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Animal Medicine

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Abstract

The range of putatively medical animal practices varies widely both functionally and mechanistically. In this article, we argue that the definitions of medicine available in the empirical literature are inadequate for distinguishing genuinely medical practices from other adaptive behaviors. We aim to improve this conceptual landscape by proposing a definition that incorporates both cognitive and functional requirements, enabling finer-grained distinctions across species and behaviors. We apply our definition to the evidence and determine which animal behaviors show a mere difference of degree with paradigmatic medical practices—and should be seen as medicine—and which should be excluded from this nomenclature.

1. Introduction

In the spring of 2024, a wild male orangutan named Rakus appeared in news outlets all over the world after he was seen applying chewed-up leaves to an open wound on his face (Laumer et al. 2024). The injury, which was likely the result of a fight with a conspecific and could easily have been infected, instead closed up within a week. The leaves that Rakus used belonged to the species *Fibraurea tinctoria*, widely employed in Southeast Asia for its analgesic, antipyretic, and antidotal properties. By the looks of it, Rakus had been treating his wound.

Scientific interest in the medical practices of nonhuman animals (hereafter, "animals") has been on the rise since the 1980s, when chimpanzees were first seen using plants to rid themselves of intestinal parasites (Wrangham and Nishida 1983; Huffman and Seifu 1989). Since then, many other examples have been reported, from fruit flies who deposit their eggs on food with higher concentrations of ethanol if they detect parasitic wasps in their surroundings (Kacsoh et al. 2013) to rats who eat clay to induce vomit after consuming poison (Nakajima 2018), ants who amputate the injured legs of nestmates (Frank et al. 2024), and capuchin monkeys who protect themselves from parasites by rubbing their fur with smelly substances (Alfaro et al. 2012).

The range of animal practices potentially classified as medical varies widely both functionally and mechanistically, and there is no agreed upon definition of the term "medicine" that can help determine which cases ought to count as such, or whether in fact any of them should. In this article, we offer a systematic characterization of medicine that can help us delineate the relevant phenomena. While we lack a shared folk concept that could offer initial guidance, this absence does not undermine the philosophical value of engaging in conceptual analysis. On the contrary, it creates the opportunity—and indeed the need—for a theoretically informed framework capable of clarifying a diverse and rapidly growing body of empirical findings. This situation is not unique: Other central scientific and philosophical notions—such as "life," "consciousness," or "belief"—lack precise lay definitions, yet this has not impeded productive theoretical debate. We do not suggest that medicine is analogous to those categories in all respects, nor that a final analysis is forthcoming. But we believe that conceptual clarification—aimed not at definition in the strict sense, but at theoretical refinement—is a necessary step for structuring inquiry and organizing empirical results in this emerging field.

We frame this effort within a naturalistic approach to philosophy of science, which treats concepts not as a priori categories but as evolving tools for organizing phenomena in ways that enhance explanation, prediction, and interdisciplinary integration (Machery 2009; Khalidi 2013). On this view, the adequacy of a conceptual proposal lies not in its fidelity to folk usage, but in its ability to track scientifically significant patterns and guide inquiry. Accordingly, our framework is both heuristic and normative. It aims to demarcate a class of behaviors that exhibit key features of paradigmatic medical practices—namely, normative bodily assessments and goal-directed interventions—even in the absence of institutions or explicit diagnoses. This orientation allows us to capture the structural differences between, say, a chimpanzee treating a wound and an ant responding to chemical cues from an injured nestmate. Such differences are not merely intuitive; they reflect underlying divergences in agency and cognition that are increasingly tractable through empirical study.

In what follows, we argue that medicine takes place when two requirements are met. First, the individual carrying out the behavior must identify a health problem in her own or another's body, an identification that must be based on normative assumptions about the right and wrong states of the body. This is the cognitive requirement. Second, the individual must deploy a measure to address the health problem. The deployed solution must be a measure that would involve a (more or less significant) fitness cost if it were applied to a healthy individual. This is the functional requirement. As we will argue in this article, both requirements are indispensable to speak of medicine in the proper sense of the term.

We develop our argument in four steps. First, we offer a review of the relevant empirical evidence. Afterward, we present the main definitions of animal medicine that can be found in the empirical literature. We argue that these definitions are unsatisfactory because, firstly, they exclude certain animal behaviors that would be regarded as medical if they were performed by humans and, secondly, they include behaviors that are questionable as instances of medicine—at least in the same sense in which paradigmatic human medical behaviors are understood. This twofold asymmetry—excluding intuitively medical cases and including problematic ones—points to the need for a redefinition of the concept of medicine, one capable of capturing the continuities and discontinuities between human and nonhuman practices. We then introduce our own definition of medicine, which we argue offers a conceptual advance over previous empirical definitions. We end by returning to the empirical evidence and offering a preliminary classification of which animal practices should indeed be considered medical and which shouldn't. Our analysis will show that our definition is simultaneously more expansive and more restrictive than other definitions, and that it serves to better identify which animal practices show a difference of degree with human medicine and which show a difference of kind.

2. Animal medical practices: The evidence

In this section, we review the evidence that points to the presence of medical practices among animals. Given that we haven't yet introduced any definition of medicine, we will simply give an overview of animal behaviors that could be put forward as instances of animal medicine[2] insofar as they involve individuals dealing with their own or another's health problem. Only some of the cases we will mention are identified as medical practices in the literature, but we are bracketing that momentarily. At this stage, we're just looking to show the broad spectrum of phenomena that we're dealing with here, as well as the kinds of conceptual distinctions that are at stake. In later sections, we will clarify which cases count as medical according to different definitions and defend a specific account of which of them should.

When searching for potential instances of medical practices among animals, a logical first place to look is at how they deal with pathogens. Accordingly, one of the very first documented phenomena was leaf swallowing and bitter-pith chewing in chimpanzees. These behaviors help chimpanzees to get rid of parasitic worms. Leaf swallowing works mechanically: The chimpanzees fold up and swallow whole the leaves of *Aspilia* plants, which have a rough texture that serves to dislodge and expel parasitic worms from the intestinal tract (Huffman et al. 1996). Bitter-pith chewing works chemically: The chimpanzees chew on the pith of *Vernonia amygdalina* plants and swallow the juices, which have antiparasitic properties (Huffman et al. 1993).

Since those initial reports on chimpanzees, other studies have found animals ingesting substances with medicinal properties in response to pathological states of the body. Alaskan brown bears consume leaves that help to expel tapeworms before hibernating, as do Canadian snow geese before their big migration south (Huffman 1997). Infected bumble bees prefer to

[2] Note that scholars in the debate tend to opt for the term "medication" rather than "medicine." However, we believe that this is due to a bias in favor of considering the use of medicinal substances as paradigmatic cases of animal medical practices. Given that we want to capture a broader range of phenomena, we opt for the term "medicine," which refers to medical practices more generally and not just those that imply the use of drugs or other medicinal substances. In addition, we consider it important to use the term "medicine" because we will argue that some animal practices show a mere difference of degree with human medicine. Some readers, however, may have the strong intuition that the term "medicine" ought to be reserved for whatever takes place within human medical *institutions*. While we do not share this intuition, these readers can substitute our use of the term "medicine" for "medical treatment" and our arguments remain unchanged.

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ingest nectar laced with nicotine, which lowers their parasite load (Baracchi et al. 2015). Rats, who are incapable of vomiting, will eat clay after having consumed toxic substances, which helps them alleviate nausea (Nakajima 2018).

However, ingesting medicinal substances in response to disease doesn't exhaust the range of potential medical practices in animals. For starters, we can distinguish between therapeutic and prophylactic medication. While the former is a response to a diseased state, the latter serves as a precaution. Companion dogs readily consume grass, which appears to be aimed at clearing out parasites from the intestinal tract before they feel sick. Although they will sometimes do this to induce vomiting when they're feeling unwell, up to 80 percent of dogs will eat grass while seemingly healthy, and analyses of wild canids' feces show that this behavior can help expel parasites (Sueda et al. 2008). Ants will increase their intake of reactive oxygen species when exposed to, but not yet infected by, a fungus (Bos et al. 2015). Asian elephants consume *Entada schefferi* before embarking on a long journey, which may give them stamina but also protect them from pain (Huffman 2003). Hamadryas baboons that live in areas with a higher presence of parasites will tend to eat more berries with antiparasitic properties (de Roode and Huffman 2024). Western lowland gorillas regularly consume bark from antioxidant and antimicrobial plants and show asymptomatic cases of *E. coli* presumably as a result (Yinda et al. 2024).

The inclusion of prophylaxis as a medical practice raises the worry of where to draw the line between medication and food consumption. Many of the foods that we eat have indirect medical benefits. In fact, both medication and food consumption are conducive to homeostasis and involve the ingestion of substances that further this end. In response to this worry, some authors have argued that the dose of the ingested substance may often be key. For example, caterpillars of the species *Grammia incorrupta* increase their consumption of pyrrolizidine alkaloids when they are infected by parasites. While this is a normal part of their diet that serves prophylactic purposes, the increased dose has therapeutic effects (Singer et al. 2009). Many have also argued that there must be a fitness cost for healthy individuals consuming that same substance, otherwise it's not medication but simply a diet choice (Singer et al. 2009; Abbott 2014; Bos et al. 2015; de Roode et al. 2013; Lefèvre et al. 2010; de Roode and Huffman 2024).

Ingestion is not the only way that an animal may interact with a medicinal substance. Recall the case of the orangutan Rakus, who smeared *Fibraurea tinctoria* pulp on his face wound, helping it heal without infection (Laumer et al. 2024). Absorption, topical application, and proximity may all help an animal benefit from the curative or prophylactic properties of a substance. Red-fronted lemurs anoint their tail and perianal area with millipedes, which protects them from nematode infections (Peckre et al. 2018). Capuchin monkeys will rub their fur with ants to eliminate parasites, and those living in urban areas may self-anoint with wet wipes, liquid soap, cologne, cigarettes, or bleach (Alfaro et al. 2012). Some species incorporate into their nests substances that inhibit bacterial and fungal growth. Wood ants (Castella et al. 2008) and honeybees (Simone et al. 2009), for instance, add resin. Dusky-footed wood rats, in turn, use bay leaves (Hemmes et al. 2002). And urban species of birds have been seen to use cigarette butts for this purpose (Suárez-Rodríguez et al. 2013).

Animals may also engage in therapeutic or prophylactic behaviors that don't involve medicinal substances. For instance, animals often regularly change where they eat or sleep, they may avoid eating feces or the remains of dead conspecifics or develop an aversion to foods or tastes associated with ill-being (Hart 2011). Rats become averse to nutritionally deficient diets (Rozin 1976) and pay attention when conspecifics are eating something unusual (Galef 1993). Red-winged blackbirds develop aversions to specific kinds of foods if they see conspecifics falling ill after eating them (Mason and Reidinger 1982). Some insects engage in corpse management, burying nestmates or extracting their remains from the colony (Sun and Zhou 2013). All these behaviors have prophylactic advantages, protecting animals from coming into contact with pathogens. With respect to therapeutic behaviors, the animal may stop eating, sleep more than usual, avoid using an injured limb, lick her wounds, and so on, all of which may aid the healing process (Hart 2011). And in a rather extreme example of a curative behavior that doesn't involve medicinal substances, pairs of injured comb jellies heal themselves by fusing into one (Jokura et al. 2024).

Animals may also engage in practices that improve others' fitness, either therapeutically or prophylactically—what's known as *allomedication* (de Roode and Huffman 2024). These others are often kin. For instance, fruit flies protect their offspring by laying their eggs in food with high levels of alcohol if they detect wasps in the environment. This way, they protect their larvae from infection by parasitic wasp larvae, who have a lower alcohol tolerance (Kacsoh et al. 2013). Monarch butterflies that are infected with parasites prefer to oviposit on toxic species of milkweed, on which their offspring will feed and, as a result, experience a reduced parasite load (Lefèvre et al. 2010). And some of the most impressive kin-directed therapeutic behaviors come from eusocial insects. Ants of the species *Megaponera analis* carry wounded nestmates back to the colony when they raid termite nests, and ants who have a termite attached to them have it removed and wounds are treated with

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antibacterial secretions (Frank et al. 2017; Frank et al. 2023). Ant queens of the species *Lasius niger* feed on their sick larvae to stop the infection from spreading (Bizzell and Pull 2024). And even more impressively, ants of the species *Camponotus floridanus* perform amputations of their nestmates' legs when these are injured (Frank et al. 2024).

Occasionally, animals will also engage in care behaviors directed at nonkin in what could be considered medical contexts. Many social species engage in mutual grooming, a behavior that serves to get rid of parasites and is often not directed at kin. We also see care behavior directed at disabled, injured, or dying conspecifics in many social species, such as elephants (Bates et al. 2008; Douglas-Hamilton et al. 2006) or dolphins (Park et al. 2012). Chimpanzees will occasionally groom, lick, and even use leaves as tools to clean the wounds of conspecifics (Clark et al. 2021). And support during parturition has been observed in different primates (Ding et al. 2013; Pan et al. 2014; Demuru et al. 2018).

3. The problem(s) with present definitions

In this section, we give an overview of definitions of animal medicine and point out the commonalities and the problems that we see in them. The definitions that we will consider all come from the empirical literature. The philosophical literature has until now been strictly concerned with the demarcation of "real," "good," or "scientific" medicine and how to distinguish it from "false," "bad," or "pseudo" medicine (see, for instance, Solomon 2015; Broadbent 2019; Fuller 2024). Given that the criteria offered to distinguish real from false medicine were all designed with the human context in mind, the resulting characterizations are too anthropocentric to be of use for present purposes. For instance, real medicine is typically taken to be that which takes place within certain established institutions, which will obviously be lacking in the case of animals. The definitions coming from the empirical literature, instead, aim to capture the phenomenon as it might manifest in nonhuman taxa. For that reason, we believe it is more fitting to take them as our starting point.

One of the first definitions that can be found in the literature comes from Clayton and Wolfe (1993):

> Self-medication can be classified into four categories according to the mode of contact: ingestion, absorption, topical application and proximity. The adaptiveness of each of these categories can be determined by jointly testing the

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> following three hypotheses: (1) the medicinal substance is deliberately contacted by the medicator; (2) the substance is detrimental to one or more parasites when contacted…; and (3) the detrimental effect on parasites leads to an increase in host fitness. (p. 60)

Four things are noteworthy about this definition. First, it only recognizes the possibility of self-medication. Second, it requires the involvement of a medicinal substance. Third, it doesn’t set any mechanistic constraints, save for the fact that the medicinal substance must be “deliberately contacted,” presumably to exclude accidental self-medication. And last, it requires the treatment to be successful, meaning that it must be detrimental to the pathogen and increase the animal’s fitness. Though this last requirement presumably was introduced with the function of testing for the adaptiveness of an animal’s behavior, it was retained in all later definitions while losing this function.

Clayton and Wolfe’s (1993) definition set the tone for many of the definitions that were to follow, but it’s missing a crucial element that was introduced by Singer et al. (2009):

> Our results demonstrate three essential components of self-medication predicted by adaptive plasticity theory: 1) self-medication behavior improves fitness of animals infected by parasites; 2) *self-medication behavior decreases fitness in uninfected animals*; and 3) infection induces self-medication behavior. (pp. 4–5; our emphasis)

This definition introduces the idea that medical behavior must be maladaptive when applied to healthy individuals. The idea of a fitness cost for uninfected animals, as we saw in the previous section, allows medication to be distinguished from general health maintenance, such as the consumption of food, and all definitions of animal medicine that followed incorporated this criterion.

Additional definitions were provided by Lefèvre et al. (2010), de Roode et al. (2013), and Bos et al. (2015). In contrast to initial definitions, Lefèvre et al. allow for the medication of kin, as do de Roode et al. Bos et al. only recognize self-medication. Lefèvre et al. don’t require the involvement of a medicinal substance, but de Roode et al. and Bos et al. do. Lefèvre et al. pose no mechanistic constraints, while de Roode et al. add the specification that the behavior must be initiated by parasitic infection and Bos et al. require the use of the substance to be deliberate. All three definitions specify that the treatment must be successful and that there must be a fitness cost for healthy individuals. And lastly, de Roode et al. introduce a new criterion that will not be picked up by later papers, namely, that the practice must occur in an ecologically valid setting (to rule out the scientific relevance of findings in the lab under very artificial conditions).

The final definition we want to consider is de Roode and Huffman's (2024), which can be thought of as a consensus definition, insofar as it was published in a review by two of the biggest names in the field, who hadn't co-authored previously:

> For therapeutic medication, observational studies need to fulfill four conditions: (i) the animal shows disease symptoms (or other health issues); (ii) the animal seeks out a particular medicinal substance specifically (rather than using it randomly); (iii) using the substance reduces infection, alleviates disease symptoms, or increases health; and (iv) the substance is costly (and/or not sensed to be palatable) to the animal and therefore avoided when not ill. (p. R809)

Like other definitions before, this definition only applies to self-medication (though elsewhere they acknowledge the existence of allomedication), it requires the deployment of a medicinal substance and needs the treatment to be successful. It also incorporates the need for a cost for healthy individuals, but makes this broader than a fitness cost, allowing for the possibility of a mere experiential cost (unpalatability). There are no mechanistic constraints, save for the condition that the substance ought to be sought out specifically instead of randomly.

To sum up: The available definitions tend to only recognize self-medication or kin medication and tend to require the involvement of a medicinal substance. All require the treatment to be successful in healing the animal to some degree for the behavior to be a case of medicine, and all (after Singer et al. 2009) require a fitness cost if the same treatment were to be applied to healthy individuals. In addition, all make very thin specifications on the causal mechanisms that must be involved for a behavior to qualify as medical, which appear to be just meant to exclude accidental medication (for instance, an animal randomly feeding on a plant that happens to have medicinal properties).

The definitions that can be found in the empirical literature are perfectly adequate for some purposes. For instance, if we wanted to find animal behaviors with the potential to uncover new medicinal plants, these definitions would all work because they would point us

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in the direction of substances with therapeutic properties. However, if we are concerned, as is our case, with the conceptual endeavor of delineating the criteria that must be met by a behavior for it to count as *medicine*, these definitions are all lacking. In what follows, we defend why this is so.

One of the desiderata that we would want a definition of animal medicine to fulfil is for it to encompass common denominators of medicine in general, thus allowing it to be applicable to paradigmatic examples of medicine, such as that carried out by human doctors in hospitals, while excluding contingent characteristics of specifically human medicine, such as the fact that it is typically carried out within an institution. If we compare the available definitions with human practices, we can easily see how they give rise to the counterintuitive result that much of what we consider prototypically medical would not be categorized as such. Indeed, a vast majority of practices in medical institutions are not directed at the self or at kin, but at strangers. Many of our medical practices, such as physiotherapy or psychotherapy, don't involve medicinal substances. And a significant proportion of the treatments dispensed at medical centers are not successful, leaving the patient in the same or worse condition than she was initially, and sometimes even killing her. While we may speak of erred diagnoses, failed treatments, or negligence, we still consider them to be medical practices.

Moreover, these definitions incorporate such thin or nonexistent mechanistic constraints that they ultimately qualify as functionalist. Functionalist approaches to animal medicine, while having the potential to uncover astounding adaptations, have significant limitations. One key shortcoming is their neglect of the cognitive mechanisms underlying these behaviors. This oversight does not give us the conceptual tools to distinguish between stereotyped adaptations and behaviors that involve deliberate problem-solving, intentionality, or learned strategies, which are the hallmarks of prototypical medical behaviors. Distinguishing between both classes of behaviors, in addition, is important when mapping how they emerge at an ontogenetic and phylogenetic level and the relationship between the two. For instance, some learned medical behaviors may develop from genetically inherited predispositions. In turn, some adaptations may emerge from acquired medical behaviors whose genetic preconditions are selected because those behaviors improve fitness.

Another critical flaw in a strictly functionalist approach is its inability to accommodate the possibility of errors, failures, or insufficient measures in medical practices. Functionalist definitions rely on health improvement as the defining outcome of a medical practice. This restricts the concept of medicine to actions that are successful, excluding

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measures that aim at healing but do not fully succeed. However, it seems reasonable to classify partially or entirely unsuccessful attempts at healing as medical, especially given that a significant proportion of human medicine fails at healing the patient. If we were to adopt a strictly functionalist definition of medicine, much of what occurs in human medical contexts would be deemed nonmedical.[3] Thus, allowing for the possibility of errors or inadequacies in medical practices is essential for developing a comprehensive and useful definition of medicine. A strictly functionalist approach, by focusing solely on successful outcomes, fails to address these dimensions, thereby limiting its explanatory power. In the following section, we offer an alternative approach.

4. Redefining (animal) medicine

In this section, we argue that it is necessary to complement the functionalist approach with one that singles out the cognitive mechanisms that allow the identification of certain conditions as medical problems and trigger the implementation of concrete measures to address them. In particular, we will defend the following general definition of medicine:

Medicine can be understood as a practice that satisfies two essential requirements:

- **The cognitive requirement**: This entails the identification of a health problem, defined as a nonnormative state of the body. Meeting this requirement involves normative assumptions about the appropriate or inappropriate states of the body.
- **The functional requirement**: This involves the implementation of measures that address the identified health problem. These measures must be directed at individuals experiencing the problem (i.e., the sick) and entail a fitness cost for healthy individuals if applied to them in the same manner or to the same extent.

[3] This issue has been explicitly addressed in contemporary philosophy of medicine by Broadbent (2019), who formulates what he calls the "Puzzle of Ineffective Medicine." Broadbent points out that medicine frequently fails to achieve its supposed core aim—healing the sick—yet it is not thereby excluded from being considered medicine (p. 56). He proposes understanding medicine primarily as a form of inquiry rather than as a tool for producing cures (p. 80). From this perspective, even ineffective or only partially effective practices remain medical insofar as they participate in the broader effort to understand, predict, and address disease.

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These two requirements—the cognitive and the functional—form the foundation of a comprehensive understanding of medicine, one that can allow us to identify medical practices in both humans and animals. In the following subsections, these requirements will be explored in detail. Note, however, that we're separating them for analytical purposes, but in reality, as will become clear from our analysis, the cognitive and functional aspects of a medical practice are intertwined, interacting and influencing each other.

4.1. The cognitive requirement

The first requirement that must be met by a medical agent is the identification of a bodily state that is understood as a problem.[4] This could be instantiated in different ways depending on the species or the individual. In what follows we give an example of how it could be instantiated through what Danón (2024) terms *instrumental ought-thoughts*, which are "first-order representations of non-actual ideal situations [that] represent a course of action as the one to be taken" (p. 6).[5]

Though Danón devised instrumental ought-thoughts as a way of making sense of the normativity of chimpanzee tool-use behavior, we believe that this notion can be fruitfully applied in this context too. According to Danón, three conditions must be met for a mental representation to qualify as an instrumental ought-thought:

1. "[A]nimals who possess such thoughts must be able to represent not only what is the case but also what ought to be the case and use these representations as standards to guide their behavior."
2. "[They] must show a tendency to comply with what these representations prescribe or recommend while still being capable of doing otherwise."

[4] For further discussion on the notion of "problems" in relation to the medical domain, see Saborido and Zamora-Bonilla (2024).

[5] Our framework is not committed to a specific theory of mental content and may be compatible with nonrepresentationalist accounts of cognition. While we adopt a representationalist stance in this article—mainly for its compatibility with prevailing models in comparative cognition—antirepresentationalist frameworks could potentially account for the kinds of normatively guided behavior we require (e.g., Segundo-Ortín 2024). Our framework could also accommodate the kind of distributed cognition that takes place in a human hospital, where an absent-minded nurse, say, may not fulfil the cognitive requirement but she's embedded in an institution built for the purpose of identifying and solving health problems.

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3. “[T]hey must be able to detect when their behavior fails to conform to what their ought-thoughts prescribe or recommend and correct [it[6]] accordingly” (ibid.)

Applied to our present interest, the first condition refers to the ability of an agent, whether human or nonhuman, to mentally represent an ideal or improved bodily state that is not present in the current reality but envisioned as a desirable goal. This representation will guide the selection of means and actions necessary to achieve it. Thus, medicine does not require the ability to formulate a theoretical definition of health but rather the capacity to grasp the contrast between a current state—characterized by disease, injury, or infection—and a nonactual state of healing, absence of discomfort, or restoration of normal functioning. This allows the agent to project a desired state where the disease or discomfort has been resolved or mitigated, using this projection as a reference point for her actions.

The second condition implies that the current state (such as being ill, experiencing pain, or dealing with parasites) is perceived as mismatched or discrepant with the ideal bodily state (being free of disease or discomfort). This gap creates the motivation for action, guiding the agent to select means that address the discrepancy. Importantly, the process is not impulsive; rather, it is normatively driven by the recognition that the current state deviates from how things ought to be. For this normativity to be in place, we need the agent to be capable of ignoring her motivation for action. If the individual cannot help but act on her motivation, then she’s not being guided by an understanding of how things ought to be but rather carrying out a behavior over which she has no control, such as a fixed action pattern. Instead, the instrumental ought-thoughts involved in a medical practice give the agent a *reason* to carry out a particular behavior, but the agent can choose to do otherwise.

The third condition implies the ability to evaluate the effectiveness of the chosen means in reducing the gap between the current and the ideal or improved state. If the means prove ineffective, or the ideal state has not been reached to a sufficient degree, the motivation to close the gap between current and ideal state reemerges. The agent must in principle be capable of adjusting her approach or choosing an alternative means, thus demonstrating a capacity for error correction. This new motivation, as before, must also be ignorable. Medical

[6] Danón’s paper says “them” rather than “it,” but this is a typo because this condition refers to the capacity to correct the behavior and not the thoughts (Danón, personal communication, January 24, 2025). However, the animal may also form an incorrect ought-thought that prescribes the wrong behavior for the intended goal and should be in principle also capable of correcting her thoughts, something that, according to this same author, does not require metacognition (Danón and Kalpokas 2024). In what follows, we will take this third condition to refer indistinctly to the animal’s capacity to correct her behavior or her ought-thoughts.

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agents therefore do not merely react automatically to stimuli but evaluate their circumstances and actively select means to achieve desired ends.

A hypothetical example might help to make this clearer. Imagine that Mikel is experiencing a stomachache. Mikel can distinguish between his current state of discomfort and an ideal state in which his stomach doesn't hurt. This creates a motivation to eat some of the leaves that he has learned, perhaps through association, can alleviate stomachaches. If they get rid of the pain, Mikel will relax. If they're not sufficiently effective, the motivation to do something about the pain will reappear, and Mikel might decide to eat some more of those leaves or try out an alternative strategy, such as rubbing his belly. This framework can also accommodate other-directed medical practices. The one experiencing the stomachache might not be Mikel, but his friend Aquiles, and yet Aquiles's stomachache might also be perceived by Mikel as something that deviates from an ideal situation in which his friend is free from pain. Mikel might then decide to offer Aquiles some of the therapeutic leaves. In either scenario, Mikel can always choose to behave differently.

4.2. The functional requirement

Implicit in our analysis of the cognitive requirement was the idea that a medical practice involves the deployment of measures to tackle the current nonideal state. This is the functional requirement: Simply identifying a bodily problem is not enough—medicine involves the implementation of measures to address the issue. However, this functional requirement differs significantly from the functionalism present in the definitions we saw in section 3. We will not argue that a behavior is medical when it *solves* a medical problem, but that it is medical if it is *intended to address*[7] a medical problem. This nuance is important because it implies the introduction of intentionality and purpose into medical behavior, while also allowing for the possibility of errors.

The cognitive requirement implied that medical behaviors are the results of a process of identifying and responding to nonnormative states of the body, but this does not mean that

[7] We are aware that "address" is a somewhat vague term. We use it to accommodate the wide range of strategies—both successful and unsuccessful, direct and indirect—that may be involved in medical responses. In this context, to *address* a health problem means to implement a measure that is aimed at alleviating or neutralizing a pathological state, whether by reducing its symptoms, removing its source, or compensating for its effects. We opt for this flexible formulation because a more specific criterion (e.g., "curing" or "eliminating") would wrongly exclude many real-world medical practices, both human and nonhuman, that are partial, exploratory, or only marginally effective. What matters, for our purposes, is not the success of the intervention, but the fact that it is selected and deployed in light of the agent's assumption that it may alter the problematic bodily state.

different societies or individuals must agree on what is nonnormative or that these responses must be univocal for each specific issue. Different medical practices can be carried out to address the same medical problem, and these practices often conflict with each other. Moreover, what is seen as a medical problem by some individuals or societies might not be seen as such by others. Our approach thus subscribes to Kukla's (2022) radical pluralism with respect to disease categorizations and medical practices. As Kukla highlights, our medical practices exist within a messy web of institutions, classifications, and conflicting approaches, suggesting that there is no singular, universally optimal medical practice. Instead, human medicine encompasses a variety of practices that may differ in form, approach, and even efficacy.

In the case of animals, we may see a variety of techniques to deal with the same issue, from ignoring it if the individual does not identify it as a problem to using different means to address it. Different species or even populations within a species may develop unique medical practices tailored to their ecological and social contexts, just as human societies develop diverse medical traditions. In addition, there may be differences across individuals of the same population, and even across the lifespan of a single individual, who may acquire more refined techniques to deal with her health problems as she ages. The shared theme is that medicine, whether human or nonhuman, is not a monolithic institution but a pluralistic, context-dependent phenomenon.

This insight aligns closely with the idea that not all medical practices—whether in humans or in animals—must be optimal, successful, or even beneficial to qualify as medicine. While some animals might engage in highly effective self-medication practices (e.g., chimpanzees consuming antiparasitic plants), others may adopt less effective or even detrimental strategies due to lack of experience or knowledge, environmental constraints, or evolutionary trade-offs. These "bad medicine" examples, such as the ingestion of ineffective or toxic substances, illustrate that the distinction between medical and nonmedical behavior does not rest on success or failure but on the presence or otherwise of an intention to address a specific bodily issue.

However, not all behaviors in response to a health issue would qualify as medical. The action taken to address the problem must be a measure that would reduce fitness if applied to healthy individuals. This condition, present in most definitions of animal medicine in the empirical literature, is worth preserving, as it allows us to distinguish medical interventions from other health-promoting behaviors. For an action to qualify as medicine, it must carry a fitness cost, meaning that, in the case of a successful treatment, it would give

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rise to a trade-off: The intervention becomes beneficial only because of the pathological condition it targets. For instance, the ingestion of bitter, toxic plants to combat intestinal parasites constitutes a medical intervention. In healthy individuals, consuming these plants would likely have negative effects, such as reduced energy availability or toxicity, thereby lowering overall fitness. However, in diseased individuals, the same action provides a net benefit by mitigating the condition's harmful effects.[8]

This criterion helps differentiate medicine from behaviors like hygiene, regular exercise, or a balanced diet, which contribute to overall health and fitness regardless of the presence of disease. While these practices reduce the likelihood of illness and promote well-being, they do not entail the specific trade-offs characteristic of successful medical interventions. Instead, they serve as preventive measures or baseline behaviors for maintaining health, rather than being responses to pathological conditions. This criterion also serves to differentiate medical practices from responses to nonideal states of the body that are not pathological. For instance, an animal may feel hunger and this can give rise to instrumental ought-thoughts about the need to alleviate this state, which in turn motivate her to eat. But we wouldn't consider this a medical practice because eating, under normal conditions, is not maladaptive.

While our functional requirement entails the need for a fitness cost, the actual costs for healthy individuals performing that same behavior may vary widely in magnitude. Some of the practices that animals engage in to deal with health problems would be direly maladaptive if applied to healthy individuals. An example of this is the amputation of injured limbs that we see in some species of ants (Frank et al. 2024). Not only might[9] this be very painful for the treated ant, but she must also relearn how to walk (ibid.), which would imply a big fitness cost if she were entirely healthy. In contrast, dabbing at one's wounds with leaves, like chimpanzees do (Clark et al. 2021), entails a very marginal fitness cost, but would still be maladaptive (in the sense of having no survival value and providing no evolutionary advantage) if the individual were entirely healthy. At the same time, any behavior ends up being maladaptive if carried out to a sufficient degree, so following Abbott (2014) we add the caveat that the fitness cost should occur if the treatment were applied to a healthy individual in the same manner or to the same extent as it is applied to the nonhealthy one.

[8] Note that the net benefit is not a *requirement* of our approach, but something that happens if the treatment is successful. We only require medical interventions to entail a fitness cost for healthy individuals—in the case of diseased individuals, that same treatment may be beneficial or not depending on its effectiveness.
[9] The jury is still out on whether insects can feel pain; see Birch (2022).

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5. The evidence revisited

Having introduced and defended our definition of (animal) medicine, in this section we return to the evidence that we presented in section 2 and apply our framework to it. While some animal practices will count as clear cases of medicine according to both frameworks, our definition singles out as borderline or nonmedical some of what the empirical literature considers medical. At the same time, our definition covers some animal practices that the empirical literature doesn't consider as potential instances of animal medicine. In what follows, we explore each of these cases. Given that the study of animal medicine is still nascent, and that our definition requires the presence of mental states that have not been directly tested for, all the empirical claims that we make in this section should be taken with a grain of salt.

5.1. Cases that count as medical in both frameworks

Great apes best exemplify the overlap of our definition with previous characterizations. As we saw, it was the observation of chimpanzees self-medicating that kicked off the whole field of study, and to this day great apes are generally considered a paradigmatic example of animals who engage in medical practices. We believe that there are also good reasons to think that they exercise medicine in our sense of the term.

The medicinal practices that we see in great apes seem firstly to satisfy the functional requirement. Bitter-pith chewing and leaf swallowing appear to happen only in the presence of parasitic infections. At the same time, they would have a fitness cost for healthy individuals because they are time-consuming practices—chimpanzees must often go out of their way to find the right plants (Huffman 1997), and stripping the bark off the pith and peeling the leaves takes time (Huffman and Seifu 1989; Freymann et al. 2024). There also doesn't seem to be any nutritional benefit to the consumption of these substances—the pith's juices have negligible nutritional value (de Roode et al. 2013), and the swallowed leaves are expelled without being digested (Wrangham and Nishida 1983). The cleaning of wounds with leaves also seems to fulfil the functional requirement, insofar as chimpanzees are not reported to rub their own or others' skin with leaves in the absence of wounds and indeed it would not have any survival value to do so. In the case of Rakus, he is reported to have spent a considerable amount of time applying the chewed-up pulp to his wound (Laumer et al. 2024, 4), which would have been maladaptive if there had been nothing wrong with his skin.

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Demonstrating that these animals' behavior also fulfils the cognitive requirement is a trickier business, especially given that research until now has not been looking for specific mental states. However, we do have some evidence that these behaviors are under cognitive control. One key piece of evidence is precisely their rarity. This is most obvious in the case of Rakus. As pointed out, his is the only known case of an orangutan treating their wounds with a medicinal substance. This suggests that the behavior emerged through individual innovation. In fact, Rakus is reported to have had a wound inside his mouth at the time, as well as the one on his cheek (ibid.). The leaves on which he was feeding, in turn, have potent analgesic properties (ibid., 5), so it's not outlandish to suppose that his mouth went numb as he fed on them, and for that reason he decided to apply the pulp to the wound on his cheek in an attempt to ease his pain.

In the case of leaf-assisted wound-cleaning, a five-year study reported one hundred sightings of wild chimpanzees with wounds, out of which twenty-nine exhibited self-grooming of wounds, and only thirteen of which used leaves. A mere four cases out of these one hundred revealed other-directed wound care (Clark et al. 2021). The infrequency of these practices is an indication that these are not stereotyped behaviors, but rather deliberate responses to wounds that these specific individuals see as problems, and that either not all chimpanzees care about their own and others' wounds or that not all of them have the requisite knowledge to deal with them.

As for bitter-pith chewing and leaf swallowing, these are much more frequent practices, but we have some evidence that these are not innate behaviors but rather learned cultural traditions. For one, they occur in several populations of chimpanzees, but not all of them, and different populations use different, though functionally similar, species of plant (Huffman 1997). An experiment on captive chimpanzees reported that they don't initially know how to swallow leaves of the sort that are used by their wild counterparts to clean out their guts. In fact, they tend to have an almost phobic reaction to their rough texture. Out of all the chimpanzees presented with the leaves, only two spontaneously folded them and swallowed them whole. Several other chimpanzees then started copying this behavior, which suggests that in the wild the behavior probably emerged from a mix of individual innovation and social learning (Huffman and Hirata 2004). In the case of pith chewing, wild infants are occasionally seen chewing on piths that their sick mothers have used, but healthy adults never do it. In addition, in at least one reported case, a mother prevented her healthy infant from picking up a discarded pith that a sick adult had left behind (Huffman 1997), hinting again at social learning.

5.2. Cases that count as medical in other frameworks and nonmedical in ours

The group of cases over which there is the starkest contrast between our framework and previous ones is the therapeutic behavior of insects. These behaviors clearly satisfy the functional requirement because they take place exclusively in the presence of a nonhealthy state of the body and the measures taken (amputation of limbs, ovipositing on toxic plants, etc.) imply a trade-off, being beneficial only because there is a health problem to begin with. However, all signs point to the behaviors not being under cognitive control, which makes them both very predictable and very rigid. For instance, fruit flies only lay eggs on fruit with high ethanol concentrations if they detect wasps visually, but not if the detection happens through other sensory modalities (Kacsoh et al. 2013). Ants who rescue injured nestmates do so only if they're found on the hunting ground or the return journey, but not on the way there. Healthy individuals sprayed with the rescue pheromone will also be taken back to the nest (Frank et al. 2017). The amputation of limbs only occurs when the injury is at the level of the femur. And in stark contrast to the case of wound care in chimpanzees, the vast majority of wounded individuals that fulfil this condition have their legs amputated, and the ants who carry out the behavior follow a very rigid behavioral sequence (Frank et al. 2024). Thus, while impressive, these behaviors are not solutions that individuals implement to solve what they perceive as problems, but rather stereotyped innate responses to very concrete stimuli. For this reason, we think it more appropriate to speak here of therapeutic adaptations, instead of medicine.

Another group of cases that is excluded from our definition is prophylaxis. Though prophylactic behaviors are not covered by the definitions of medicine that can be found in the literature, they are often cited as examples of animal medicine (Lozano 1998; Vitazkova et al. 2001; Castella et al. 2008; Hart 2011; de Roode et al. 2013; Kacsoh et al. 2013; Abbott 2014; Bos et al. 2015; Frank et al. 2018; Peckre et al. 2018; Neco et al. 2019; de Roode and Huffman 2024; Freymann et al. 2024; Laumer et al. 2024). Our characterization of medicine has the implication that prophylaxis is excluded because it doesn't fulfil either requirement, given that there's no actual physical problem that needs solving. Behaviors like corpse-management in eusocial insects, avoidance of rotting food in many mammals, and so on, are better seen as prophylactic adaptations, but not medicine.[10]

[10] While our definition excludes prophylactic behaviors, we recognize that some prophylactic strategies—particularly those involving anticipatory behavior based on prior experience—might approach the cognitive threshold we require. For example, the ingestion of medicinal substances by animals before a known seasonal

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5.3. Cases that count as medical in other frameworks and borderline in ours

Some therapeutic behaviors in animals don't appear under as much cognitive control as the great apes', but don't seem to be as stereotyped as the insects'. These are cases like monkeys who anoint themselves with different antiparasitic substances, rats who eat clay to deal with nausea, or domestic animals who purge themselves by eating grass. These behaviors satisfy the functional requirement—they are responses to health problems that involve a fitness cost such as skin irritation or vomiting—but they don't seem to satisfy the cognitive requirement. While the data on these practices is scarce, they appear to be homogeneous across each species, which suggests that they are the result of innate predispositions rather than learned behaviors, and thus don't seem to involve much, if any, understanding of the situation by the animal. Still, we label them as "borderline" rather than "nonmedical" because we believe that these animals are cognitively complex enough that throughout their lives they might realize that these substances alleviate their symptoms and eventually seek them out more deliberately.

The type of learning required for animals to reach this understanding is not very complex at all, simply a form of associative learning, and there are reasons to think it will be widespread. Animals are generally predisposed to monitor how different substances affect their body, to avoid toxic substances (Rozin 1976; Galef 1990; Huffman 1997; Villalba et al. 2006; Moore et al. 2013). This learning capacity must be sufficiently prevalent for animals who signal toxicity through bright colors or who mimic the appearance of toxic species to have evolved countless times. The ability to learn that something cures you is the same type of learning involved in avoiding food that upsets your stomach, but in reverse. And given the right circumstances, animals appear to learn this easily. For instance, experiments have shown that sheep who are given medicinal substances after eating something toxic will learn to associate each antidote with the corresponding toxin (Villalba et al. 2006). We propose, then, that the borderline behavior of animals can become medical the moment this learning has occurred and a treatment is deliberately sought out to alleviate a health problem. In line with this hypothesis, older dogs are more likely to vomit after, or look sick before, eating plants, which suggests that as they age the behavior shifts from an innate predisposition to a more targeted response to physical discomfort (Sueda et al. 2008).

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stressor could reflect learned associations that approximate a diagnosis of expected ill-health. Future work could examine the possibility of including such cases under an expanded category of "anticipatory medicine."

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5.4. Cases that count as nonmedical in other frameworks and medical in ours

There are, lastly, some animal practices that our framework would count as medical but are not considered in the empirical literature. One example is the care behavior displayed toward individuals who are disabled, dying, or dead. These behaviors are relatively rare, and they seem to fulfil the functional and cognitive requirements. To give but one example, Park et al. (2012) documented a group of dolphins helping a dying conspecific breathe by making a raft-like formation with their bodies to keep her afloat. If the dolphin had been healthy and able to swim properly, it would have been maladaptive for her freedom of movement to be constrained that way. The behavior only made sense because she was ill, thus fulfilling the functional requirement. At the same time, it was a coordinated, goal-oriented action that showed that the dolphins understood her situation and were adapting to her bodily needs. If the dolphins, say, were just looking to alleviate their own discomfort at her distress signals, it would have been less costly to swim away and let her die. The evidence thus suggests that they fulfilled the cognitive requirement. Something similar may be said about the cases of support during parturition, where the helper is usually a multiparous female who appears to understand the needs of the parturient (Ding et al. 2013; Pan et al. 2014).

A final group of practices that is excluded from previous definitions but covered by ours is that of bad medicine. Here we must admit to a lack of evidence of animals treating their ailments in a misguided way, but we believe this may be due to a skewed attention on the scientists' part because all previous definitions require a treatment to be successful for it to count as medicine. The only potential example we have found is that of chimpanzees rubbing their own and others' wounds with insects, which has been observed in a population in Loango national park (Mascaro et al. 2022). The authors claim that it "may" be a case of animal medicine, but that "further systematic research is needed to elucidate the efficacy of the treatment associated with an improvement in healing of wounds" (p. R113). Within our framework, the efficacy of the treatment is not required, but instead we would need evidence that the chimpanzees perceive the insects as a (misguided) solution to the problem that is a wound. While we don't currently have such evidence, we do know that chimpanzees are emotionally affected by images of hurt conspecifics (Sato et al. 2019) and they have been seen to dismantle snares in the wild (Ohashi and Matsuzawa 2011), in addition to all the evidence of (tool-assisted) wound care in this species. So, if the insects applied don't aid the healing process, this behavior might still be an instance of medicine in chimpanzees, albeit of the bad sort.

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6. Conclusion

We have introduced a conceptual framework for identifying medical practices based on two key conditions: a cognitive requirement—concerning the identification of a bodily problem—and a functional requirement—concerning the use of a costly intervention. This dual approach gives us conditions to determine when an animal's health-promoting behavior becomes medical. Moreover, our approach allows us to identify as medical animal practices that have been overlooked in the literature, such as care toward dying or disabled individuals, support during parturition, and bad medicine, while allowing us to discard as nonmedical other animal practices like prophylaxis, highly stereotyped behaviors, and health-promoting activities with no fitness costs (such as nutrition).

Our account is not intended as a universal framework, but as a conceptual tool designed for specific explanatory purposes—namely, distinguishing intentional, normatively structured practices from other forms of health-related behavior. We acknowledge that different research contexts may call for different classificatory tools. In areas such as pharmacological prospecting or veterinary research, broader functionalist definitions may be more appropriate, especially when the focus lies in identifying beneficial outcomes. We thus don't claim that ours is the only viable taxonomy but believe it to be the most useful for studying the continuities and discontinuities between human and animal health-related behaviors.

Moreover, we have been solely concerned with offering a theoretical demarcation of the phenomenon of (human and nonhuman) medicine. Though we have made some empirical claims, the available evidence is too ambiguous for these to amount to more than tentative speculation. However, our hope is that our definition can serve to better guide future empirical research. Crucially, to identify animal practices that are continuous with human medicine, we need to turn the focus away from studying the therapeutic properties of the substances they interact with and toward their cognitive abilities. A central methodological challenge for our proposal concerns the kind of evidence that could support the claim that an animal perceives a behavior as a response to a health problem—particularly when the behavior is only partially effective or ultimately unsuccessful. We suggest that indicators such as behavioral flexibility, sensitivity to outcomes, and the ability to modify or abandon ineffective strategies may point to a form of normative evaluation. For instance, if an animal discontinues the use of a particular substance after repeated failure to improve a condition, or if she adopts an alternative approach, this suggests a responsiveness to feedback rather than a

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stereotyped response. While the details still have to be worked out, we believe our framework provides a promising and testable route for empirical investigation.

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