Embodied Cognition and Evolutionary Psychology as Foundations of Design Research

William A. Stubblefield, Ph. D
Sandia National Laboratories
P. O. BOX 5800, MS1137
Albuquerque, New Mexico 87185
wastubb@sandia.gov

ABSTRACT
Embodied cognition and evolutionary psychology offer an alternative to formalist models of intelligent activity and, ultimately, the design of interactive systems. By recognizing that intelligent behavior depends upon innate cognitive abilities, rather than the general computational processes, embodied theories can help us understand the durability of human behavior and how it shapes people's ability to adopt interactive systems. The suitability of embodied cognition as a foundation for design research comes from three features: its generality, its ability to improve the quality of artifacts, and its representation of the social forces for change design must manage.

Author Keywords
Design research, embodied cognition, Darwinian psychology, evolutionary psychology, situated cognition.

INTRODUCTION

This paper addresses the role of theory in design, and also introduces the topic of foundations for design research.

By taking a computational approach, cognitive science filled a critical gap in theories of mind: it could provide formal models of critical aspects of thought including intention, reason, decision-making, and communication – phenomena that formerly had been viewed as beyond scientific treatment. This makes it uniquely suited to contribute to the needs of design, which must reason about these ill-defined aspects of our mental lives.

In its early days, cognitive science took the brain to be a general-purpose machine that was capable of running any well-formed program. However, as the field developed, it uncovered the limitations of this model: many cognitive activities, such as perception, or our ability to learn language, navigation in the world, or social interaction cannot be explained computationally without assuming some prior bias: innate, semantically meaningful mental structures that can compensate for the complexity and ambiguity of these tasks.

Embodied cognition (Varela, Thompson et al. 1991; Lakoff and Johnson 1999) views the mind/brain as a depending on innate cognitive, perceptual, emotional, linguistic and social abilities. The flexibility of human behavior derives, not from a universal computer, but from the accumulation of these innate abilities. Evolutionary psychology (Barkow, Cosmides et al. 1992) completes the embodied view by giving us a theory of the origins of these abilities. Our minds were shaped by millions of years of evolution to survive in the world (at least the world of the Pleistocene). The reason our innate abilities do such a good job of enabling intelligent activity in the world is precisely that they evolved to do so.

EMBODIED COGNITION'S IMPORTANCE FOR DESIGN

The body of this paper explores the importance of these theories for design research. To share in the workshop's goal of exploring design theory through a "playful discourse," I will draw its organization from poetry. "Notes toward a Supreme Fiction" (Stevens 1954), by Wallace Stevens consists of three sections, named:

- It must be abstract
- It must give pleasure
- It must change

In mapping these categories into the particulars of design theory, I will reinterpret *abstraction* as theoretical generality; *pleasure* to encompass the general quality of good design; and *change* as addressing the shifting social to which our designs must respond.

IT MUST BE ABSTRACT: THEORETICAL GENERALITY

Information as a biological process

Embodied models derive much of their generality by rethinking information and its role in intelligent action. De-emphasizing formal representation and referential semantics, embodied approaches view information as fundamentally a biological process. This replaces the idea

that symbol structures "capture" information with the implicit nature of meaning and the importance of interpretation. It replaces referential semantics by emphasizing the actions information enables or causes (Brown and Duguid 2000). In defining information as a biological process, embodied theories address many concerns of design, including its emotional and aesthetic dimensions, role of implicit knowledge in intelligent activity, and the social context of design.

Applicability across the life cycle

Ideas from embodied cognition influence the entire life cycle of design and implementation, and explain both the iterative nature of design processes and their resolution into an artifact. The role of these theories in such early stage activities as fieldwork is clear, as is their relevance to interaction and interface design. However, they also can contribute to later stages of design and engineering.

In developing a data management system for a micro-mechanical systems fabrication laboratory (Stubblefield, Rogers et al. 2003), we used narrative structure as an organizing principle for software architecture, representing interaction narratives explicitly into the software's internal architecture. The result was improved maintainability in that requests for change corresponded directly to both use narratives and software architecture.

Embodied theories can extend the reach of design theory into the end stages of validation and product acceptance. Traditional models of software development define a valid system as one that satisfies its requirements. However, as any experienced designer understands, we cannot assure that an artifact meets user needs until we observe its successful use in context. Embodied theories provide theoretical support for this observation.

Cultural independence

By grounding its theory of behavior and interaction in biology, embodied theories are culturally general. They do not deny the influence of culture on behavior, but by working at a deeper cognitive level, can articulate general principles underlying the many expressions of cultural diversity designers encounter. Every culture is unique, but every culture is governed by the same general principles. These range from the universal patterns of ritual (all cultures bury their dead, all sanction marriage socially), to quantitative constraints on the size and organization of extended families, tribal units, and communities.

A bridge to natural science

Simon has defined design as a "science of the artificial," whose focus is on human creations, rather than the natural world (Simon 1969). This is of mixed value for design theory in that it frees us to develop new theories and methods more suited to design, but hinders our ability to address the phenomena that arise when our designs enter the social world of use and maintenance. By grounding design theory in our evolved nature, embodied cognition connects the sciences of the artificial and the natural world. This offers the chance of a more consiliant (Wilson 1998) design theory, one that gains in validity through broad connections to the natural sciences.

IT MUST GIVE PLEASURE: DESIGN QUALITY

Ability to address experience

By tracing the roots of cognition to our biological embodiment, these theories provide a scientific basis for approaching experience, which has long been regarded as beyond the reach of science. Theories of emotion address how these archetypically subjective phenomena influence behavior (Damasio 1994). Darwinian psychology has traced the roots of aesthetics in our innate need for intimacy, and the social negotiation of meaning (Dennett 1991; Dissanayake 2000). Although the problem of qualia remains beyond our reach (Dennett 1991), embodied cognition at least offers a descriptive basis for understanding people's experience of interactive systems.

The role of metaphor

Any useful design theory must explain the importance and use of metaphor and narrative. Embodied theories are unique in their ability to do so. Lakoff and Johnson (Lakoff and Johnson 1980; Lakoff and Johnson 1999) take metaphoric extensions of bodily experience to be the foundation of abstract concepts. For example, direct manipulation interfaces, succeed by building on our embodied understanding of grasping and manipulating physical objects. Similarly, narrative, which is so important to interaction design (Carroll 2000), also has its roots in Darwinian psychology's view of storytelling's innate roots (Bruner 1991; Landau 1991).

Generalizing usability

The embodied roots of narrative also offer an opportunity to generalize our theories of usability. Classical usability theory draws on psychological models of memory and perception. By grounding design theory in embodied roots of socially situated action (Suchman 1987) and the social role of narrative, we add the dimension of intention and meaning to interface design. We can use interaction narratives, for example, to guide screen layout so as best to queue users to the next steps in an interaction narrative.

IT MUST CHANGE: DESIGN AS SITUATED

The situated nature of interactive artifacts

One of evolutionary psychology's most powerful contributions is in grounding social interactions in our evolutionary history (Barkow, Cosmides et al. 1992). The deletion of the social has long plagued formal theories of software design and use. Although social science theory and methods have done much to remedy this problem,

their focus is on human-to-human interaction, and may not be fine-grained enough to be of use for design.

By tracing the roots of community in our ability to recognize emotional states in others, or the hypothesized innate foundations of ethical reasoning, embodied and evolutionary theories give us the potential for a more relevant theory of communication and collaboration. Many of the pressures for change on a design come from social factors, and this understanding can help us to anticipate their effects on an interactive system.

The social context of the design process

In addition to helping understand the social factors behind the pressures for change an interactive artifact will encounter, embodied theories can help us better to understand our own design practices. It is widely recognized that design is a process of interpretation: of interpreting people's needs, and anticipating their response to an interactive system. Hermeneutics (Meuller-Vollmer 1988) provides an epistemic model for this process, but does relatively little to address the social aspects of design. Embodied and situated theories can address this limitation.

Pace and patterns of change

One of the biggest problems facing designers is fostering the changes in work and communication that the use of interactive software generally requires. Many systems fail to be used because the changes they require are too great or too rapid, with designers blaming "user resistance" for the failure. By grounding social behavior in innate neural structures, embodied theories explain the durability of social behaviors and can give designers more realistic expectations for their users. In addition, many theories build on insights of embodied cognition to anticipate the patterns of social change designers will face, further helping us to address these problems.

CONCLUSION

This work fits into the broader context of design research in the area of theoretical foundations. In particular, it complements the pragmatic approach taken to much design work by providing a unifying, general foundation in the biology of information and cognition.

ACKNOWLEDGMENTS

Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94aAL85000.

REFERENCES

1. Barkow, J. H., L. Cosmides, et al., Eds. (1992). The Adapted Mind: Evolutionary Psychology and the Generation of Culture. Oxford, Oxford University Press
2. Brown, J. S. and P. Duguid (2000). The Social Life of Information. Boston, Harvard Business School Press.
3. Bruner, J. (1991). "The narrative construction of reality." Critical Inquiry 18(1): 1-12.
4. Carroll, J. M. (2000). Making Use: Scenario-based design of human-computer interactions. Cambridge, Mass, MIT Press.
5. Damasio, A. R. (1994). Descartes Error: Emotion, Reason, and the Human Brain. New York, Grosset/Putnam.
6. Dennett, D. (1991). Consciousness Explained. Boston, Little Brown.
7. Dissanayake, E. (2000). Art and Intimacy: How the Arts Began. Seattle, University of Washington Press.
8. Lakoff, G. and M. Johnson (1980). Metaphors We Live By. Chicago, University of Chicago Press.
9. Lakoff, G. and M. Johnson (1999). Philosophy in the Flesh: The Embodied Mind and Its Challenge to Western Thought. New York, Basic Books.
10. Landau, M. (1991). Narratives of Human Evolution. New Haven, Yale University Press.
11. Meuller-Vollmer, Ed. (1988). The Hermeneutics Reader. New York, Continuum.
12. Simon, H. A. (1969). The Sciences of the Artificial. Cambridge, MA, MIT Press.
13. Stevens, W. (1954). The Collected Poems of Wallace Stevens. New York, Alfred A. Knopf.
14. Stubblefield, W. A., K. S. Rogers, et al. (2003). The LIGA Traveler: Social and Technical Invariants in Interactive System Design. DUX 2003: Designing User Experiences, San Francisco.
15. Suchman, L. A. (1987). Plans and Situated Actions: The Problem of Human Machine Communication. Cambridge, Cambridge University Press.
16. Tooby, J. and L. Cosmides (1992). The Psychological Foundations of Culture. The Adapted Mind: Evolutionary Psychology and the Generation of Culture. J. H. Barkow, L. Cosmides and J. Tooby. Oxford, Oxford University Press.
17. Varela, F. J., E. Thompson, et al. (1991). The Embodied Mind: Cognitive science and human experience. Cambridge, Mass., The MIT Press.
18. Wilson, E. O. (1998). Consiliance: The Unity of Knowledge. New York, Alfred A. Knopf.