentify the objects we are dealing with, especially when given insufficient information about the objects in question. Returning to the toy box example, imagine that the *robot* from the toy box was actually a *transformer* that could convert into a *truck*. In this case, we would have failed to identify the *transformer* when it emerged looking like a truck. However, had we known that such a transformation was possible before making a judgment about the number of toys in the box, we likely would have inferred there was one object instead of two. These examples illustrate how object individuation and identification go beyond the representations of surface-level features to incorporate learned knowledge about the object kinds.

Both individuation and identification mechanisms license certain inferences about the number of objects involved in an event. These numerical expectations can be exploited by developmental scientists to determine what sortal kinds young learners represent. Generally, individuation paradigms assess the representations of sortal-kind concepts by asking the learner to hold one representation of an object in mind while showing them another object, then the learner's expectations are assessed either through spontaneous responses (e.g., looking behavior or search behavior) or elicited responses (e.g., answering yes/no to whether the object is the same as before). Importantly, even when learners are able to encode and maintain the representations of perceptual features of objects, these featural differences may not be sufficient for object individuation. In adults' conceptual systems, these differences are used to infer the number of objects in combination with our knowledge about specific kinds (e.g., adults believe that a small plant can grow into a much larger one, whereas a small chair is not going to grow into a bigger chair). Instead, learners may rely on symbolic representations of sortal kinds and let kind membership dictate how many objects are in an event.

In other words, three pieces of evidence are needed in order to diagnose what sortal-kind concepts infants have: (a) kind distinctions lead to successful individuation (e.g., seeing a duck followed by a ball, one at a time, leads the learner to draw the inference there must be two objects in the event, namely, a duck and a ball) because kind membership is stable over time; (b) within-kind featural distinctions are less likely to lead to successful individuation (e.g., seeing a red ball followed by a green ball, one at a time, may not license the inference of two objects in the event) because infants may not have the knowledge that for some kinds' color matters for individuation but for other kinds it does not (e.g., a green banana may ripen to become a yellow banana); (c) lack of individuation can occur even in the face of perceptible, encoded featural changes. In the studies we review below, we will look for empirical evidence that fits these criteria as diagnostic representations of sortal-kind concepts.

Representations of Sortal-Kind Concepts in Infants

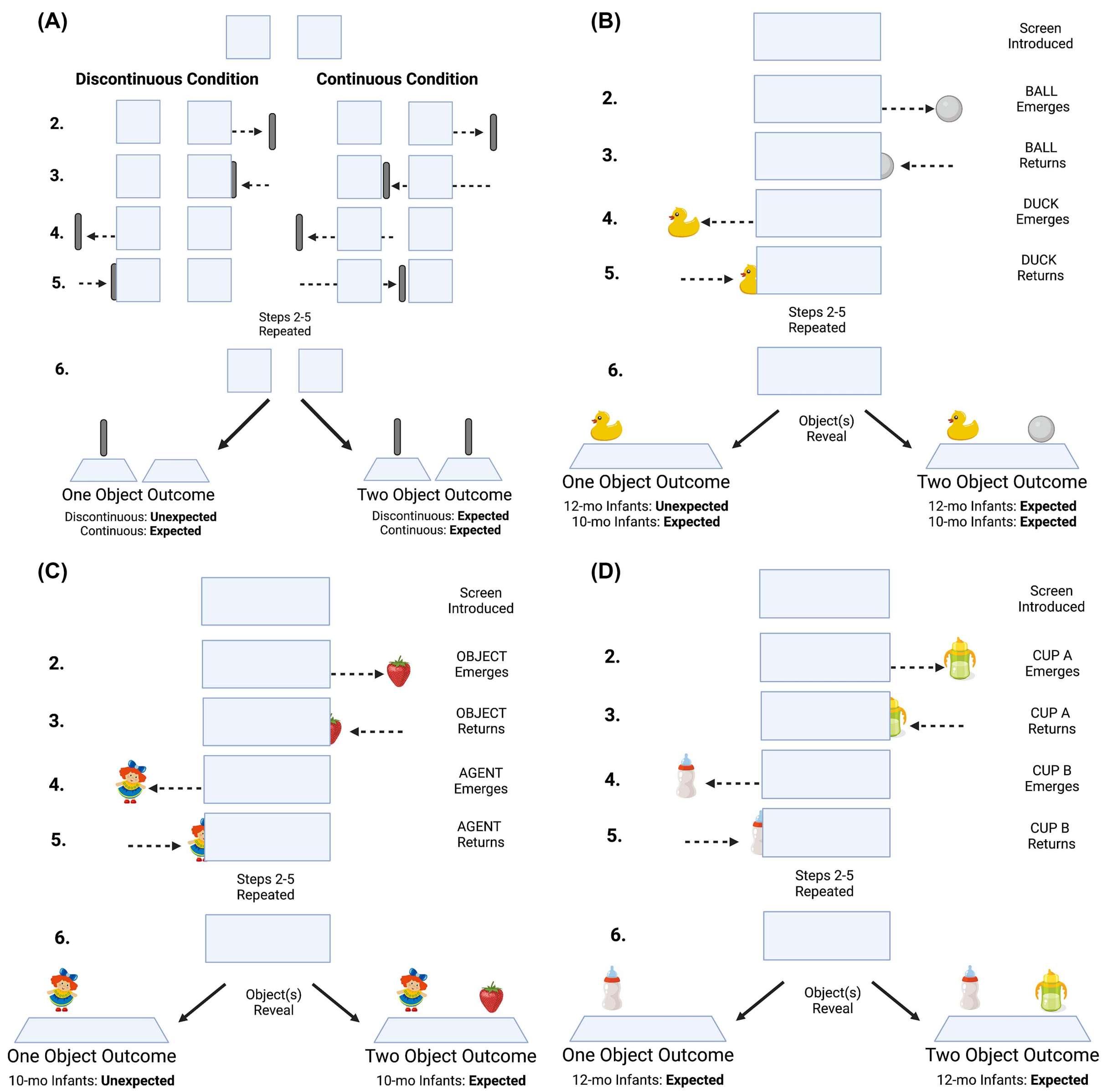
In this section, we will review object individuation studies that have provided empirical evidence for infant's early conceptual repertoire. We will argue that infants represent at least three sortal kinds: OBJECT, AGENT, ANIMATE, and potentially ARTIFACT. We view these sortal-kind representations as rich conceptual structures that support infants' reasoning and inferences about the world.

OBJECT

The sortal-kind concept available to young infants that has received the most attention and empirical support is the concept of a physical OBJECT. In a seminal study, E. S. Spelke, Kestenbaum, et al. (1995) demonstrated that objects moving on spatiotemporally discontinuous paths are individuated by 4-month-old infants. Infants were familiarized with a rod that disappeared behind two screens separated by a small gap and then randomly assigned to one of the two conditions. Infants in the first condition saw a rod go behind the first screen, pass through the gap, and go behind the second screen. The rod then emerged on the other side of the second screen and returned behind it

Figure 1

Object Individuation Experiments



Note. (A) E. S. Spelke, Kestenbaum, et al. (1995; 4-month-old infants), (B) the "one-object-at-a-time" condition from Xu and Carey (1996; 10- and 12-month-old infants), (C) L. Bonatti et al. (2002; 10-month-old infants), and (D) Xu et al. (2004; 12-month-old infants). See the online article for the color version of this figure.

(Figure 1, Panel A). That is, infants saw the rod follow a spatiotemporally continuous path. By contrast, infants in the second condition saw a nearly perceptually identical display except that the rod never passed through the gap between the two screens, resulting in a rod that followed a spatiotemporally discontinuous path. After being habituated to these events, the two screens were removed to reveal either one or two rods. Infants who saw the rod travel a spatially discontinuous path looked longer at a one object display compared to a two object display. Infants who saw the rod travel a continuous path showed the opposite looking time pattern. These findings have been replicated with infants as young as 2.5- month-old as well as with 10-month-old infants (e.g., Aguiar & Baillargeon, 1999; Xu & Carey, 1996).

These findings indicate that infants' individuation judgments are guided by the principle of spatiotemporal continuity, but is this a defining characteristic of their representation of the sortal-kind OBJECT? Subsequent research has shown that infants make similar individuation decisions when viewing rigid objects but fail to do so when viewing piles of sand being poured in a discontinuous manner from one location to another (Huntley-Fenner et al., 2002). This is consistent with the idea that infants represent objects as being spatiotemporally continuous, solid, and cohesive entities

(E. S. Spelke, 1990), and their individuation judgments are not made in the same manner for substances or objects that violate these principles (Cheries et al., 2008; Chiang & Wynn, 2000; Rosenberg & Carey, 2006). That is, infants' responses demonstrate their kind-based expectations about OBJECTS. But do infants represent any finer-grained basic-level kinds? After all, spatiotemporal principles such as continuity and cohesiveness apply to all physical objects such as rods, chairs, and dogs. Infants could have succeeded in the E. S. Spelke, Kestenbaum, et al. (1995) study by representing the rod as an OBJECT or a member of a specific sortal-kind ROD.

Motivated by the above question, Xu and Carey (1996) conducted a seminal study using the "Is-It-One-or-Two" task to investigate whether 10-month-old and 12-month-old infants use basic-level kind information to individuate objects. Unlike E. S. Spelke, Kestenbaum, et al. (1995), only one screen was present in the kind condition and the corresponding spatiotemporal condition. In the one-object-at-a-time condition, one object emerged from and returned behind the screen before the other object emerged (Figure 1, Panel B). This ensured that the objects never appeared on the stage at the same time so infants could not use spatiotemporal location to individuate the objects. In the two-objects-at-the-same-time condition, both objects emerged from and returned behind the screen in tandem, one on each side, facilitating the use of spatiotemporal location for individuation. After familiarization, the screen was removed to reveal either one object or two objects. Xu and Carey (1996) found that the 10-month-old infants were only able to successfully individuate the objects in the two-objects-at-the-same-time condition. In contrast, the 12-month-old infants were able to successfully individuate the objects in both conditions. Furthermore, 12-month-olds' success in the one-object-at-a-time condition was positively correlated with their word comprehension of the objects used in the experiment based on parental reports. These results indicate that infants younger than 12 months are not using more specific sortals like DUCK or BALL to establish a representation of two distinct objects and suggest a potential role for language in the acquisition of basic-level sortal kinds.

The developmental shift from representing the superordinate sortal-kind OBJECT at 10-month-olds to the emergence of basic-level sortal kinds at 12-month-olds using the "Is-It-One-or-Two" task has been well documented at this point (L. Bonatti et al., 2002; Surian & Caldi, 2010; Wilcox & Baillargeon, 1998; Xu, 2002; Xu et al., 2004). Converging evidence of this developmental shift at 12-month-olds has been found using other behavioral measures, such as object segmentation tasks (Xu et al., 1999) and manual reach tasks (Van de Walle et al., 2000) as well as with neurophysiological measures (Pomiechowska & Gliga, 2021). Taken together, the evidence strongly indicates that infants first treat all objects as members of the sortal-kind OBJECT.

ANIMATE

In addition to individuating OBJECTS based on spatiotemporal principles, infants have been found to individuate ANIMATE objects from inanimate OBJECTS. Here, we define ANIMATES as objects that engage in self-propelled motion based on the current evidence, although it is possible that other features are relevant to this sortal kind. In an experiment conducted by Surian and Caldi (2010), 10-month-old infants were familiarized with two computer-animated versions of the standard "Is-It-One-or-Two" task. One version of the task involved a dynamic caterpillar and a stationery cup: a caterpillar emerged from one side of the screen via self-propelled motion and interacted contingently with a disembodied hand (e.g., running away from the hand) before returning back behind the screen. Next, a cup was moved by the same disembodied hand from behind the screen to the stage and dropped. The cup was retrieved by the same hand and returned behind the screen. We will call this animation the ANIMATE/OBJECT version. In the other version of the task which we will call the ANIMATE/ANIMATE version, infants were familiarized with two computer animations of a rabbit and a bee. In this version, both the rabbit and the bee displayed self-propelled movement and interacted contingently with a disembodied hand like the caterpillar in the ANIMATE/OBJECT condition. Importantly, the rabbit and the bee never appeared on the screen at the same time and did not follow identical motion paths. After familiarizing infants with these events, the screen was removed to reveal either one object or two objects.

Infants in the ANIMATE/OBJECT condition reversed their baseline preference for two-object displays and looked significantly longer at the one-object reveal than the two-object reveal. In contrast, infants in the ANIMATE/ANIMATE condition showed no statistically significant differences in looking time between the one-object and two-object reveals. These results suggest that infants individuated the objects in the ANIMATE/OBJECT condition, because the objects were represented as members of two different sortal kinds (i.e., the caterpillar as an ANIMATE and the cup as an OBJECT), and therefore, the caterpillar could not be mistakenly re-identified for the cup. However, infants in the ANIMATE/ANIMATE condition failed to individuate the two objects because both stimuli were represented as members of the same sortal-kind ANIMATE. Although a compelling story, this interpretation is not without critique.

An alternative reason why infants may have individuated the objects in the ANIMATE/OBJECT condition is because living things are inherently more interesting to infants than inanimate objects. On this account, the infants robustly encoded the dynamic caterpillar's features, which facilitated a feature-based individuation of the caterpillar and cup. Surian and Caldi later dispel this criticism based on the idea that because infants did not individuate the distinct objects in the ANIMATE/ANIMATE condition, this feature-based account is inconsistent with the results obtained. However, this fails to consider that simultaneously maintaining two feature-rich object representations may exceed 10-month-old infants' working memory capabilities. For example, work by Kibbe and Leslie (2016) suggests that 6-month-old infants can only maintain a few distinct features for objects (e.g., shape). To determine whether infants utilize feature-based or kind-based individuation would require an experiment that pits feature information against kind information in a way that does not tax infants' working memory capabilities.

Such an experiment was carried out by Decarli et al. (2020). In this experiment, 10-month-old infants were again familiarized with an animated version of the "Is-It-One-or-Two" task, this time involving simple objects such as a red ball or a blue box with yellow stripes. Regardless of the exact objects employed, the animations were similar. Using self-propelled motion, an object would emerge from one side of the screen and then return back behind it. After the object returned, an identically looking object would be moved by a disembodied hand from behind the screen to the stage and then returned behind the screen. After familiarizing the infants to these events, the screen lifted to reveal either one or two identical objects. Infants looked significantly longer at the one-object display than at the two-object display, indicating that they successfully individuated the self-motile ANIMATE from the passive OBJECT. Critically, the objects emerging from either side of the screen had identical features so individuation based on the features was unavailable to the infants. These results are consistent with the idea that infants expect objects to possess stable kind memberships and use those kind memberships to re-identify. Furthermore, they also support the idea that infants privilege kind information over feature information when they are required to form and maintain object representations that they lack visual access to.

AGENT

Another line of infant individuation work suggests the existence of a third sortal kind: AGENT. Before reviewing the relevant individuation studies, it is important to first define what we mean by agency and how agency contrasts with animacy. Agency requires the existence of intentions, goals, or beliefs that predict and guide decisions and behaviors. A key signature of agency is intentionality, whether that be basic perception-goal psychology or a more sophisticated belief-desire psychology (for a review on the development of how infants and children understand other people's intentionality, see Rakoczy, 2022). By contrast, animacy relies on action cues such as contingent interaction and self-propelled motion to be instantiated. In other words, the critical difference between agency and animacy is that agency requires intentional reasoning whereas animacy does not. The line between agency and animacy is hard to draw, especially given that agency requires animacy according to our adult understanding of these concepts, but we think the infant literature suggests the existence of such a distinction—at least initially in development. Keeping this distinction between animacy and agency in mind, we will now turn to reviewing the relevant literature.

Inspired by infants' early failures to individuate OBJECTS into basic-level kinds, L. Bonatti et al. (2002) conducted an experiment designed to determine whether infants individuate human AGENTS from OBJECTS. A group of 10- and 12-month-old infants participated in the standard "Is-It-One-or-Two" task using a humanlike object (e.g., a doll head) and an inanimate object (e.g., a strawberry; Figure 1, Panel C). Both the 10- and 12-month-old infants were able to successfully individuate the doll head from the object, displaying looking behaviors like the 12-month-olds in Xu and Carey (1996). Although the 10-month-olds successfully individuated the doll head from the object, it is unclear how these infants successfully individuated the objects. Three potential explanations exist. First, infants could have represented the doll heads as individuals, encoding and maintaining a veridical representation of the doll head. Given that infants are known to process face-like stimuli differently than other kinds of stimuli (M. H. Johnson et al., 1991; Mondloch et al., 1999; Valenza et al., 1996), it is possible that when infants encounter faces they do not represent them generically but instead represent them as individuals. Second, infants could have represented the doll heads as ANIMATE beings like bees, caterpillars, and dogs. This explanation is unlikely given that 10-month-old infants in the original Xu and Carey (1996) experiments did not individuate ducks with faces from balls, suggesting that face-like configurations are not enough to activate an ANIMATE representation. Last, infants could have represented the doll heads as AGENTS, distinct from ANIMATES, given their human facial configurations. To determine which of these explanations were most parsimonious, L. Bonatti et al. (2002) conducted two follow-up experiments with 10-month-olds using the "Is-It-One-or-Two" task.

In the first follow-up experiment, L. L. Bonatti et al. (2005) pitted human doll heads against dog puppet heads. Importantly, both the human and dog heads had two eyes and a mouth in a canonical facial layout and similar levels of featural complexity. Ten-month-olds in this experiment successfully individuated the dog head from the doll head, indicating that infants were not using a generic ANIMATE representation for the doll heads. In the next follow-up experiment, a new group of 10-month-olds was tested using two distinct human doll heads that varied in material, facial expression, and physical features such as hair and skin color. The 10-month-olds in this experiment failed to individuate one doll head from another.[2] A corroboration of this pattern was obtained in a reaching version of this task that found 12-month-olds successfully individuate canonical human face from nonhuman face patterns (a between-kind distinction) but do not individuate on the basis of gender (a within-kind distinction) until 24 months (Pickron & Cheries, 2019). Further work from L. L. Bonatti et al. (2005) demonstrated that infants only individuated upright puppet faces from objects; inverting a puppet face caused infants to treat that puppet like an OBJECT. Taken together, this work suggests that (a) infants can individuate AGENTS from both OBJECTS and ANIMATES; (b) the presence of a canonical upright humanlike face activates the AGENT sortal kind; and (c) AGENT sortal kinds do not require self-propelled motion in order to be instantiated, making them distinct from ANIMATES.

Although this work is suggestive of an AGENT sortal kind in the first year, we remind the reader that the important distinction between animacy and agency lies in intentionality. If infants truly possess an AGENT sortal kind, they should also be able to ascribe goals, beliefs, or desires to that AGENT. In other words, if infants understand AGENTS as fundamentally mental entities, we should be able to find the evidence of this understanding using individuation paradigms. Recent works by Bródy et al. (2022) and Taborda-Osorio et al. (2019) provide evidence that infants ascribe intentional features to AGENTS and can individuate AGENTS on the basis of such features.

Taborda-Osorio et al. (2019) used a modified version of the "Is-It-One-or-Two" task to determine whether the 11-month-old infants could individuate AGENTS on the basis of sociomoral disposition. In this study, infants watched as a puppet protagonist engaged in two events modeled after the box task from Hamlin and Wynn (2011). Both events began with the protagonist emerging from behind a screen. In the helping event, the protagonist helped a different looking puppet open the box and then disappeared behind a screen. In the hindering event, the protagonist prevented a different looking puppet from opening the box and then disappeared behind a screen. After observing these events, infants were then presented with either one or two puppets that were identical looking to the protagonist. Following the standard pattern of looking time results for successful individuation, the 11-month-old infants reversed their preference for

[2] In a working memory paradigm using a two-object, two-location identification task (M. M. Kibbe & Leslie, 2019). In this study, 6-month-olds defaulted to representing the kind-identity difference between a doll head and a ball despite not recalling more specific perceptual characteristics of those individuals (e.g., color or surface pattern).

two-object displays and looked significantly longer at the one-agent reveal than the two-agent reveal. Critically, when infants were exposed to two identical helping events, two identical hindering events, or the helping/hindering actions performed in the absence of another puppet, infants did not hold these same numerical expectations for the number of AGENTS behind the screen. This suggests that infants view sociomoral dispositions as stable and use them as the basis for individuating AGENTS.

Employing a similar procedure, Bródy et al. (2022) investigated whether infants might also individuate AGENTS based on the preferences. In this study, 10-month-old infants were familiarized with two animated 3D geometric shapes that displayed self-propelled motion. Infants in the preference demonstration condition saw the geometric shapes display unique preferences by emerging from behind a screen, approaching a unique object in either the back left or back right corner of the display, and returning behind the screen. Preferences were consistently demonstrated such that if Shape A approached the back left box, it always approached the back left box, and Shape B consistently demonstrated the opposite preference. In the exposure-only condition, infants saw the shapes display the same motion sequences except that the target objects were missing. Ten-month-old infants in the preference demonstration condition successfully individuated Shape A from Shape B while the 10-month-old infants in the exposure-only condition did not show the same pattern of looking time results. These findings suggest that infants treat self-propelled motion and goal-directed motion differently. Goal-directed motion supports the individuation of AGENTS, presumably because infants use goals as stable and a reliable cue for individuating AGENTS. By contrast, the presence of self-propelled motion can only be used to individuate an ANIMATE from an OBJECT; when two featurally distinct ANIMATES both engage in self-propelled motion, infants fail to individuate the objects involved. We believe this evidence further suggests that infants treat AGENTS differently from ANIMATES.

Finally, work with older infants suggests that additional features such as internal properties or in-group/out-group status may be incorporated into AGENT representations. A study by Taborda-Osorio and Cheries (2018) suggests that 13-month-old infants individuate AGENTS but not OBJECTS based on the internal properties (see Anderson et al., 2018, for similar results using an alternative paradigm). In this experiment, infants were familiarized with AGENTS and OBJECTS that had different colored insides and outsides. Using a manual reach paradigm, Taborda-Osorio and Cheries demonstrated that 13-month-old infants formed numerical expectations for AGENTS based on how many different colored insides they saw. By contrast, infants used the number of different colored outsides to form a numerical expectation for the number of OBJECTS involved. The findings of this work have recently been extended by Fogiel et al. (2023). Using a similar paradigm, Fogiel et al. asked whether 12-month-old infants would be more likely to individuate AGENTS based on their in-group/out-group status. They found that 12-month-old infants were more likely to individuate AGENTS who were a member of the infants in-group, indicating that infants were sensitive to the social status of the AGENTS in the task. Collectively, these four studies provide converging evidence that infants treat AGENT as an intentional sortal kind distinct from ANIMATES.

ARTIFACT

Finally, we turn to infants' representations of ARTIFACTS. In this context, we take ARTIFACT to describe a sortal-kind representation for an object that is intentionally designed to serve a function. For example, a boulder that diverts a stream into two separate flows would not meet our criteria but a man-made dam serving the same function would. Although there exists a large body of work examining infants' early expectations regarding the artifact functions and categorization (e.g., Horst et al., 2005; Träuble & Pauen, 2007, 2011), few individuation studies investigating whether infants treat these concepts as sortal kinds have been conducted. The strongest individuation evidence for an ARTIFACT sortal kind comes from Futó et al. (2010). Across a series of three experiments using the "Is-It-One-or-Two " task, Futó et al. investigated whether 10-month-old infants could individuate ARTIFACTS based on their functions. In the first experiment, infants were randomly assigned to one of the two conditions and then familiarized with two featurally distinct objects. In the full demonstration condition, an object emerged from one side of the screen while the experimenter ostensively directed the infant's attention to the object. After making eye contact with the infant, the experimenter demonstrated the object's unique function twice (e.g., by pulling a lever down or turning a dial), before returning the object back behind the screen. Importantly, the objects were never present at the same time and each performed a unique function. In the control condition, no functional demonstration occurred, but the infants were given additional time to encode the objects. Infants in the full demonstration condition, but not the control condition, reversed their baseline preferences for two-object displays suggesting that the 10-month-old infants individuated the ARTIFACTS based on the function as opposed to visual features. These results have been replicated in infants as young as 4 months old, albeit with a simpler task design (Stavans & Baillargeon, 2018).

Returning to the definition of ARTIFACTS, the successful individuation of objects based on functional demonstrations is not a conclusive evidence in favor of an ARTIFACT sortal kind. By 9 months of age and possibly even earlier, infants are known to individuate objects they otherwise would not, based on the number of distinct labeling events (Dewar & Xu, 2007, 2009; Langus & Höhle, 2021; Xu, 2002; Xu & Baker, 2005). Given these findings, it is possible that infants might have treated the demonstrations like labeling events because they were performed in a communicative context. Furthermore, it is possible that infants individuate all OBJECTS based on function or actions. In this case, we would expect infants to individuate OBJECTS based on functions in both communicative and noncommunicative contexts, and importantly, regardless of whether the function was intentional. Finally, another possibility is that infants more readily encoded the object features after seeing them engaged in dynamic displays involving humans. Importantly, none of these alternative explanations require infants to represent ARTIFACT as a sortal kind. To make the case that infants represent the sortal kind ARTIFACT would require that the infants only successfully individuate artifacts based on intentional functions.

To determine the mechanism driving the individuation effect, Futó et al. (2010) conducted two follow-up experiments with 10-month-old infants. In the first follow-up experiment, infants were assigned to one of the two conditions. In the no causal intervention condition, infants observed the ARTIFACTS automatically perform the functions while an experimenter engaged the infant by pointing at the demonstration. In the nonostensive condition, infants observed an experimenter performing the object functions without engaging the infant. In other words, the experimenter created either a communicative or noncommunicative context for the infant to observe two functions. In both conditions infants failed to individuate the objects, ruling out the possibilities that infants were interpreting the demonstrations as "labels" or individuating all objects based on the function/action. In the second follow-up experiment, the infants watched as the experimenter ostensively demonstrated distinct functions on two similar looking objects. In this case, feature-based individuation was unavailable to the infants; only individuation based on the intentional function was possible. Nonetheless, the 10-month-old infants successfully individuated the two nearly identical objects. Collectively, we believe this set of experiments makes a strong case that the infants represent and individuate ARTIFACTS.

That said, of the four sortal kinds we have so far reviewed, we believe the evidence is the weakest for the ARTIFACT. Additional experiments should be conducted to determine whether infants would individuate objects with identical intentional functions but different surface features or identical functions but varying whether those functions are intentional or not (e.g., like in the case of the boulder and dam). Furthermore, additional experiments contrasting ARTIFACTS with OBJECTS, ANIMATES, or AGENTS would bolster the case that infants treat ARTIFACT as a sortal kind. As we argued above, the strongest case for individuation by sortal kind is made when the salient feature differences are ignored in favor of sortal-kind membership.

Conclusion and Discussion

We argued for three diagnostic criteria to evaluate the existence of a sortal-kind concept: (1) kind distinctions lead to successful individuation; (2) within-kind featural distinctions are less likely to lead to successful individuation; and (3) lack of individuation can occur even in the face of perceptible, encoded property changes. With regard to the first criterion, we reviewed the evidence that suggest OBJECTS, ANIMATES, and AGENTS all meet this criteria. In other words, there is evidence that 10-month-old infants individuate OBJECTS from ANIMATES (e.g., Decarli et al., 2020), OBJECTS from AGENTS (e.g., L. Bonatti et al., 2002) and ANIMATES from AGENTS (e.g., L. Bonatti et al., 2002). Unfortunately, the relevant experiments contrasting ARTIFACTS with other superordinate kinds have not been conducted, and therefore, we are unable to conclude that ARTIFACTS meet this first diagnostic criteria.

Our second diagnostic criterion concerns within-kind individuation. If our theoretical framework is correct, infants should be less likely to individuate within superordinate kinds (e.g., OBJECT_{A} from OBJECT_{B}) because within-kind contrasts are only relevant for object individuation when a particular feature is considered kind-relevant (e.g., at some point in development, children will learn that a green banana may ripen into a yellow banana, but a green chair is not going to spontaneously turn into a yellow chair). Therefore, early in development, only kind distinctions will strongly support object individuation, which is supported by the empirical findings in our review showing that infants often do not use within-kind featural differences to individuate OBJECTS (e.g., Xu & Carey, 1996), ANIMATES (e.g., Surian & Caldi, 2010), AGENTS (e.g., L. Bonatti et al., 2002), nor ARTIFACTS (e.g., Futó et al., 2010). However, we also reviewed evidence that sometimes, infants do pay attention to within-kind featural contrasts. For example, 10-month-old infants will individuate two AGENTS if the AGENTS possess different goals (Bródy et al., 2022) or two ARTIFACTS if an experimenter demonstrates that the ARTIFACTS fulfill different functions (Futó et al., 2010). How should we think about these potentially contradictory findings?

These results are consistent with at least two different interpretations. For example, in the case of Bródy et al. (2022), the 10-month-old infants could have individuated two agents both belonging to the same superordinate kind ($\text{AGENT}_{\text{Burt}}$ vs. $\text{AGENT}_{\text{Ernie}}$; representations akin to "Burt" vs. "Ernie"). This within-kind individuation would occur on the basis of the AGENTS having two different kind-relevant properties, namely, different object preferences. On this interpretation, the goal preference is a salient but idiosyncratic feature of the agent that can be used to differentiate them from other agents (e.g., "Ernie prefers dogs"). On the other hand, it is also possible that infants' individuation was based on the representations of two different basic-level sortal/kind concepts, defined by the agents' contrasting goal preferences (e.g., DOG PERSON vs. CAT LOVER; "Ernie is a 'dog person'"). Importantly, either interpretation lends support for our overarching hypothesis that young infants' representations are constrained by kind-relevant properties (such as AGENTS possessing preferences but not inanimate OBJECTS) when individuating objects. That said, we suggest two ways to help decide between the two interpretations of these results.

First, we can examine infants' expectations about the stability of the kind-relevant property in question. For example, just as CUPS should not magically turn into BALLS, infants who represent two agents as belonging to two different basic-level kinds (e.g., a "dog person" and a "cat lover") might find it unexpected when the agents swap preferences. On the other hand, infants should allow such a change if an agent's preference is represented as something more transient and superficial.

Second, if infants' within-kind individuation judgments are driven by representations of basic-level sortal-kind concepts, we might expect corroborative evidence of two different types: (1) We might find correlations with when infants learn to count nouns that refer to sortal-kind concepts. For example, if helping and hindering define two different kinds of things, we may expect infants to acquire count nouns like "helper" and "hinderer." Given what we know about the development of the early lexicon, however, it is unlikely that any 1-year-old infant knows these words. Perhaps the more likely interpretation here is that helping and hindering are agent-relevant features as opposed to bona fide sortal-kind concepts (see The Role of Language: Count Nouns and Generics section for an extended discussion on the role of language and the development of sortal-kind concepts). (2) We might expect to see representations of kind-relevant properties play an important conceptual role in other inferences. For instance, by 12 months, infants represent an agent's preference as determining in-group from out-group membership. Agents who choose the same toy as the infant are more likely to be chosen by the infant (Mahajan & Wynn, 2012), are more likely to be judged as worthy of being helped (Hamlin et al., 2013), and are more easily individuated from other in-group members (Fogiel et al., 2023). Future work could examine the extent to which such results depend on kind-relevant properties of agents, per se, versus more arbitrary and superficial features.

We believe that the selectivity of when infants decide to use featural contrasts to individuate within superordinate kinds (i.e., psychological dispositions for AGENTS, functions for ARTIFACTS) demonstrates the richness of superordinate sortal-kind representations. It also suggests a potential avenue for the development of later basic-level kinds. Our perspective is that these superordinate-level sortal-kind concepts start out parallel to each other. If this is correct, it follows that superordinate kinds then provide the initial starting point for the later development of basic-level sortal kinds. We propose that basic-level kind concepts inherit the causally relevant features of superordinate kinds. For example, concepts of DOG and HORSE inherit the defining feature for ANIMATES, namely, self-propelled motion. The idea that basic-level concepts are hierarchically nested under superordinate-level ones is not a new idea in psychology. For example, prototype theory presupposes that categories exist at different hierarchical levels (e.g., Rosch et al., 1976). Likewise, Mandler (1992) argued that infants use sensorimotor schemas to construct the concepts of animals and furniture before constructing specific concepts like cats and chairs. However, the argument we advance in this article is distinct from previous theories.

We concern ourselves specifically with kind concepts as opposed to image schemas (like Mandler) or the structure of categories in general (like Rosch). It is not a given that infants would organize kind concepts in the hierarchical manner we propose. Infants might develop the basic-level sortal-kind concepts such as APPLE or DOG independent of the superordinate sortal-kind concepts we propose. For example, the recent connectionist theories that model early infant conceptual development via associative mechanisms (e.g., Benton et al., 2021; Benton & Lapan, 2022) do not predict that the superordinate kinds should necessarily emerge prior to basic-level kinds.

Our proposal does not necessarily preclude the possibility that later in development, children develop naive theories of psychology and biology that necessitate that an AGENT is also an ANIMATE. Likewise, children may later come to understand that all AGENTS, ANIMATES, and ARTIFACTS are also OBJECTS.[3] That said, we believe the evidence in early infancy is most commensurate with the view that these superordinate kinds develop independently. For example, tentative evidence suggests that 5-month-old infants temporarily suspend the principle of spatiotemporal continuity when individuating humans, indicating that AGENTS do not possess the same individuation principles as OBJECTS (Kuhlmeier et al., 2004). However, the earliest individuation evidence we have concerns 4-month-old infants using spatiotemporal continuity to individuate OBJECTS (E. S. Spelke, Kestenbaum, et al., 1995). This leaves open the possibility that OBJECT may be available first and be a special case in development.

Theories of Concepts: Sortals, Core Knowledge, and Psychological Essentialism

By the end of the first year, as reviewed above, infants represent three global or superordinate-level sortal concepts: OBJECT, AGENT, and ANIMATE (as we have argued in the previous section, a fourth sortal concept, ARTIFACT, has weaker empirical support). This is a claim about how sortal-kind concepts develop in young human learners. In this section, we situate this body of research on sortals in the larger context of theories of conceptual development, comparing it with two other important theoretical frameworks: core knowledge (Carey, 2009; E. Spelke, 1994, 2022; E. S. Spelke & Kinzler, 2007; E. S. Spelke et al., 1992) and psychological essentialism (Gelman, 2003, 2004, 2023; Mendin & Ortony, 1989; Neufeld, 2022).

The core knowledge view posits that a small number of concepts are either innate or early developing, and they may be universal and evolutionarily ancient (i.e., shared with other animals; see E. S. Spelke, 2022, for a comprehensive exposition of this view). A key diagnosis for claiming that these are *concepts* is that they are abstract and inferentially rich (Carey, 2009; E. S. Spelke, 2022). For example, the principles that guide young infants' reasoning about objects make use of only the "body" representation (see Li et al., 2023, for evidence in adults) as opposed to specific visual features such as color, size, and so on. The principles that guide young infants' reasoning about agents not only apply to things that have faces and eyes but also to blobs that are capable of self-generated motion and contingent interaction (see S. C. Johnson, 2000, for a review). However, we suggest that a key diagnosis that may be missing from the current construal is that these concepts *define the infant's ontology—a commitment about what sorts of things are out there in the world.* The object individuation work provides evidence for such an ontology: By the end of the first year, objects, agents, and animates are *distinct kinds of things* such that an object cannot turn into an agent or an animate. This framework fills in a major gap in claims about early concepts: Not only do we need evidence that these early concepts are inferentially rich and abstract but also evidence that this is what infants are committed to *ontologically*. In this sense, the research on object individuation compliments the core knowledge view. There appears to be some consensus that by the end of the first year, a small set of superordinate-level concepts are in place. However, the distinct kinds revealed by object individuation studies correspond well with the core knowledge systems discussed in E. S. Spelke and Kinzler (2007)'s study but less so with those characterized in E. S. Spelke's study (2022; see the Future Directions section for further discussion, and how our view might differ from the core knowledge view).

A second influential theory of concepts we will consider is the psychological essentialism. "Essentialism is the view that certain categories have an underlying reality or true nature that one cannot observe directly but that gives an object its identity and is responsible for other similarities that category members share" (Gelman, 2004, p. 4). Some have suggested that psychological essentialism is the view that essences are "placeholders": We may believe that a category has an essence without knowing what it is. Gelman (2003) has argued that evidence for psychological essentialism includes the following: (a) Categories have rich inductive potential, and perceptual similarity can be overridden; (b) learners' belief about innate potential; (c) the importance of causal and nonobvious properties; and (d) learners' belief about sharp and immutable category boundaries. Since both we and Gelman are interested in a theory of concepts and concept acquisition, how does the research on object individuation and sortal kinds relate to the

[3] While it is possible to eventually hold an explicit belief that AGENTS belong to the superordinate category OBJECT, this achievement might develop relatively late and remain unnatural even for adults, who some have argued remain "intuitive dualists" in many respects (Bloom, 2005).

work on psychological essentialism? Current evidence, as we see it, suggests that the infants' sortal-kind concepts are partially essentialized. We also consider this a worthy exercise because although both the infant individuation literature and the essentialism literature are robust, there has been little intersection between the two lines of inquiry (although see Cacchione et al., 2013, 2020 and Kovács et al., 2017).

Infants Prioritize Causal Features in Their Sortal-Kind Representations

Reinterpreting the results from object individuation studies, we argue that infants demonstrate a primacy of deeper kind information over surface-level featural information, a signature of essentialism. We present evidence that (a) infants ignore within-kind feature differences when individuating objects, (b) infants selectively attend to cross-kind feature differences when individuating objects, and (c) which types of feature changes are treated as cross-kind versus within-kind is modulated by the sortal-kind concept activated.

The first piece of evidence we present is that infants are less sensitive to feature differences that are not diagnostic of kind membership. For example, infants often fail to individuate within-kind objects even when they have highly salient featural differences such as differences in color, shape, texture, or emotion (L. Bonatti et al., 2002, 2005; Decarli et al., 2020; M. M. Kibbe & Leslie, 2019; Surian & Caldi, 2010; Van de Walle et al., 2000; Xu, 2002; Xu & Carey, 1996; Xu et al., 1999, 2004). Importantly, infant's failure to use featural information to individuate within kinds does not indicate a lack of ability to encode or use feature information in individuation tasks at all (see Two Modes of Construal: Sortal-Kind Concepts Versus PR section for a discussion of feature-based individuation). In fact, some work suggests that even in the cases where infants fail to use featural information for individuation, their habituation/dishabituation data are consistent with featural encoding (Xu et al., 2004).

Second, it is not that infants neglect featural information entirely in individuation tasks. Rather, infants only use features such as shape or color, when they are diagnostic of kind membership (L. Bonatti et al., 2002; Cacchione et al., 2013; Futó et al., 2010; Schaub et al., 2013; Surian & Caldi, 2010; Taborda-Osorio & Cheries, 2018; Xu et al., 2004). For example, 12-month-old infants successfully individuate a sippy cup from a ball of roughly the same size while simultaneously failing to individuate a sippy cup with two handles from an open-topped cup with one large handle (Figure 1, Panel D; Xu et al., 2004). In this case, cross-kind shape differences are treated as evidence of two distinct objects while within-kind shape differences are not. In other words, infants ignore within-kind feature changes (e.g., a two-handled sippy cup transforming into a one-handled cup) while selectively attending to cross-kind feature changes (e.g., a sippy cup transforming into a ball).

Third, what types of featural changes are treated as cross-kind versus within-kind is dependent on the kind in question. For example, 14-month-old infants will individuate AGENTS based on the color of their insides while simultaneously individuating OBJECTS based on the color of their outsides (Taborda-Osorio & Cheries, 2018). In other words, internal properties are treated as more salient and causally relevant compared to external properties when individuating AGENTS but not OBJECTS. Infants can also be induced to update their diagnostic feature criteria by being taught a new kind category through a nonverbal demonstration (Cacchione et al., 2013; Futó et al., 2010; Kovács et al., 2017; Pomiechowska & Gliga, 2021). In these nonverbal demonstration studies, a hidden property such as an object transformation, nonobvious function, or kind category is demonstrated to one group of infants while another group of infants remains ignorant to the hidden property. Infants who watch demonstrations of hidden causal properties individuate these objects differently from a control group of infants who did not see the demonstration (Cacchione et al., 2013; Futó et al., 2010; Kovács et al., 2017; Pomiechowska & Gliga, 2021). For example, 14-month-old infants who observe a carrot that can transform into a bunny do not individuate bunny-shaped objects from carrot-shaped objects while infants ignorant to this transformation do individuate bunny-shaped objects from carrot-shaped objects (Cacchione et al., 2013).

The evidence presented in this section suggests that infants prioritize essentialized kind information over surface-level featural information in the service of object individuation. The primacy of causally deep properties lends support to the idea of partially essentialized kind concepts early in development.

Infant Kind Concepts Are Inductively Rich

We argue that infants dynamically use kind concepts to make inductive generalizations, inferences, and predictions. For example, infants selectively extend eating and drinking behaviors as well as nonlinear motion paths to ANIMATES over OBJECTS (Baker et al., 2014; Mandler & McDonough, 1996, 1998). When individuating or categorizing AGENTS, infants prioritize internal properties over external properties (Anderson et al., 2018; Newman et al., 2008; Taborda-Osorio & Cheries, 2018). Infants also appear to infer the existence of a hidden AGENT when presented with regular nonrandom sampling events or when presented with an inanimate OBJECT that moves on its own (Ma & Xu, 2013; Saxe et al., 2005). In the case of ARTIFACTS, when infants are shown a hidden function of a toy (e.g., a horn honk, a removable center sponge), they persist longer in their manual exploration of a similar looking toy when that function is absent, indicating that infants predict ARTIFACT functions to be stable enduring properties (Baldwin et al., 1993). In fact, evidence from 13.5-month-olds suggests that infants learn enduring functions for ARTIFACTS from a single demonstration and these function–ARTIFACT mappings are resistant to subsequent counterexamples (Hernik & Csibra, 2015).

Summary

In the previous sections, we argued that infant kind concepts share signature characteristics of adult kind concepts. Specifically, we argued that (a) infants prioritize causally deep properties when reasoning about objects and often ignore superficial features in favor of these deeper essentialized properties and (b) infants' kind concepts are inductively rich. Furthermore, the very fact that infants' ontology consists of OBJECTS, AGENTS, and ANIMATES and that an inanimate OBJECT cannot change into an AGENT or an ANIMATE object supports the claim about immutable boundaries in psychological essentialism. To our knowledge, there have not been studies investigating the claim about innate potential in infants—one of the tenets of psychological essentialism. The characterization of early concepts—based on evidence from object individuation studies—fits well with the main claims of essentialism. Future work may investigate further the relationship between these two bodies of research.

Mechanisms of Learning: The Emergence of Basic-Level Sortal Kinds

If superordinate sortal kinds are the initial conceptual state for full-blown kind concepts, then a significant open developmental question arises. How do children construct basic-level kind concepts from superordinate kind concepts? We believe there is good evidence supporting at least two distinct proposals on the development of basic-level kind concepts.

Many studies have demonstrated a tight link between verbal labeling events and representing objects as distinct basic-level kinds in children as young as 6 months (Dewar & Xu, 2007, 2009; Gliga et al., 2010; Langus & Höhle, 2021; LaTourrette & Waxman, 2020; Xu, 2002; Xu & Baker, 2005; Yin & Csibra, 2015). Similarly, other studies have underscored the importance of ostensive communicative signals such as eye contact, pointing, and other socially contingent interactions in activating already existing generic kind-based representations (Csibra & Shamsudheen, 2015; Futó et al., 2010; Pomiechowska et al., 2021). We believe that these individuation studies parallel findings in the essentialism literature where generic language, such as the use of indefinite generics (e.g., "boys" in "Boys play with trucks"), seems to play an important role in acquiring essentialist beliefs about social categories such as trait stability, core causal properties, and inheritance (Benitez et al., 2022; Gelman, 2004; Gelman & Bloom, 2007; Graham et al., 2004; Jaswal & Markman, 2007; Kemler Nelson et al., 2000; Leshin et al., 2021; Neufeld, 2022; Neufeld & Haslanger, 2024; Rhodes et al., 2012; Schulz, Standing & Bonawitz 2008; Ware & Booth, 2010). In fact, the proposals we review may also be able to partially explain the development of essentialized social kinds as well as natural kinds.

In the next two sections, we interpret these general findings as they relate to two specific proposed mechanisms. The first proposal concerns the causal role of *natural language* (specifically nouns and generics) in the development of basic-level sortal-kind concepts. The second proposal concerns *natural pedagogy* or the theory that humans are born with certain innate predispositions for interpreting information given in a pedagogical context. It may also be the case that these mechanisms can account for the development of superordinate sortal kinds but for now, we will only concern ourselves with the development of basic-level sortal kinds.

The Role of Language: Count Nouns and Generics

Here, we suggest that verbal labels play an important role in the acquisition process of basic-level kind concepts. We present evidence that (a) infants individuate objects based on the number of distinct noun labels they hear, (b) infant vocabulary is predictive of success at basic-level kind individuation, and (c) noun labels are not functioning as mnemonic devices but instead as referential devices for object kinds. Taken together, this presents strong evidence of a causal relationship between language and the development of kind concepts.

It has been previously proposed that noun labels function as conceptual placeholders for basic-level kind representations to later fill in (Xu, 2002, 2007). In other words, either the noun label or basic-level kind concept can be learned first, but when the noun label is learned first, it should not be assumed that children understand the corresponding kind concept. Instead, learning a noun just demonstrates that a child has opened up a "slot" to build a representation under that individuating label. We believe the current evidence is most commensurate with this view.

First, it has been demonstrated that infants will individuate objects based on the number of distinct noun labels they hear (Dewar & Xu, 2007; Xu, 2002; Xu & Baker, 2005). Importantly, these labels must be count nouns, otherwise infants fail (Xu, 2002; see Hall et al., 2008, for evidence that toddlers treat count nouns and adjectives differently in individuation tasks). In these types of verbal labeling type studies, objects are given either distinct labels or identical labels and then infants' expectations are assessed using a standard individuation task. Infants who hear distinct labels expect two hidden objects while infants who hear the same label repeatedly do not seem to possess the same expectations (Dewar & Xu, 2007; Xu, 2002; Xu et al., 2005). For example, in Xu et al. (2005), infants watched as an experimenter labeled the contents of a box with either two distinct labels (e.g., "Look a fep! Look a zav") or two identical labels (e.g., "Look a fep! Look a fep!"). After these labeling events, infants were allowed to reach inside the box and retrieve one object. After retrieving this first object, infants were then allowed to reach back into the box, and subsequent reaching behavior was recorded. Infants who heard two distinct noun labels reached back into the box significantly more than infants who heard the same label repeated.

These results are compatible with the hypothesis that by default infants expect count nouns to refer to object kinds and that infants also expect kind membership to be stable (Csibra & Shamsudheen, 2015; Dewar & Xu, 2007). Furthermore, we believe these results provide additional evidence that infants prioritize causally relevant features (i.e., in this case, the essence/name of the object kind) when individuating objects. However, an alternative hypothesis may be that infants simply encode the features of individual objects better after a labeling event. We believe there are three good reasons why we should reject this alternative interpretation.

First, in the original Xu and Carey (1996) individuation study succesful individuation was positively correlated with word comprehension. Specifically, infants succeeded on the object individuation task when they knew the corresponding noun for both objects; knowing the name of only one object was not enough (Xu & Carey, 1996, p. 146). Others have replicated this finding; knowing the name of both objects (but not only one object name) predicts individuation success even when controlling for other associated variables like total receptive vocabulary or physical knowledge (Rivera & Zawaydeh, 2007). These results suggest that nouns are not simply mnemonic devices that reduce the cognitive load required to represent the occlusion events. If this were the case, infants' performance would improve slightly when they know at least one of the object names; however, the evidence suggests that knowing the name of both objects is crucial for successful individuation.

Another reason to reject the notion that labels simply serve as mnemonic devices is the study conducted by Xu et al. (2005). As previously described, an experimenter opened a box and pointed to the inside labeling the contents with two distinct noun labels (i.e., "Look, a wub!" and "Look, a fep!") or the same label repeated (i.e., "Look, a zav!" and "Look, a zav!"). Importantly, the infants did not see the objects inside the box; all they saw was the outside of a box and the experimenter looking inside while labeling. If labels and communicative demonstrations help facilitate encoding of an object's features, then what were the nouns in the Xu et al. (2005) helping to encode? The infants in this study never saw the objects that were labeled, so there was no featural information for the label to bind. Instead, we reiterate that these results suggest that infants expect noun labels to refer to object kinds.

Finally, evidence from an electroencephalogram (EEG) study involving 12-month-olds has corroborated these findings by showing that infants process objects differently depending on whether they can name them or not (Gliga et al., 2010). In this study, EEG recordings were taken from 12-month-old infants as they passively viewed objects they knew the name for (e.g., cup), familiar objects they did not know the name for (e.g., umbrella), and unfamiliar objects they did not know the name for (e.g., harp). Gliga et al. (2010) found enhanced γ band activity over the visual cortex in the familiar named condition as compared to both the unfamiliar unnamed and familiar unnamed conditions. We interpret this as evidence that knowing the name of a kind causes infants to represent an object of that kind differently. Importantly, these differences could be induced by the infant's own vocabulary knowledge or by teaching an infant a new label for a kind category. Taken together, we believe these results strongly suggest that infants understand noun labels as referential devices for the object kind.

Although many studies have demonstrated the importance of providing count noun labels in the development of sortal-kind concepts (e.g., Perszyk & Waxman, 2018; Xu, 2007), it remains unclear how to characterize this link. One possibility is that nouns act as "essence placeholders" in early development (Dewar & Xu, 2007; Xu, 2007; Xu et al., 2005). By this account, infants have an early developing referential expectation that words that occupy the syntactic position of a noun denote kinds of objects as opposed to specific instantiations of objects. In other words, hearing a unique noun label causes an infant to set up a unique mental symbol for the kind of object referred to. Importantly, the "mental symbol" might not contain any information at first aside from the label itself.

A second possibility, endorsed by E. S. Spelke (2022), is that the language aids in conceptual development by compressing complex conceptual representations. Specifically, Spelke suggests that as children learn their first language, they begin to map core knowledge representations to structures in natural language (e.g., objects to nouns). Once mapped, "the expression may point to the abstract content in these representations automatically, without attention" (E. S. Spelke, 2022, p. 442). This "pointing" mechanism provides children with two critical abilities. First, it allows children to overcome attentional constraints, which prevent the compositional use of core knowledge representations. Second, and perhaps more importantly, it also allows children to go beyond simple concatenations of original core knowledge representations by allowing children to recursively generate new concepts. Under this proposal, the process of learning nouns and generics facilitates the emergence of basic-level kinds by reducing the cognitive resources required to represent such concepts.

Natural Pedagogy

Another possibility is that word learning is a subset of more general learning mechanisms. For example, it may be the case that any kind of human communication induces the generic referential expectations early in development, as argued by the proponents of the natural pedagogy view (Csibra & Gergely, 2009; Csibra & Shamsudheen, 2015). Natural pedagogy refers to the hypothesis that humans have evolved specific cognitive mechanisms which facilitate the transmission of generic cultural knowledge (Csibra & Gergely, 2011). These evolutionary adaptations are threefold, including (1) a heightened sensitivity to ostensive communication signals like eye contact, pointing, and motherese; (2) an innate expectation that ostensive contexts are referential; and (3) a second innate expectation that ostensive-referential contexts transmit generic information (see Csibra & Gergely, 2009, for a review). Importantly, all three of these cognitive mechanisms are thought to be innate, or at the very least, developed in advance of the first birthday.

Returning to the development of kind concepts, these cognitive adaptations are supposed to work in tandem to produce and activate the infant kind concepts. For example, when infants are ostensively addressed by an experimenter (e.g., "Hi baby! Watch this!" or "Look baby! A fep!"), this activates an expectation that whatever follows is both referential and generic. In other words, the event infants observe becomes an act of exemplification (Goodman, 1976). Exemplification is when an object, by virtue of being the kind of object it is, stands in as a representative of its kind. Exemplification occurs often in human communication. For example, when someone eats a chocolate and laments to a coworker, "Ugh. These are not worth the money," that person is referring to the kind of chocolate they are eating—not the chocolates themselves. In this case, the reason infants map nouns and generics to kind concepts is not because infants have special referential expectation for nouns and generics. Instead, infants map nouns to kinds because they map all communication generically, and we use nouns to talk about objects.

There is empirical support for this theoretical proposal. First, it has been found that nonverbal demonstrations can induce kind representations in 12-month-old infants (Kovács et al., 2017; Pomiechowska & Gliga, 2021). In Pomiechowska and Gliga's (2021) first experiment, infants were shown pictures of both familiar and unfamiliar objects while EEG recordings were taken. During this experiment, the objects were hidden behind an occluder, and the occluder lifted to either reveal the same object (no change), an object from the same category (within category change), or an object from a different category (cross-category change). Importantly, as evidenced by their EEG recordings, infants only detected within category changes in the unfamiliar object condition. In the second experiment, new 12-month-old infants were randomly assigned to an ostensive demonstration condition or control condition. In the ostensive demonstration condition, the experimenter greeted the baby and asked them to watch while she sorted the unfamiliar objects into their kind categories. In the control condition, the objects were sorted randomly. After watching the experimenter sort the objects, EEG recordings were taken while the infants observed occlusion events involving the unfamiliar objects. This time infants who observed the ostensive demonstration did not detect within category changes of the "unfamiliar objects," possibly because they had set up new kind-based representations following the demonstration. Other studies have also found nonverbal demonstrations to be sufficient for setting up or activating kind-based representations (Futó et al., 2010; Kovács et al., 2017; Stavans & Baillargeon, 2018).

Additional work has extended these neurophysiological findings to a behavioral paradigm investigating the development of mutual exclusivity (Pomiechowska et al., 2021). Mutual exclusivity refers to an early developing bias infants have to apply a novel label to an unknown object as opposed to an object they already know the name for (see Lewis et al., 2020, for a recent review and meta-analysis). A peculiar finding is that infants do not develop this bias until around 18 months, despite the fact that many of the requisite abilities are already developed. Pomiechowska et al. exploited this peculiarity by attempting to induce mutual exclusivity at 12 months by providing children with ostensively communicative context (e.g., pointing and labeling) as opposed to a noncommunicative context (e.g., object wiggling and labeling). They found that 12-month-old infants succeed in applying mutual exclusivity in the communicative condition but not in the noncommunicative condition.

An important distinction between the two proposals reviewed is that natural pedagogy predicts that any communicative signal induces a generic referential bias while the essence placeholder hypothesis limits the generic referential bias to count nouns. Future work should examine these hypotheses. For example, what other kinds of generic representations can be communicated and activated in early infancy? If it turns out that the infants only represent kind concepts but no other types of generic concepts in early infancy, that may be difficult to reconcile with a theory of natural pedagogy. Furthermore, at the moment, it remains unclear exactly how a generic referential bias develops under either hypothesis but future work on the development of verbal reference in general may lead to important insights on this issue (Luchkina & Waxman, 2021; Luchkina & Xu, 2022).

A Critical Test: Kind Representations in Nonhuman Animals?

It is important to note that, thus far, both mechanisms we have proposed are uniquely human. In this way, a powerful test of language- and pedagogy-based explanations for the development of kind concepts comes from comparative studies with nonhuman animals. Do animals perform in a similar fashion to infants when tested in analogous tasks? And does this performance reflect the same level of conceptual understanding? The answers to these questions can be useful for constraining theories about the origins of kind concepts in humans.

Kind-Based Individuation in Nonhuman Animals?

Previous work with chicks, apes, and rhesus monkeys shows comparable levels of performance to human infants in kind-based individuation tasks (Cacchione et al., 2016, 2020; Fontanari et al., 2014; Kersken et al., 2020; Mendes et al., 2008; Santos et al., 2002; Shutts et al., 2009). For example, rhesus macaque monkeys successfully represent that a box must contain two objects after seeing subsequent presentations of an object with different colors (e.g., a white vs. blue apple slice) or different shapes (e.g., a triangle-shaped vs. donut-shaped apple slice) placed inside (Santos et al., 2002). Furthermore, rhesus monkeys' individuation decisions are driven by precise feature bindings, such that monkeys will continue to reach into a box until they discover an object with the correct combination of shape and color that they had seen previously (Cheries et al., 2006).

If language plays an important role in the construction of human kind concepts, then how do the animals in these individuation studies succeed? One possibility is that these nonhuman animals deploy a sophisticated version of feature-based individuation described in the Two Modes of Construal: Sortal-Kind Concepts Versus PR section and that their performance reflects a strong *perceptual* rather than *conceptual* representation of objects in an event. That is, the difference between a yellow triangle and a green circle is sufficient for them to be represented as different individuals or tokens of the same type (e.g., "inanimate object"). On this interpretation, individuation judgments made by nonhuman animals may be driven much more by salient, visible, and surface-level differences than those of human infants. In fact, individuation by surface property may be the default in many species due to the relative simplicity of the underlying computation: "If an object looks different, then assume it *is* a different object." In contrast, kind-based individuation is characterized as being *less* sensitive to surface property changes that fall within the same kind category and computing that two different looking objects are actually instances of the same object *despite* their feature changes. For example, infants who only represent the superordinate kind OBJECT will not reliably individuate a duck from a ball even though the two differ wildly in their colors and shapes because they both belong to the same kind OBJECT (Xu & Carey, 1996) and infants who possess the basic-level kind *cup* will fail to individuate a black mug from a red drinking glass (Xu et al., 2004). It is these within-kind individuation "failures," relative to cross-kind successes that argue for the existence of kind-based individuation in human infants. Therefore, the fact that monkeys individuate based on the simple perceptual changes may be evidence that they are not representing the kind OBJECT.

One argument against the view that rhesus monkeys' individuation judgments are driven solely by surface-level features comes from studies showing that they successfully individuate two identical looking objects based on an unobservable difference, namely, taste. For example, monkeys who saw a square white object pulled from behind an apple and placed into a container will search significantly more after retrieving an identical looking object that tastes like coconut and vice versa (Phillips & Santos, 2007). The argument being that despite the two white chunks looking identical to one another, monkeys represented that they belong to two different *kinds* of things because they taste different. This interpretation was bolstered by follow-up work demonstrating that rhesus monkeys resist the notion that an apple can be turned into a coconut merely by transforming what it looks like on the surface; rhesus monkeys will exhibit a pattern of reaching consistent with the expectation that a white chunk pulled from an apple and changed to look like a coconut will still taste like an apple and vice versa (Phillips et al., 2010). This appears to be analogous to studies with young children demonstrating their essentialist understanding (e.g., Keil, 1989).

While this pattern of results is strikingly similar to those exhibited by human infants, it is important to note that there are some characteristics of kind-based individuation that have not yet been documented in these comparative studies. For example, as mentioned previously, one signature of kind-based individuation is that we are less sensitive to within- versus across-kind differences, such that two objects with different shapes and colors (e.g., a red glass vs. a white mug) may still be represented as belonging to the same kind (e.g., *cup*; e.g., L. Bonatti et al., 2002; Surian & Caldi, 2010; Xu et al., 2004). While nonhuman primates are clearly capable of individuating objects on the basis of very subtle or even unobservable property differences, it is not yet known whether they will ignore such property differences when they belong to objects of the same kind.

Sensitivity to Pedagogical Cues in Nonhuman Animals?

While a vast literature has documented the myriad ways that animals both communicate with and learn from one another (e.g., see Csibra, 2007; Kaplan, 2014, for reviews), there is currently no evidence for the intentional transmission of generalizable knowledge in nonhuman subjects (Csibra & Gergely, 2011). On the one hand, there are demonstrations of animals' sensitivity to some of the same pedagogical cues that human infants respond to. For example, domesticated dogs but not human-reared wolves will spontaneously follow the pointing gestures of a human experimenter (Hare et al., 2002), and semiwild rhesus macaques are highly sensitive to a competitor's gaze and will use eye contact to make decisions about who to approach versus who to avoid (Flombaum & Santos, 2005). On the other hand, however, no such studies have revealed a corresponding ability to use such ostensive cues in the service of learning something referential that is not restricted to a particular episodic fact.

The strongest arguments for the human uniqueness of pedagogical learning come from studies using the same methodologies with both human and nonhuman subjects. For example, Senju and Csibra (2008) found that infants are biased to attend to objects that have been the ostensive focus of another's attention, whereas adult chimpanzees (Kano et al., 2018) and rhesus macaques (Bettle & Rosati, 2021) in analogous tasks are not. A similar contrast was found between the use of ostensive cues in mitigating performance errors in infants versus domesticated dogs. For example, human infants are less likely to make the repetitive error of searching for an object repeatedly hidden in Location A, even after they have seen it move to Location B in conditions where the experimenter points to Location B (Neilands et al., 2021). Dog subjects in an analogous task, on the other hand, continue to perseverate despite the communicative gesture and despite being sensitive to pointing gestures in other contexts (Hare et al., 2002). Taken together, such evidence supports the argument that natural pedagogy as a mechanism for acquiring general kind-based knowledge is human-specific.

An alternative explanation for the development of kind concepts that integrates such results with nonhuman primates is that despite the overwhelming evidence indicating a communication-based mechanism in the acquisition of kind concepts, it is possible that language and natural pedagogy together are sufficient but not necessary to construct kind concepts. In other words, there are multiple acquisition pathways available to young infants and animals when it comes to acquiring kinds. Future work should determine whether there are noncommunicative contexts in which children acquire kind concepts and whether those kind concepts differ in any meaningful way from kind concepts acquired via cultural transmission.

Two Modes of Construal: Sortal-Kind Concepts Versus PR

An ongoing tension in research on object individuation is that it is difficult to draw a distinction between representing clusters of features versus representing kinds. Indeed, young infants appear capable of making individuation judgments governed by both (a) features we think of as *conceptual* (e.g., intentionality) and (b) also by features that are represented in a purely perceptual manner (e.g., changes of an object's color, size, or shape). For example, infants as young as 4 months can use rudimentary featural differences as grounds for object individuation (e.g., Brower & Wilcox, 2012; Lin et al., 2021; Wilcox, 1999; Wilcox & Baillargeon, 1998; Wilcox & Chapa, 2004; Woods & Wilcox, 2006) but not use these features in the service of making kind-based distinctions until 10 or 12 months of age (e.g., L. Bonatti et al., 2002; Xu & Carey, 1996). Furthermore, studies on PR suggest a nuanced picture about when infants use various object features/properties such as width, height, size, and material to support reasoning about occlusion, containment, and other events (see Baillargeon, 2008; Baillargeon et al., 2012 for reviews; Aguiar & Baillargeon, 1999; Hespos & Baillargeon, 2008; Kotovsky & Baillargeon, 1998; Luo & Baillargeon, 2005; Wang & Goldman, 2016; Wilcox, 1999; Wilcox & Chapa, 2002).

Here, we offer a framework for connecting these bodies of research. We argue that given a developmental starting point of OBJECT—a sortal-kind concept as well as a critical unit of computation in visual cognition and attention (Aguiar & Baillargeon, 1999; Scholl, 2001; E. S. Spelke, Kestenbaum, et al., 1995)—two developmental trajectories unfold during the first year of life and beyond. One trajectory centers around the development of sortal kinds, psychological essentialism, and eventually intuitive theories (see the Theories of Concepts: Sortals, Core Knowledge and Psychological Essentialism section; Xu, 2007). The other trajectory centers on the development of object file representations[4] and a complex PR system (see also Baillargeon, 2008; Stavans et al., 2019), where at its core is the concept of a physical OBJECT. We suggest these *two modes of construal of OBJECT* may help us understand the conceptual distinctions and the empirical findings.

First, it is important to describe the ways in which some seemingly discrepant results—namely, finding success at individuating objects on the basis of property distinctions at an earlier age than the studies we have already reviewed—can be explained by important differences in methodology. Stavans et al. (2019) did an excellent job detailing these differences but we will briefly outline them here. One key difference is that many of the studies that find earlier success use paradigms that have reduced task demands. In the standard Is-It-One-or-Two task, infants are required to map object representations from an occlusion event (i.e., the objects hidden behind the screen) to a no-occlusion event (i.e., the one or two objects reveal). In two of the tasks that find early successes in feature-based individuation, infants are not required to map representations across the events. For example, in one version, the screen flips down to reveal another screen that is transparent with one or two hidden objects visible behind the transparent screen,

[4] We acknowledge that here we assume that object-file representations are part of the mid-level visual attention mechanism, as discussed in the object-file literature (e.g., Scholl, 2001; Scholl & Pylyshyn, 1999). It is an open empirical question whether object-file representations contain conceptual content, as suggested by Green and Quilty-Dunn (2021) and Quilty-Dunn et al. (2023; see also the commentaries that argue against this proposal). Regardless of whether object files contain conceptual content like kind concepts, we believe that it is useful to think about the development of sortal-kind concepts as a separate construal from reasoning about objects in physical events.

allowing the occlusion event to continue post-reveal (Wilcox & Chapa, 2002). In another version, called the remainder task, one of the objects emerges from behind the screen and stays visible (McCurry et al., 2009; Wilcox & Baillargeon, 1998; Wilcox & Schweinle, 2002). Then, the screen is lifted and the infant's looking behavior is assessed. In either case, infants are not required to maintain a representation of the object across the event types.

Another major methodological difference is whether both objects are simultaneously visible to the infants during the familiarization phase (Van de Walle et al., 2000; Zosh & Feigenson, 2015). As we have already discussed, spatiotemporal information is primary in both infant and adult individuation of objects. When infants succeed with two distinct objects that were present simultaneously, it is impossible to conclude that their success is a direct result of feature integration without considering the role of spatiotemporal information as well. In other words, it is unclear whether infants succeed in this version of the task by using feature information, spatiotemporal information, or both.

Finally, many of these studies only consider infants' looking responses for one object reveals as opposed to comparing their responses from one versus two object reveals. A critical result from the individuation work initiated by Xu and Carey (1996) is that infants will reverse their preference for two object displays and look longer at one object display when given kind or spatiotemporal information that contradicts one object outcome. When researchers only compare responses to one object displays, it is unclear whether infants look longer in a condition because they expected two objects or because they were habituated to the previous object's features, or if they simply found the one object "odd" in some way without committing to a representation of two distinct objects based on the featural differences.

We believe that the methodological differences we have described between the way feature-based versus kind-based object individuation studies are conducted make it difficult to directly compare the results. That said, here we hypothesize that these discrepant results may reflect a different underlying phenomenon than those studies on sortal-kind concepts we have reviewed in this article. As we reviewed in the Representations of Sortal-Kind Concepts in Infants section, by the end of the first year, infants represent at least three superordinate sortal kinds: OBJECT, AGENT, ANIMATE, and perhaps ARTIFACT. These are among the most important conceptual distinctions a young learner needs to make: Objects are three-dimensional entities that obey the principles of cohesion, continuity, solidity, and contact. Agents (most commonly people) are entities that interact contingently, with salient morphological features (such as faces or eyes, though not a necessary condition), and most importantly, with unobservable mental states such as goals, intentions, desires, and beliefs that guide behavior. Animates (most commonly animals, eventually also plants, see Setoh et al., 2013; Wertz & Wynn, 2014a, 2014b, 2019) are entities that are capable of self-generated motion, eat food, grow, and reproduce. Artifacts are entities with intended functions, as they are made by people with intentions (Greif et al., 2006; Kelemen & Carey, 2007; Setoh et al., 2013); they tend to be rectilinear and have functional parts, which distinguish them from inanimate natural kinds. These early sortal-kind concepts lay the foundation for further conceptual development: each of these concepts corresponds neatly with domains of intuitive theories that children construct during early childhood—intuitive physics, intuitive psychology, intuitive biology, and perhaps an intuitive theory of artifacts (Hirschfield & Gelman, 1994; Wellman & Gelman, 1992).

In contrast, a second developmental trajectory is all about OBJECT and PR. PR refers to a core knowledge system for representing and reasoning about objects involved in causal interactions like one object occluding another object or an object being lowered into a container (Baillargeon, 2008; Baillargeon et al., 2012; Lin et al., 2022; Stavans et al., 2019). The domain of PR revolves around building event categories and figuring out which object properties matter for different event categories. For example, 4-month-old infants appear to form expectations about whether an object can be contained based on the relative object widths but do not begin to incorporate object heights into representations of containment events until about 7.5 months of age (Hespos & Baillargeon, 2001, 2006; Wang & Baillargeon, 2005). A second system for tracking OBJECTS, often referred to as the object-file system, maintains a distinct and temporary representation of objects regardless of whether they are involved in physical events (Scholl, 2001; see Stavans et al., 2019, for a proposal about how object files, and PR may come into conflict at times). This object-file representation includes "what" and "where" information about objects; however, neither object files nor event categories are concerned with sortal-kind concepts.

Object files have been discussed extensively in the literature (e.g., Carey & Xu, 2001; Leslie et al., 1998; Scholl, 2001; Xu, 1999). The consensus appears to be that object files keep track of a small number of objects over time and space, along with their features such as color, shape, and so on. Importantly, these features are only loosely attached to the object files, and they can be updated if strong spatiotemporal information is available. For example, an object file with the features green and rectangular may be updated with the features red and square. That is, object features do not define what an object is.

Similarly, PR about event categories does not require kind concepts. If an occluder is taller and wider than an object, then that object can be completely occluded by the occluder, regardless of what *kind* of object it is. The object could be a duck, a rock, a book, a block, or a person. That is, the ontological distinctions that are so important in our conceptual system/intuitive theories do not matter here. Similarly, a container may be shorter than an object, but as long as it is wider than the object, it can contain it—that is, once the object is inside the container, one can simply move the container, and the object will come along for the ride. Again, the conceptual distinctions that matter for our intuitive theories are not important here: anything can be put inside of a container if it satisfies the physical constraints.[5] Infants learn that the height and width—two features—are important for deciding whether an object will be fully occluded, or whether an object can be lowered completely into a container. However, many kinds of objects can be used as occluders, containers, or supports (e.g., a cup, a toy dog, a real dog, a box) so we would not view these featural representations as inductively rich nor as serving as essence placeholders. The lack of concern with important conceptual distinctions is a signature of the PR system.

[5] It is worth noting that these distinctions may themselves be "kind-based" in the way that they represent particular event roles (Rips et al., 2006; Strickland & Scholl, 2015). For example, maybe infants gradually learn what features are causally relevant to different event categories, for example, occlusion events, containment events, and support events.

We propose that these two modes of construal—kind concepts versus PR system—develop in parallel.

Previous studies provide suggestive evidence for this account. For example, Aguiar and Baillargeon (1999) used mini dolls in their experiments on continuity and obtained similar results as E. S. Spelke, Kestenbaum, et al. (1995) that used rods as their stimuli in studying spatiotemporal continuity. Support experiments used blocks that have faces painted on them but infants were able to ignore the faces and focus on the fact that the blocks have certain physical dimensions that are most relevant for figuring out whether there is sufficient overlap between the surfaces for the top object to be supported by the bottom object (Baillargeon et al., 1992).

Does this view help us understand the empirical findings on object individuation, which appear to present a conflict? One way to reconcile these findings and provide a unified account is that sensitivity to color, size, and shape found in other studies is a product of the PR system, and these features will matter regardless of whether OBJECTS, AGENTS, or ANIMATES are presented. In contrast, critical for the conceptual mode of construal (i.e., sortal-kind concepts), some features will matter more than others depending on whether OBJECTS, AGENTS, or ANIMATES are presented. The further development beyond the first year is indeed all about learning that, for example, animates can change size due to growth and agents can have very different appearances but remain the same individual.

This view makes some empirical predictions that are yet to be tested. For example, L. L. Bonatti et al. (2005) found that when a doll's head is right side up, it is individuated from an inanimate object, but when it is upside down (which disrupts the representation of a face), it is not individuated from an inanimate object. For the PR system, suppose an infant is asked to reason about an occlusion or a containment event, it should make no difference whether a doll's head is right side up or upside down. More generally, whether something is an inanimate object, an animal or an agent should not matter when infants reason about occlusion or containment or covering events, since what is important are the physical dimensions of all these objects. That is, if infants have figured out that height is a relevant variable for reasoning about occlusion at 6 months of age, this knowledge should apply to all OBJECTS, AGENTS, and ANIMATES.

Another way to think about the present proposal is that infants and older human learners can and do think about ANIMATES, AGENTS, and certainly ARTIFACTS as physical objects, following the physical principles of cohesion, continuity, solidity, and contact (note that contact is an optional constraint, since even infants appear to understand that action at a distance might be possible for agents; E. S. Spelke, Phillips, & Woodward, 1995). On our account, important conceptual distinctions may be suppressed/unrepresented when learners are asked to reason about agents and animates *qua objects*, in contrast to when learners are asked to think about them *qua agents or animates* (contra Kuhlmeier et al., 2004, where they argued that infants think agents are angels that do not obey physical constraints).

Future Directions

Origin of Superordinate Sortal Kinds

Despite concerning ourselves with infants' earliest kind concepts, we have yet to develop a coherent story for where OBJECT, ANIMATE, AGENT, and ARTIFACT come from. That said, the core knowledge account may bring some evidence to bear on this question (E. S. Spelke, 2022; E. S. Spelke & Kinzler, 2007). The most obvious parallel exists between our OBJECT superordinate kind and the core knowledge system that facilitates the tracking and individuation of spatiotemporal objects. The other three superordinate kinds have less clear parallels. On the one hand, it may seem obvious that the AGENT superordinate kind may find its parallel in the core knowledge system, which governs agency representations; however, the agency core knowledge system as conceptualized in E. S. Spelke (2022) includes both the representations of beings that engage in contingent, self-generated motion (ANIMATE) and of beings which possess intentional stances (AGENT). We clearly distinguish between these two forms of conceptual representation because previous work has found that 10-month-old infants individuate human faces from other animate faces (e.g., a human face from a dog face; L. Bonatti et al., 2002).

One potential way we might account for the ANIMATE kind under the core knowledge account is to consider E. S. Spelke's (2022) form core knowledge system. E. S. Spelke (2022) proposed that the form module, "… recognize[s] and categorize[s] objects by using shape descriptions that capture the characteristic forms of plants and animals," (p. 202). Spelke argues that the ability to recognize naturalistic forms (i.e., branching, symmetric shapes) allows infants and adults to link these forms to functions. For example, one may link a particular form, say that of an apple tree, to the edibility of its fruit. Importantly, Spelke provided four possible domains for the form system to govern: (1) all perceptible objects, (2) all living things and their products, (3) plants and animals, and (4) plants. She quickly rejects the first three domains and then proceeds to provide evidence in favor of the hypothesis that the form system evolved to represent plants. That said, much of the evidence in favor of the form system involves the discrimination of animates generally, like the ability to detect the biological motion from birth (Simion et al., 2008) or the ability to discriminate between the two different skeletal shapes (Ferry et al., 2010). If the domain of the form system was found to be both plants and animals, then our ANIMATE superordinate may have found its core knowledge parallel.

There are additional difficulties with reconciling our proposed superordinate kinds with the core knowledge view. First, it is difficult to reconcile the ARTIFACT kind with any current proposed core knowledge system (although see Kelemen & Carey, 2007, for an alternative view). Second, most of the evidence reviewed for our superordinate kind hypothesis comes from infants 10 months and older. For OBJECT, we have some evidence that 2.5- to 4-month-old infants can use spatiotemporal information for object individuation (Aguiar & Baillargeon, 1999). For ARTIFACT, we might have evidence from one study with 4-month-olds (Stavans & Baillargeon, 2018), and for AGENT, we might have evidence with 6-month-olds (M. M. Kibbe & Leslie, 2019). That said, the majority of the evidence we have for superordinate kinds comes from infants who are 10 months or older. If superordinate kinds come from core knowledge systems, we would expect to see robust early evidence of these object representations.

There may well be other proposals as to the origins of superordinate kind concepts. It is also possible that other superordinate kind representations exist prior to the first birthday. For example, perhaps infants possess superordinate kind concepts of plants, paralleling E. S. Spelke's (2022) arguments. Furthermore, more evidence is needed for the proposed ARTIFACT kind. Future work should seek to expand and validate the set of proposed superordinate kinds available to young infants; future work should also directly address the role core knowledge systems play in the early individuation of objects.

The Developmental Origins of Psychological Essentialism

Another promising area of research may address important questions regarding the development of essentialism. There has been some debate as to whether Platonic essentialism or causal essentialism best characterizes how human essentialism operates (see Newman & Knobe, 2019). Causal essentialism postulates that natural kinds have three defining characteristics: essences, inheritance, and inductive potential (Gelman, 2003, 2004). By contrast, Platonic (or Aristotelian) essentialism does not posit the same three defining characteristics. Platonic essentialism instead focuses on the relationship between essences and individual members of a kind. In this framework, properties of an individual are said to bear a principled connection to the kind concept instantiated in the individual (Haward et al., 2018). Another important difference in Platonic essentialism is the clear distinction made between generic properties and essentialized properties. While essentialized properties bear principled connections to kind concepts, generic properties just tend to co-occur with the kind concept. For example, barns are often red but it is not necessarily the case that redness is an essentialized property of being a barn. This distinction between essentialized properties and generic properties finds evidence both conceptually and linguistically (Haward et al., 2018, 2021; Prasada, 2021).

While it remains unclear to us whether these frameworks are complementary or competing, we believe that individuation paradigms could help get at some of the critical questions. For example, causal essentialism and Platonic essentialism make different assumptions about the relationship between essences and causal properties. Specifically, causal essentialism posits that essences cause particular properties, whereas Platonic essentialism assumes it is the features themselves, which realize the essence. We think this tension poses an interesting developmental question as to whether essences or causal properties come first in kind concept development. In other words, do infants expect all objects to have an essence or do infants first need to identify causal properties in order to essentialize a kind? Through the clever use of individuation paradigms, researchers may be able to address which comes first.

Furthermore, the distinction Platonic essentialism makes between causal and generic properties is an important one. It may be the case that in very early development, there is no difference between causal and generic properties. Alternatively, this distinction may be operational for the first kind concepts. By pitting statistical properties against causal properties in an individuation paradigm, researchers may be able to shed light on when and how this distinction develops. Furthermore, researchers could test whether the presence/absence of certain core causal properties influences the types of inductive generalizations infants make.

Criteria for Sortal-Kind Concepts: Further Considerations

Using the criteria we laid out earlier in this article, there is strong empirical evidence that OBJECT, ANIMATE, and AGENT are superordinate-level sortal-kind concepts available to infants by the end of the first year. Beyond the first year, we also have evidence that the concepts of *cup* and *ball* support object individuation; furthermore, *helper* appears to be an attribute that infants use for individuating agents. Does this mean that all three concepts *cup*, *ball*, and *helper* are also sortal-kind concepts? This raises a critical question for our theoretical framework: When are we warranted to say that sortal-kind concepts underlie the successes we see in object individuation tasks, as opposed to the representations of features and attributes? Although it may be intuitive to accept *cup* and *ball* as basic-level sortal-kind concepts, it would be more difficult to accept *helper* as a sortal-kind concept.[6]

Here, we suggest one possible solution to this problem. If we are correct in suggesting that the superordinate-level sortal-kind concepts are partially essentialized (see the Theories of Concepts: Sortals, Core Knowledge, and Psychological Essentialism section), we can also ask whether the candidates for more specific sortal-kind concepts are also essentialized. That is, in addition to the important criterion that these concepts support object individuation, do we also have evidence of whether causal features are prioritized in representations of these concepts and whether these concepts are inductively rich? Furthermore, a defining characteristic of belonging to a particular sortal-kind is *stability*, the expectation that the member's causally central features will not change. So while infants may individuate agents on the basis of their helpful and unhelpful actions, interpreting this as evidence of a basic-level sortal-kind *helper*, for example, would require evidence that infants represent these behaviors as enduring trait-like attributes rather than transient behaviors. These additional diagnostic criteria may help us decide the ontological status of these more specific concepts.

Alternative Theoretical Approaches

Finally, it is important to note that not everyone is on board with the philosophical analysis we present here, that sortals are the basis for individuation and identity. In particular, one prominent alternative approach is the causal continuity theory, which focuses on the criteria we use for tracing the identity of an object (i.e., how people decide that a description of an object at one time, t_0, belongs to the same object as a description of it at another time, t_1; Rips et al., 2006). The proposal is that among a set of contenders, the object at t_1 that is the closest to the object at t_0—measured by causal continuity—is judged to be the same object. Proponents of the sortal view argued that causal continuity entails a whole host of factors and our judgments of causal continuity depend on representations of sortal concepts (see the exchanges between Blok et al., 2007a, 2007b; Rips et al., 2006, and Rhemtulla & Xu, 2007a, 2007b, and also Leonard & Rips, 2015). More research is needed to directly test these alternative proposals.

Conclusions

In summary, we have reviewed object individuation studies from the last two decades suggesting that in the first year of life, infants represent at least three (and potentially four) superordinate sortal-kind concepts: OBJECT, ANIMATE, AGENT, and possibly ARTIFACT. Our review demonstrates that infants' understanding of these superordinate kinds is conceptually rich and parallels adult

[6] We thank an anonymous reviewer for raising this important point.

intuitions about natural kinds. Specifically, these superordinate kind representations are partially essentialized and inductively rich. We further suggest that two mechanisms—language and natural pedagogy—are key for the development of basic-level kind concepts beyond the first year, and these mechanisms may be uniquely human. Finally, to reconcile seemingly conflicting results in this research literature, we propose that two modes of construal characterize the developmental paths we observe: one begins with sortal-kind concepts, such as OBJECT, ANIMATE, and AGENT, and these concepts provide the foundation for later development of basic-level sortal-kind concepts and intuitive theories; the other centers around OBJECT, and the object's features and properties enrich these representations in the service of object tracking and PR. We hope it is clear to the reader that many questions remain open, and more empirical work is needed to bring evidence to bear on our proposals.

The philosophical idea of a sortal has been discussed extensively by those interested in logic, semantics, and metaphysics, and its introduction to psychology and cognitive science has generated a rich body of research using object individuation methods. We argue that both theoretical discussions and empirical investigations about sortal concepts and object individuation have opened up new ways of addressing key questions in developmental and cognitive psychology and have shed light on the origin of concepts, mechanisms of learning, and the relationship between language and thought.

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Received December 20, 2023
Revision received October 1, 2024
Accepted October 13, 2024 ■