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OVERVIEW

Comparative metaphysics: Evolutionary and ontogenetic roots of essentialist thought about objects

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How do animals and young children see the world around them in its most basic structure, and how do such world-views develop over time? These are questions of what could be called comparative and developmental metaphysics. The present paper gives an introduction to this newly emerging field of research. Special emphasis is put on thinking about the world as made up of discrete and enduring objects as the most fundamental form of objective thought. The paper discusses whether language is necessary for such basic forms of objective thought, and whether thinking about objects, in turn, may lay a foundation for psychological essentialism.

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1 | INTRODUCTION

How do different kinds of animals see the world? How do human infants see the world? And how do such world-views change over time? These questions define the study of comparative and developmental metaphysics, respectively (Cheney & Seyfarth, 2007; Xu & Carey, 1996): the study of how agents, across species and across ontogenetic stages, perceptually and conceptually represent their surroundings or *Umwelt* in its most fundamental structure. In a long tradition following, among many others, Kant in philosophy and Piaget in psychology, researchers have discussed and studied various basic aspects that necessarily structure any form of an organism's representation of the world around it such as time, space and causality (Dehaene & Brannon, 2010).

This tradition has emphasized that one of the most prominent and fundamental aspects of our general world-view is that it builds on the representation of individual things (Strawson, 1959). Thinking of the world as made up of objects—stable, countable individual entities that retain their identity over time and that exist independently of our perceptions - is the primordial form of objective thought: thought that involves, at least implicitly, a distinction between how things are out there, objectively, and how we relate to them perceptually. Thinking about objects in this sense is also a basic requirement of any truly propositional representational system that involves logic and quantification (Burge, 2010).

In this paper, we given an overview of recent work in developmental and comparative psychology on the evolutionary and ontogenetic roots of object cognition. Commonalities and differences between humans and other species are reviewed, with a special focus on the potential role of language in shaping uniquely human forms of parsing the world. One particular question we discuss is whether certain forms of thinking about objects—as entities with deep and essential properties that constitute their identity and that differ from their merely superficial and accidental attributes—may lay the evolutionary and/or ontogenetic foundation of the much more general and pervasive phenomenon of psychological essentialism.

2 | WAYS OF THINKING ABOUT OBJECTS

Piaget was the first to suggest that the study of object cognition provides access to the understanding of basic forms of thought. According to Piaget (1954), thought begins where an object concept enables the organism to keep track of, reason about and rationally act vis-à-vis the external material world. Setting the bar for attributing object representations relatively highly, Piaget assumed that proper thought would not take effect before the end of the first year of life. Thanks to methodological innovations that enable the investigation of cognitive abilities independently of action, more recent research has demonstrated that basic forms of object cognition may be a much more fundamental property of our perceptual and cognitive makeup (Carey, 2009; Spelke, 1990).

Recent cognitive science research has shown how perception and cognition allow us to perceive an external world of stable bound and enduring objects. In a complex (re)construction process, our cognitive apparatus gradually processes different types of information, assembling them into a holistic experience of the world. This cognitive process likely starts without semantic interpretation or categorical knowledge by a purely perceptual individualizing mechanism, indexing relevant visual patterns in the field of vision[1] (e.g., Pylyshyn, 2007). It progresses with the processing of spatiotemporal information, segmenting the world into discrete, solid and cohesive bundles of matter, which occupy certain positions in space-time and thus a rudimentary notion of physical object (sometimes termed “Spelke object”; Carey, 2009). Many argue that this is where conceptual (rather than merely perceptual) access to the external world is initiated, since a rudimentary notion of object identity over time (object permanence) is now in place. This rudimentary concept of objecthood applies to all kinds of physical bodies but does not yet offer a tool to discriminate between them in more fine-grained ways according to their appearance or their kind.[2] On a further level, also the specific outward appearance of objects is processed (e.g., color, form etc.; Wilcox, 1999; Wilcox & Baillargeon, 1998; Woods & Wilcox, 2006). Finally, full-blown object cognition does not only track bodies spatiotemporally or as a function of their surface features, but individuates objects qua objects of a given kind (e.g., “this ball,” “that duck”) in ways that supply criteria for transtemporal identity (“Is this the same ball as the one seen before?”) and countability (“How many ducks are in this room?”; Baillargeon et al., 2012; Xu & Carey, 1996).

2.1 | Spatiotemporal tracking and “Spelke objects”

According to the core knowledge and related accounts, a core object concept confers the (probably innate and modular) capacity to appreciate physical objects as solid, cohesive material bodies moving continuously in space-time. This abstract notion of objecthood has been described as *Spelke objects* (Carey, 2009; Spelke, 1990). Comparative research has dealt extensively with the notion of object continuity (i.e., representing objects as continuously existing in space and time), and to a significantly lesser extent also with the notions of object cohesion (i.e., representing objects as having a cohesive inner structure) and solidity (i.e., representing objects as solid extended bodies).

Object continuity. Object continuity, or “object permanence” in Piaget's terminology—the grasping of objects as mind-independently enduring entities—is generally viewed as a foundational prerequisite of objective thought. While Piaget assumed that object permanence develops slowly in a stage-like fashion over the course of the first 2 years of life, more recent accounts draw a less conservative picture. They consider a basic awareness of the continuity of bodies (corresponding to Piaget stage 4 capacities, from around 9 months in human ontogeny) as the first and proper form of object permanence (see Cacchione & Rakoczy, 2017). A mind endowed with the core notion of object continuity appreciates that physical bodies follow exactly one connected trajectory in space-time (i.e., understanding *visible displacement* according to Piaget) and would therefore be surprised by the sight of objects jumping in and out of existence (continuity violation).

Studies involving lower executive and motoric demands than the search tasks used by Piaget suggest that human infants from about 2.5 months of age appreciate object continuity (e.g., Baillargeon & deVos, 1991; Spelke, Breinlinger, Macomber, & Jacobson, 1992). Likewise, research literature provides extensive evidence of rich representations of solid, three-dimensional and continuously existing objects in non-human animals (e.g., Fujita, 2001).

Search tasks (the preferred method of Piaget) are not only conceptually more demanding, but also require higher executive and action planning efforts, therefore diagnose this ability only later in human development (see, e.g., Thelen, Schöner, Scheier, & Smith, 2001 for a review). Nevertheless, there are numerous studies showing that a very large number of different primates (e.g., apes, tamarins, marmosets, and lemurs) and other mammals (e.g., wolves, dogs, cats, and dolphins), as well as birds (e.g., ravens, crows, parrots, jackdaws, parakeets, cockatiels, etc.) are able to locate visibly displaced objects in a classic setting by searching (see Cacchione & Rakoczy, 2017 for a review).

From Piaget's point of view, the acquisition of object representations provides a general appreciation of constancy which is a prerequisite for grasping the persistent structures of the world and translating them into an ordered set of notions and concepts. Thus, apart from appreciating the temporal constancy of objects, an organism endowed with thought also appreciates the constancy of some of their defining properties (e.g., constancy of mass, volume, size and shape). This view was also taken up by the core knowledge approach. Children with a core object concept would not only appreciate the temporal consistency of objects, but also expect the objects to remain constant in their present manifestation as bound cohesive (solid) bodies.

Object cohesion. Research of the last decades suggests that object cohesion may be a, perhaps the, primary cue we use in determining objecthood (e.g., Pinker, 1997; Spelke, 1990): We represent portions of matter that move as bounded cohesive units as solid physical bodies. Studies of perceptual completion suggest that from about 2 month of age, human infants view objects as unitary connected wholes (e.g., Johnson, 2004). This capacity appears to be even more basic than the perception of object form (Kellman, Spelke, & Short, 1986) and is present also in non-human primates (e.g., chimpanzees and capuchin monkeys, Sato, Kanazawa, & Fujita, 1997; Fujita & Giersch, 2005). From the core knowledge approach, it does not follow clearly, which basic object property (cohesion, solidity, or continuity) is the most fundamental in the recognition process. Is representing continuity a primary capacity, setting the stage for the capacity to detect stable bundles of matter in the visual display (i.e., because I experience the world as persistent, I am able to detect that there are bound and cohesive patterns)? Or is the notion of cohesion primary, allowing for detecting cohesive bundles of matter in the visual display, to which in a second step, a continuity expectation is attached (i.e., because I am able to recognize a part of the world as bound object, I can attribute continuity as a property to it?)

Empirical studies have addressed this question. Some conclude that at a very early stage of development, cohesion might be the more fundamental principle and that for young infants the notion of permanence pertains to object-like entities only, whereas non-solid substances (e.g., water, sand) or decomposed[3] (noncohesive) objects are not recognized as continuously existing (e.g., Cheries, Mitroff, Wynn, & Scholl, 2008; Huntley-Fenner, Carey, & Solimando, 2002). Later studies revealed, however, that human infants as well as great apes, appreciate that also decomposed entities are permanent, which suggest that the notion of continuity is primary (Cacchione, 2013; Cacchione & Call, 2010a; Cacchione, Hrubesch, & Call, 2013). A very exciting possibility is therefore, that the notion of permanence comes in degrees and is not provided but exponentiated by object concepts. Instead, the ability to cognitively maintain an overduring correspondence to specific individuals in the world and the default expectation that they will continue to exist within the narrow timeframe set by the current act of reference might be a preconceptual capacity (and does not ground in innate knowledge about properties of objects in the world).

Object solidity. A mind appreciating that physical bodies follow exactly one connected trajectory in space-time, would as a consequence also be surprised by the sight of objects moving through each other (solidity violation). Human infants perceptually appreciate object solidity from the age of 2 months (e.g., Spelke et al., 1992), but only systematically relate to solidity when searching for invisibly displaced objects from around 2.5 years of age (e.g., Hood, Carey, & Prasada, 2000).

Comparative research has shown that also non-human animals appreciate the solidity of physical bodies and form rudimentary expectations regarding the way in which solidity and related properties (e.g., mass, weight, and extension) affect the interaction of physical bodies. Various studies have shown that non-human animals expect that solid objects, for example, create an inclined orientation in a concealing screen (apes: Call, 2007; chicks: Chiandetti & Vallortigara, 2011; long-tailed macaques: Schloegl, Waldmann, & Fischer, 2013; pigs: Albiach-Serrano, Braeuer, Cacchione, Zickert, & Amici, 2012; but see horses: Haemmerli, Thill, Amici, & Cacchione, 2018), produce a sound when hitting against the wall of a shaken container (apes: Call, 2004; bears: Amici, Cacchione, & Bueno-Guerra, 2017; pigs: Albiach-Serrano et al., 2012), and come to a halt at a solid barrier (dogs: Pattison, Miller, Rayburn-Reeves, & Zentall, 2010; rhesus macaques: Santos & Hauser, 2002) etc.

Although many non-human animals in these studies showed a sensitivity for object solidity and the way it affects the causal interaction of objects, they also showed typical patterns of difficulties: The typical perception-action dissociation was also observed (rhesus macaques: Hauser, 2003; see also Gomez, 2005; dogs: Osthaus, Slater, & Lea, 2003; Müller, Riemer, Range, & Huber, 2014); vertical object displacements were more demanding than horizontal displacements, possibly due to a "gravity bias" (Cacchione & Call, 2010b; Cacchione, Call, & Zingg, 2009; Gomez, 2005) and most prominently, difficulties arose in conditions imposing high demands on logic-causal processing (e.g., Call, 2007; Schloegl et al., 2013).

2.2 | More complex forms of object permanence and logical-causal reasoning

Object permanence—enabling the persistent cognitive access to the external world and the building of representations about objects that exist out there in the world independently of us—is generally considered a necessary precondition for attributing the capacity for objective thought. Such basic capacities, however, may not necessarily be integrated with higher cognitive functions such as logical-causal reasoning and does therefore not necessarily translate into rational thought or action. Higher-order cognitive capacities are secondary developments, resulting from the integration of basic object cognition with more domain-general reasoning capacities. However, the ability to engage in higher-order reasoning and planning was exactly what Piaget had in mind when attributing a mature concept of object permanence and thus genuine representational capacities (termed "semiotic function") to an organism.

According to Piaget, such advanced cognitive capacities are present once children can solve so-called *invisible displacement* tasks. In these tasks, subjects need to keep track of and reason about the movements of objects even if they cannot be seen. In a typical invisible displacement task, an experimenter hides an object in her hand and then visits some locations (say, boxes A, B, and C) but not others (say, boxes D and E) and finally reveals her empty in such a way that it is clear that the object must have been left in one of the location (i.e., A, B or C) but unclear where exactly. Human children reliably solve such tasks (i.e., search in A, B, and C but not in D and E) from around 18–24 month of age (Piaget's stage 6 of sensorimotor development). From this time, human children succeed increasingly better in constructing and comparing multiple or even hypothetical models of the world. The demonstration of comparable higher-order cognitive abilities in non-human animals thus provides important insights in the phylogenetic development of complex thought (Suddendorf & Whiten, 2001). Comparative research of recent years has documented that great apes and parrots understand invisible displacements (e.g., Barth & Call, 2006; Collier-Baker, Davis, Nielsen, & Suddendorf, 2006; Pepperberg, Willner, & Gravitz, 1997; but see Jaakkola, 2014), while findings on other species are more mixed and controversial (see Cacchione & Rakoczy, 2017 for a review).

One rich interpretation of invisible displacement tasks argues that successful performance indicates complex logical reasoning in the form of a series of inferences involving disjunction and negation. In the above-mentioned example: "The object must be in A or B or C; it is not in C, therefore it must be in A or B; it is not in B; therefore it must be in A." Whether indeed such rich interpretations are correct, or whether subject solve the tasks in simpler ways is difficult to tell from searching behavior alone. But comparative studies have begun to use more fine-grained measures that have the potential to distinguish rich from alternative interpretations. One such measure is search latency as an indicator of (un-)certainty. If indeed subjects go through inferential chains of the sort "The object must be in A or B or C"—Search in C—"It is not in C, therefore it must be in A or B"—Search in B—"It is not in B; therefore it must be in A"—search in A, their certainty and thus their latencies should change over time. With each step, certainty should increase and latencies should thus decrease—in particular in the last step in which all alternatives but one (in the example above, A) are excluded and subjects thus are in a position to know by inference where the object must be. Results with this measure so far indicate that human children do follow exactly this pattern whereas dogs, while passing some invisible displacement tasks, do not show such latency/certainty patterns (Watson et al., 2001). How far the integration of domain-specific object knowledge with higher order domain general reasoning capacities extends evolutionarily into the primate lineage or beyond, thus remains an important question for future research.

2.3 | Featural and sortal object information: Thinking about objects proper

Keeping track of the spatiotemporal history of objects does not allow for very sophisticated identity judgments. As adults, humans experience a much richer external world and think of objects as pertaining to different kinds with specific properties—for example, flowers, cows, stones, etc. Individuating objects by processing their properties and kinds enables highly specific judgments of the numerical ("How many dogs are there?") and transtemporal identity ("Is this the same dog as the one I saw there before?") of objects we encounter in the world.

In human infants, the capacity to individuate objects by featural/kind information emerges much later than spatiotemporal tracking. Shape is processed from around 4.5 months; surface features from around 7.5 months and kind information from around 1 year of age (see Xu, 2007 for a review). In a typical looking time paradigm to measure kind processing, infants witness two objects of different kinds appearing/disappearing one after the other behind a screen (e.g., a ball and a duck). Importantly, across the event the duck and the ball are never seen simultaneously, as a consequence numerical identity cannot be assessed by spatiotemporal processing (the two objects can only be distinguished from each other on the basis of property/kind information). At the end of the sequence, the screen is removed, revealing two outcomes: either one (unexpected) or two objects (expected) are present behind the screen. What is required to solve this task is sortal object individuation – discriminating which kinds of objects are present in the event ("a duck," "a ball"), and as a consequence, assessing their exact number ("at least two").

In human infants, performance in the above-mentioned paradigm is related to language (Xu, 2002; Xu & Carey, 1996): it correlates with receptive language proficiency (e.g., children who understand the words "duck" and "ball" are more likely to individuate them), and is boosted when the objects are labeled ("Look, a duck/a ball!"). These findings have fed the assumption that sortal object individuation is based on language acquisition (e.g., Xu, 2002) and should therefore be a uniquely human capacity, a claim long popular in philosophy: "The mother, red, and water are for the infant all of a type: each is just a history of sporadic encounter, a scattered portion of what goes on. […] It is only when the child has got on to the full and proper use of individuative terms like 'apple' that he can properly be said to have taken to using terms as terms, and speaking of objects") (Quine, 1957, p. 9).

Comparative research in recent years provided evidence refuting such linguistic determinism by testing various species with analogous tasks as those used with human infants (explained above). They show that also non-human animals individuate objects based on property/kind information in the absence of language (e.g., apes: Mendes, Rakoczy, & Call, 2008, 2011; rhesus macaques: Phillips & Santos, 2007; Santos, Sulkowski, Spaepen, & Hauser, 2002; dogs: Bräuer & Call, 2011; chicks: Fontanari, Rugani, Regolin, & Vallortigara, 2011, 2014).

However, a fundamental question remains unanswered by the above-mentioned studies. Do the individuation tasks implemented by these studies really require participants to apply sortal object concepts, or can they be solved by mere feature processing.

The underlying problem is the following: in normal circumstances, object kinds and object features are necessarily confounded—balls are different in kind from ducks, banana slices different from carrot slices (an example from ape studies), but they also simply differ in terms of all kinds of superficial perceptible features (see Xu, Carey, & Quint, 2004). Perhaps, thus, subjects were not individuating objects in terms of their kinds, and thus searching for a missing object of a certain kind (as if saying to themselves "there still must be this banana slice around here"). Rather, they might have relied on simpler feature-based individuation, searching for some missing features (as if saying to themselves "there must still be some yellowness around here…"). The only way to stringently address this concern is to systematically de-confound "deep" properties of an object (that define its kind and thus cannot be changed without altering the nature of the object), and merely superficial features (that can be transformed without changing the object as such). Such contrasts have long been used in verbal studies with older children and adults to probe their intuitions of the identity of natural kind objects such as animals (e.g., Keil, 1989). In some classical vignettes, an animal was superficially transformed to look like another one (e.g., a raccoon was shaved and painted like a skunk), and subjects were asked to judge what kind of animal the animal would turn out to be. Adults and older children in such studies base their explicit identity judgments exclusively on the original kind of the animal and disregard superficial property transformations.

Recent studies on object individuation have implemented non-verbal transformation scenarios structurally analogous to those used in verbal format with older children and adults. For example, in one study, infants saw events of the following structure: at time 1, an object with appearance A (e.g., a toy bunny) entered into a box, and at time 2 infants either saw an object with appearance A (same bunny) or with appearance B (e.g., toy carrot) come out of the box (Cacchione, Schaub, & Rakoczy, 2013). In reality, the two appearances belonged to the very same object (a revertible soft toy with carrot-appearances on one side, and bunny-appearances on the other). But only one of two groups of infants was aware of this fact: This group had been previously familiarized with such dual-aspect objects, while the other group remained naïve. These naïve infants considered the difference in superficial appearance to be diagnostic regarding numerical identity: they searched longer in the bunny/rabbit condition than in the bunny/bunny condition. The non-naïve infants (familiar with such dual-identity objects), in contrast, ignored the superficial differences when making judgments about numerical identity: they did not search differently in the two conditions. Given the relevant background knowledge, infants thus disregard superficial feature differences in much the same way as older children and adults disregard the superficial feature differences between a normal raccoon at time 1 and a skunk-looking raccoon at time 2 (after it has been painted etc.) when it comes to the question of the animal's identity.

In a conceptually related study with a slightly different approach, great apes saw the following: a food item of kind A (e.g., slice of banana) entered into a box and a food item either of kind A or of kind B (e.g., slice of carrot) came out of the box. In some conditions, the food item entering the box was first changed in its superficial properties (e.g., the banana slice was painted orange) so that it was perceptually more similar to items of kind B than to other items of kind A. Results revealed that apes prioritized kind information over feature information when estimating the number of objects in the box. They searched longer in those conditions that involved a difference in kind between the object placed and the object retrieved from the box (as compared to conditions that involved only superficial feature differences; (Cacchione, Hrubesch, Call, & Rakoczy, 2016).

Converging evidence for systematic distinctions between deep, essential and superficial, accidental features in human infants comes from a study by Newman and colleagues (Newman, Herrmann, Wynn, & Keil, 2008): When trying to figure out the sources of behavior of a self-propelled object (e.g., a toy cat moving by itself), infants expected its internal (deep) features to be more relevant than its external (superficial) ones. They thus seem to appreciate that the self-generated movement of agents is more likely to be caused by deep internal properties than by more accidental external features.

3 | SORTAL OBJECT INDIVIDUATION AS BASIS OF PSYCHOLOGICAL ESSENTIALISM?

Much of adult human cognition is characterized by a pervasive cognitive tendency termed psychological essentialism (Gelman, 2003). In its broadest form, essentialism is a conceptual framework that underlies our naïve-metaphysical perspective on the world. Its basis is the distinction between two types of properties: Objects of a given kind can have many *accidental (or merely characteristic)* properties: properties that the object in question can but need not have, and in respect to which it can change without becoming a different kind of object. *Essential* (or defining) properties, in contrast, make an object the kind of object it is and that thus constitute its very identity. Whether something is a piece of silver is a question of its deep, essential (in this case, chemical) properties. Change these properties and the object in question is no longer a piece of silver. At the same time, pieces of silver usually have some prototypical surface features like looking silver. But these are merely accidental, not defining or essential, features. You can change them, for example by painting the piece golden, without altering the very identity of the object. Psychological essentialism is a rather general and abstract framework. Often, we do not need to know anything about the potential essential properties in question in order to assume that there are some. Many of our natural kind concepts illustrate the point most clearly. Usually, the folk have no idea what the essential properties of being a tiger, elm or piece of silver may be (Kripke, 1972; Putnam, 1975). We are able to refer to and pick out objects of these kinds demonstratively ("This is an elm"), and we assume that there must be a deep, underlying essence (its elm-ness) that defines its natural kind; but when wondering what this essence may be, we usually defer to authority ("botanists know") or future research ("they'll find out"). Concepts such as "tiger," "elm," and "gold" function, as it were, as *essence placeholders* (Medin & Ortony, 1989).

Typically, in human adults psychological essentialism has a characteristic bundle of signatures or patterns of cognitive manifestations (Gelman, 2003, 2004): (a) Kinds to which psychological essentialism applies are seen as *natural* kinds that (in contrast to merely nominal kinds such as "Mondays") are real, objective, independent from our view on them and about which deep facts can be discovered. (b) Though different, essential and accidental properties are seen as causally related: Tokens of a given type have (many) accidental properties in virtue of their hidden essences that (elms look like elms because of their elm-hood). (c) Membership in such categories (and thus the identity of a given object as object of this kind) is a binary (rather than continuous and fuzzy) matter. (d) Membership in such a category remains stable over time, even over major transformations of accidental properties. (e) Within such categories, members are often viewed as more homogenous than they really are (similarly to categorical perception, where quantitatively identical stimulus differences are underestimated within and overestimated between categories).

These signatures of psychological essentialism can be tapped empirically in various ways. Most prominently, the paradigm mentioned above studies subjects' intuitions of identity and stability of kind membership over time in the face of surface property changes (Keil, 1989). In adoption vignettes, for example, animals of a given kind (say, piglets) are adopted and raised by animals of another kind (say, tigers). In similar kinds of vignette, animal of a given kind (e.g., raccoons) are superficially transformed (by being shaved, painted or even by surgical treatments) to look (and smell) like animals of a different kind (e.g., skunk). The target question in both cases is what the original animal will turn out to be (Keil, 1989). In both cases, human adults and children from age 4–5 have strong intuitions that neither adoption nor superficial costume and transformation will ever turn an animal into a token of a different type.

With such methods, psychological essentialism has been amply documented in adult humans and older children. But so far, little is known about its origins, both ontogenetically and phylogenetically. This may be partly due to methodological reasons (most of the methods to tap essentialism are essentially linguistic). Partly, however, this may also be due to theoretical reasons. Psychological essentialism has been argued to be a historically and ontogenetically "late and sophisticated achievement" (Fodor, 1998, p. 159) arising on the basis of linguistic and technological foundations. On such a view, it would little make sense to even search for psychological essentialism in infants or non-human animals.

The new research on sortal object individuation in pre-verbal infants and non-verbal animals challenges this view. What this research shows is that before the full-blown onset, or even in the complete absence, of language agents (infants, apes) are capable of thinking about some kinds of objects and their identity conditions in ways that reveal at least some signatures of psychological essentialism: they systematically distinguish between deep, essential properties (whichever those may be) that are identity-relevant and merely superficial, accidental features such that an individual can survive massive transformations in the latter without altering its identity. Sortal object individuation may be one, perhaps even the, primordial form of psychological essentialism (Rakoczy & Cacchione, 2014).

This is an exciting possibility that raises many questions for future research: If psychological essentialism is conceived in such a way that its core is the distinction between essential and accidental properties and that it can otherwise come in degrees, sortal object individuation appears as a (perhaps the) basic form of essentialist cognition. But how then do the other signatures typically associated with psychological essentialism (such as assumptions about the causal relations between essential and accidental properties, or homogenization tendencies) develop through ontogeny, and how may they have emerged over evolution? How do children develop the barebones of essentialist sortal object individuation into the full-fledged adult framework of essentialist reasoning?

Relatedly, which other potential foundations of psychological essentialism may there be (and how may they relate to sortal object individuation)? One influential theory, for example, claims that essentialism emerges from a basic explanatory tendency to focus on inherent features of objects and events, the so-called "inherence heuristics" (Cimpian & Salomon, 2014). Future research needs to clarify whether and, if so, how this heuristics and sortal object individuation may play together over development as joint foundations of essentialism.

4 | CONCLUSION

Comparative and developmental metaphysics deal with the question how different species and humans at different developmental stages represent the world around them in its most basic structure. Of particular relevance is object cognition—the capacity to conceive of one's surroundings as made up of mind-independent, enduring individual entities. Thinking about objects in this way is the foundational for of any notion of objectivity (of a world out there, independently of our perceptions of them) and the basis for propositional, logical and quantified thought.

Notions of objecthood come in degrees. Basic capacities to identify and track physical bodies or "Spelke object" (cohesive, solid portions of stuff that move continuously in space-time) are widespread in the animal kingdom and develop very early in human ontogeny. Rudiments of our full-blown sortal conception of objects—as objects of a given kind with corresponding criteria for identity and countability—develop later in human ontogeny. However, in contrast to influential claims in philosophy and recent arguments in psychology, sortal object individuation has been documented before proper language in human ontogeny, and in the complete absence of language in non-human great apes. In human children, thinking about the trajectories of objects is intimately connected to logical reasoning (involving negation and disjunction) from early on (see Watson et al., 2001). Whether this functional integration extends to other species is currently still unknown.

Both from ontogenetic and from evolutionary perspectives, sortal object individuation (involving the core distinction between essential properties that determine object identity and superficial properties that can vary over time without affecting identity) may be one, perhaps even the, foundation for the development of psychological essentialism—the more general pervasive tendency to distinguish between deep, essential, kind-constituting properties and merely superficial, accidental ones.

Many questions remain to be addressed in future research: There are commonalities in basic sortal object individuation and rudiments of essentialist thinking between human infants and great apes (and possibly other species in the primate lineage and beyond). But how far do these commonalities go? Are there fundamental differences such that only for humans, object cognition becomes functionally integrated in flexible ways with domain-general cognition such as logical reasoning? And if so, is the acquisition of a natural language crucial as a medium for this integration? Such a picture would be in line with theoretical claims and empirical evidence coming from recent core knowledge approaches (e.g., Carey, 2009; Spelke, 2003). Developmentally and evolutionarily, is psychological essentialism one coherent and unitary cognitive phenomenon with single ontogenetic and phylogenetic trajectories, respectively? Or may there actually be different forms of essentialism that all share some general representational properties (the core distinction between essential and accidental properties), yet crucially vary in other ways including their history (Barrett, 2001; Gelman, 2013)?

CONFLICT OF INTEREST

The authors have declared no conflicts of interest for this article.

ENDNOTES

[1] In contrast to the traditional notions of visual objects as bundles of features and locations (e.g., Goodman, 1977), contemporary research suggests that the visual system can represent objects as "this/that," in abstraction from their qualities. Within philosophy, this purely individualizing characteristic is termed "thisness" (Skrzypulec, 2018).

[2] Some interpret this basic notion as an object sortal (e.g., Xu, 1997; Xu & Carey, 1996), a view controversially discussed in the philosophical community (e.g., Ayers, 1997; Hirsch, 1997).

[3] The problem of composition refers to the question of whether parts of composed entities may be addressed as entities in their own right; see Rose and Schaffer (2017) for a recent discussion.

RELATED WIREs ARTICLE

The development and developmental consequences of social essentialism

FURTHER READING

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