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# Beyond the Bounds of Cognition

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## Abstract

One of the questions that frequently come up in discussions of situated, embodied and distributed cognition is where to draw the boundary between cognisers and their environment. Adams and Aizawa (2001) have recently formulated a critique of what they consider a “radical view of tool use”, i.e., the view of tools as part of the cognitive system. We analyse their critique and show that much of what they consider ‘radical’ turns out to be compatible with what they consider ‘common sense’. Hence, we argue that much of the debate boils down to a disagreement over different uses of the term ‘cognitive’, whereas there is growing agreement about the central role that agent-environment interaction in general, and tool use in particular, play in cognitive processes. We therefore suggest to drop the ‘bounds of cognition’ debate, and conclude by raising what we consider more important questions in the study of cognitive tool use.

## Introduction

The question exactly where to draw the boundary between a cognitive system and its environment is as old as the study of mind itself. Polanyi (1964) and Bateson (1972) illustrated the question with the now classical example of a blind man using a stick, and asked what the bounds of the blind man’s system are. More specifically, does it or does it not include the stick? Another classical example, that of the knot in the handkerchief, comes from Vygotsky (1978), who argued that the knot serves as a reminder that changes the psychological structure of the memory process, and it extends the operation of memory “beyond the biological dimensions of the human nervous system” (ibid., p. 39). Vygotsky emphasised in particular the role of cultural artefacts in both evolutionary and individual development, elaborating that in “[t]he use of notched sticks and knots, the beginnings of writing and simple memory aids all demonstrate that even at early

stages of historical development humans went beyond the limits of the psychological functions given to them by nature and proceeded to a new culturally-elaborated organization of their behavior” (ibid. p. 39).

The question of the bounds of cognition received somewhat less attention during the first decades of cognitive science, which predominantly equated cognition with internal computational processes implemented by the brain and paid relatively little attention to the interaction of agents and environment. The question is currently going through a certain revival triggered by increasing interest in theories of *situated cognition* (e.g., Clancey, 1997; Suchman, 1987), *embodied cognition* (e.g., Clark, 1997; Varela, Thompson & Rosch, 1991) or *distributed cognition* (e.g., Hutchins, 1995), all of which emphasise the close coupling between agent and environment and its central role in cognitive processes.

This shift in what is considered the appropriate unit of analysis in the study of cognition has noticeably also led to a corresponding shift in the use of the term ‘cognitive’. While the term traditionally has been used mostly for internal processing, in the 1990s it started to appear in expressions like “cognitive tools” or “cognitive artifacts” (Norman, 1991, 1993). Furthermore, several authors have started to characterise the whole of humans and the technical tools they use, e.g., a pilot interacting with the instruments in her cockpit, or even a group of humans interacting with each other and the instruments on the bridge of a ship, as *one* ‘cognitive system’ (Hutchins, 1995) or as a “joint cognitive system” (Hollnagel, in press).

Others consider this a “radical view of tool use” (Adams & Aizawa, 2001), which blurs the distinction between cognitive agents and the non-cognitive tools they use (cf., for instance, Nardi, 1996; Neuman & Bekerman, 2000). Perhaps most notable among these critics are Adams and Aizawa (2001) who formulated a

detailed critique of several theories they consider guilty of going too far in blurring that distinction (Clark & Chalmers, 1998; Dennett, 1996; Donald, 1991; Hutchins, 1995). They defend a ‘common sense’ view, which they refer to as ‘intracranialism’, considering cognition as “restricted to the confines of our brains” (Adams & Aizawa, 2001, p. 44).

We will here argue that Adams and Aizawa, as well as other critics arguing along similar lines, might be tilting at windmills, since most of the views that they describe as ‘radical’ are in fact highly compatible with what they consider as ‘common sense’.

## The Bounds of Cognition

It is commonly agreed that humans use calculators, road signs, notes, calendars, computers, pen and paper, and even other people as external resources and as a way around the limitations of their own cognitive capacities. In other words, as Clark (1997, p. 68) formulated it, we “call on external resources to perform specific computational tasks”<sup>1</sup> and thus depend on cultural artefacts to “augment and enhance biological cognition” (Clark, 1999, p. 350).

Consider, for example, the use of Scrabble tiles (Clark, 1997; Clark & Chalmers, 1998; Kirsh, 1997; Kirsh & Maglio, 1994). As described by Clark (1997), the tiles are physically ordered and re-ordered during play, thereby prompting our own on-line neural resources. We manipulate the tiles externally and thereby create a variety of fragmentary inputs (new letter strings) capable of prompting the recall of whole words from the pattern-completing resource. It seems that our own biological resources do not easily provide for this kind of manipulations, which might therefore be considered as a set of operational capacities that emerge from the interaction between brain and world. That means, through the flexible use of environmental resources we enhance or augment our own cognitive abilities – we use such resources as scaffolds. The Scrabble tiles, for instance, scaffold our thinking, and, thus in a very real sense it can be said that “the re-arrangement of tiles on the tray is not part of action; it is part of *thought*” (Clark & Chalmers, 1998).

Consider a second example, provided by Clark (1999):

“Most of us, armed with pen and paper, can ... solve multiplication problems that would baffle our unaided brains. In so doing we create external symbols (numerical inscriptions) and use external storage and

manipulation so as to reduce the complex problem to a sequence of simpler, pattern-completing steps that we already command. On this model, then, it is the combination of our biological computational profile with the fundamentally different properties of a structured, symbolic, external resource that is a key source of our peculiar brand of cognitive success. The external environment, actively structured by us, becomes a source of cognition –enhancing ‘wideware’– external items (devices, media, notations) that scaffold and *complement* (but usually do not replicate) biological modes of computation and processing, creating extended cognitive systems whose computational profiles are quite different from those of the isolated brain” (Clark, 1999, p. 349, original emphasis).

The general point of both these examples, that cognitive processes can be complemented, augmented and transformed by environmental scaffolds, in particular the use of tools, is relatively uncontroversial. Adams and Aizawa’s critique, however, is directed at the idea of the environment as a “source of cognition” and the characterisation of agent and environment as an “extended cognitive system”. According to them, “common sense has it that *our cognitive faculties*, restricted to the confines of our brains, can be aided in any manner of ways, by cleverly designed *non-cognitive* tools” (Adams & Aizawa, 2001, p. 44, emphases added). That means, they agree that the coupling of internal cognitive processes with the environment can augment those processes, but they maintain that coupling “of some process with a broader environment ... [does not] extend that process into the broader environment” (ibid, p. 56). However, despite a certain disagreement over the use of the term ‘cognitive’, Adams and Aizawa’s position is highly compatible with, for example, that of Norman (1991, 1993). Norman used the term ‘cognitive tools’ for tools that enhance human cognitive abilities, and never intended it to refer to tools literally having any of the cognitive processes or abilities that humans are endowed with. Considering processes as extending into the broader environment is not necessarily the same as saying that the environment, or some part of it, actually comes to have human-like cognitive processes or capacities itself.

However, Clark and Chalmers (1998) who referred to their view of the extended mind as an “active externalism”<sup>2</sup>, argued that this is not just a matter of terminology, but much more a matter of methodology:

“... in seeing cognition as extended one is not merely making a terminological decision; it makes a significant difference to the methodology of scientific investigation. In effect, explanatory methods that might once have been thought appropriate only for the analysis of ‘inner’ processes are now being adapted for the study of the

<sup>1</sup> Adams and Aizawa, as well as several of the authors they criticise, refer to cognitive and brain processes as ‘computational’. This is, of course, not uncontroversial (cf., e.g., Clark, 1997), but the reader should not get distracted by this; the discussion in this paper is relatively independent of whether ‘computation’ is the appropriate term in all cases.

<sup>2</sup> To be distinguished from the ‘passive’ externalism of, e.g., Putnam (1975) and Burge (1979).

outer, and there is promise that our understanding will become richer for it" (Clark & Chalmers, 1998).

Concrete examples of extending the application of traditional cognitive scientific methods and terminology from 'inner' to 'outer' processes can be found in Hutchins' (1995) work on *distributed cognition*. Hutchins is concerned with cognition at a 'higher' level, such as team performance in ship navigation, i.e. inter-individual rather than intra-individual cognition. Analysing ship navigation, Hutchins (1995) showed how multiple embodied biological brains combine with tools (sextants, alidades, etc.), and media (maps, charts, etc.) during performance. The artefacts allow the human users "to do the tasks that need to be done while doing the kinds of things people are good at: recognizing patterns, modeling simple dynamics of the world, and manipulating objects in the environment" (ibid., p. 155).

In this type of analysis, Hutchins, as he pointed out himself, deliberately applied "the principal metaphor of cognitive science – cognition as computation – to the operation of this system" (ibid., p. 49). Adams and Aizawa (2001), however, argue that in doing so Hutchins "threatens to depart from common sense, toward Dennett's radical transcranial cognition" (ibid, p. 45), because "[i]f cognition is simply computation over representational states, and if one's tools, such as paper and pencil, form or contain representations, then one has a case for the radical view that, in at least some cases of tool use, cognition extends beyond the boundary of the brain" (ibid, p. 46). In Adams and Aizawa's view,

"... the kinds of computational processes we find operating over external representations, such as marks on a piece of paper ... will turn out to differ from the kinds of computational processes that we find operating over representations in brains. Compare the intracranial computation of the product of 347 and 957 from the computation of this product with pencil and paper. We may assume that there are computational processes at work in both cases, but that these computational processes are different. In particular, the internal processes are cognitive computational processes, where only some of the computational processes in the transcranial cases are cognitive. In particular, it will be only the internal portions of the transcranial computation that turn out to be cognitive" (Adams & Aizawa, 2001, p. 59).

They further argue that it is "obvious" that brain processes are "causally distinct" from the processes involved in tool use, such as 'moving beads up and down on rods in an abacus, or pressing buttons on an electronic calculator' (Adams & Aizawa, 2001, p. 44).

A similar critique was formulated by Nardi (1996) who argued that the conceptual framework of distributed cognition

"... views people and things as conceptually equivalent; people and artifacts are 'agents' in a system. This is

similar to traditional cognitive science, except that the scope of the system has been widened to include a collaborating set of artifacts and people rather than the narrow 'man-machine' dyad of cognitive science ... Treating each node in a system as an 'agent' ... leads to a problematic view of cognition. We find in distributed cognition the somewhat illogical notion that artifacts are cognizing entities. Flor and Hutchins (1991) speak of 'the propagation of knowledge between different individuals and artifacts'. But an artefact cannot know anything; it serves as a medium of knowledge for a human" (Nardi, 1996, pp. 86-87).

It should be noted that while Adams and Aizawa as well as Nardi might very well be right about the differences between human and machine 'computation' or 'information processing', their criticisms are nevertheless misguided in the sense that none of the criticised authors actually denied those differences. As the reader might have noticed in the above quotes, Clark (1999), for example, also referred to biological computation and external resources as "fundamentally different". Furthermore, he made it clear that he views the environment as a "source of cognition", but only in the sense that it complements, rather than replicates, biological computation and processing. Similarly, Hutchins (1995) explicitly pointed out that he uses the notion "cognition as computation" as a "metaphor" in the description of distributed cognitive systems, and he never denied the differences between intra-individual and inter-individual cognitive processes. Hence, much of what Adams and Aizawa (2001) characterise as a "radical view of tool use" turns out to be less radical than it might seem at first.

The same applies to Adams and Aizawa's critique of Donald (1991), whose view they consider "in many respects ... the same as Dennett's and Clark and Chalmers'" (p. 45). Donald's theory is concerned with 'exograms', or external representations, and the way they have impacted, in the course of evolution, the architecture of human cognition, allowing to off-load biological memory. Donald claims that "[t]he existence of exograms eventually changed the role of biological memory in several ways". While the first two evolutionary transitions increased the load on biological memory, "the final step in this tremendous cognitive expansion might have *reduced* the load on some aspects of biological memory, by gradually shifting many storage tasks onto the newly developed ESS [external symbol storage]" (Donald, 1991, p. 320, original emphasis).

According to Adams and Aizawa (2001), Donald implicitly refers to psychological laws of human memory and those will not generally hold for external memory storage. However, in Donald's (1991) description the biological and the external are two quite different things: while engrams refer to single entries in the biological memory system, exograms refer to single

entries in the ESS, and are considered external memory records of ideas. Even though both engrams and exograms are described in similar terms, exograms do not become biological, not even ‘implicitly’. In fact, Donald notes that systems of exogram storage are much more flexible than engrams and thus a symbolic information environment frees us from wholly depending on biological memory. He therefore concludes that a “cognitive system containing exograms will have very different memory properties from a purely biological system” (Donald, 1991, p. 315). Obviously, this is much in line with Clark’s (1999) aforementioned argument that extended cognitive systems of biological brains and external resources perform very differently than the ‘naked brain’ on its own. However, neither Donald nor Clark argue that hooking the biological system to external resources transforms the external into biologically cognitive entities, but in fact both are careful to point out the fundamental differences.

Bateson (1972), in the example of the blind man using a stick, argued that questions concerning whether a mental system is bounded by skin or skull, whether artefacts should be included or not, and so on, are in fact “nonsense questions”. Polanyi (1964) argued that “The way we use a hammer or a blind man uses his stick, shows in fact that in both cases we shift outwards the points at which we make contact with the things that we observe as objects outside ourselves. While we rely on a tool or a probe, these are not handled as external objects ... We pour ourselves out into them and assimilate them as parts of our own existence.” (Polanyi, 1964, p. 59)

Similarly, Bateson described the blind man’s stick as “a pathway along which transforms of difference are being transmitted”, and “the way to delineate the system is to draw the limiting line in such a way that you do not cut any of these pathways in ways which leave things inexplicable” (p. 465). Subsequently, the boundaries of cognition, as well as the appropriate units of analysis in the study of cognition, depend on what we want to explain. Human activities, for the most part, cannot be studied without considering things like the artefacts we use. Neither can artefacts be studied in isolation since in itself a tool is ‘nothing’ (Ingold, 2000). Hence it is only natural for cognitive scientists interested in situated, embodied and distributed cognition to choose as their units of analysis cognitive agents *in situ*, i.e. embedded in their environments. Whether or not such units of analysis should be referred to as extended *cognitive* systems, and whether or not the tools involved should be referred to as *cognitive* artefacts, is only a secondary question. What is important in the notion of ‘cognitive’ artefacts or systems is the recognition of a close coupling between the individual’s internal cognitive processes and the outer world.

## Beyond the Bounds

The close coupling between the individual and the outer world is realised through two major cultural mediators in human cognition, namely tools and language (Preston, 1998; Vygotsky, 1978). However, the role of artefacts and tools have mainly been left unattended while language, for instance, has received far more attention (Preston, 1998; Wynn, 1991)<sup>3</sup>. In language research there is “a sophisticated body of theory on how utterances are constructed. Nothing comparable exists for tool behaviour ... [t]here is almost no concern with how tools are made and used and there are no well-developed theories of how sequences of tool-use are constructed” (Wynn, 1993, p. 392). Others have also pointed out that development and tool use is largely an overlooked issue in cognitive development (e.g., Gauvain, 2001; Smitsman, 1997). However, artefacts and tools have a similar role in cognitive processes as that of language, “in particular they constitute the other major form of cognitive mediation between individual and world” (Preston, 1998, p. 514). Yet, we do not fully understand the relation between cognition and artefacts, and there are several unanswered questions. For instance, how should we understand the concepts ‘artefact’ and ‘tool’? While both terms can be grappled with intuitively (or folk-psychologically), there do not seem to be any coherent definitions of them. A related question, as pointed out by Preston (1998), concerns what objects and behaviours should count as tools and tool use, respectively.

For further development of theories concerning artefacts and cognition we should attend, for instance, research on tool making and tool use that has been conducted in the field of primatology (e.g., Boesch & Boesch 1993; McGrew, 1992; Taylor Parker, Mitchell & Lyn Miles, 1999). According to Tomasello (2000), human cognition is a particular form of primate cognition, since many structures of human cognition are identical with non-human primate cognition. Tomasello (2000) therefore argues that the study of non-human cognition can provide important information to cognitive scientists. Research in ape-language has, for instance, led to insights concerning the nature of language that might have been overlooked had we only focused on language in human children (e.g., Savage-Rumbaugh et al., 1998). Likewise, we might miss out aspects of tool use unless we take into consideration findings in the field of primate tool use. The other way around, primatologists have attended findings in cognitive science, e.g., by taking distributed cognition as a framework for analysis of social interactions

<sup>3</sup> In the field of AI, for example, there are thousands of papers on AI models of language, but hardly any studies of AI systems’ tool use (i.e. the use of tools by AI systems, rather than the use of AI systems as tools).

among non-human primates (Forster, 2002; Johnson, 2001; Strum, Forster & Hutchins, 1997). Such cross-fertilisation of areas (like cognitive science and primatology) might be advantageous for both fields.

When it comes to artefacts in the context of human activities, a lot of studies have focused on the *individual* level and it is commonly recognised that

“... the inclusion of a tool in the process of behavior ... abolishes and makes unnecessary several natural processes, whose work is accomplished by the tool; and alters the course and individual features (the intensity, duration, sequence, etc.) of all the mental processes that enter into the composition of the instrumental act, replacing some functions with others (i.e., it re-creates and reorganizes the whole structure of behavior just as a technical tool re-creates the whole structure of labor operations)” (Vygotsky, 1981, pp. 139-140, in Cole & Wertsch, 1996).

However, we need to consider the role of artefacts beyond the level of the individual - the question is, what kind of replacements do artefacts cause at a multi-individual level? We know that artefacts provide, e.g., an external means for organising cooperative behaviour (Hutchins, 1995; Susi & Ziemke, 2001), but how do artefacts effect cognition in shared activities? Distributed cognition clearly has taken a step towards explaining cognition at the multi-individual level. However, further work is needed in order to understand the role of artefacts in ‘higher’ level cognition.

## Conclusions

Should the bounds of cognition be drawn so as to include the artefacts we use? From the classical information processing view of cognition the answer is clearly ‘no’: cognition takes place solely within the boundaries of the brain. From a situated view of cognition, however, quite a different picture emerges: cognition is not purely what goes on inside the brain. Rather, cognition emerges from the interaction between brain, body and the environment (Clark, 1997), and in order to understand cognition, the units of analysis in cognitive studies need to be extended to include external resources brought into our activities. In addition, we need to take notice of findings in other fields of research, such as primatology, to a greater extent than presently done. As shown in this paper, the inclusion of artefacts as part of extended cognitive systems does not necessarily lead to illogical or absurd assumptions of artefacts coming to have human cognitive processes or abilities, as some have argued. It could therefore be concluded that debating where to draw the bounds of cognition to some extent simply is ‘much ado about nothing’. Where the boundary is drawn is not the main issue – more importantly, we need to attend the role of artefacts themselves in cognition.

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