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ORIGINAL RESEARCH

Human uniqueness in using tools and artifacts: flexibility, variety, complexity

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Abstract

The main goal of this paper is to investigate whether (and how) humans are unique in using tools and artifacts. Non-human animals exhibit some impressive instances of tool and artifact-use. Chimpanzees use sticks to get termites out of a mound, beavers build dams, birds make nests, spiders create webs, bowerbirds make bowers to impress potential mates, etc. There is no doubt that some animals modify and use objects in clever and sophisticated ways. But how does this relate to the way in which humans make and use objects to achieve their goals? To answer this question, this paper first presents a taxonomy of artifacts, identifying four overlapping categories, namely embodied, perceptual, cognitive, and affective artifacts. It then discusses definitions of animal tool-use, arguing that we need a more liberal approach, one that goes beyond the use of tools that are embedded in occurrent perception-action cycles. This paper ends by analysing how instances of animal tool and artifact-use can be classified according to the four identified categories, concluding that some animals use embodied, perceptual, cognitive, and affective artifacts. In this sense, humans are thus not unique in the kinds of tools and artifacts we use. What is unique, however, is our unprecedented flexibility and openness to deeply incorporate a large variety of complex tools and artifacts into our embodied, perceptual, cognitive, and affective systems.

Keywords Taxonomy of artifacts · Animal tool-use · Niche construction · Representations · Homo faber · Natural-born cyborgs · Ratchet effect

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1 Introduction

Humans are sometimes characterized as “Homo faber”, a notion meant to capture and emphasize our ability to make and use tools. Henri Bergson characterised the notion in his 1911 book *Creative Evolution* as follows:

> “If we could rid ourselves of all pride, if, to define our species, we kept strictly to what the historic and the prehistoric periods show us to be the constant characteristic of man and of intelligence, we should say not Homo sapiens, but Homo faber. In short, intelligence, considered in what seems to be its original feature, is the faculty of manufacturing artificial objects, especially tools to make tools, and of indefinitely varying the manufacture” (Bergson 1911, p. 139).

In characterising our species, Bergson thus emphasizes our ability to produce material culture, specifically emphasising two features: our ability to make tools for making other tools and the variety of material culture. The latter, it seems, partly depends on the former. Once you have a basic toolkit, the number of things you can make with it are limited only by your imagination and the (properties of the) available resources.

There is indeed an enormous variety in tools and material culture, both presently and historically. Periods in human history are sometimes characterized in terms of the material of the tools we use: from the stone age, bronze age, to the iron age[1]. Anthropologists claim that the first stone tools in the hominin lineage were handaxes, made approximately 3.3million years ago (Harmand, Lewis, Feibel et al. 2015). Since the invention of the first manufactured tools - enabled through the interaction between our complex embodied brains and cumulative culture (Buskell, 2020; Schulz, 2020) - the quantity and variety of tools and artifacts is staggering. Every facet of human culture and activities are saturated with human-made objects. Agriculture, transportation, education, sport, art, religion, science, medicine, healthcare, and (of course) engineering is made possible through tools and artifacts.

Humans are, however, not the only species that make and use tools. Tool-use is widespread across the animal kingdom: mammals, birds, fish, cephalopods, and insects are known to use tools (Bentley-Condit & Smith, 2010). They do so because using tools is evolutionarily beneficial, as it gives an organism (or a collective of organisms) more access to food, shelter, or mates. Tool-using behaviours are adaptive behaviours and make good evolutionary sense (Biro et al., 2013). In fact, it is perhaps surprising that not more species use tools (Hunt et al., 2013). The notion of Homo faber is thus incorrect insofar as humans aren’t the only species that make and use tools (Ihde & Malafouris, 2019). Animal cognition researchers such as Frans de Waal (2016) therefore stress the continuity between animal and human tool-use. In this paper, I investigate the nature of this continuity, specifically analysing whether there is a kind of tool and artifact-use that is uniquely human. One goal of this paper is to better understand our relation to other animals and to conceptualise humans as natural-born cyborgs (Clark, 2003): creatures that naturally form hybrid systems

[1] Future anthropologists and archaeologists may refer to our current age as the plastic age.

with a variety of complex technological artifacts that are deeply incorporated into our motor, perceptual, cognitive, and affective systems.

The analysis unfolds as follows. I first distinguish between "techniques", "tools", "artifacts", and "naturefacts". Then, drawing on (Heersmink, 2021; see also Gray, Osiurak & Heersmink 2021), I outline a taxonomy of artifacts, identifying four overlapping categories, namely embodied, perceptual, cognitive, and affective artifacts. Embodied artifacts such as a hammer are absorbed in the body schema and are typically experienced as transparent extensions of the motor system. Perceptual artifacts such as glasses are used to help us perceive or quantify the world better. Cognitive artifacts such as a map are used to complete cognitive tasks like navigating. And, finally, affective artifacts such as a sculpture are used to induce certain affective states in the maker or viewer.

Thereafter, I discuss a number of prominent definitions of animal tool-use (van Lawick-Goodall, 1970; Alcock's 1972; Beck 1980; St Amant & Horton, 2008), pointing out some drawbacks, and arguing that (for the purpose of this paper) focussing on animal tool-use is too narrow. Current definitions claim that a tool has to be embedded in occurrent perception-action cycles, for example using a rock to crack open a nut or a stick to get termites out of a mound. Whilst this carves out an important type of animal behaviour, it leaves out many interesting behaviours where animals create material objects or structures that are, when finished, not embedded in occurrent perception-action cycles. Examples include bird nests, beaver dams, beehives, termite mounds, pufferfish "crop circles", and bowerbird bowers. These can be characterised not as mere tools, but as proper artifacts, i.e., material objects or structures *modified* or *made* for some specific purpose.

Having a basic grasp of categories of artifacts and ways in which animals use tools and artifacts, I investigate how instances of animal tool and artifact-use can be classified according to the four identified categories. I will argue that some animals use embodied, perceptual, cognitive, and affective artifacts. The analysis in this paper thus shows that humans are not unique in the kinds of tools and artifacts we use. So, in terms of the use of tools and artifacts, the difference is in degree, not in kind. However, the flexibility in which humans incorporate a large variety of complex tools and artifacts into their practices is unprecedented in nature. This difference in degree matters and is realised through cumulative cultural processes (specifically the ratchet effect), constantly increasing the distance between us and other species on the spectrum of tool and artifact-using organisms.

2 A taxonomy of artifacts

2.1 Sorts of human-used objects

It is helpful to start the analysis by distinguishing between "techniques", "tools", "artifacts", and "naturefacts" (Heersmink, 2013, 2021). Techniques (or skills) are not material objects, but ways to perform a task and achieve a goal. For the purpose of this paper, I'll focus on bodily techniques, ways to use the body to achieve a goal (Mauss, 1973). Such techniques often involve interacting with tools or artifacts.

There are bodily techniques for tying your shoelaces, making coffee, using chopsticks, playing guitar, driving a car, writing with pen and paper, etc.

"Tools are a specific kind of object employed to alter or interact with other objects" (Schettler et al., 2019, p. 7). Many tools are used with our hands. Given humans are bipedal creatures with opposable thumbs, we have our hands available to use tools. Most of our evolutionary history we have used tools ranging from handaxes, spears, swords, ploughs, spades, hammers, screwdrivers, and many other handheld tools. Making and using tools requires specific bodily techniques. Note that tools are characterised by being embedded in perception-action cycles.

Artifacts are material objects or structures modified or made for some specific purpose (Hilpinen, 2011). This is a much broader category than tools. It includes any item of material culture, also those that aren't handheld or embedded in perception-action cycles, such as chairs, washing machines, traffic signs, paintings, or satellites. This category includes any object or structure made through intentional agency. Because of its much wider focus, artifact is the preferred term in the philosophy and metaphysics of technology[2] (e.g., Dipert 1993; Houkes & Vermaas, 2010). Like with tools, making and using artifacts requires specific bodily techniques. Techniques are intentionally developed for some goal and are in that sense *artificial*, i.e., they are human-made. However, it is important to note that they are not artifactual (Heersmink, 2013). A technique is not a tangible entity or structure but is characterised by a series of intentional changes in bodily states. Ontologically, techniques are dispositional, they only come into being when they are needed, whereas artifacts usually continue to exist for a certain period after they are made (Heersmink, 2021).

Naturefacts are material objects taken from their natural environment and used for some purpose. Such objects are made by nature, not through intentional (human) agency. But when a naturefact is intentionally modified to improve its function, it becomes a genuine artifact (Hilpinen, 2011). So, when I find a branch to use as a walking stick, it is a naturefact, but when I modify it by making it into a more suitable length, it becomes an artifact. Or when our evolutionary ancestors started flaking the stones they used, as to make them more effective for the tasks they were doing, they were no longer mere opportunistic users of naturefacts, but became makers and users of artifacts, which was an important event in human evolution. Tools can be both artifactual (e.g., using a pen to write) and naturefactual (e.g., using an unmodified branch as a walking stick), though the vast majority of tools is artifactual. Like with tools and artifacts, using naturefacts requires specific bodily techniques.

2.2 Embodied artifacts

Heersmink (2021) develops a taxonomy of artifacts on the basis of the functional relation between an embodied human agent and an artifact. This taxonomy has four

[2] In her entry on "Artifact" in the *Stanford Encyclopedia of Philosophy*, Preston (2018) points out that other philosophers have a more inclusive notion of artifact. Dipert (1993) includes musical performances, Risto Hilpinen (1995) includes belief systems, and Evnine (2016) includes actions as artifactual, not as artifactual objects but as artifactual events. In this paper, I focus on artifacts as material objects, not as performances, belief systems, or events.

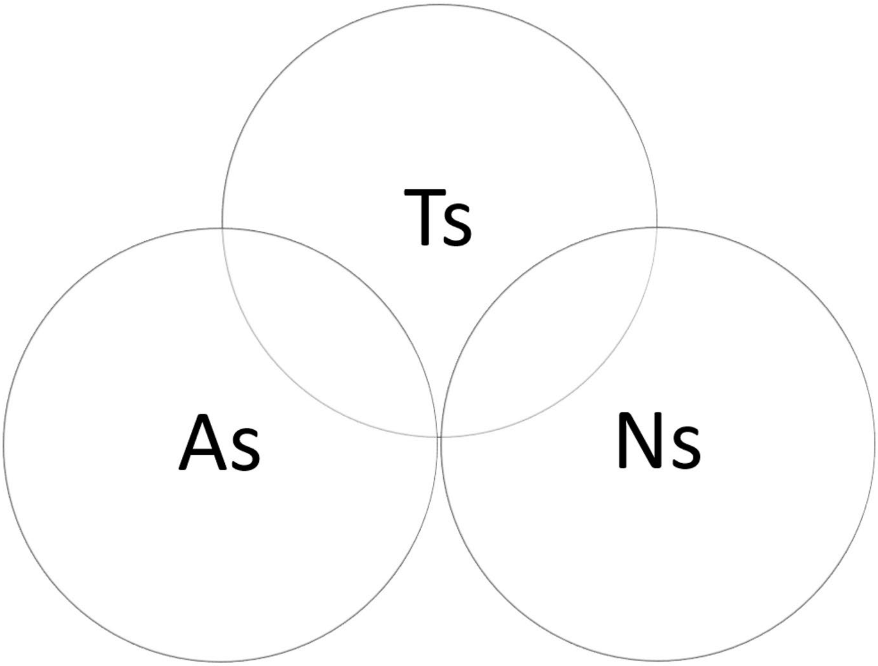

Fig. 1 A Venn diagram of the relations among tools (Ts), artifacts (As), and naturefacts (Ns), showing that tools can be both artifactual (e.g., using a hammer) and naturefactual (e.g., using an unmodified branch as a walking stick), but that artifacts and naturefacts do not overlap and are mutually exclusive

overlapping categories: embodied, perceptual, cognitive, and affective artifacts. Embodied artifacts are absorbed in the body schema and are, when properly embodied, experienced as transparent extensions of the motor system. The user then experiences an enhanced agency through using the artifact (Mangalam et al., 2022). A body schema is a subpersonal representation of the body's size, shape, and position (Gallagher, 2006). In order to successfully interact with the world, we need to take into account the size, shape, and position of our body. The information provided by the body schema feeds into action programmes.

Body schemas can be recalibrated as to include tools and artifacts (Schettler et al., 2019). A key example from the history of phenomenology is a carpenter using a hammer (Heidegger, 1962). So, when a carpenter uses a hammer, when a chef uses a knife, or when a painter uses a brush, their body schema is recalibrated, and the artifact is experienced as part of the human body (Ihde, 1990). Such embodied artifacts are often used to act on the world, and when we do, our focus is not on the agent-artifact interface but on the artifact-environment interface. A distalization of the end effector then occurs (Arib et al. 2009). Our ability to embody an artifact goes back to (at least) the stone age. The first handaxes were embodied artifacts. It's possible that the flexibility of the human body schema is one of the reasons why humans are so good at interacting with tools and artifacts. Most embodied artifacts are tools, as most are handheld devices (e.g., hammers, knifes, brushes, pens, cutlery, toothbrushes, swords) used to interact with other objects.

2.3 Perceptual artifacts

Perceptual artifacts are used to help us perceive or quantify the world better. Humans have various senses and artifacts can aid our senses to perform better. Glasses, binoculars, telescopes, microscopes, and rear-view mirrors allow us to see more, either by correcting physiological deficiencies or by enhancing our normal vision. Hearing aids and stethoscopes correct or enhance the auditory system. These artifacts enhance or extend our vision or audition within their normal range. In case of vision, that is light between approximately 380–750nm and in case of audition, that is sounds between approximately 20–20.000Hz. Some perceptual artifacts allow us to go beyond those limits. For example, ultrasound, x-ray, MRI, night vision goggles, radar systems, and infrared satellites, allow us to see and hear things that are not normally detectable with our biological senses. They do so by translating informational input (e.g., high frequency sounds) into an external representation, which is either fixed or dynamic and in real-time, allowing its users to indirectly perceive some part of the world that we would not otherwise be able to perceive.

2.4 Cognitive artifacts

Our embodied brains are impressive feats of biological and cultural evolution. They do, however, have limited information storage and processing capacities. Some of these limits are overcome by using cognitive artifacts. We calculate with the aid of abacuses, we navigate with the aid of maps, we remember our appointments with the aid of calendars, we remember our personal past with the aid of photographs, and so on (Norman, 1991; Hutchins, 1999; Brey, 2005; Fasoli, 2018). Such artifacts have informational properties that help us to perform a cognitive task. Using cognitive artifacts often enhances our cognitive capacities, making cognitive tasks easier, faster, more reliable, or possible at all.

The first material traces of Homo sapiens externalising their thoughts and affects in external representations are most likely cave paintings, ancient rock engravings, and figurines. Archaeologists date the first cave paintings back to approximately 45,000 years ago, found in the caves of Sulawesi in Indonesia (Brum et al., 2021). Our capacity to represent the world not just in our mind, but in external material traces marks a breaking point with our evolutionary ancestors and has generated a new stage in our cognitive evolution, creating a shift "from internal to external memory storage devices" (Donald, 1991, p. 273)[3].

Scholars estimate that a kind of spoken proto-language evolved approximately 2,5million years ago, possibly to aid the social transmission of tool-making techniques (Morgan et al., 2015). Writing systems evolved millions of years later. The first advanced writing systems appeared in Sumer and Egypt, approximately 6,000

[3] However, it is unclear whether cave paintings qualify as proper cognitive artifacts, as we don't know whether they were used to perform cognitive tasks.

years ago (Donald, 2010). The Sumerian archaic (pre-cuneiform) writing and Egyptian hieroglyphs are generally considered the earliest true writing systems. Writing developed independently in China (1200 BCE) and Mesoamerica (500 BCE). Written language is so important that it has been referred to as "the ultimate artifact" (Clark, 1997; Wheeler, 2004; see also Tylen et al., 2010). Writing provides humans with enormous cognitive and cultural advantages. It allows us to offload and store information in clay tablets, papyrus scrolls, paper, and computers, and then use that information for the tasks we are doing. Other key developments in the history of cognitive artifacts are the invention of number systems, maps, measuring devices, and computing systems. These are all relatively recent inventions. So, on an evolutionary timescale, using cognitive artifacts to perform cognitive tasks is a very recent behaviour.

Cognitive artifacts are material objects or structures made to functionally contribute to performing a cognitive task (Heersmink, 2013, 2016)[4]. Such cognitive tasks may include calculating, navigating, remembering, reasoning, and others. Heersmink (2013) develops a taxonomy of cognitive artifacts, identifying a number of categories in which artifacts with similar informational properties can be grouped. A first distinction is between representational and non-representational cognitive artifacts. The first are artifacts that contain a representation, the latter do not. For the purpose of this paper, I won't discuss non-representational artifacts (but see Heersmink 2013 for more detail). Representations are information-structures that are about some other thing or structure (Haugeland, 1991; Peirce, 1935a, b) identified three sorts of representations (or signs in his terminology): icons, indices, and symbols (Atkin, 2008). An icon (such as a map, photo, or scale model) represents information in virtue of a similarity to its target domain. An index (such as a weathervane, thermometer, or speed meter) represents information in virtue of a direct causal connection between the target and the index. A symbol (such as a word, sentence, number, scientific formula) represents information in virtue of socially agreed upon rules or conventions. A particular representation may exhibit a combination of iconicity, indexicality, and symbolicity, but in most cases, one of these representational properties is predominant.

2.5 Affective artifacts

Affective artifacts are material objects or structures made to induce an affective state in the viewer (Colombetti & Roberts, 2015; Colombetti & Krueger, 2015; Piredda 2020; Colombetti 2020). On a phenomenological level, affect can include states such as feelings (e.g., feeling of warmth), emotions (e.g., anger), and moods (e.g., having the blues). Affective states, processes, and capacities interact with material artifacts in various ways. For example, creative or aesthetic artifacts such as paintings, sculptures, cinema, and installation art are made and used to induce affective and cognitive states in the viewer. The same is true for advertisements and commercials.

[4] Heersmink (2013) defined cognitive artifacts as "human-made, physical objects that functionally contribute to performing a cognitive task" (p. 465). Here I characterise them in a non-question begging way, leaving out the "human-made" part of the definition.

Also, when using musical instruments such as a guitar, cello, or piano to make music, it is typically used to express affective states. Collections of, for example, stamps, old cameras, antiques, or cars are affectively meaningful to the collector. Some artifacts may unintentionally or accidentally induce some affective reaction in an agent, but the paradigm cases of affective artifacts are those that are intentionally made to induce some affective state in the user.

Drawing on Andrea Scarantino's classification of theories of emotion (Scarantino 2016) , see also Scarantino & de Sousa 2018), Viola (2021) identifies three types of affective artifacts, namely evaluative, feeling, and motivational artifacts. These three types of artifacts relate to different features of emotional episodes, focussing on appraisals, physiological and phenomenal feelings, and motivations for actions. Evaluative theories of emotion regard some kind of evaluation of salient situations or stimuli as a key feature of emotion. Feeling theories of emotion regard some bodily consciousness of a physiological sensation as a key part of emotion. Motivational theories of emotion construe emotion as (dispositions to) specific patterns of behavior[5]. In this paper, I'm not committed to or prioritise any one of these theories. They capture different aspects of our overall affective capabilities. The point here is that artifacts can influence these different features of affect.

So, for example, an evaluative artifact may include a communist propaganda poster depicting workers as to induce appraisals of pride in some observers, an app on your smartphone with the capacity to detect poisonous mushrooms may induce appraisals of fear, and a metal detector at an airport may scaffold the guards in evaluating whether a person or piece of baggage may be dangerous. A feeling artifact may include a piece of clothing, a handbag, or a vintage car as these induce bodily feelings of warmth, security, or safety. And, finally, a motivational artifact may include a self-help book, smoke detector, or a photo of a diseased person on a package of cigarettes, as these are made to tap into the motivational system and to nudge people to behave in certain ways. These categories pick out specific parts of the affective relational landscape between embodied agents and their artifactual environment. There is, however, overlap in these types of affective artifacts, e.g., an evaluative artifact may also motivate agents to act in a certain way.

So far, I have presented the categories of embodied, perceptual, cognitive, and affective artifacts separately, which is useful in characterising the specific properties of each category, but they sometimes overlap. A blind person's cane, for example, is embodied, perceptual, and cognitive. It's absorbed in the body schema, used to sense objects in the environment by having a direct causal connection to those objects, i.e., by having indexical properties. A measuring device (e.g., a speed meter) provides its user with an external representation that is used in performing a cognitive task. So, it's both perceptual and cognitive in nature. Lastly, a photo can trigger personal memories, but also generate affective states like nostalgia, so it can both cognitive and affective.

[5] These three aspects or features of emotion are not mutually exclusive and so some theories combine different aspects of emotion.

3 Definitions of animal tool-use

Since the 1960 and 1970s, animal tool-use has been put on the map of animal behavioral researchers, and there are now many definitions of animal tool-use in the literature (for helpful overviews and discussion see St Amant & Horton 2008; Bentley-Condit & Smith, 2010; Shumaker et al., 2011; Colbourne et al., 2021). Below I discuss four prominent ones.

- "Tool use is the use of an external object as a functional extension of mouth or beak, hand or claw, in the attainment of an immediate goal" (van Lawick-Goodall, 1970, p. 195).
- "Tool-using involves the manipulation of an inanimate object, not internally manufactured, with the effect of improving the animal's efficiency in altering the form or position of some separate object" (Alcock, 1972, p. 464).
- "Tool use is the external employment of an unattached environmental object to alter more efficiently the form, position, or condition of another object, another organism, or the user itself when the user holds or carries the tool during or just prior to use and is responsible for the proper and effective orientation of the tool" (Beck, 1980, p. 10).
- "Tool use is the exertion of control over a freely manipulable external object (the tool) with the goal of (1) altering the physical properties of another object, substance, surface or medium (the target, which may be the tool user or another organism) via a dynamic mechanical interaction, or (2) mediating the flow of information between the tool user and the environment or other organisms in the environment" (St Amant & Horton, 2008, p. 1203).

The first three definitions focus on using tools for practical purposes. The last definition is broader as it also includes cases where a tool mediates information flow. Information flow has two aspects, one has to do with mediating sensory input, the other with mediating communication. When a gorilla uses a stick to test the depth of water it is wading through, the tool extends the gorilla's sensory capabilities, in that way mediating sensory input. When a gorilla tears up and brandishes a sapling to discourage an intruder, it communicates to the intruder via the sapling, in that way mediating the communication. Robert St Amant & Thomas Horton point out that "when another organism controls a freely manipulable object to mediate the information perceived by another organism (i.e., to mediate or produce an influence interaction), this is tool use" (2008, p. 1205).

What all the above definitions have in common is that a tool is defined as an object that is embedded in occurrent perception-action cycles. The notion of "tool" is defined as an "external object", "inanimate object", "unattached environmental object", and "freely manipulable external object". The notion of "use" is characterised as bodily interacting with the tool in the here-and-now to achieve an immediate goal. The tool has to be interacted with during its use, otherwise it is not considered tool-use. Whilst Beck's definition has been the most influential in the literature, I find St Amant & Horton's definition most adequate, as it captures more sorts of animal tool-use than the other ones, also those to do with sensing and communicating. It carves out an important class of animal behaviours that we need to study and better understand.

Moreover, better understanding animal tool-use is important in and of itself, but also - as St Amant & Horton (2008) point out - because research on animal tool-use has influenced other research fields, including the study of the evolution of cognition (Sterelny, 2003), niche construction (Laland et al., 2000; Iriki & Taoka, 2012), cognitive science (Maravita & Iriki, 2004), human–computer interaction (Baber, 2003), robotics (St Amant & Wood, 2005), and philosophy of mind (Preston, 1998). Surprisingly, animal tool-use has almost been completely ignored in the philosophy of technology (but compare Shew 2017). One of the goals of this paper is to draw stronger connections between research on animal tool-use and the philosophy of technology.

My main issue with definitions of animal tool-use is *not* that they don't characterise tool-use adequately, but that tool-use as a behavioral category is too narrow. Why? Because it excludes bever dams, beehives, termite mounds, termite pheromone trails, bird nests, spider webs, pufferfish "crop circles", and the decorative structures made by bowerbirds. These are amongst the most cognitively sophisticated instances of animals modifying and using their environment to achieve their goals. Rather than changing or refining the definition of animal tool-use, what we also need is a definition of animal artifact-use. A tool is an object (e.g., a rock, stick, leaf, sponge, etc.) embedded in occurrent perception-action cycles that may or may not have been modified. Recall that a tool doesn't have to be a modified object and in case of animals, most of them aren't and are thus naturefactual. Recall that a naturefact is an unmodified object taken from its natural environment and used for some purpose. An example of an animal naturefact is a chimpanzee using a rock for some purpose. To the best of my knowledge, it seems that all animal naturefacts are tools. An artifact, by contrast, is a material object or structure *modified* or *made* for some specific purpose. An example of an animal artifact is a bever building a dam. Animals making these artifacts are very clever and competent engineers and niche constructors with the capacity to make complex structures to perform a function. We need to cast our net wider and also focus on animal artifact-use if we want to properly compare the way animals and humans modify and use their environment for their purposes.

In case of artifacts, we need to distinguish between "making" the artifact and "using" it. Animal artifact-making can be characterised as creating or modifying a material object or structure as to achieve a goal, either immediately or at some later point in time. The making or constructing of artifacts can be done in at least three ways (Arib et al. 2021). First, various objects can be *added* together as to make a larger artifactual structure such as, for example, a bird's nest. Second, parts of an object can be *subtracted* such as, for example, when a chimpanzee removes parts of a small stick as to make it more efficient to extract ants from a nest. Finally, objects can be *transformed*, for example when a New Caledonian crow bends a straight wire into a wire with a hook. Using an artifact, by contrast, is realising its function. One difference between a tool and an artifact is that artifacts can realise their function without the animal directly interacting with it. We need a more liberal interpretation of "use". In case of artifact-use, use doesn't mean directly and physically interacting with the artifact. Tools have to be manipulated in the here-and-now, but artifacts do not. A beaver can use its dam when it's creating a pond. A bowerbird's bower is used when a female is merely looking at it.

My definition of animal artifact-use excludes using (or collaborating with) other organisms (either conspecifics or another animal species) to achieve a goal. When dolphins are hunting in groups, they collaborate to catch prey. In some sense, they are "using" each other for some mutually beneficial goal. But on my view, this doesn't count as *artifact*-use. Symbiotic relationships between different animal species are also excluded. So, for example, a symbiosis between a clownfish and an anemone is not an instance of artifact-use. The anemone (which is poisonous for other fish but not for the clownfish) provides the clownfish with a safe environment. In return, the clownfish provides food to the anemone, helps to get rid of harmful parasites, and chases away fish like butterflyfish that feed on anemones. In cases of symbiosis, two organisms enter into a mutually beneficial relation and, in some way, can be said to "use" each other. But on my view, this doesn't count as *artifact*-use.

My definition also excludes animal auditory communication systems. Many animal species have auditory communication systems. Meerkats, for example, have guards that are on the lookout, scanning for dangerous animals. These use different sounds to indicate whether a predator is coming over land or from the air. Other animal species with auditory communication systems include dolphins, chimpanzees, elephants, and many others. Their communication systems include sounds with a specific meaning (semantics) and some of these systems even have a form of grammar (syntax) (Zuberbühler, 2019). This is very impressive but including intentionally made sounds to communicate to other animals in a category of artifacts is stretching the definition too far. In my view, artifacts are *material objects* or *structures*. A sound is not an artifact, but a communicative act. However, some animals communicate with scent. For example, some animals demarcate their territory with scent. Wolfs mark their territory by urinating on specific scent posts, as to communicate to other wolfs what their territory is and to stay away. They create a material trace that serves some purpose, so it can be seen as an artifact.

4 The use of tools and artifacts in animals

Up to now, I've presented a taxonomy of artifacts and discussed definitions of animal tool-use, arguing that we need to cast our net wider and also look at animal artifact-use. In this section, I analyse how animals use tools and artifacts on the basis of the categories identified above.

4.1 Embodied tools and artifacts

There are many cases of embodied tools and artifacts in animals. Chimpanzees use rocks to crack open nuts. They sometimes do so by first placing the nut on a hard surface and then use a small rock in their hands to repeatedly hit the nut until it cracks open. Young chimpanzees learn this from older chimpanzees, and it may take them years to fine-tune their bodily technique. Dolphins use a sponge in their mouth when they forage the seabed, in that way protecting their rostrum. Sometimes animals modify tools, in that way creating artifacts. A New Caledonian crow has bent a straight wire into a wire with a hook, as to use it to retrieve food from a cavity, making and using an artifact (Weir et al., 2002).[6] But because it is embedded in occurrent perception-action cycles, it is also a tool.

There are no phenomenological data on this sort of tool and artifact-use, and we know very little about the body schemas of chimpanzees, dolphins, and crows. We only have observational and behavioral data. So, whether these tools and artifacts are absorbed in the body schema and experienced as transparent extensions of their motor system remains unclear. What is clear from the observational and behavioral data is that they are very skilful in how they use these embodied tools and artifacts. It is certainly possible that animals feel as though the tool or artifact is embodied in a phenomenological manner, and research suggests this may be the case in Japanese macaques.

Angelo Maravita and Atsushi Iriki (2004) summarise previously done research in which Japanese macaques were trained to use a rake to retrieve food on a table and investigated the effect of this on their body schema. Whilst macaques rarely exhibit tool-use behaviour in their natural habitat, in a few weeks they can be trained to become skilful rake-users. When a piece of food was put on a table beyond the reach of their hands, the macaques skilfully used a rake to pull the food closer. In real-time, brain activity was recorded from the intraparietal cortex, which is where somatosensory and visual information is integrated. Researchers specifically focussed on bi-modal neurons, which are neurons responding to both somatosensory and visual stimulation. After using the rake, some of these bi-modal neurons expanded to code the space now accessible with the rake. So, the extended reach enabled by the rake, induces changes in how they perceive space. Maravita and Iriki suggest that these neurons may constitute the neural substrate of use-dependent assimilation of the tool into the body schema. This indicates that macaques can be trained to use (human-made) embodied tools, which possibly feel like a transparent extension of their motor system.

4.2 Perceptual tools and artifacts

An adult female gorilla has been observed using an unmodified branch to sense how deep the water is. She slowly walked into the water and when she was waist deep in it, she walked back to grab a straight branch of approximately 1m long and 2cm thick. She grasped the branch firmly with her right hand and repeatedly prodded the water in front of her with the end of the branch to test how deep it is (Breuer et al., 2005). The branch has indexical properties, as there is a direct causal connection between the gorilla's sensory states and the depth of the water, facilitated by the branch. It allows her to get information beyond the reach of her senses and use that information to navigate the water. This is somewhat similar as a blind person using a cane to sense objects and structures in the environment (Merleau-Ponty, 1965). For the blind person, the cane is experienced as a transparent extension of the motor system,

[6] The wire is of course already an artifact, as it is a human-made object. But because the crow modifies it to achieve its goals it also becomes an artifact for the crow.

allowing the person to sense objects in the environment. Whilst the gorilla isn't blind, she uses the branch to sense something that is beyond her visual reach. Whether and how transparent the branch is, is difficult to say, but it appears embodied to some degree, and the focus is on the branch-environment interface, not on the hand-branch interface.

Hilton Japyassú and Kevin Laland (Japyassú and Laland 2017) argue that when spiders build their web, they extend their cognitive system (see also Cheng 2020). Applying the mutual manipulability criterion, they argue that there are reciprocal causal links between the spider and its web, in that way constituting an extended cognitive system in the sense of Andy Clark and David Chalmers (Clark and Chalmers 1998). My goal here is not to evaluate whether or not the spider actually extends its cognitive system, but to conceptualize its web as a perceptual artifact. It's a structure *made* by the spider (and is thus artifactual) to catch prey, but also allows the spider to sense the prey in its web. The spider senses the vibrations caused by a prey caught in the web with its legs. It constantly monitors any vibrations and can locate the prey in its web on the basis of these vibrations. The web has indexical properties, as there is a direct causal connection between the spider's sensory states and the location of the prey in its web, facilitated by the web. Because both the branch and web exhibit indexical properties, they share some features with cognitive artifacts.

4.3 Cognitive artifacts

Termites secrete pheromones from an abdominal gland when they are foraging for food, leaving behind a trail for the orientation and recruitment of other termites from the nest to the food sources. These pheromones are secreted when a termite presses its abdomen to a surface. There are at least two sorts of trails: exploratory trails and recruitment trails, the difference between the two may be both quantitative and/or qualitative. Scout workers will explore the area for food and leave exploratory trails. When they have found food, they will trace back the original trail but will add more pheromones or a different type of pheromone, in that way creating a recruitment trail. The recruitment trail indicates how rich the resource is and will attract other forager termites to follow the trail to the food source (Wen et al., 2014). Once the resource is exhausted, returning workers no longer lay down a pheromone trail, which then soon dissolves. In discussing this example, first consider a quote from Daniel Dennett on cognitive offloading.

> "Our brains are modestly larger than the brains of our nearest relatives (…) but this is almost certainly not the source of our greater intelligence. The primary source, I want to suggest, is our habit of offloading as much as possible of our cognitive tasks into the environment itself - extruding our minds (that is, our mental projects and activities) into the surrounding world, where a host of peripheral devices we construct can store, process, and re-represent our meanings, streamlining, enhancing, and protecting the processes of transformation that are our thinking. This widespread practice of off-loading releases us from the limitations of our animal brains" (Dennett 1996, p. 134).

Dennett here suggests that our animal brains are limited, that cognitive offloading allows us to transcend these limits, and that offloading is the source of our intelligence. It's not our biological brains in themselves that make us smart, rather it's offloading information storage and processing functions onto the environment and then using that offloaded information for the cognitive tasks we're doing (Risko & Gilbert, 2016). So, our interactions with cognitive artifacts is what makes us smart (Norman, 1993).

To what extent do animals engage in cognitive offloading? Pheromone trails by termites (and other social insects such as bees) and pheromone marking by wolfs (and other mammals such as elephants) can be seen as a form of cognitive offloading. But what sort of offloading is this? The function of pheromone trails made by termites is to communicate to conspecifics of the same colony where food is located. The function of pheromone markings made by wolfs is to communicate to conspecifics outside the pack where the borders of the territory are and to stay away. So, termites make a network of roads in which the kind of road indicates where it leads to, whereas wolfs create warning signs around their territory. These pheromones respectively signify "follow this route to get to food" and "do not enter". In Peirce's terminology, these can be seen as material symbols, because the meaning of the pheromones is determined socially, as conspecifics know how to interpret the scent. In case of pheromone trails, there is also a direct causal connection between the location of the food source and the pheromone trail. So, it also has indexical properties. These pheromone trails are information pathways, guiding termites' navigation through their environment. At first it may perhaps seem surprising that of all the animal species discussed in this paper, the one with the smallest brain is the one that engages in the most advanced sort of cognitive offloading. But it's because of their limited brains, that they engage in this sort of offloading.

A final example is Kanzi, a male bonobo who learned to communicate by means of "lexigrams", which are symbols with an arbitrary structure, not like pictures or Egyptian hieroglyphs. Kanzi was extensively trained by primatologist Sue Savage-Rumbaugh (1996) to use a lexigram keyboard consisting of 256 printed symbols, each the equivalent of an English word. Kanzi could learn to associate a spoken word with an (arbitrary) symbol for that word on a keyboard. When a word was uttered, Kanzi could point to the lexigram representing it. Kanzi could also communicate what he wants (e.g., kinds of food) by pointing to or touching the lexigrams. These lexigrams thus mediate the communication between Kanzi and his caretakers. They are symbols in Peirce's terminology because they obtain meaning in virtue of a shared social agreement between Kanzi and his caretakers. To what extend this truly transforms Kanzi's cognition is unclear. Animal cognition researcher Joseph Call puts it as follows: "It is true that symbols may enhance the use of abstraction by allowing subjects to make explicit judgments about relations or by giving them a vehicle for the expression of their abstract mental representations, but it may not create those mental representations in the first place. Similarly, a symbolic code (or a history of enculturation) does not substantially alter the motivation to communicate with others" (Call, 2011, p. 15). However, what it does show is that when trained and enculturated, a bonobo can learn to use external symbols to communicate, in this way offloading his cognitive-communicative processes onto a (human-made) artifact.

4.4 Affective artifacts

Male bowerbirds of New Guinea and Australia make elaborate and complex structures as part of courtship rituals. These structures are referred to as "bowers" and contain little clustered sticks put in the ground vertically, decorated with leaves, flowers, shells, and sometimes also plastic objects. Female bowerbirds evaluate these structures in terms of their "aesthetic" properties. These structures are thus made to induce an evaluative state in the female. Given the aesthetic properties of bowers, Diamond (1986) has referred to them as "animal art".

Similarly, small male pufferfish of approximately 10cm build large and complex geometric structures in the seabed to attract females. These structures are sometimes referred to as "crop circles", they are approximately 2m in diameter and contain an outer ring and a central region. The circle consists of radially arranged deep ditches in the outer ring region, and maze-like shallow ditches in the central region (Mizuuchi, Kawase, Shin et al. 2018). Constructing it can require 7–9 days. During the construction, the pufferfish also decorates some of the peaks with shell and coral fragments (Kawase et al., 2013). If the pufferfish is successful in attracting a mate, the "crop circle" will function as a nest to lay eggs in. Researchers argue that "it appears reasonable to assume that females visiting male nest sites evaluate nest characteristics and that these characteristics play an important role in female mate choice" (Kawase et al., 2013, p. 4).

I think these two examples can be seen as animals creating and using an affective artifact. The function of these decorative structures is to generate an evaluative state in a female. Female bowerbirds and pufferfish have to evaluate the aesthetic properties of the male-built structure. Is it not clear exactly how they do this. They may evaluate the location, size, symmetry, and/or complexity. But what does seem clear is that they *evaluate* something about the structure. There is competition between different "crop circles" and bowers. Some are even destroyed by other male bowerbirds, and some are perceived by females as better than others. Given that evaluative states are affective states, bowers and "crop circles" can be seen as affective artifacts; in terms of Viola (2021) primarily as evaluative artifacts, but perhaps also as motivational artifacts as they motivate female bowerbirds and pufferfish to either mate or not to mate. We don't know what phenomenology is associated with this evaluative perception, but it's possible that bowers and "crop circles" influence the appraisal system in bowerbird and pufferfish.

5 (How) is human tool and artifact-use unique?

Up to now, the analysis has shown that some animals use embodied, perceptual, cognitive, and affective artifacts. These are clever and sophisticated instances of animals using tools or artifacts, showing a high level of intelligence and an ability to construct their niche. Humans are thus not unique in the kinds of tools and artifacts we use. The difference is in degree, not in kind. In this sense, de Waal (2016) is thus right in stressing the continuity between animal and human tool and artifact-use. However,

Table 1 A list of types of tools and artifacts and one animal species that uses them

Embodied tool	Chimpanzee using a rock to crack open a nut
Embodied artifact	New Caledonian crow using a bent wire to retrieve food
Perceptual tool	Gorilla using a stick to sense how deep the water is
Perceptual artifact	Spider using its web to sense whether it has caught a prey
Cognitive artifact	Termite laying down pheromone trails indicating where food is
Affective artifact	Bowerbird's bower to impress female

as I argue below, the difference in degree is very significant and is increasing with each generation.

What is unique in the way humans use tools and artifacts is our flexibility and openness to incorporate tools and artifacts into our practices. We are "natural-born cyborgs" (Clark, 2003): creatures that naturally form hybrid systems with technological artifacts that are deeply incorporated into our motor, perceptual, cognitive, and affective systems, in that way defining our capabilities, mind, and identity in important ways (Heersmink, 2017). Our embodied brains have an openness to rely on material culture in a way that is unique in the animal kingdom. One animal species may use an embodied artifact (e.g., a New Caledonian crow), another animal species may use a perceptual artifact (e.g., a spider), another may use a cognitive artifact (e.g., a termite), and yet another species may use an affective artifact (e.g., a bowerbird); however, there is no other animal species that use tools and artifacts in all the richness and complexity that humans do. Yes, in some ways, we are on the same spectrum as other species, in that some other animals can use tools and artifacts in all the four identified categories, but it is clear that we are very far removed from other animal species on that spectrum.

Focusing on tool-use, Matteo Baccarini & Angelo Maravita (Baccarini & Maravita 2013) , 77,78) point out that "while other forms of animal tool use are basically stereotyped and relatively simple, only humans can use them in complex and flexible ways, so that the very same tool can be used in different contexts and for accomplishing different tasks". Our improvisation skills (enabled by our imagination and reasoning skills) are much more developed, allowing us to use tools for tasks they weren't designed or intended for (e.g., using a hammer as a paperweight). Conversely, we can also use different tools and artifacts for the same task (e.g., using a shoe to hammer nails into a wall). Another difference is that most of the tools we use aren't made by the user but by others. In case of humans, the division of labour between the makers and users is often such that most users never make a tool in their life, though they may occasionally improvise and use a tool or artifact in a way that it wasn't designed or intended for. We even have rules of etiquette for using embodied tools. For example, in some cultural settings, cutlery is expected to be used in a certain way or in a certain order. So, in some cases, the use of tools has a normative component.

Chimpanzees, our closest evolutionary cousin, use different sorts of embodied tools such as a rock to crack open a nut or different types of sticks to get termites out of a mound. For this reason, they are referred as having a "tool set" (Sanz et al., 2010). However, the variety of human embodied tools and artifacts is of a different scale. We use pens, cutlery, spades, brushes, hammers, screwdrivers, cricket bats, but also more advanced technologies such as robotic telepresence surgery systems, exoskeletons, and neuro-electronic prostheses. Indeed, some professions are characterised by the sorts of embodied tools and artifacts they utilize. Carpenters, painters, artists, mechanics, surgeons, and other professions are partly characterised by the kind of embodied tools and artifacts they use in their practices. It seems that human body schemas are much more flexible and open to incorporate a large variety of complex tools and artifacts. A final point of difference I want to present is that humans integrate tools and artifacts, not just in their body schema, but in their biological body[7]. Prostheses for arms and legs are now relatively common across most human cultures. These are physically attached to the human body and sometimes even directly integrated with the central nervous system of its user, allowing a bi-directional communication between the prosthesis and the brain (Srinivasan et al., 2019), in that way constituting a cyborg technology.

The versatility of our perceptual tools and artifacts, too, is unparalleled. A gorilla can sense how deep the water is with a branch and a spider can sense a prey in its web. However, the human use of perceptual tools artifacts correcting deficiencies (e.g., glasses and hearing aids), enhancing well-functioning perceptual systems (e.g., microscopes and stethoscopes) and those that allow us to see beyond the limits of our perceptual systems (e.g., radar systems and MRI scanners) goes much further. We can even add new sensory capabilities such as a small device attached to our body (called North Sense) that vibrates when we face north, transforming our experience in unexpected ways (Wheeler, 2019). After using North Sense for a while, users report that spatiality and location play a more central role in their episodic memories. Sensing, measuring, and mapping our world with perceptual tools and artifacts puts us in a better position to understand and manipulate it, creating enormous progress for virtually all fields in engineering, science, and trade. It is safe to say that the history of measurement is one that created significant progress for the human species.

The diversity and complexity of human cognitive artifacts in relation to pheromone trails is staggering. Pheromone trails are material symbols with indexical properties. It's very clever that termites have evolved ways to create such information pathways, allowing them to navigate their environment. One key difference between pheromone trails as cognitive artifacts and human cognitive artifacts is transmissibility. Pheromone trails disappear when they are no longer useful. Human cognitive offloading creates enormous benefits because it allows us to pass on important information from generation to generation, which is referred to as "downstream epistemic engineering" (Sterelny, 2003). Importantly, we don't just inherit our parents' cognitive artifacts, we also improve them. The ability to store and transmit information across time in clay tables, papyrus scrolls, paper, and more recently computers, has propelled human material culture into realms of unmatched complexity. Importantly, humans don't

[7] A reviewer pointed out that some animals self-medicate by modifying leaves of medicinal plants into balls before swallowing them whole (Shurkin, 2014). So, technically what these animals incorporate into their bodies are artifacts, namely objects intentionally modified for a purpose. This is a neat example, but the difference with prostheses is that these modified leaves aren't integrated into the body schema, are not used to act on the world, and in this sense aren't embodied artifacts in the way that prostheses are.

just use artifacts for navigating, but also for other cognitive tasks such as calculating, reasoning, visualising complex problems, etc. And one type of cognitive artifact that animals don't make and use are icons, external representations exhibiting a similarity to its target domain (such as a drawing, painting, map, or scale model). Offloading a pheromone trail is relatively straightforward compared to offloading iconic information by drawing, painting, designing, or modelling.

It's very impressive that some animals can make aesthetic structures. But the two species known to engage in this behaviour do so in a stereotyped manner. Each can only make one sort of structure in a (probably) instinctual manner. To date, there is no research (that I am aware of) suggesting that bowerbirds or pufferfish learn how to make these structures from conspecifics. Human art is much more diverse and complex, ranging from sculptures, architecture, paintings, cinema, literature, poetry, installation art, and so on. Human creativity and creative output are unparalleled, engaged in by humans of all ages and both sexes, playing more social and cultural roles than merely as displays in courtship rituals.

Finally, tools and artifacts have a strong transformative effect on their users. We have a co-evolutionary relation with the tools and artifacts we use, that is almost certainly missing in other animal species. We started using embodied tools and artifacts approximately 3.3million years ago, when we developed the first handaxes, thereby initiating a cascade of technological innovations that has had a deep transformative impact on us as individuals and society at large. Paraphrasing McLuhan (1964), first we shape our tools and then our tools shape us. Animal tool-use, clever as it is, has never evolved much further than semi-instinctual and stereotyped behaviours. Whilst chimpanzees may learn from other chimpanzees how to use stones and sticks as tools, transmitting tool-using techniques across generations and thus exhibiting some form of culture, their tools aren't improved. Current humans stand in relation to a long evolutionary history of tool and artifact-use (Madary, 2021). The cultural evolution of tools and artifacts is characterised by what Tomasello (1999; Tomasello et al., 1993) refers to as the "rachet effect", which means that we improve existing tools and artifacts and pass on those improvements to the next generation. Each new generation is born into the informational and artifactual environments created by parent generations. In this sense, human tools and artifacts are the result of cumulative processes, explaining why current technology is much more complex than previous technology. Chimpanzees - by contrast - "do not seem to accumulate modifications over time with any kind of ratchet effect" (Tennie et al., 2009, p. 2413). This is not a difference in degree, but a difference in kind. Please note that this difference in kind is a difference in the way artifacts and the manner in which they are manufactured evolve over time, it's not so much a difference in the use of artifacts[8].

Importantly, the ratchet effect is speeding up, almost exponentially. The stone age lasted more than 3million years and it took approximately 100.000 generations to improve the Acheulean handaxe; the bronze age lasted approximately 2000 years; and (depending on the region) the iron age lasted between 2500 and 400 years. In these periods in human history, increasingly complex tools and artifacts were made

[8] A reviewer pointed out that it's possible a ratchet effect can't get off the ground in animal species because their manufacturing is so minimal.

and passed on to the next generation. The computer age has only just begun but has, within a century, generated an enormous amount of informational, artifactual, and computational complexity. In just a couple of decades, we went from the first digital general-purpose computer (the ENIAC, made in 1945) to the internet, smart phones, virtual reality, and artificial intelligence. Put bluntly, we went from cave paintings to virtual reality in 45.000 years, which is only approximately 2250 generations. Extrapolating this trend to the future, it looks like the human species is facing accelerated technological change, significantly transforming the tools and artifacts we use to achieve our goals. This will continue to increase the distance between humans and other species on the spectrum of tool and artifact-using organisms.

6 Conclusion

This paper analysed how instances of animal tool and artifact-use can be classified according to the four identified categories, concluding that some animals use embodied, perceptual, affective, and cognitive artifacts. Humans are thus not unique in the kinds of tools and artifacts we use. However, the flexibility and complexity of the way in which humans use tools and artifacts is unprecedented. We may not best be characterised as Homo faber, because making and using tools and artifacts is not uniquely human, but we are natural-born cyborgs, creatures that naturally form hybrid systems with a variety of complex technological artifacts that are deeply incorporated into our motor, perceptual, cognitive, and affective systems. The co-evolutionary relation between embodied human agents and technological tools and artifacts - realised through cumulative processes, specifically the ratchet effect - is unique in the animal kingdom.

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