Extended animal cognition

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Abstract:

According to the extended cognition thesis, an agent's cognitive system can sometimes include extracerebral components amongst its physical constituents. Here, we show that such a view of cognition has an unjustifiably anthropocentric focus, for it depicts cognitive extensions as a human-only affair. In contrast, we will argue that if human cognition extends, then the cognition of many non-human animals extends too, for many non-human animals rely on the same cognition-extending strategies humans rely on. To substantiate this claim, we will proceed as follows. First (§1), we will introduce the extended cognition thesis, exposing its anthropocentric bias. Then, we will show that humans and many non-human animals rely on the same cognition-extending strategies. To do so, we will discuss a variety of case studies, including "intrabodily" cognitive extensions such as the spinal cord (§2), the widespread reliance on epistemic actions to solve cognitive tasks (§3) and cases of animal cognitive offloading (§4). We'll then allay some worries our claim might raise (§5) to then conclude the paper (§6).

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Keywords: Extended cognition, Epistemic actions, Non-human cognition, Animal Cognition, Cognitive offloading

1 - Introduction

According to the extended cognition thesis (EC) an agent's cognitive system is at times partially constituted by elements laying outside the agent's brain (Clark & Chalmers 1998; Clark 2008). If EC is correct, then cognitive systems may include, amongst their bits and pieces, certain extracerebral components, such as certain bodily actions or environmental props.

EC had a sizable impact on both the philosophy (see Menary 2010; Colombo, Irvine & Stapleton 2019) and empirical practice (e.g. Vallé-Tourangeau *et al*. 2016; Bocanegra *et al* 2019) of cognitive science. It has thus been widely debated. But for the most part, we will ignore this debate. Here, our aim is therapeutic: we want to expose an unwarranted background assumption[1] that characterizes EC, to then reject it.

To see the target assumption, consider the fairly *standard* formulation of EC above. It begins by mentioning "cognitive agents", which is pretty generic. In principle, many different system types may be cognitive agents, including human, non-human animals, plants, robots, fungi and aliens. Thus, EC can be applied to *all* these systems. This, of course, does not entail that it is true of all of them: indeed, it might be false of some such systems - or even all of them. But even in this latter case, EC would be false only because it can be *literally and legitimately* applied to each of these systems (cf. Figdor 2018).

But then, in a single line's space, EC gains an *at least* a vertebrate-centric focus, as it explicitly mentions *brains* (cf. Sims & Kiverstein 2022). A sizable restriction in the scope of EC has just sneaked in. And notice that the word "brain" is not just a metonymy for "centralized inner control system", as such a metonymic reading fails to capture the way in which EC is *de facto* discussed. For, barring three papers (Japyassú & Laland 2017; Sims & Kiverstein 2022; Parise *et al* 2023), EC has only been applied to humans. Just consider the standard, go-to cases invoked when discussing EC: they're button presses when playing video games (Kirsh & Maglio 1994; Clark and Chalmers 1998), smartphones (Chalmers 2008), wearable "intelligent" technologies (Clark 2003; Bach-y-Rita & Kercel 2003; Wheeler 2019a) and, more recently, the internet (Smart 2021). Even "low tech" cognitive extensions seem exclusively human, as they are typically exemplified by language (Clark 1997) and notational systems (Dutih-Novaes 2012; De Cruz & De Smedt 2013; Malafouris 2013; Menary 2015). Given the state of the debate, the word "brain" looks more like a synecdoche for "human brain" than a metonymy for "inner control system".

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[1] Or set of assumptions - we're using the singular just for simplicity's sake.

This human-centric focus is often only *implicit*, but sometimes it has been explicitly formulated, suggesting that cognitive extensions are what makes human cognitively unique:

> "[...] human beings, I want to convince you, are *natural-born* cyborgs. [...] I do believe that it is the plain and literal truth. I believe, to be clear, that it is above all a SCIENTIFIC truth, a reflection of some deep and important facts about (a whiff of paradox here?) our special, and distinctively HUMAN, nature. Certainly I don't think this tendency toward cognitive hybridization is a modern development. Rather, it is an aspect of our humanity, which is as basic and ancient as the use of speech and which has been extending its territory ever since." (Clark 2003, pp. 3-4; capitalizations in the original; see also Wheeler and Clark 2008; Sterelny 2003 for further examples)

In Clark's view, cognitive extensions are part of our *special and distinctively* human nature. They make us the oh-so special cognitive agents we are. They're a human-only affair, which makes us stand out in the cognitive crowd.

Here, we aim to show that EC should widen its focus.. We will show EC is best understood as a claim ranging on all sorts of cognitive systems. Indeed, we will claim that cognitive extensions, *if they exist*, are not uniquely human cognitive traits (c.f. Figdor 2022). Our argumentative strategy is simple: first, we will introduce some *paradigmatic* cases of cognitive extension in humans. Then, we show that they have (a number of) animal[2] analogues. Thus, *if* cognition extends in the human case, *then* it extends also in the animal case(s).[3]

Why focus on animals? First of all, for ease of exposition. The cognitive status of animals is less contested than the status of modern-day robots, plants, fungi or intelligent materials (cf. Adams 2018). Thus, we can *directly* argue that animal cognition extends - without arguing that animals really are cognitive systems beforehand. This streamlines our discussion, making it more easily manageable. It also allows us to stay officially agnostic on what cognition is. Since all definition of cognition are contested (cf. Facchin 2022), this sort of agnosticism is extremely desirable.[4]

Secondly, we wish to contribute in closing the gap separating the cognitive status of humans from other animals (cf. Figdor 2021, 2022). By showing that, if human cognition extends, then animal cognition extends too, we are counteracting a possible source of anthropocentrism. We're also indirectly stimulating the creation of novel experimental paradigms, aimed at investigating the role of animal cognitive extensions. Such novel experimental paradigms have yielded interesting and unexpected results in the human case (see references given above), and it seems reasonable to expect similar results in the animal case. Moreover, showing that animal cognitive systems are extended may force us to take a deeper look to the environment at large, as we might be forced to re-conceive large swathes of it as parts of some animal's mind. Such a novel way to look at the environment may have significant ethical implications, especially when it comes to the protection of biodiversity (cf. World Economic Forum 2019).

Here's our plan. §2 looks at "intrabodily" cognitive extension, arguing that we've good reasons to believe they extend animal cognition too. §3 discusses cognition-extending epistemic actions, highlighting their

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[2] From now on, we'll use "animal" to mean "non-human animal".

[3] *Mutatis Mutandis,* the same claim holds also for distributed cognition and scaffolded cognition (cf. Hutchins 1995; Sterelny 2010). Here, we will focus on extended cognition because it is the most discussed, conceptually regimented and clear of the three.

[4] To be clear, this means that we will identify the cognitive *in extension*, by looking at paradigmatic and uncontested cases.

ubiquity in the animal kingdom. **§4** discusses artifact-based cognitive extension in the animal kingdom. **§5** deals with some worries our views might raise, and **§6** provides a brief conclusion.

2 - Warming up: animal intrabodily cognitive extensions

EC often highlights the cognitive role of agent-environment sensorimotor interactions - like the usage of pen and paper to solve a complex equation. Yet these are not the only cognitive extensions around. There are also *intrabodily* cognitive extensions: extra-cerebral (or otherwise distributed) "bits and pieces" of the cognitive machinery which are nevertheless spatially located within the agent's body. Two such extensions have been identified: the spinal cord (Facchin *et al*. 2021) and the gut-brain axis (Boem *et al*. 2021). Since, as discussed in these papers, intrabodily cognitive extensions can meet all the challenges to EC head on, and since they're less counterintuitive than traditional extra-bodily ones, they provide optimal warm-up cases to discuss animal EC.

The spinal cord is an anatomically defined component of the vertebrate central nervous system, and, just like the brain, is a neural structure. Yet, the spinal cord is rarely characterized as a cognitive processor. It is traditionally thought of as nothing but a "big nerve": an informational channel allowing for brain-sensory periphery communication and taking care of "hard wired" reflexes (cf. Wolpaw & Tenissen 2001; Kandel *et al*. 2012 pp. 790-810). This traditional characterization, however, appears increasingly outdated: both spinal functional imaging and the devastating effects of spinal lesions have revealed that the spinal cord plays a key role in numerous cognitive and affective processes, including: the representation of an agent's "space of action" (e.g. Scandola *et al*. 2016, 2020; Sedda *et al*. 2019), motor imagery (e.g. Fiori *et al*. 2014) and motor learning (Vahdat *et al*. 2015). There is thus an intense, bi-directional and cognitively relevant coupling knitting together the spinal cord and the brain in a single cognitive system, of which the spinal cord is an extracerebral, *extended* component (see Facchin *et al.* 2021 for an in-depth defense).

The gut-brain axis is a functional axis which includes the autonomic nervous system, the enteric (i.e. intestinal) nervous system, the endocrine system, the immune system and the central nervous system (spinal cord included). One important, and surprising, component of such an axis is the *gut microbiota*: a community of various types of microorganisms that inhabits an animal's body, entering in a mutually beneficial, symbiotic relation with its host. Importantly, modifications in its composition have been shown having an important impact in shaping an agent's emotional control (often eliciting anxiety-related and depressive behaviors) and spatial memory (see Foster and Neufeld 2013 for a review). Again, here we observe the dense, bi-directional and cognitively relevant coupling between the brain and a number of extra-cerebral components. Again, such coupling knits them together in a single cognitive system which, whilst still inside the body of the cognitive agent, is extended as it encompasses numerous extra cerebral components (see Boem *et al*. 2021 for discussion).

Now, here's our claim: *if* one accepts that the spinal cord or the gut-brain axis are intrabodily cognitive extensions in humans, *then* one has also to concede that many animals - perhaps all vertebrates - have similar intrabodily cognitive extensions. There are at least two reasons to hold that such a claim is true.

First, the human nervous system is homologous to the nervous system of vertebrates, especially mammals. And the same holds for their gross bodily plan. More noticeably still, homologous cognitive structures generally play homologous cognitive roles. Sure, there are exceptions: for example, the simian homolog of Broca's area may not be a language area. But these exceptions are exceptions to a *rule*. Further, these exceptions are only partial: Broca's simian homolog is is sensitive to the violation of certain quasi-linguistic rules (e.g. Wilson *et al*. 2015), and both Broca's area and its simian homolog are motor areas (cf. Rizzolatti & Sinigaglia 2006). Now, if these homologies are the rule rather than the exception (as the research on animal models assumes, see references below), then it is extremely unlikely that the spinal cord will play a cognitive

role *only* in the human case. Something similar holds for the gut brain axis too, at least insofar it involves homologous structures.[5] Further, both the gut-brain axis and the spinal cord are evolutionary ancient, at least if compared with behaviorally modern humans. It is, to put it mildly, extremely unlikely that they've both acquired *all* their cognitive roles in the single evolutionary step (or few evolutionary steps) that led to modern humans. Cognitive functions just don't "pop up" this way (cf Cao 2022). It is far more likely that some such functions have been acquired "along the way", and that have might have been preserved or re-used through various speciation events. But, if this is the most likely case, then we should expect at least some of these cognitive roles to be played in animals too. Hence, we should expect various animals to have intrabodily cognitive extensions.

Secondly, we have *observed* the spinal cord and the brain-gut axis play homolog cognitive functions in animal models. Rat models showed that the spinal cord is quite the sophisticated learning system, capable of both operant and instrumental conditioning (Grau 2014). Rat models have also shown the spinal cord being able of some *top-down* control. Consider shock-induced antinociception (see Allen *et al*. 2009 for a nice review). Shock-induced antinociception is a form of stress-induced analgesia, whereby exposure to a mild shock inhibits pain reactivity (measured, in rats, via the tail-flicking, spinally controlled, reflex). Since shock-induced antinociception can be disrupted by distractors, it is tempting to think of it as a top-down control effect due to an attentional (and thus likely *cerebral*) mechanism. And yet, not only shock induced antinociception is observed in the hindlimbs of spinally transected (paraplegic) rats, but distractors effects are maintained in such conditions too (Meagher *et al*. 1993). Thus the top-down control effects *cannot* be due to cerebral signals - they *must* be due to some spinal mechanism. On the fairly uncontested assumption that top-down control roles are cognitive roles, the spinal cord of rats has been observed playing a cognitive role. That seems enough to deem it an intrabodily cognitive extension. Manipulations of the gut microbiota in mice models provides an analogous case for the brain-gut axis. Altering the gut microbiota of mice - either letting specific microorganisms colonize the intestine of a mice population or *via* fecal transplant - leads to specific alterations of their exploratory behaviors, revealing either heightened or lowered anxiety levels (Bercik *et al*. 2011, Neufeld *et al*. 2011a,b). Similar, yet more tentative, results have also been established concerning spatial memory (Gareau *et al*. 2011, Wang *et al*. 2015).

Thus, both reasoning and empirical evidence strongly suggest that the cognitive system of at least some animals encompasses extracerebral - but intracorporal - components. What should prevent us from concluding that such animals' cognitive systems are extended? Nothing, it seems - at least if we allow for analog evidence to establish that the human cognitive system extends. What is good for the (metaphorical) goose is good for the (literal) gander.

Following Chalmers (2019), one may object that cases of intrabodily cognitive extension are not really metaphysically interesting.[6] According to Chalmers, what's relevant about EC is that it puts pressure on the idea that our cognitive systems (and minds) are *functionally* bounded by perception and action. Genuine cases of extended cognition, Chalmers claims, force us to see perception-action loops as gears in the cognitive machinery, thereby eroding such boundaries. Cases of intrabodily cognitive extension do nothing of that sort: neither the spinal cord nor the brain-gut axis lay outside the boundaries of perception and action. Thus they are not *genuine* cases of extension. They're only cases of what Chalmers calls "extended circuitry". In these cases, the machinery of cognition is extended only in a *mere spatial* sense, which does not put any pressure on traditional, broadly speaking "cartesian" views of the mind. Clark (2019) seemingly agrees.

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[5] We're a bit hesitant in considering microorganisms inhabiting various species of hosts as "homologous structures".

[6] Yet, as (Facchin *et al*. 2021) and (Boem *et al*. 2021) notice, they might still have important implications concerning the methodology and the conceptual toolbox of the mind sciences and biological sciences.

If Clark and Chalmers are right, then, we've not yet shown that EC is true of animals too - at least, not in any substantial sense. The next section addresses this important challenge.

3 - Breaching the sensorimotor boundary: the epistemic actions of non-human animals

One, fairly standard, way to make sense of Clark (2019) and Chalmers's (2019) claim that, when cognition is genuinely extended, perception-action loops are part of the cognitive processing is by casting such loops as *epistemic actions* (Maglio & Kirsh 1992; Kirsh & Maglio 1994; Kirsh 2019; Clark 2008, 2022). Roughly, epistemic actions are embodied actions that transform informational structures in the environment, so as to facilitate the achievement of certain pragmatic goals. Using a classic example: going to a museum is a "standard" pragmatic action, which brings about a desired goal (e.g. seeing an exhibit). Conversely checking the museum's address on a notebook is an epistemic action, which manipulates environmental sources of information to make the desired goal (i.e. seeing the exhibit) more easily attainable (cf. Clark and Chalmers 1998). Now, if Clark, Chalmers and many others (see Menary 2010, Colombo, Irvine & Stapleton 2019) are right, such actions extend our cognitive processing - they are spinning cogs of our cognitive machinery.

Notice, importantly, that epistemic actions *need not* involve the manipulation of artifacts or tools. Clark himself discusses many such "prop-less" epistemic actions, such as bodily movements used to retrieve information "just in time" for its usage (Clark 2008, pp. 11-15), the usage of movement to elicit novel, information-rich, multimodal sensory streams (*idem*, pp. 17-22) and the epistemic role of gesturing (*idem*, pp. 123-126). In this paragraph, we present some "prop-less" *animal* epistemic actions. Again, our claim is conditional: if "prop-less" epistemic actions extend human minds, then they extend animal minds too.

As a first example of animal epistemic action, we want to treat the case of head-bobbing in birds. We argue that as humans use saccades to focus on the environment, so some species of birds use head-bobbing for the same reason. In fact, head-bobbing, in addition to being useful for balance stabilization (Theunissen & Troje 2017), also improves visual perception. So, proceeding with order, first we will explain what saccades are and why they are epistemic actions and then we will treat head-bobbing as an epistemic action.

Saccades are rapid eye movements, and the saccadic movement serves to control the position of the retinal image in space. Indeed, saccades have the role of gathering high quality of information in the environment. This information is glimpsed at with the extrafoveal function (cf. Huber-Huber, et al. 2021). The movement performed by saccades is an epistemic action that has the function of improving visually guided human performances. It is well known that human visual fields are markedly not uniform: only the foveal region of our visual field collects high-fidelity information. The surrounding region of our visual field collects much less detailed information; for example, it does not collect information concerning the color of objects. Scanning via saccadic eye movements allows us to move the foveal region of our visual field on various salient objects, to acquire high quality information on them (Liversedge & Findlay 2000; Ibbotson & Krekelberg 2011). By gathering and collecting this high-quality information just-in-time to control an agent's conduct, saccadic eye movements provide a prototypical example of cognition-extending epistemic action (Clark 2008, pp. 11-15; Rowlands 2010; Constant et al. 2022). But the same can be said about the depth information obtained by birds thanks to head-bobbing.

Head-bobbing is the rhythmic head movement that characterizes several species of birds, such as pigeons (*Columba livia*), ring-billed Gulls, (*Larus delawarensis*) and quails (*Coturnix coturnix*) (cf. Nyakatura & Andrada 2014; Lisney & Troje 2016). Thus, it is a common activity that several species of birds engage in by moving their head back and forward in a rhythmic manner. These head movements are said to play a variety of roles and they are helpful in many of the activities that birds perform every day, from foraging to stabilizing their balance (cf. Fujita 2006). Crucially, certain studies suggest that head-bobbing is an epistemic action playing a variety of functions within birds' cognitive economy. Therefore, the purpose of

head-bobbing is precisely to simplify many of the activities carried out daily by some species of birds (Kral 2003).

In head-bobbing two different phases of head movement can be identified, namely the hold phase and the thrust phase. In particular, in the case of the pigeon, the head is quickly pushed forward in the thrust phase, while remaining motionless with respect to the translation along the axis of the roller during the hold phase (Troje & Frost 2000). Moreover, the thrust phase is fundamental, because it allows the bird to gather depth cues through motion parallaxes (cf. Lisney & Troje. 2016; Kral & 2003). Motion parallax is the phenomenon whereby still objects closer to a moving observer appear faster than still objects further away from the observer. Consider, for example, the different perceived velocities of the objects at various distances when gazed from a moving train, by thrusting their head at controlled velocities. The very same phenomenon allows birds to determine an object's distance (Fux & Eilam 2009). Thanks to parallax motion, it is also possible to learn information about the environment. First, animals, and not just birds, can sense distance by generating parallaxes. In addition, birds can also generate parallaxes of motion by peering, that is, moving the head on one side and the other while resting. In this way they get spatial information about their environment (Pritchard & Healy 2018; Kral 2003).

The phenomenon of head-bobbing enhances cognition in some bird's species. Therefore, the cognitive tasks of these species of birds could not be carried without this functional movement of the head. Indeed, birds manage to maintain a stable image of the visual field without moving its eyes relative to the visual environment. Consequently, we can state that just as humans perform foveal movements to gather high-quality visual information in order to be able to orient and recognize objects around us, birds adopt head-bobbing movements.

As a second example, consider how jumping spiders move their whole body in order to see. Jumping spiders are active predators, which stalk and proactively seek their prey. This lifestyle requires sophisticated perceptual capabilities, and in fact, unlike many spiders, jumping spiders have a complex visual system. Their anterior median eyes (i.e. the front-facing pair) have a striking visual resolution, allowing them to form detailed images of their surroundings. All other eyes lack such a rich visual resolution, functioning just as motion detectors. Their visual fields, thus, consist of a central high-resolution area surrounded by a larger low-quality sea of motion detection. As seen above, humans have a similarly-structured visual field, and gather environmental information by moving around the central high-resolution area (fovea) through saccadic eye movements. But jumping spiders' eyes cannot move in their sockets.[7] Thus, unlike mammals, they can't just move their eyes to focus on something at the periphery of their visual field. They have to move their whole body. Thus, the various movements by means of which jumping spiders turn to face, and track, salient environmental contingencies are functionally analogous to our saccadic eye movements - they're whole-body saccades (cf. Land 1969). So, if one is persuaded that information-gathering saccadic eye movements extend the human mind (see references above) one seems forced to concede that jumping spiders' minds are similarly extended.

Further, in at least some species of jumping spiders these whole-body saccades play further cognitive roles. *Portia fimbriata* is one such species. These spiders boast an impressive, even "mammalian level" ability to *detour* (see Tarsitano & Jackson 1994; 1997). Detouring is the ability to reach one's prey through very *indirect* paths, even when such paths force one to lose sight of the prey, or to temporarily move away from it. But how are these detours planned? *Portia* brains seem just too little to have the horsepower needed to create and update a spatial map of the spider's surroundings. And in fact, *portia* do not plan these detours using an internal map. Rather, complex series of whole-body saccades allow these spiders to *act out* the evaluation

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[7] Jumping spiders can however move the retinae of their anterior median eyes to selectively "bring into focus" various bits of the perceptual image they capture.

process whereby the detour is selected via a process of vicarious trial and error. Vicarious trial and error is typically taken to be the behavioral manifestation of an inner deliberative process, through which various options are assessed so as to pick the best one (cf. Reddish 2016). In the case of *portia*, however, the "behavioral manifestation" seems to be part and parcel of the deliberative process. Simplifying, spiders orient themselves towards their goal, identify horizontal features (that is, pathways) departing from it, and trace the length of such features through whole-body saccades. When the line breaks, the spider reorients towards the goal and tracks another feature. Through repeated iterations of this procedure, the spider traces and "tests" numerous paths (horizontal lines) bringing it to the goal, eventually selecting the first (and thus likely shortest) uninterrupted one (Tarsitano & Andrews 1998; Tarsitano 2006).

In this latter case, one could argue in favor of spider cognition also on a non-analogical basis. In fact, a straightforward application of the parity principle (cf Clark 2008, p. 77) seems sufficient to guarantee the extension. The parity principle is a rule-of-thumb test to adjudicate cases of cognitive extension. When considering a putative piece of extended cognitive processing, the parity principle asks us how we would evaluate a *cerebral* functional isomorph of that piece of processing. If we would deem the latter as cognitive, then we need to recognize the former as cognitive too; else, we would fall prey to a neurocentric bias (for further discussion, see Clark 2011; Wheeler 2011, 2019b). Now, given that a cerebral analog of the spider's processing *is in fact* typically considered cognitive in both animals and humans (cf. Tolman 1939), one can safely conclude that *portia*'s extended processing is a case of extended cognitive processing.

In conclusion, jumping spiders' whole-body saccades provide us a potent and empirically well supported case in favor of the extension of animal minds. Notice that, even if such an example were to be defused, accepting that human saccadic eye movements extend human cognition likely entails that animal cognition is extended too. For, most likely, the saccadic eye movements of other primates - and mammals more generally - will play similar functional roles in their cognitive lifes. But, if these roles are cognitive in the human case, then they will most likely be cognitive in the animal case too.

That should not be surprising. For, "prop-less" epistemic actions seem to be widely distributed in nature; so much so, that one might find them performed even by what *might*[8] be the most basic cognitive systems around, namely unicellular organisms. The bacterium *Salmonella Typhimurium*, for example, determines in which way to swim by comparing whether the concentration of nutrients "sampled" at two different times has increased. But in order for such a comparison mechanism to make sense, the bacterium must constantly be on the move, so as to sample different points of its environment - otherwise, it will always be unable to detect any nutrient gradient (cf. Macnab & Koshland 1972)! So, *if* such bateria are cognizers, it could be appropriate to depict them as active information foragers, locked in a perennial series of cognition-extending epistemic actions.

To sum up, animals are capable of executing "prop-less" epistemic actions. Thus, just like human cognition, animal cognition seems able to breach the sensorimotor frontier, leaking into the environment thanks to the purposeful motion of their active bodies.

At this point, however, a defender of an anthropocentric reading of the extended mind might argue that human and non-human extended cognitive systems are still worlds apart because of an important difference. Human cognition extends *also* by means of external information-encoding props such as tools or external representations. These external props permanently alter the human cognitive niche, thereby allowing for novel cognitive extensions to build on top of older ones. In this way, human cognitive extension improve through time, allowing humans to reach otherwise impossible cognitive achievements (cf. Menary 2007,

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[8] Recall that, for the purpose of this paper, we are officially neutral on whether unicellular organisms qualify as cognizers or not.

2015; Wheeler and Clark 2008, Malafouris 2013; Fabry 2020). On the contrary, animal cognitive extensions are just impermanent epistemic actions. However, as we will soon argue, animal cognition extends via external, information-encoding props too.

4 - Cognition-extending props and non-human animals

Human cognitive extensions often involve external, information-encoding props - consider again, for instance, the examples of cognitive extension given in §1. But what about animals? Can their cognitive extension involve similar props? We'll argue that yes, they do. But two *caveats* are needed beforehand.

First, we will interpret "external props" in a very broad way, so as to include all sorts of tools, artifacts (i.e. objects or structures *built* to achieve a goal) and naturefacts (i.e. naturally occurring objects or structures that allow us to achieve a goal, like a rock used to hammer a nail, cf Hilpinen 2011; Preston 2022). This seems to be in line with the range of possible cognition-extending props in the human case, which range from complex technologies to very mundane things like a stick planted in the sand to create a primitive sundial. Secondly, our aim here is not that of establishing that animals use tools - for that has already been established on solid empirical grounds (cf. Bentley-Condit *et al* 2010). Our purpose here is to show that animals interact with certain relevant props in a mind-extending way. So, not *every* case of animal prop usage will do.

One paradigmatic case of prop-involving human cognitive extension is *cognitive offloading* (cf. Risiko & Gilbert 2016). During cognitive offloading, an agent performs epistemic actions so as to modify her surrounding environment in a way such that the environment itself "takes care" of certain cognitive tasks. By writing a shopping list, one forces the environment to do the remembering. By operating on a small-scale model, one forces the model to display the likely results of certain interventions. And so forth.

Many different animals seem to offload cognition when building their nests. Consider, for example, the mud wasp *parlastor sp.* Wasps of this species use mud to build fairly complex nests, consisting of an inner chamber (buried quite deep) and a fairly long entrance that protrudes several centimeters above the ground. Crucially, the entrance is not just a straight tube. Rather, its entrance is bent downwards, and expands so as to assume a bell-shaped form. How do *parlastor* manage to build such nests? One option is that *parlastor* build their nests consulting an inner model or set of instructions that "tells" them what to do. But this internal-processing heavy strategy does not seem the one adopted. Rather, *paralastor* use the nest *itself* as the relevant instructions to follow. For, *paralastor* seems to be exquisitely sensitive to certain perceptual cues, which immediately trigger certain nest building behaviors. For example, seeing the entrance tube protruding over a certain, critical, threshold will cause the wasp to shift behavioral patterns: she will stop elongating the tube and start bending it to then work at the bell-shaped entrance. But if mud is then added to the base of the nest, so that the entrance tube does not reach the threshold level, the wasp will simply go back to her elongating behavior - as if oblivious of the overall shape of the nest. Similarly, the perception of a hole in the mud causes the wasp to start building an entrance tube - even when the hole has been carved *on top* of the bell-shaped entrance to the nest (see Smith 1978).

So, it appears that *parlastor sp.* does not harbor an inner model or set of instructions "telling" them how their nests should be built. Rather, their inner architecture is simply responsive to certain perceptual features of the nest-in construction, in a way such that perceiving these features causes them to engage in the behavior required to proceed with the next stage in nest construction. The inner model and instructions, then, have been offloaded on the relevant perceptual features of the model. If cognitive offloading extends our human minds, then, it appears that wasps' minds are extended too. And not just wasps' minds that are extended. For, a similar offloading strategy has been observed in nest-building spiders (for a summary

focused on cognitive extensions, see Japyassú & Laland 2017) and even in certain species of birds (see Collias and Collias 1962).

Furthermore, this kind of self-cueing has been recognized as a special case of *stigmergy*, that is, the usage of signals to indirectly manipulate and organize an agent's behavior (see Heyligen 2015, 2016a,b). This is important to notice for two reasons. First, it tells us that the relevant cues are signals: they carry *information* about what to do, and are thus likely used as *representations* of what to do.[9] This is important to notice, for if the relevant cues are *used as* representations, then the agent behavior is not just a blind, mechanical and reflexive tropism triggered by a mere stimulus. For, an agent sensitive to the content of representations is likely behaving in a mindful, cognition-revealing, manner.[10] Secondly, since stigmergic behaviors involves dense and bidirectional causal loop that are markedly non-linear (see references above), noticing that the case of cognitive offloading thus far discusses are case of stigmergic behavior opens up the space for a *second* argument to the effect that these animals' cognitive processing is extended. In fact, several authors take such loopy non linear dynamics to support the extension of cognition in the human case (Hurley 1998; Chemero 2009; Lamb and Chemero 2018). We just see no reason as to why they *shouldn't* support the extension of cognition in the animal case. Thus, they offer a second argument for our conditional claim: if loopy dynamics extend cognition in the human case, they also extend it in the animal case.

One might worry that the cases thus far examined do not suffice to substantiate our claim. For, in standard cases of human cognitive offloading, the *epistemic* actions whereby one offloads information and then deploys it are clearly separated from the *pragmatic* actions whereby one attains one's goal. When one writes and consults a shopping list, one's pragmatic goal is not to read/write something, but rather to *buy* certain things. The writing and reading are not goals *per se*, they're only brought about to access information. But in the case examined above no such thigh separation between epistemic and pragmatic action holds. The relevant perceptual cues are brought about and used when the animal is pursuing a *pragmatic* goal and are directly involved in its attainment. Thus, they might not qualify as epistemic actions in any relevant sense - thereby failing to extend animal minds.

We believe such a worry is misguided for two reasons. First, there are paradigmatic cases of human cognitive offloading in which no such separation holds. Secondly, there are cases of animal cognitive offloading in which the relevant separation holds. Thus, the separation might not be needed; but even if it were, that would not damage our claim.

Consider a paradigmatic case of cognitive offloading: the usage of pen and paper (and numerals) as an external memory, to "remember" the partial results involved in a long mathematical operation (cf. Wilson 1994, Menary 2015). Now, imagine a school child dealing with a math test. Suppose her grade will not depend only on her final answer to the questions, but also by the procedures used to compute them. On the reasonable assumption that she's aiming for a good grade, her writing down the relevant partial results and operations carried out is directly involved in bringing about the desired good. The barrier separating epistemic and pragmatic actions is thus breached, just as it was breached in the animal cases above. So, if in

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[9] Some philosophers might object to this on the grounds that information-carrying *alone* is not sufficient for representing. However, even philosophers espousing this view allow for "mere" information-carriers to be used as representations by *entire agents* (see for instance Ramsey 2007). Since here we're dealing with entire agents, the representation talk is entirely unproblematic.

[10] One could object that in at least some cases the "tropism-based" reading should be preferred. After all, aren't mud wasps the *go-to case* of an animal whose behavior is orchestrated by cunningly arranged tropisms? Our answer is "yes, but actually no". Yes: mud wasps *are* the go-to case of behavior guided by tropisms. Yet, that traditional description is grossly exaggerated and misrepresents their behavior (see Keijzer 2001). So: actually no, we *shouldn't* actually prefer the tropism based reading.

this case the child's cognition extends (as many supporters of EC would argue), then no rigid distinction between pragmatic and epistemic actions is needed, and the worry above is defanged.

But what if the distinction were needed? Strange as it may sound one could technically hold that the teacher's intentions in the example above prevent any cognitive extension from obtaining. Still, there would be cases of "purely epistemic" animal cognitive offloading. Consider, as an example, *patch marking*. Patch marking is a behavior found in numerous species of parasitoid insects, whereby the insect "marks", often with a chemical marker, a previously explored patch of the environment. Importantly, these insects tend to respond aversively to these marks, spending less time in the "marked" regions. In this way, they do not have to recall *which* region of the environment they have already visited, the mark does the remembering for them (see Holler & Hormann 1993; Sheelan *et al*. 1993 Bernstein & Driessen 1996; Nakashima *et al*. 2002). Now, depositing the marks does not directly contribute to these insects' goals (typically, injecting their eggs in a suitable host). So, patch marking seems an epistemic action separated from pragmatic ones in the desired way.

Summarizing: several animals seem able to manipulate their own environments so as to offload certain cognitive processes to the environment itself. So, if cognitive offloading extends the cognitive systems of humans, then the cognitive systems of certain animals will be extended too.

5 - Allaying some worries

Thus far, we've made the case for our conditional claim: *if* human cognition extends, then animal cognition extends too. Human and animal cognitive systems are either *both* extended or *both* non-extended. Either way, cognitive extensions are not a human-only affair, nor do they tell humans apart from all other animals. EC should lose its anthropocentric focus. We know such a claim might generate some worries. Here, we allay the ones we find the most pressing.

First, one may worry our claim is based on a conceptual sleight of hand. Our discussion started in **§1** with intrabodily cognitive extensions, which are tied to the "first wave", computational and representational rendition of EC. But then, subsequent sections veered towards a more sensorimotor, dynamical and enactive rendition of EC, based on loopy and non-linear interaction dynamics. That's the trademark of "second" and "third wave" EC (cf. Gallagher 2018, Wheeler 2019b on the "weaves" of EC) or even a symptom that we've been relying on a stronger thesis, according to which cognitive systems are *always* constitutively extended (Hutto *et al* 2014). Such a conceptual shift invites three problems. First, if cognition is *always* extended, then the claim that animal cognition is extended becomes trivial. Secondly, these renditions of EC hinge on a number of contested assumptions - for example, to anti-representationalism - that are not justified in our paper. Lastly, the claim that *all* agent-environment interactions extend an agent cognition (cf. Hutto *et al*. 2014) seems to lead to a *reductio* of EC. Surely defenders of EC should allow that an agent might find it useful to go for a walk to think without thereby having to count *roads* as part of the agent's extended cognitive system!

These are all genuine problems. But they do not affect us here. For, we've carefully avoided "buying into" any specific rendition of EC. We're not committed to *any* particular variant of EC. And we don't need to commit. Our claim is that if certain props or processes extend the human mind *somehow*, then they also extend some animal minds. Of course, to maintain this agnosticism we had to discuss a number of examples compatible with various renditions of EC. Thus, the perceived shift does not reveal an implicit commitment to contested claims concerning the non-representational, always extended nature of cognition. Which, to be crystal clear, does not entail that we're here accepting the claims concerning the representational nature of

cognition and suggesting a sort of cognitive primacy of the brain made by "first wave EC".[11] We remain neutral on such matters.

For the same reason, we're not moving *too* fast by not discussing all the various different objections to EC, as the *second worry* goes. For, all standard objections EC hinge on *some* assumption made only by *some* rendition of EC, but not others. For instance, objections based on representational contents (Adams and Aizawa 2001) are pretty toothless against non-representational renditions of EC (Cf. Chemero 2009, Hutto & Myin 2013, pp. 139-145). Since here we're not committed to *any* specific rendition of EC, we do not feel the need to engage with *any* of these objections. Moreover our claim has a *conditional* form: if EC (in *any variant*) is true of humans, then EC is true of at least some animals too. Now, a well known fact about conditional is that the falsity of the antecedent makes them always true, regardless of the truth-value of the consequent. So, if any of the objections to EC were to hit the mark, then EC is false; and, *a fortiori*, not true of humans - which would make our claim (vacuously) true! And surely this is not what the objector wants.

A *third worry* is that our claim is based on the implicit adoption of a "biogenic" conception of cognition, according to which pretty much every adaptive, flexible and information-guided organism-environment interaction qualifies as an instance of *full blown* cognition (see Lyon 2006, 2020). But many find such a conception of cognition objectionable, as it fails to properly identify cognitive processes, states and agents (see Adams 2018). As such, "biogenic" cognition should be rejected, together with our claim.

Two points in response. First, we stress that here we stay agnostic on what cognition is. So, our claim does not presuppose the truth of "biogenic" approaches, and their falsity would not damage our claim. Second, we find objections to our claims based on the view that cognition *really* is something else that we've not discussed here fairly unpersuasive. For, looking at the current research in the mind sciences, one can't help but notice that "cognition" is used in a *variety* of different ways across various different research programs (cf. Allen 2017; Favela and Martin 2017; Facchin 2022). So, looking at the current cognitive sciences, cognition doesn't *really* seem to be a single thing (or kind of process) that can be easily put in contrast with the things and processes we've discussed here. How, then, do we know that the cases we've discussed are cases in which cognition - in one of the relevant senses of the world - is involved? Our answer is simple: the cases we've discussed are described *as cognitive* by the scientists that have studied them. On the hopefully uncontested assumption that scientists literally mean what they write in their papers,[12] then the cases we've discussed here qualify as cognitive according to our current best scientific practices.

In *fourth place*, one may worry that, if true, our claim would merely replace a form of human cognitive exceptionalism with a form of *animal* cognitive exceptionalism. What we've shown, this worry goes, is that only animals' cognitive systems are extended. But what about other cognitive agents such as plants (cf Calvo & Keijzer 2011), robots (cf Tani 2016), single-celled organisms (Lyon 2015) and so-called "intelligent" materials (Mcgivers 2019)? By being silent on those, we reinforce a prejudiced view of cognition that sees it as an animal-only affair (cf. Calvo 2022, Tripaldi 2022).

This worry misconstrues our argumentative strategy. As we said above (**§1)** our focus on animals is partly instrumental: it allows us to streamline our argument without having to debate on whether systems such as plants, fungi and bacteria are *really* cognitive. Importantly, were such systems cognitive, nothing of what we've argued thus far would prevent their cognition from extending. So, our claim does not support a form of animal cognitive exceptionalism.

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[11] Whether or not "first wave EC" *actually* makes such claims is a complex matter we won't discuss here (see Clark 1998 2008, 2011 for discussion). Suffice it to say that "first wave EC" is typically read as making them (see Ghallagher 2018).

[12] See (Figdor 2018) for a defense.

Conversely, the *fifth* worry is that our anti-antropocentric argument is far too glib. After all there still are relevant differences between human and animal extended cognitive systems. Parasitoid insects might offload some small piece of their cognitive processing - but that's not the same as using pen and paper to do a complex mathematical operation. Human cognitive extensions allow to individually improve on them and innovate (cf. Wheeler and Clark 2008). Further, human cognitive extension often require the agent to master some cultural practices with a relevant normative dimension: only certain ways of manipulating numerals are *right* (cf. Menary 2007, 2015; Fabry 2020). They're also highly personalized and the information they convey will be trusted in a special way (cf. Sterelny 2010). Insects' extensions, in contrast, are most likely genetically determined, in a way that does not allow for extensions to be individually improved and personalized, and does not require the agent to learn any cultural practice. These, the worry goes, are *significant* differences our claim simply fails to acknowledge.

These are significant differences indeed - but our claim is compatible with their acknowledgement. For the view that cognitive extension is not a human-only affair can logically co-exist with the view that human extensions and animal extensions have significant differences. Compare: it is typically accepted that tool-use is *not* exclusively human. But it is also typically accepted that human and animal tool use are importantly different (cf. Heersmink 2022). Does this mean that we're forced to recognize a difference *in kind* between human and animal's cognitive extensions? We're not sure. Whilst comparing human cognitive offloading and insects' cognitive offloading makes it tempting to give a positive answer, things look much more murky when it comes to human *vs* animals' epistemic actions (**§4**). Further, there seems no significant difference when it comes to intrabodily cognitive extensions. Perhaps, then, to correctly answer this question we might have to dissolve the generic kind "cognitive extension" into more specific sub-types of cognitive extensions, just as the generic kind "memory" has been dissolved into various sub-types of memories.[13] Be as it might, our claim establishes that if there are such things as cognitive extensions, then they are widespread in the animal kingdom. As such, cognitive extensions are not uniquely human, and thus, cognitive extensions alone cannot be what makes humans unique.

6 - Conclusion

This paper began (**§1**) by noticing that EC acquired an anthropocentric bend. According to a fairly commonplace view, cognitive extensions are exclusively human, and may be described as the physical basis of humans' cognitive uniqueness (cf. Clark 2003). We've argued that such an anthropocentric focus should be abandoned. For, if human cognition extends, then animal cognition extends too. In fact, many non-human animals have the same intrabodily cognitive extensions humans have (**§2**), perform epistemic actions comparable to ours (**§3**) and are even capable of offloading cognition in the environment through the usage of specific environmental props (**§4**). We then defended our claim from a number of objections (**§5**).

In closing, we wish to point out an implication of our claim that we wish to stress. Consider a case reported in (Clark 2003, pp. 139-141). Patients suffering from Alzheimer's syndrome were tested, obtaining incredibly low scores in standard psychological tests. Thus, according to the tests, the patients were unable to live alone and take care of themselves. And yet they did. How? By cleverly structuring their environments, so as to offload on it the cognitive load their brains were no longer able to handle. Psychological testing, then, failed to take into account the *entirety* of these agent's cognitive systems - it tested only a part of it. If our claim is right, however, we might have been making the same mistake when it comes to the cognition of animals - as animals are often tested in artificial, un-ecological settings (cf. Barrett 2016) that may *in fact* "amputate" part of the animal's cognitive system. And whilst a detailed discussion of the extent and effects of such a mistake will have to wait for another time, we here wish to stress that such a mistake may have been made.

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[13] On dissolving kinds see also (Ramsey 2021).

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