AMERICAN PSYCHOLOGICAL ASSOCIATION
Journal of Comparative Psychology

ISSN: 0735-7036
2023, Vol. 137, No. 3, 200–208
https://doi.org/10.1037/com0000339

Anthropomorphism as a Contributor to the Success of Human (*Homo sapiens*) Tool Use

Michael Haslam
Birsay, Orkney, United Kingdom

Humans anthropomorphize: as a result of our evolved ultrasociality, we see the world through person-colored glasses. In this review, I suggest that an interesting proportion of the extraordinary tool-using abilities shown by humans results from our mistakenly anthropomorphizing and forming social relationships with objects and devices. I introduce the term *machination* to describe this error, sketch an outline of the evidence for it, tie it to intrinsic reward for social interaction, and use it to help explain overimitation—itself posited as underpinning human technological complexity—by human children and adults. I also suggest pathways for testing the concept's presence and limits, with an explicit focus on context-specific individual and temporal variation. I posit cognitive pressure from time constraints or opaque mechanisms as a cause for machination, with rapid, subconscious attribution of goals or desires to tools reducing cognitive overload. Machination holds promise for understanding how we create and use combinatorial technology, for clarifying differences with nonhuman animal tool use, and for examining the human fascination with objects.

Keywords: technology, sociality, cognition, overimitation, animal tool use

Humans are self-regarding creatures, leading to two related concepts: anthropocentrism and anthropomorphism. The former places humans at the center of the universe and regards humanity as the yardstick by which that universe is measured (Ramsay & Teichroeb, 2019). The latter sees the world through person-colored glasses, transferring human characteristics onto nonhuman living, inanimate, or invented entities (Epley et al., 2007).

Both anthropocentrism and anthropomorphism, although widespread in human thinking, have been regarded as pitfalls to be avoided in objective science (see Barrett, 2011; Bräuer et al., 2020; de Waal, 1999; Wynne, 2004 for discussion). They can jointly bias the way we interpret things that may have little in common with an upright, large-brained, symbol-using, land-dwelling mammal. However, anthropomorphism can potentially be put to use: as a source of metaphorical explanations for evolutionary adaptations, for example, or for entertainment, or to improve human–device compatibility, or to assist conservation and protection of other species (Root-Bernstein et al., 2013; Manfredo et al., 2020).

Here, I suggest a further option, which is that a mistaken anthropomorphic view of objects and tools—which I refer to as *machination*—can help us understand humanity's affinity for building and using complex technology. In essence, machination is a process in which people temporarily and automatically treat nonliving objects as social partners while interacting with them, resulting in reduced cognitive effort and increased comfort around structurally or causally opaque tools. Machination increases the amount of time that people engage with technologies, and their willingness to do so, via intrinsic biological reward.

Anthropomorphic Resonance

Human lives are structured around other humans, a cooperative bent that has been termed *ultrasociality* (Henrich & Muthukrishna, 2021). This social drive affects our development, our decisions, and our perception (Tomasello, 2020). Anthropomorphism emerges from this perception, when the way that we think about and interact with each other is transferred uncritically to parts of the nonhuman environment. The result may be human-like gods, personified natural forces, attribution of human motivations to other animals, and

Michael Haslam https://orcid.org/0000-0001-8234-7806
This work was supported in its early phases by European Research Council Starting Investigator Grant 283959 (Primate Archaeology), awarded to Michael Haslam. My thanks to everyone who has discussed tool use with me over the years, especially Tom Loy and Bill McGrew, as well as Dora Biro, Jimbob Blinkhorn, Adam Brumm, Susana Carvalho, Chris Clarkson, Fred Coolidge, Remy Crassard, Alison Crowther, Robin Dunbar, Jim Estes, Tiago Falotico, Rob Foley, Doree Fragaszy, Jess Fujii, Michael Gumert, Huw Groucutt, Thibaud Gruber, John Gowlett, Jay Hall, Bruce Hardy, Adriana Hernandez-Aguilar, Ian Lilley, Lydia Luncz, Janet Mann, Carney Matheson, Tetsuro Matsuzawa, Julio Mercader, Edu Ottoni, Alejandra Pascual-Garrido, Alex Piel, Tom Proffitt, Jill Pruetz, Katherine Ralls, Christian Rutz, Crickette Sanz, Ceri Shipton, Fiona Stewart, Claudio Tennie, Tim Tinker, Natalie Uomini, Elisabetta Visalberghi and Tom Wynn. Meg Heaslop gave valuable feedback on early drafts. All opinions remain my own.
Michael Haslam served as lead for conceptualization, funding acquisition, writing – original draft, and writing – review and editing.
Correspondence concerning this article should be addressed to Michael Haslam, Runa, Birsay, Orkney KW17 2LR, United Kingdom. Email: mahaslam@gmail.com

seeing human-like mindedness in objects, images, or machines (Hortensius & Cross, 2018).

Just as with social understanding, anthropomorphism depends on context, and the same target may be viewed as minded at one point in time, and not others. This context-dependence also underlies the imaginative perception of objects or phenomena, for example, one person may see faces in a natural rock wall while another person does not, or the same person may switch between seeing faces and seeing only rocks. As pointed out by Airenti (2018), the way that early painters incorporated existing bumps and curves of cave walls into their depictions of animals suggests that such perceptive illusions have an ancient heritage.

Anthropomorphism takes this perceptive fluidity a step further, by considering nonhuman things to have human-like intent and reasoning. Critically, the anthropomorphized object does not need to resemble a human to gain these abilities; amorphous or even invisible entities such as a thunderstorm or viral pandemic may be attributed favorable or malicious motives. What matters is that we are personally engaged and interacting with an entity, such that a key is merely a lump of metal until it refuses to turn in the lock, whereupon it becomes a stubborn, minded foe. Our attention and attempted cooperation with the object temporarily ramps up our anthropomorphic perception (Airenti, 2018)—if the key turns smoothly we may not think of it as minded at all.

Along with its ubiquity, Epley and colleagues identified three psychological factors that contribute to anthropomorphic thinking: (a) the accessibility and applicability of anthropocentric knowledge, (b) the motivation to explain and understand the behavior of other agents, and (c) the desire for social contact and affiliation (Epley et al., 2007). The latter two of these are the most relevant to this review, which posits a cognitive advantage when people deal with material objects via implicit anthropomorphism. The advantage comes from using our impressive social cognition as a substitute—or cognitive offload—for understanding the workings of opaque or complex tools.

For example, as part of research into whether "teleological promiscuity"—assigning goals to nonminded objects—persists beyond childhood, university students in the United States were given variable amounts of time to agree on whether a statement was true (Kelemen & Rosset, 2009). The statements included both correct and incorrect assignment of wants or goals, such as "trees produce oxygen so animals can breathe." The less time people had to view the statements, the more they endorsed unwarranted goals, essentially taking an anthropomorphic standpoint. Later work showed that even professional adult physical scientists significantly increased their acceptance of incorrect anthropomorphic explanations under time pressure (Kelemen et al., 2013), while deliberately adding cognitive load via memory tasks likewise pushes people toward a more anthropomorphic interpretation of witnessed events (Spatola & Chaminade, 2022). The temporary and induced nature of this mistaken response forms part of the foundation of machination.

The Intentional Stance

Human-made items can be viewed from what Dennett (2009) terms the *design stance*. This mindset assumes that an artificial object was made for a reason, and that knowing or guessing the reason helps us understand what it will do and how to interact with it. However, the anthropomorphic intentional stance—described by Dennett as a subspecies of the design stance—allows even more rapid inference about what an entity may do. This stance harnesses our ultrasociality to attribute beliefs or desires to things other than ourselves, as a way of better or more easily predicting their behavior. A similar concept is captured by Csibra and Gergely (2007) in their discussion of teleological reasoning and action-to-goal inference, whereby an artifact's function is equated with its goal, "frozen" in the physical form of the tool itself.

At first glance, it may appear that the intentional stance and my proposed machination concept are one and the same, but there are a few crucial differences. Creatures and artifacts toward which the intentional stance may be directed are assumed to have both desires (wants) and beliefs (opinions about the world). This stance helps us make sense of the actions of even supposedly minimally cognitive living forms, such as bacteria or plants, as well as computerized systems such as chess-playing machines. However, machination does not attribute beliefs to objects or tools, only desires or goals, and even then only temporarily. It is not deliberate, and not about trying to understand or abstractly predict the behavior of the object in front of us. Rather, it involves forming a practical, short-term social partnership with that object to achieve both of our goals. One potential way to spot the difference between the two ideas—the intentional stance and machination—would be to track attempted communication with the object during use, signaling that the interaction involves expected cooperation from both (self and tool) participants.

The intentional stance presents a coherent approach to searching for and recognizing intentional behavior and its underlying motivations in the real world. It is substrate independent, and unlike for machination, the intentional stance does not rely on the misattribution of mental qualities as part of its core definition. If an object or artifact can be more adequately described using functional language without attributing internally held goals, as in a simple alarm clock, then the design stance is more appropriate (Dennett, 2009). If there is no assumed function, then using the laws of physics such as gravity—the physical stance—is even more apt for interpreting and predicting an object's movements.

My interest here is in the error that results when things that should be considered from the design stance are viewed instead as having goals—imputing Ryle's (1949) mental "ghostly shadow world" to artifacts. It is a basic error, and one that happens rapidly and repeatedly in our interactions with novel entities. When we encounter something or someone to which we assign cognitive traits, their intentionality (or goals) and desires (wants) are the quickest and most commonly inferred attributes (Malle & Holbrook, 2012). Only with more time are inferences made about beliefs—moving into the realm of the intentional stance—and finally possible personality traits. From a theory of mind perspective, assigning intentions and desires involves first-order attribution, in which we act as though an entity is goal-driven, but do not assume that it has any ability to make the same inference about us. This is the world in which machination operates.

Deus Ex Machina

Homo sapiens groups show an extreme dependence on artifacts for their survival, and if we accept anthropomorphism as a real, albeit variable, part of human cognition, then it is natural to explore how these two fundamental traits intersect. As part of that exploration, I chose the term machination both for its allusion to machines, and for its common usage to mean a hidden plot or scheme. It is a process directly derived from interactions between user and tool, and at its core lies the temporary misattribution of hidden desires or intent to tools or devices. For concision, I would exclude the anthropomorphic treatment of nonhuman animals—which may or may not actually have beliefs and desires—but include artificial, moving entities (e.g., vehicles) along with simple inanimate objects. Machination may be ancient: Lombard and Gärdenfors (2021) suggest that users of the Levallois stone-knapping technique tens to hundreds of thousands of years ago "understood how a [stone] core would 'behave' in the future."

How does machination manifest? To start with, it is not a stage of development or restricted to children (unlike Piaget's, 1929 animism, for instance). Children readily see agency in the natural world and in human-made things, but adults also often turn to anthropomorphic characterizations of why things happen in nature (Kelemen et al., 2013). They do so especially under time constraints, highlighting both machination's temporal contingency and the fact that it plays an automatic (or subconscious or System 1) role in cognition. And although machination can happen for anything from a rock to a robot, it is particularly important when objects, tools, or devices are causally opaque. Multicomponent tools, from bows and arrows to smartphones, may include attachments, enclosed or moving parts that defy quick recourse to simple physical causation. An object with an ambiguous function or operation can be cognitively more easily dealt with as a social agent (Waytz, Morewedge, et al., 2010), via our evolved capacity for interpreting the ambiguous motives and triggers of our social companions.

Human sociality includes morality, and one strand of evidence for machination therefore would be the treatment of nonliving artifacts as moral agents. Kominsky and Phillips (2019) found that this is the case, with malfunctioning artifacts considered not only to be breaking the causal norm expected of them (their proper function) but also often judged as violating a moral norm—they were misbehaving. This addition of moral judgment to the design stance suggests that working with tools can involve both making them work correctly in a physical sense, and making them do what is correct in a socially conforming sense.

What might trigger machination? Humans are intrinsically rewarded by social interaction (Eisenberger & Cole, 2012; Tamir & Mitchell, 2012). We do not need to achieve a specific outcome by manipulating our family and friends to get those rewards. Through machination, we can also be intrinsically rewarded by interacting with physical objects and tools, whether or not we have a specific goal that we want to achieve with them. If Lego blocks want to connect, or cars want to be driven, then we gain biological satisfaction by accidentally treating them as social beings. We can also end up feeling guilty about leaving tools or machines unused, denying them their needs. The result is that humans may be motivated to interact with mistakenly socialized tools more often, or for longer, than other animals that do not make the same error. In turn, these interactions increase the likelihood of successful or novel tool use and act to reduce anxiety around complex technologies. Emotional attachment strengthens anthropomorphism in children (Gjersoe et al., 2015), and machination is not restricted to social connections formed with person-like objects such as dolls or humanoid robots, although these do supply ready examples of the process in action (Waytz et al., 2014).

Just as the strength of anthropomorphism varies from person to person (Waytz, Cacioppo, et al., 2010), machination is expected to vary, especially with sociality. Maintaining connection, or "social homeostasis," benefits a variety of social-living animals (Matthews & Tye, 2019). Epley et al. (2008) found that loneliness—whether chronic or induced—is positively linked to anthropomorphism. They posit that social disconnection is compensated or ameliorated through interaction with objects, tools, and devices, as well as through anthropomorphizing nonhuman animals such as pets. This link raises the possibility that technical competence can tie directly to machination through social disconnection. A further implication is that, even if some machination occurs when we transfer a person's agency onto a tool they are using, misattribution of intent may occur without such a connection.

Human social relationships are built on fluid, often nested groupings (Dunbar, 2009). Most of us are comfortable with one-on-one interactions, as well as being among extended family, or friendship groups, or teammates, or colleagues, or tens of thousands of fellow humans at a concert or sporting event. I suggest that this social flexibility, in which people align their wants to create cooperative groups of different sizes, also contributes to how machination helps with complex technologies. Whereas the physical complexity of combining different objects or devices may be daunting, if we implicitly misperceive that components intend to be combined, or want to be joined, then we are able to generate additional tools and machines of greater complexity with less cognitive effort. Naturally, this ability calls on other capacities such as recursion, working memory, and manual dexterity, but I propose that the cognitive ease of building additive or cumulative technologies is enhanced by machination. Certainly, humans seem to be naturally additive rather than subtractive when confronting technical problems (Adams, 2021; Arthur, 2011). This tendency stands in stark contrast to the primarily subtractive tool manufacture seen in wild nonhuman animals: for example, the reductive stick tool making of chimpanzees, New Caledonian crows, orangutans, palm cockatoos, elephants and Galapagos finches (Shumaker et al., 2011), deliberate stone breaking by capuchin monkeys (Proffitt et al., 2016), leaf-tool making by *Aphaenogaster* ants (Lőrinczi et al., 2018), and sponge-detachment by bottlenose dolphins (Mann et al., 2008).

Our control over technology directly influences the extent to which we attribute it agency (Barrett & Johnson, 2003; Waytz, Morewedge, et al., 2010). When we do not have control, and especially when something violates our expectations while under our control, there is a greater tendency to attribute intentions to an inanimate object. It is the reason why the idea of someone frustratedly asking a nonfunctioning printer what it needs, or a recalcitrant suitcase why it does not want to close, does not seem irrational. The multifunctional ambiguity of tools, present from the origins of tool use in the human lineage over three million years ago (Harmand et al., 2015), can be eased by mapping it onto the ambiguity inherent in social situations. Just as a single human can switch between friend, colleague, and sports rival depending on the context, interacting with tools that have multiple or opaque purposes is less daunting when they are treated as social partners. Our desire for control also means that reliable and cooperative tools are valued and trusted (Merritt & Ilgen, 2008), just as reliable and cooperative friends are. Moral judgments of tool function are built on these expectations and their violations.

Neurological work on anthropomorphism is still emerging, but it has uncovered targets relevant to testing machination. For example, the left midsuperior temporal cortex has a distinct subregion that codes for agents (active doers), separate from patients (those done-to), or their specific actions (Frankland and Greene, 2015). Those agents may be human or nonhuman, providing a potential pathway for treating mindless entities as agents. Gray matter volume in the left temporoparietal junction also differs significantly from self-reported anthropomorphic tendencies of healthy humans (Cullen et al., 2014). As might be expected, this area is one of the principal regions associated with theory of mind, or mentalizing (Wiese et al., 2018), but it also overlaps with lesions in patients that can no longer name tools (Tranel et al., 1997). And Waytz et al. (2019) noted that lesions to the basolateral amygdala left people able to anthropomorphize living and moving things, but not inanimate objects. Biochemical factors may also play a role: Oxytocin not only helps us identify salient social cues, but it also increases the tendency to anthropomorphize (Scheele et al., 2015).

Machination and Overimitation

Let us consider a more concrete example: the human oddity dubbed overimitation. This term describes the fact that when many people, especially but not only children, see someone perform causally irrelevant actions on an object while achieving a given outcome, they tend to reproduce those actions in pursuit of the same outcome (Hoehl et al., 2019). Imitation is often contrasted with emulation, in which the results of a task are achieved without copying the precise behavior pattern demonstrated (Horner & Whiten, 2005). The fact that humans overimitate across cultures (Berl & Hewlett, 2015; Kapitány et al., 2018), but other great apes do so much less commonly, has led to its proposal as a prime factor underlying human technological complexity and uniqueness (Clay & Tennie, 2018). Overimitation in other species (e.g., dogs: Huber et al., 2020) is a matter of ongoing research.

Machination predicts that individuals who mistakenly attribute wants or needs to objects will “cooperate” with those objects, moving or manipulating them in a particular way, even if those movements are not causally relevant to a particular outcome set by an experimenter. This cooperation may be labeled by the experimenter as overimitation: copying of actions unnecessary to fulfill the experimenter’s aim. However, the same actions may be unintentionally or unconsciously considered necessary by the tested individual to fulfill the supposed aims of the manipulated tool. Machination therefore predicts increased overimitation by individuals with higher anthropomorphic tendencies, when time or other cognitive pressures apply (Schleihauf & Hoehl, 2020), or when complex technologies prevent an easy understanding of the causal mechanisms involved. Note that we should not expect any given individual to be entirely consistent in their use (or not) of machination, and both intra- and interindividual variation should be examined alongside group or species-wide comparisons.

Sociality is relevant here: One explanation for overimitation is that we use social cues from a demonstrator to reduce the pressure of learning about opaque or complex mechanisms. This cuing has been discussed alongside such social frameworks as normativity or rituals (Keupp et al., 2013; Nielsen et al., 2018). Machination suggests that people may also or instead perform irrelevant actions because they are treating them as part of the needs or wants of the object itself. This explanation is supported by experiments in which children and adults continue to overimitate even when the demonstrator is absent, not explicit, or nonhuman (Schleihauf et al., 2021; Sommer et al., 2020; Whiten et al., 2016). However, they imitate irrelevant actions less when performed on a physically separate object (Lyons et al., 2007; Schleihauf & Hoehl, 2020). Tellingly, children also overimitated more when irrelevant actions were performed with a tool that was then used to solve the task, compared with the irrelevant use of a second, separate tool (Frick et al., 2021). The same study showed that the emotions of the (human) demonstrator did not change overimitation rates, although children’s perception of the internal state of the tool, emotional or otherwise, was not reported. The potentially central social role in imitation tests of the manipulated object itself has been largely overlooked.

Overimitation has been studied most often in humans and our great ape cousins. The seminal work of Horner and Whiten (2005) showed that young, wild-born chimpanzees performed irrelevant actions on a puzzle box much more often when the box was opaque than when it was clear, which led the authors to link chimpanzee imitation to times when causal information was not readily available (vs. using emulation when it was). Human children given the same task imitated irrelevant actions whether or not the box was opaque, suggesting that humans have a stronger propensity to follow the behavior of a model and not rely on emulation. However, the children did not have the human demonstrator present while they interacted with the box, and they were unaware that they were being filmed. They also tended to return the puzzle box to its original state before calling in the demonstrator, removing any evidence of their solving process. The primary relationship in the test was therefore essentially one between the puzzle box and the child. The same relationship is present in video demonstrations of puzzle boxes that exclude most of the demonstrating human (McGuigan et al., 2007), and more recent work found that adults are not immune from the same tendency to overimitate when the demonstrating person is absent (Whiten et al., 2016).

Overimitation in the absence of a living social partner (such as a demonstrator) is less surprising if we ask: “What does the object want?.” I expect that most readers will not be aware of routinely asking themselves this question, at least outside of the occasions that they have been frustrated by an uncooperative machine or tool. However, I am proposing that the switch from a physical or design stance to machination is most likely to occur when confronted with situations that reward the use of automatic responses, including when under time pressure and in circumstances of cognitive overload. In these conditions, deliberate and conscious decisions about how to use a particular tool based on its designers’ assumed intent, physical format, and connections are replaced by a rapid, mistaken, and often unrecognized assumption that the tool is part of a social alliance with the user. Importantly, cognitive overload might result from external pressures, but it may also be generated by the perceived complexity of the device itself.

Although machination predicts an increase in overimitation while it operates, it only does so for those that misperceive an object as at least minimally self-directed. The influence of modifiers, for example, personality, experience, age, or interventions such as teaching (Buchsbaum et al., 2011), remain to be tested, and, as in all social relationships, context matters. Anthropomorphism also comes with conditions that do not always apply to our relationships with other people, such as ownership (Kiesler et al., 2006). Ultimately, discerning machination will require a more explicit focus on the cases and times in which people (or other animals) appear to interact with objects or tools as though they are social agents, even when such cases are in the minority in a given situation or experiment.

What Objects Want

My intention in focusing on machination is to help broaden ideas on how humans interact with our external worlds. My own perspective on such interaction includes notions of embodied cognition, with actions playing an integral role in perception (following Fragaszy & Mangalam, 2020; Gibson, 1979), and the physical environment scaffolding and affording those actions (Sterelny, 2010). However, machination is generally compatible with other perspectives. Although I hypothesize, therefore, that artifacts and devices are most likely to be viewed as having goals or desires when we directly interact with them as cooperative partners (Airenti, 2018), I cannot rule out the same misattribution occurring when we see them being used by someone else, or even inertly strewn about the local environment.

Intrinsic motivation is not only valuable in human cognition. Machine learning in cases of sparse feedback is considerably enhanced by the inclusion of intrinsic reward (Ecoffet et al., 2021). The likelihood that some nonhuman animals can also gain intrinsic value through a form of machination, and thereby either offload cognitive effort or persist in interacting with a tool for longer than would otherwise occur (leading to successful or novel use), is nonnegligible. The wide phylogenetic spread of the many species that currently use tools or build nests in the wild (Biro et al., 2013; Hansell & Ruxton, 2008) provides many targets for investigation. However, the fact that animal tool use is variably expressed, for example, increasing in captivity (Haslam, 2013), suggests that machination may manifest only in certain contexts for any specific animal. In this respect, machination would be most likely observed as a context-dependent individual characteristic, not measured as an average response to objects or tools across a group. For example, in one study, a group of captive chimpanzees were found to more readily imitate actions when they involved directing objects toward other objects rather than toward the animal's own body, but one female (Ai) showed a much greater ability to repeat actions on the first attempt than her companions (Myowa-Yamakoshi & Matsuzawa, 1999).

Candidates for machination in nonhumans would be individuals of species that combine highly evolved sociality with regular object manipulation, and the clearest evidence would involve the treatment of objects as needy beings. Unambiguous evidence for an understanding of nonself goals is currently lacking for most species, but captive great apes have repeatedly shown this ability (Tomasello, 2022). Wild chimpanzee stick and orangutan leaf "dolls" are therefore candidates for nonhuman animal machination (Bastian et al., 2012; Kahlenberg & Wrangham, 2010), and evidence for "favorite" or reused tools could be another (Carvalho et al., 2009). A recent report of a chimpanzee mother in the Budongo Forest in Uganda carrying a twig as a possible replacement for her deceased infant (Soldati et al., 2022) suggests at least the capacity for social attachment to objects in wild great apes, although it does not in itself amount to complex tool manufacture or use. Similarly, New Caledonian crows have been reported to "value" certain plant tools above others, keeping them safe and reusing them in a manner that could be seen as a cooperative alliance between bird and tool (Klump et al., 2021). At a minimum, the idea that an object may be an unwitting extra social player in a scene (even when an individual is otherwise alone) may require reframing some purely causal explanations for tool use in animals and humans alike. Note that machination does not require higher order attribution of mental states, such as beliefs, to objects (Povinelli, 2020), but it does need an individual to act as if there are nonself agents in the world.

Testing for machination will require evidence on whether and how people and other animals treat tools as cooperative partners, before, during, and after use or manufacture, and over developmental timescales. As an attempt to advance this work, I include here seven initial, testable predictions:

1. Machination—and a sense of having a temporary shared goal with devices—will be increasingly evident as people confront more complex (i.e., multipart) and causally opaque objects. Few other animals will show the same proclivity, and observed differences in how humans and other animals deal with opacity and complexity will increasingly derive from human reliance on machination. Evidence for machination could include more time spent engaged with opaque or complex technologies, willingness to experiment with those technologies, and a tendency to combine or add to existing tools, especially when the behavior is not externally rewarded or encouraged.

2. Members of animal species with higher levels of cooperation will tend to engage with complex and opaque devices for longer, and use (or "solve") them more rapidly than members of individualistic species. Examples could include wild dolphins and elephants and exclude most octopuses (although the cooperative nature of individual octopus arms and reports of multispecies hunting groups involving octopuses (Sampaio et al., 2021) makes this a matter for further investigation). Members of a generally cooperative species that individually show antisocial tendencies toward conspecifics may nonetheless still succeed in tool use via machination, provided they receive intrinsic rewards for doing so. In other words, intrinsically rewarding cooperative behavior is a prerequisite to machination. An ability to dexterously handle tools, or a particular brain size or configuration, will only contribute to complex tool use when an evolved and the intrinsic cooperative tendency is also present.

3. Individuals matter more than statistical populations when examining complex tool use. I mean this not in the sense that an exceptional individual can act as a proxy for the "capacity" of a species, but that individuals who interact with complex technologies for longer and without having to fully understand the causal mechanisms of those objects—by mistakenly treating them as social partners—can generate successes that act as a spark that repeatedly

introduces innovation into populations. Even if the majority of a group does not readily engage in machination, individuals who do so can drive wider technological invention and innovation. The fact that machination may be inconsistently expressed even in the same individual at different times (just as anthropomorphism is) means that summed or averaged behaviors will likely miss important aspects of the human/animal-tool partnership.

4. Machination will be more prevalent in humans who are under time pressure or other stresses such as divided attention, and will spike during direct interaction with an object or device. This might manifest as frustration directed toward an uncooperative device or tool, as well as an increased willingness to abandon causal understanding and accept that a device or object has its own motivations for behaving the way it does. In nonhuman animals, switching from an ineffective tool to a seemingly identical one during a demanding task could suggest similar treatment of tools as either helpful or hindering social partners.

5. Machination will play an important role in the discovery of novel tool functions or combinations of tools seen in child's play and adolescent exploration (Riede et al., 2021). Evidence of increased anthropomorphism among socially disconnected people leads to the hypothesis of greater machination among socially disenfranchised members of a society, including younger individuals and those on the social margins. As a result, machination is a candidate process for easing and expanding younger individuals' acceptance and use of complex technologies. Object play is a potentially fertile area of research for investigating machination in both human and nonhuman animals, especially where the materials involved are also those used as tools by the same population (Ramsey and McGrew, 2005).

6. Tools or devices mistakenly perceived as having intentions will continue to be used as they deteriorate past their point of maximal efficiency, or when "better" (lower cost) alternatives are available. A tool's social value, not as a signifier to others but as intrinsically valued by an individual, needs to be considered alongside other means of tracking by which tool-use behaviors are judged efficient or effective. Whether or not long-term familiarity or training with a device will eventually reduce the effects of machination, via increased causal understanding of how it works, remains to be tested.

7. As a fundamentally social process, machination will vary between human groups in ways that mirror differences in interpersonal groupings and interactions. The construction and use of multicomponent tools therefore could be taken as evidence of machination in past human societies, and those of our ancestors. Evidence for this process may include hafted stone tools and strung beads, as well as more overtly anthropomorphic evidence such as therianthropes (Aubert et al., 2019).

As our tools (machines, robots, programs; see Bongard & Levin, 2021) become more complex, there may come a point where machination ceases to be a category error, and becomes a valid understanding of how a device works: a tool may actually be fairly said to have intent (Hancock et al., 2011). For now, though, I believe that machination as a concept does useful work by describing a commonly overlooked exaptation. I do not deny that objects can and do have social value and meaning aside from their technical aspects or any anthropomorphic mistakes (Coward, 2019). Similarly, artifacts have been seen by some as irrevocably entangled or engaged in human thought, or as literal pieces of human cognition (Gallagher, 2018; Hodder, 2011; Malafouris, 2013). Machination differs by emphasizing its mistaken and implicit but beneficial character, accidentally aiding human cognitive simplification by hijacking our evolved sociality.

Conclusion

Machination adds another lens to our microscope for examining object use and manufacture. I am suggesting that, alongside perceiving what an object or device can physically do, and knowing how to use it, an interesting proportion of human tool use—and a differentiator from most nonhuman animal tool use—actually involves misconceived social cooperation. Whether this concept proves useful, or irrelevant, remains to be seen. For now, this is unexplored territory. Rather than fencing off folk psychology from folk physics along the person/object boundary, or even the animate/inanimate boundary, my contention is that machination allows objects to wander over to the psychology side. I propose that we find out more about what they are doing over there.

References

Adams, G. S., Converse, B. A., Hales, A. H., & Klotz, L. E. (2021). People systematically overlook subtractive changes. *Nature*, *592*(7853), 258–261. https://doi.org/10.1038/s41586-021-03380-y

Airenti, G. (2018). The development of anthropomorphism in interaction: Intersubjectivity, imagination, and theory of mind. *Frontiers in Psychology*, *9*, Article 2136. https://doi.org/10.3389/fpsyg.2018.02136

Arthur, W. B. (2011). *The nature of technology: What it is and how it evolves*. Allen Lane.

Aubert, M., Lebe, R., Oktaviana, A. A., Tang, M., Burhan, B., Hamrullah, Jusdi, A., Abdullah, Hakim, B., Zhao, J.-X., Geria, I. M., Sulistyarto, P. H., Sardi, R., & Brumm, A. (2019). Earliest hunting scene in prehistoric art. *Nature*, *576*(7787), 442–445. https://doi.org/10.1038/s41586-019-1806-y

Barrett, L. (2011). *Beyond the brain: How body and environment shape animal and human minds*. Princeton University Press.

Barrett, J., & Johnson, A. H. (2003). The role of control in attributing intentional agency to inanimate objects. *Journal of Cognition and Culture*, *3*(3), 208–217. https://doi.org/10.1163/156853703322336634

Bastian, M. L., van Noordwijk, M. A., & van Schaik, C. P. (2012). Innovative behaviors in wild Bornean orangutans revealed by targeted population comparison. *Behaviour*, *149*(3–4), 275–297. https://doi.org/10.1163/156853912X636726

Berl, R. E. W., & Hewlett, B. S. (2015). Cultural variation in the use of overimitation by the Aka and Ngandu of the Congo Basin. *PLoS ONE*, *10*(3), Article e0120180. https://doi.org/10.1371/journal.pone.0120180

Biro, D., Haslam, M., & Rutz, C. (2013). Tool use as adaptation. *Philosophical Transactions of the Royal Society of London: Series B,* Biological Sciences, 368(1630), Article 20120408. https://doi.org/10.1098/rstb.2012.0408

Bongard, J., & Levin, M. (2021). Living things are not (20th Century) machines: Updating mechanism metaphors in light of the modern science of machine behavior. *Frontiers in Ecology and Evolution*, *9*, Article 650726. https://doi.org/10.3389/fevo.2021.650726

Bräuer, J., Hanus, D., Pika, S., Gray, R., & Uomini, N. (2020). Old and new approaches to animal cognition: There is not "one cognition". *Journal of Intelligence*, *8*(3), Article 28. https://doi.org/10.3390/jintelligence8030028

Buchsbaum, D., Gopnik, A., Griffiths, T. L., & Shafto, P. (2011). Children's imitation of causal action sequences is influenced by statistical and pedagogical evidence. *Cognition*, *120*(3), 331–340. https://doi.org/10.1016/j.cognition.2010.12.001

Carvalho, S., Biro, D., McGrew, W. C., & Matsuzawa, T. (2009). Tool-composite reuse in wild chimpanzees (*Pan troglodytes*): Archaeologically invisible steps in the technological evolution of early hominins? *Animal Cognition*, *12*(S1), 103–114. https://doi.org/10.1007/s10071-009-0271-7

Clay, Z., & Tennie, C. (2018). Is overimitation a uniquely human phenomenon? Insights from human children as compared to bonobos. *Child Development*, *89*(5), 1535–1544. https://doi.org/10.1111/cdev.12857

Coward, F. (2019). Technological intelligence or social wisdom? Promiscuous sociality, things and networks in human evolution. In A. Fuentes & C. Deane-Drummond (Eds.), *Evolution of wisdom: Major and minor keys* (pp. 41–56). Center for Theology, Science, and Human Flourishing. https://ctshf.pressbooks.com/chapter/technological-intelligence/

Csibra, G., & Gergely, G. (2007). 'Obsessed with goals': Functions and mechanisms of teleological interpretation of actions in humans. *Acta Psychologica*, *124*(1), 60–78. https://doi.org/10.1016/j.actpsy.2006.09.007

Cullen, H., Kanai, R., Bahrami, B., & Rees, G. (2014). Individual differences in anthropomorphic attributions and human brain structure. *Social Cognitive and Affective Neuroscience*, *9*(9), 1276–1280. https://doi.org/10.1093/scan/nst109

Dennett, D. (2009). Intentional systems theory. In A. Beckermann, B. P. McLaughlin, & S. Walter (Eds.), *The Oxford handbook of philosophy of mind* (pp. 339–350). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199262618.003.0020

de Waal, F. B. M., & University of Arkansas Press. (1999). Anthropomorphism and anthropodenial: Consistency in our thinking about humans and other animals. *Philosophical Topics*, *27*(1), 255–280. https://doi.org/10.5840/philtopics199927122

Dunbar, R. I. M. (2009). The social brain hypothesis and its implications for social evolution. *Annals of Human Biology*, *36*(5), 562–572. https://doi.org/10.1080/03014460902960289

Ecoffet, A., Huizinga, J., Lehman, J., Stanley, K. O., & Clune, J. (2021). First return, then explore. *Nature*, *590*(7847), 580–586. https://doi.org/10.1038/s41586-020-03157-9

Eisenberger, N. I., & Cole, S. W. (2012). Social neuroscience and health: Neurophysiological mechanisms linking social ties with physical health. *Nature Neuroscience*, *15*(5), 669–674. https://doi.org/10.1038/nn.3086

Epley, N., Waytz, A., & Cacioppo, J. T. (2007). On seeing human: A three-factor theory of anthropomorphism. *Psychological Review*, *114*(4), 864–886. https://doi.org/10.1037/0033-295X.114.4.864

Epley, N., Akalis, S., Waytz, A., & Cacioppo, J. T. (2008). Creating social connection through inferential reproduction: Loneliness and perceived agency in gadgets, gods, and greyhounds. *Psychological Science*, *19*(2), 114–120. https://doi.org/10.1111/j.1467-9280.2008.02056.x

Fragaszy, D. M., & Mangalam, M. (2020). Folk physics in the twenty-first century: Understanding tooling as embodied. *Animal Behavior and Cognition*, *7*(3), 457–473. https://doi.org/10.26451/abc.07.03.12.2020

Frankland, S. M., & Greene, J. D. (2015). An architecture for encoding sentence meaning in left mid-superior temporal cortex. *Proceedings of the National Academy of Sciences of the United States of America*, *112*(37), 11732–11737. https://doi.org/10.1073/pnas.1421236112

Frick, A., Schleihauf, H., Satchell, L. P., & Gruber, T. (2021). Carry-over effects of tool functionality and previous unsuccessfulness increase overimitation in children. *Royal Society Open Science*, *8*(7), Article 201373. https://doi.org/10.1098/rsos.201373

Gallagher, S. (2018). The extended mind: State of the Question. *The Southern Journal of Philosophy*, *56*(4), 421–447. https://doi.org/10.1111/sjp.12308

Gibson, J. J. (1979). *The ecological approach to visual perception*. Houghton Mifflin.

Gjersoe, N. L., Hall, E. L., & Hood, B. (2015). Children attribute mental lives to toys when they are emotionally attached to them. *Cognitive Development*, *34*, 28–38. https://doi.org/10.1016/j.cogdev.2014.12.002

Hancock, P. A., Billings, D. R., Schaefer, K. E., Chen, J. Y. C., de Visser, E. J., & Parasuraman, R. (2011). A meta-analysis of factors affecting trust in human-robot interaction. *Human Factors*, *53*(5), 517–527. https://doi.org/10.1177/0018720811417254

Hansell, M., & Ruxton, G. D. (2008). Setting tool use within the context of animal construction behaviour. *Trends in Ecology and Evolution*, *23*(2), 73–78. https://doi.org/10.1016/j.tree.2007.10.006

Harmand, S., Lewis, J. E., Feibel, C. S., Lepre, C. J., Prat, S., Lenoble, A., Boës, X., Quinn, R. L., Brenet, M., Arroyo, A., Taylor, N., Clément, S., Daver, G., Brugal, J.-P., Leakey, L., Mortlock, R. A., Wright, J. D., Lokorodi, S., Kirwa, C., . . . Roche, H. (2015). 3.3-million-year-old stone tools from Lomekwi 3, West Turkana, Kenya. *Nature*, *521*(7552), 310–315. https://doi.org/10.1038/nature14464

Haslam, M. (2013). 'Captivity bias' in animal tool use and its implications for the evolution of hominin technology. *Philosophical Transactions of the Royal Society of London: Series B, Biological Sciences*, *368*(1630), Article 20120421. https://doi.org/10.1098/rstb.2012.0421

Henrich, J., & Muthukrishna, M. (2021). The origins and psychology of human cooperation. *Annual Review of Psychology*, *72*(1), 207–240. https://doi.org/10.1146/annurev-psych-081920-042106

Hodder, I. (2011). Human-thing entanglement: Towards an integrated archaeological perspective. *Journal of the Royal Anthropological Institute*, *17*(1), 154–177. https://doi.org/10.1111/j.1467-9655.2010.01674.x

Hoehl, S., Keupp, S., Schleihauf, H., McGuigan, N., Buttelmann, D., & Whiten, A. (2019). 'Over-imitation': A review and appraisal of a decade of research. *Developmental Review*, *51*, 90–108. https://doi.org/10.1016/j.dr.2018.12.002

Horner, V., & Whiten, A. (2005). Causal knowledge and imitation/emulation switching in chimpanzees (*Pan troglodytes*) and children (*Homo sapiens*). *Animal Cognition*, *8*(3), 164–181. https://doi.org/10.1007/s10071-004-0239-6

Hortensius, R., & Cross, E. S. (2018). From automata to animate beings: The scope and limits of attributing socialness to artificial agents. *Annals of the New York Academy of Sciences*, *1426*(1), 93–110. https://doi.org/10.1111/nyas.13727

Huber, L., Salobir, K., Mundry, R., & Cimarelli, G. (2020). Selective overimitation in dogs. *Learning and Behavior*, *48*(1), 113–123. https://doi.org/10.3758/s13420-019-00400-w

Kahlenberg, S. M., & Wrangham, R. W. (2010). Sex differences in chimpanzees' use of sticks as play objects resemble those of children. *Current Biology*, *20*(24), R1067–R1068. https://doi.org/10.1016/j.cub.2010.11.024

Kapitány, R., Davis, J. T., Legare, C., & Nielsen, M. (2018). An experimental examination of object-directed ritualized action in children across two cultures. *PLoS ONE*, *13*(11), Article e0206884. https://doi.org/10.1371/journal.pone.0206884

Kelemen, D., & Rosset, E. (2009). The human function compunction: Teleological explanation in adults. *Cognition*, *111*(1), 138–143. https://doi.org/10.1016/j.cognition.2009.01.001

Kelemen, D., Rottman, J., & Seston, R. (2013). Professional physical scientists display tenacious teleological tendencies: Purpose-based reasoning as a cognitive default. *Journal of Experimental Psychology: General*, *142*(4), 1074–1083. https://doi.org/10.1037/a0030399

Keupp, S., Behne, T., & Rakoczy, H. (2013). Why do children overimitate? Normativity is crucial. *Journal of Experimental Child Psychology*, *116*(2), 392–406. https://doi.org/10.1016/j.jecp.2013.07.002

Kiesler, S., Lee, S., & Kramer, A. D. I. (2006). Relationship effects in psychological explanations of nonhuman behavior. *Anthrozoös*, *19*(4), 335–352. https://doi.org/10.2752/089279306785415448

Klump, B. C., St Clair, J. J., & Rutz, C. (2021). New Caledonian crows keep 'valuable' hooked tools safer than basic non-hooked tools. *eLife*, *10*, Article e64829. https://doi.org/10.7554/eLife.64829

Kominsky, J. F., & Phillips, J. (2019). Immoral professors and malfunctioning tools: Counterfactual relevance accounts explain the effect of norm violations on causal selection. *Cognitive Science*, *43*(11), Article e12792. https://doi.org/10.1111/cogs.12792

Lombard, M., & Gärdenfors, P. (2021). Causal cognition and theory of mind in evolutionary cognitive archaeology. *Biological Theory*. Advance online publication. https://doi.org/10.1007/s13752-020-00372-5

Lőrinczi, G., Módra, G., Juhász, O., & Maák, I. (2018). Which tools to use? Choice optimization in the tool-using ant, Aphaenogaster subterranea. *Behavioral Ecology*, *29*(6), 1444–1452. https://doi.org/10.1093/beheco/ary110

Lyons, D. E., Young, A. G., & Keil, F. C. (2007). The hidden structure of overimitation. *Proceedings of the National Academy of Sciences of the United States of America*, *104*(50), 19751–19756. https://doi.org/10.1073/pnas.0704452104

Malafouris, L. (2013). *How things shape the mind: A theory of material engagement*. MIT Press. https://doi.org/10.7551/mitpress/9476.001.0001

Malle, B. F., & Holbrook, J. (2012). Is there a hierarchy of social inferences? The likelihood and speed of inferring intentionality, mind, and personality. *Journal of Personality and Social Psychology*, *102*(4), 661–684. https://doi.org/10.1037/a0026790

Manfredo, M. J., Urquiza-Haas, E. G., Don Carlos, A. W., Bruskotter, J. T., & Dietsch, A. M. (2020). How anthropomorphism is changing the social context of modern wildlife conservation. *Biological Conservation*, *241*, Article 108297. https://doi.org/10.1016/j.biocon.2019.108297

Mann, J., Sargeant, B. L., Watson-Capps, J. J., Gibson, Q. A., Heithaus, M. R., Connor, R. C., & Patterson, E. (2008). Why do dolphins carry sponges? *PLoS ONE*, *3*(12), Article e3868. https://doi.org/10.1371/journal.pone.0003868

Matthews, G. A., & Tye, K. M. (2019). Neural mechanisms of social homeostasis. *Annals of the New York Academy of Sciences*, *1457*(1), 5–25. https://doi.org/10.1111/nyas.14016

McGuigan, N., Whiten, A., Flynn, E., & Horner, V. (2007). Imitation of causally opaque versus causally transparent tool use by 3- and 5-year-old children. *Cognitive Development*, *22*(3), 353–364. https://doi.org/10.1016/j.cogdev.2007.01.001

Merritt, S. M., & Ilgen, D. R. (2008). Not all trust is created equal: Dispositional and history-based trust in human-automation interactions. *Human Factors*, *50*(2), 194–210. https://doi.org/10.1518/001872008X288574

Myowa-Yamakoshi, M., & Matsuzawa, T. (1999). Factors influencing imitation of manipulator actions in chimpanzees (*Pan troglodytes*). *Journal of Comparative Psychology*, *113*(2), 128–136. https://doi.org/10.1037/0735-7036.113.2.128

Nielsen, M., Tomaselli, K., & Kapitány, R. (2018). The influence of goal demotion on children's reproduction of ritual behavior. *Evolution and Human Behavior*, *39*(3), 343–348. https://doi.org/10.1016/j.evolhumbehav.2018.02.006

Piaget, J. (1929). *The child's conception of the world*. Kegan Paul, Trench & Trubner.

Povinelli, D. J. (2020). Can Comparative Psychology Crack its Toughest Nut? *Animal Behavior and Cognition*, *7*(4), 589–652. https://doi.org/10.26451/abc.07.04.09.2020

Proffitt, T., Luncz, L., Falótico, T., Ottoni, E., de la Torre, I., & Haslam, M. (2016). Wild monkeys flake stone tools. *Nature*, *539*, 85–88. https://doi.org/10.1038/nature20112

Ramsay, M. S., & Teichroeb, J. A. (2019). Anecdotes in primatology: Temporal trends, anthropocentrism, and hierarchies of knowledge. *American Anthropologist*, *121*(3), 680–693. https://doi.org/10.1111/aman.13295

Ramsey, J., & McGrew, W. (2005). Object play in great apes: Studies in nature and captivity. In A. Pellegrini & P. Smith (Eds.), *The nature of play* (pp. 89–112). The Guilford Press.

Riede, F., Walsh, M. J., Nowell, A., Langley, M. C., & Johannsen, N. N. (2021). Children and innovation: Play, play objects and object play in cultural evolution. *Evolutionary Human Sciences*, *3*, Article e11. https://doi.org/10.1017/ehs.2021.7

Root-Bernstein, M., Douglas, L., Smith, A., & Veríssimo, D. (2013). Anthropomorphized species as tools for conservation: Utility beyond prosocial, intelligent and suffering species. *Biodiversity and Conservation*, *22*(8), 1577–1589. https://doi.org/10.1007/s10531-013-0494-4

Ryle, G. (1949). *The concept of mind*. Hutchinson's University Library.

Sampaio, E., Seco, M. C., Rosa, R., & Gingins, S. (2021). Octopuses punch fishes during collaborative interspecific hunting events. *Ecology*, *102*(3), Article e03266. https://doi.org/10.1002/ecy.3266

Scheele, D., Schwering, C., Elison, J. T., Spunt, R., Maier, W., & Hurlemann, R. (2015). A human tendency to anthropomorphize is enhanced by oxytocin. *European Neuropsychopharmacology*, *25*(10), 1817–1823. https://doi.org/10.1016/j.euroneuro.2015.05.009

Schleihauf, H., & Hoehl, S. (2020). A dual-process perspective on overimitation. *Developmental Review*, *55*, Article 100896. https://doi.org/10.1016/j.dr.2020.100896

Schleihauf, H., Hoehl, S., Tsvetkova, N., König, A., Mombaur, K., & Pauen, S. (2021). Preschoolers' motivation to over-imitate humans and robots. *Child Development*, *92*(1), 222–238. https://doi.org/10.1111/cdev.13403

Shumaker, R., Walkup, K., & Beck, B. (2011). *Animal tool behavior*. Johns Hopkins University Press.

Soldati, A., Fedurek, P., Crockford, C., Adue, S., Akankwasa, J. W., Asiimwe, C., Asua, J., Atayo, G., Chandia, B., Freymann, E., Fryns, C., Muhumuza, G., Taylor, D., Zuberbühler, K., & Hobaiter, C. (2022). Dead-infant carrying by chimpanzee mothers in the Budongo Forest. *Primates*, *63*(5), 497–508. https://doi.org/10.1007/s10329-022-00999-x

Sommer, K., Davidson, R., Armitage, K. L., Slaughter, V., Wiles, J., & Nielsen, M. (2020). Preschool children overimitate robots, but do so less than they overimitate humans. *Journal of Experimental Child Psychology*, *191*, Article 104702. https://doi.org/10.1016/j.jecp.2019.104702

Spatola, N., & Chaminade, T. (2022). Cognitive load increases anthropomorphism of humanoid robot. The automatic path of anthropomorphism. *International Journal of Human-Computer Studies*, *167*, Article 102884. https://doi.org/10.1016/j.ijhcs.2022.102884

Sterelny, K. (2010). Minds: Extended or scaffolded? *Phenomenology and the Cognitive Sciences*, *9*(4), 465–481. https://doi.org/10.1007/s11097-010-9174-y

Tamir, D. I., & Mitchell, J. P. (2012). Disclosing information about the self is intrinsically rewarding. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(21), 8038–8043. https://doi.org/10.1073/pnas.1202129109

Tomasello, M. (2020). The adaptive origins of uniquely human sociality. *Philosophical Transactions of the Royal Society of London: Series B, Biological Sciences*, *375*(1803), Article 20190493. https://doi.org/10.1098/rstb.2019.0493

Tomasello, M. (2022). Social cognition and metacognition in great apes: A theory. *Animal Cognition*. Advance online publication. https://doi.org/10.1007/s10071-022-01662-0

Tranel, D., Damasio, H., & Damasio, A. R. (1997). A neural basis for the retrieval of conceptual knowledge. *Neuropsychologia*, *35*(10), 1319–1327. https://doi.org/10.1016/S0028-3932(97)00085-7

Waytz, A., Morewedge, C. K., Epley, N., Monteleone, G., Gao, J.-H., & Cacioppo, J. T. (2010). Making sense by making sentient: Effectance motivation increases anthropomorphism. *Journal of Personality and Social Psychology*, *99*(3), 410–435. https://doi.org/10.1037/a0020240

Waytz, A., Cacioppo, J., & Epley, N. (2010). Who sees human? The stability and importance of individual differences in anthropomorphism. *Perspectives on Psychological Science*, *5*(3), 219–232. https://doi.org/10.1177/1745691610369336

Waytz, A., Heafner, J., & Epley, N. (2014). The mind in the machine: Anthropomorphism increases trust in an autonomous vehicle. *Journal of Experimental Social Psychology*, *52*, 113–117. https://doi.org/10.1016/j.jesp.2014.01.005

Waytz, A., Cacioppo, J. T., Hurlemann, R., Castelli, F., Adolphs, R., & Paul, L. K. (2019). Anthropomorphizing without social cues requires the basolateral amygdala. *Journal of Cognitive Neuroscience*, *31*(4), 482–496. https://doi.org/10.1162/jocn_a_01365

Whiten, A., Allan, G., Devlin, S., Kseib, N., Raw, N., & McGuigan, N. (2016). Social learning in the real-world: 'Over-imitation' occurs in both children and adults unaware of participation in an experiment and independently of social interaction. *PLoS ONE*, *11*(7), Article e0159920. https://doi.org/10.1371/journal.pone.0159920

Wiese, E., Buzzell, G. A., Abubshait, A., & Beatty, P. J. (2018). Seeing minds in others: Mind perception modulates low-level social-cognitive performance and relates to ventromedial prefrontal structures. *Cognitive, Affective and Behavioral Neuroscience*, *18*(5), 837–856. https://doi.org/10.3758/s13415-018-0608-2

Wynne, C. D. L. (2004). The perils of anthropomorphism. *Nature*, *428*(6983), 606–606. https://doi.org/10.1038/428606a

Received February 1, 2022
Revision received November 1, 2022
Accepted November 7, 2022 ■