



## Types of technology

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### ARTICLE INFO

#### Article history:

Received 29 November 2009

Received in revised form 24 January 2010

Accepted 25 January 2010

#### Keywords:

Technology

Evolution

Animal

Human

Tool

Machine

Networks

Technological systems

Stigmergy

### ABSTRACT

Technology is a concept rife with confusion. Here, I argue that technologies can be distinguished as a combination of type of producer and an idealized artefact life history. Using this definition, a number of technologies are identified. The first technology historically, in the Protostomes, was the production of individual or family dwellings. Next came objects such as spider webs for trapping prey. Stigmergy followed, with the social insects, as a collective endeavour to construct a mega-structure using simple rules of accretion. Some birds and primates began to make tools, or simple technological objects whose function is closely related to their form. Humans are distinguished by their ability to make machines. Traditional technology took place once people voluntarily organised into groups with specialised knowledge to produce more complex objects and structures. Monumental objects like ceremonial pyramids came with the command economies of the early agrarian societies, which also resulted in a new category of artefact, the network. Finally, with modern civilizations came ad hoc accretion, or population-level addition, to make truly complex technological systems. Developing a theoretical framework within which artefacts, production processes and ways of interacting with them are identified should help the study of technology to become more scientific.

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### 1. Introduction

Many historians suggest that technology is the driving force in history [1–6]. This claim has become so prevalent that it's recognized as a doctrine, called 'technological determinism' [7]. Technological superiority is what allows certain groups to conquer or subjugate others, and so expand their domain of influence [8–11].

Technology is also what separates us from every other creature on Earth. After all, the best chimpanzees can do on this front is to use small stones to break nuts open on large stones [12], whereas we build skyscrapers and rocket to the moon. Indeed, it seems blindingly obvious if one just looks around a modern city while thinking of the chimpanzee's forest habitat that technology is what separates us from the rest of creation. Technology thus appears to be a central driver of events we care very much about – human evolution and history – yet we have a very poor understanding of how it evolves. To understand the human condition, we must be able to explain how human technology has become increasingly complex, and increasingly central to modern life, while the technology of other species remains mired in a much more primitive state.

However, a problem arises at this point. Historians don't have the conceptual tools to deal with growing complexity – they may compare one civilization to another, but they aren't in the business of explaining how humans differ from other species. They leave that task to archaeologists and paleoanthropologists. But these 'pre-historians' don't have a commonly held, widely accepted notion of what technology is either, much less a theory of how it changes, while anthropologists have tended to argue that a variety of different features make humanity unique – ranging from opposing thumbs and bipedality to grammatical language and consciousness – but generally ignore technology.

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Thus, we are left with only a commonsense understanding of technology derived from our direct experience of its effects on our everyday lives. This understanding is vague, as reflected by the definitions of technology currently circulating: ‘a body of knowledge used to create tools, develop skills, and extract or collect materials’ (<http://science.education.nih.gov/supplements/nih4/technology/other/glossary.htm>); ‘the practical application of knowledge especially in a particular area’ (Merriam-Webster dictionary); ‘a broad concept that deals with a species’ usage and knowledge of tools and crafts, and how it affects a species’ ability to control and adapt to its environment’ (<http://en.wikipedia.org/wiki/Technology>). It is difficult to know what counts as technology given this heterogeneity – is it a body of knowledge, the application of that knowledge to some domain of action (e.g., arts and crafts), the results of a particular kind of action (e.g., tools), or all of these? [13].

The result of this amorphous conceptualization is that we can only describe changes in technology in the form of historical narratives (e.g., the Industrial Revolution), or imagine alternative worlds and futures not dominated by technology as a moral critique of this force in our lives [14,15]. What we cannot do is predict how technology will change our lives. Science has thus far only been associated with technology at the ‘front end’ – with innovation, by applying science in engineering – not at the ‘back end’, when the innovation has an impact on our way of life.

This is unfortunate, especially given the central place of technology in contemporary life. A more scientifically meaningful and empirically fruitful concept of technology would be of great service. The objective of this paper is therefore to provide a better understanding of what kind of phenomenon technology is, and the ways in which technology has changed over evolutionary time.

### 1.1. A uniformitarian approach

Part of the reason we have only a primitive understanding of technology, I argue, is that human technology has been conceptually separated from similar activities in other species. Human beings are able to produce very complex artefacts, ranging from automobiles to skyscrapers and globe-encircling computer networks. No other species produces such a range of artefacts. Indeed, the incredible gap between what we and our closest relatives, the apes, are capable of producing in this regard causes many to assert that there is no evolutionary continuity along this dimension of life [16,17]. Rather, human technology is something altogether *sui generis* – that is, without a prior history in other animals. Thus, in anthropology textbooks, for example, there is no mention of ‘animal architects’ [18–20]. This might be thought to be due to the traditional concern (evident in the name of the discipline) with only human phenomena. But such textbooks treat other aspects of non-human primate life-ways as evolutionary foundations for human developments, such as social organisation, brain evolution, life history differences, and reproductive strategies. Then there are the histories of technology, which sometimes dwell briefly on the perceived origin of technology in primitive tool-making by chimpanzees, or with Neanderthal grave-goods, but then swiftly move on to accounts of Greek arches and the Industrial Revolution [21,22]. Even in books explicitly concerned with the evolution of technology, there is no mention of non-human technology [16,23].<sup>1</sup> Current thinking about technology is therefore largely non-uniformitarian: human technology is ‘something else’.

Admittedly, the standard story of human technological transformation – which begins with *Homo habilis* (‘handy man’), the oldest human genus – is a compelling one. The handaxes and choppers produced by these early hominids seem about as simple a kind of artefact as can be imagined: roundish stones with only minimal modification to make them serve a bit better as cutting implements. The story then continues through the making of complex tools, machines, the advent of science, and ends in the present day with a dizzying array of high-tech gadgets and technological paraphernalia.<sup>2</sup> In this view, the story of human evolution is coincidental with that of how technology has developed [22]. The human-based story also seems to be complete in an evolutionary sense: it begins, as it should, at the simplest possible origin and dramatically ends in contemporary times, with our incredible diversity of complex technological phenomena, grown from this simple seed.

However, there are several important advantages to rethinking the nature of technology such that it links human and non-human artefact production together. First, if human technology did evolve from non-human progenitors, then our picture of the origins and perhaps later evolution of technology could look different. Identifying common features of human and non-human technology might transform our understanding of how aspects of human technology arose. Second, if human and non-human technologies are members of the same category of phenomena, then better theory about technology will come from considering them together, because that theory will then cover its proper domain.

I will argue here in favour of a ‘continuity thesis for technology’ which suggests that human technology is an evolutionary phenomenon with its roots in the technologies of related species. Further, I will argue that, like other evolutionary phenomena, the evolution of complex artefacts has taken place through a sequence of developments in phylogenetic time. This story will be told in terms of a sequence of steps, arising from mechanisms which are clearly understandable and motivated by selectionist logic [27].

<sup>1</sup> The opposite is not so true: studies of non-human animal technology consider some aspects of how these precedents led to human manifestations. In particular, comparisons are made between the means of production – that is, the presence or absence of specific mental abilities in animals or humans – and resulting artefacts of animals to human constructions [24,25]. For example, animal technologists suggest that many types of trap made by animals have human equivalents, or that the walls of a termitarium are less subject to cracks than human-built mud houses. There are also discussions of how human and animal tool use are systematically different, [26] or how human technological psychology differs from that of animals, with suggestions that humans have a ‘naïve’ or ‘folk’ physics which provides a sense of cause–effect relationships that support complex artefact production [24]. However, this literature has not produced a systematic story of how human technology evolved from antecedents in other species.

<sup>2</sup> Note that archaeologists tell the beginning of this story, then pass the torch to the historians of technology to tell what happens after the rise of civilization. So it currently takes two disciplines to tell the story of human technological advance.

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