

Philosophy

Query paper:

Title: Natural-Born Cyborgs?

Abstract: Cognitive technologies, ancient and modern, are best understood (I suggest) as deep and integral parts of the problem-solving systems we identify as human intelligence. They are best seen as proper parts of the computational apparatus that constitutes our minds. Understanding what is distinctive about human reason thus involves understanding the complementary contributions of both biology and (broadly speaking) technology, as well as the dense, reciprocal patterns of causal and co-evolutionary influence that run between them.

Candidate papers:

1. **Title:** Being there: Putting brain, body, and world together again

Abstract: Brain, body, and world are united in a complex dance of circular causation and extended computational activity. In *Being There*, Andy Clark weaves these several threads into a pleasing whole and goes on to address foundational questions concerning the new tools and techniques needed to make sense of the emerging sciences of the embodied mind. Clark brings together ideas and techniques from robotics, neuroscience, infant psychology, and artificial intelligence. He addresses a broad range of adaptive behaviors, from cockroach locomotion to the role of linguistic artifacts in higher-level thought.

2. **Title:** The extended mind

Abstract: Where does the mind stop and the rest of the world begin? The question invites two standard replies. Some accept the demarcations of skin and skull, and say that what is outside the body is outside the mind. Others are impressed by arguments suggesting that the meaning of our words “just ain’t in the head,” and hold that this externalism about meaning carries over into an externalism about mind. We propose to pursue a third position. We advocate a very different sort of externalism: an active externalism, based on the active role of the environment in driving cognitive processes.

3. **Title:** Intelligence without representation

Abstract: Artificial intelligence research has foundered on the issue of representation. When intelligence is approached in an incremental manner, with strict reliance on interfacing to the real world through perception and action, reliance on representation disappears. In this paper we outline our approach to incrementally building complete intelligent Creatures. The fundamental decomposition of the intelligent system is not into independent information processing units which must interface with each other via representations. Instead, the intelligent system is decomposed into independent and parallel activity producers which all interface directly to the world through perception and action, rather than interface to each other particularly much. The notions of central and peripheral systems evaporate—everything is both central and peripheral. Based on these principles we have built a very successful series of mobile robots which operate without supervision as Creatures in standard office environments.

4. **Title:** Magic words: How language augments human computation

Abstract: Of course, words aren't magic. Neither are sextants, compasses, maps, slide rules and all the other paraphrenalia which have accreted around the basic biological brains of Homo sapiens. In the case of these other tools and props, however, it is transparently clear that they function so as either to carry out or to facilitate computational operations important to various human projects. The slide rule transforms complex mathematical problems (ones that would baffle or tax the unaided subject) into simple tasks of perceptual recognition. The map provides geographical information in a format well suited to aid complex planning and strategic military operations. The compass gathers and displays a kind of information that (most) unaided human subjects do not seem to command. These various tools and props thus act to generate information, or to store it, or to transform it, or some combination of the three. In so doing, they impact on our individual and collective problem-solving capacities in much the same dramatic ways as various software packages impact the performance of a simple PC.

5. **Title:** A dynamical systems perspective on agent-environment interaction

Abstract: Using the language of dynamical systems theory, a general theoretical framework for the synthesis and analysis of autonomous agents is sketched. In this framework, an agent and its environment are modeled as two coupled dynamical systems whose mutual interaction is in general jointly responsible for the agent's behavior. In addition, the adaptive fit between an agent and its environment is characterized in terms of the satisfaction of a given constraint on the trajectories of the coupled agent-environment system. The utility of this framework is demonstrated by using it to first synthesize and then analyze a walking behavior for a legged agent.

6. **Title:** An embodied cognitive science?

Abstract: The last ten years have seen an increasing interest, within cognitive science, in issues concerning the physical body, the local environment, and the complex interplay between neural systems and the wider world in which they function. Yet many unanswered questions remain, and the shape of a genuinely physically embodied, environmentally embedded science of the mind is still unclear. In this article I will raise a number of critical questions concerning the nature and scope of this approach, drawing a distinction between two kinds of appeal to embodiment: (1) 'Simple' cases, in which bodily and environmental properties merely constrain accounts that retain the focus on inner organization and processing; and (2) More radical appeals, in which attention to bodily and environmental features is meant to transform both the subject matter and the theoretical framework of cognitive science.

Exemplary analysis:

1. **Relevance:** Clark's interdisciplinary approach, weaving together robotics, neuroscience, and artificial intelligence, provides a foundational perspective on how external tools and technologies can be seen as extensions of human cognitive processes.

Reason for Citation: This paper is likely cited because it aligns with the query paper's theme of the interconnectedness of brain, body, and technology. Andy Clark's discussion on the complex dance of circular causation and extended computational activity supports the query paper's argument that cognitive technologies are integral to human intelligence.

2. **Relevance:** "The Extended Mind" by Clark and Chalmers introduces the concept of active externalism, which posits that the environment plays a crucial role in driving cognitive processes.

Reason for Citation: This paper is foundational to the query paper's thesis, as it directly addresses the idea that human intelligence extends beyond the biological brain to include external devices and technologies. The notion that cognitive processes can be supported and enhanced by external elements is central to understanding the co-evolution of humans and technology, a key point in the query paper.

3. **Relevance:** Brooks' paper on "Intelligence without representation" challenges traditional AI research's reliance on symbolic representation, advocating instead for a more embodied approach to intelligence.

Reason for Citation: This citation supports the query paper's argument by illustrating a shift in understanding intelligence: from a purely internal, representational view to one that emphasizes direct interaction with the world. Brooks' work on building mobile robots that operate in real-world environments without predefined representations aligns with the query paper's view of technology as an integral part of human cognitive systems.

4. **Relevance:** This paper likely supports the query paper's argument by showing how language, a human technology, augments cognitive capabilities.

Reason for Citation: The comparison of words to tools like slide rules and maps illustrates how external artifacts can enhance human computational abilities. This aligns with the query paper's thesis that cognitive technologies, whether ancient (like language) or modern, are deeply integrated into the fabric of human intelligence, serving to extend and transform our cognitive capacities.

5. **Relevance:** The dynamical systems approach, which views agent and environment as coupled systems, supports the query paper's argument about the co-evolutionary relationship between humans and technology. This perspective helps frame the discussion on how technologies are not just tools but integral components of the human cognitive system.

Reason for Citation: The citation of this paper suggests an interest in the theoretical framework it provides for understanding the interaction between agents (humans) and their environment (which includes technology).

6. **Relevance:** The distinction between simple and radical embodiment reflects the query paper's exploration of how technologies are not merely external aids but fundamental to the structure and function of human intelligence. The discussion on embodied cognitive science provides a broader context for understanding the integration of technology with human cognition, reinforcing the query paper's thesis.

Reason for Citation: This paper is cited probably because it questions and expands the scope of cognitive science to include the body and the environment, which is crucial for the query paper's argument

Exemplary ranking: Ranked order: paper 2, paper 1, paper 3, paper 4, paper 5, paper 6

1. **Explanation:** Andy Clark's interdisciplinary approach to the interconnectedness of brain, body, and technology offers a comprehensive background that supports the query paper's theme. The discussion on the extended computational activity and the role of external tools as extensions of

human cognitive capabilities is essential for understanding the integration of technology with human intelligence.

2. **Explanation:** The concept of active externalism and the environment's role in cognitive processes is foundational to the discussion of cognitive technologies as integral to human intelligence. This paper provides a direct theoretical underpinning for the idea that human cognition extends beyond the brain to include external devices and technologies, making it a critical citation for further exploration of the co-evolutionary relationship between humans and technology.
3. **Explanation:** Brooks' work challenges traditional views of AI and supports a more embodied approach to intelligence, aligning with the query paper's argument against a purely internal view of cognition. This paper's emphasis on direct interaction with the world and the rejection of predefined symbolic representations is crucial for discussions on how technology and human cognition co-evolve.
4. **Explanation:** This paper illustrates how language, as a form of human technology, augments cognitive capabilities, which is a key aspect of the query paper's argument. The analogy of words to tools like slide rules and maps provides a tangible example of how external artifacts can enhance human computational abilities, making it a relevant citation for discussions on the role of cognitive technologies in human intelligence.
5. **Explanation:** The dynamical systems approach to understanding the interaction between agents and their environment supports the query paper's view of technology as an integral part of the human cognitive system. This theoretical framework is important for framing the co-evolutionary relationship between humans and technology, making it a relevant citation for further exploration.
6. **Explanation:** This paper expands the scope of cognitive science to include the body and the environment, which supports the query paper's exploration of technologies as fundamental to human intelligence. The discussion on embodiment is crucial for understanding the integration of technology with human cognition, although it might be seen as providing a broader context rather than direct evidence of cognitive technologies' role in human intelligence.