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INVITED COMMENTARY

Affordances: Commentary on the Special Issue of *AI EDAM*

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The concept of affordances has an interesting history, starting with the keen observations and thoughts of the perceptual psychologist J.J. Gibson in the late 1970s (see Gibson, 1979), moving into the world of design through the 1988 publication of my book *Design of Everyday Things* (originally titled *Psychology of Everyday Things*), and then making its way into engineering design in the paper by Maier and Fadel (2001).

As a result of this disciplinary migration, the concept of affordance leads several rather separate lives within these different fields (ecological psychology, design, and engineering design), with each field barely aware of the work being done in the others. Those who use the concept in ecological psychology and philosophy seem unaware of its use in design and engineering. Similarly, those in design are mostly unaware of its use in engineering, and those in engineering and design are unaware of the work that has continued on the concept since its introduction into their own domains. Disciplinary silos still exist. For example, see the detailed analysis by Dotov et al. (2012), and the one by Chemero (2003), both of which ignore the work outside of perceptual and ecological psychology, even though both claim to be broad, comprehensive reviews. Gibson would be puzzled, delighted, and dismayed. Me, too: I am delighted and somewhat puzzled, but I replace dismay with amusement.

A word of caution is needed here about my use of the terms “engineering,” “engineering design,” and “design.” In the design and manufacture of a product or service, many different disciplines play a role. Moreover, even with a single discipline, there are many subdisciplines, sometimes with competing approaches. Thus, I speak of engineering design as if it were a single, cohesive approach, but this is not the case. First, engineering is itself divided into numerous disciplines, often with very little in common (and each discipline has many subdisciplines). Second, every discipline of engineering includes Design. Thus, semiconductor design is a legitimate design discipline with very little in common with product design as practiced within mechanical engineering departments, and product design within mechanical engineering has its own differing philosophies and methods.

In this article, I comment primarily on the design of products. Within engineering, most of this work can be found in mechanical engineering, computer science, and industrial engineering: most, but not all. In this essay, I use the term “engineering” to reflect the more formal, rigorous process of design that primarily comes from product design within mechanical engineering departments.

A similar problem appears with the use of the word *design*. In this essay, I capitalize the word when referring to the discipline in order to distinguish the discipline of design from the activity of designing or the resulting product, “the design,” and I use “designer” to refer to people trained in design. The discipline of design is well established, although somewhat torn between its heritage as a craft and skill and its place within academia as a full-fledged academic field. Similarly, the teaching of design is well established, with its own schools, departments, accrediting agencies and, of course, divergent, competing methods and philosophies. Most design programs started out as part of art or architecture programs, although today a number of the better programs reside in academic departments in universities or technical universities.

Much design work occurs within the fields of human–computer interaction, usability studies, user- and human-centered design, interaction design, and user experience design. These arenas are nestled somewhat uncomfortably within psychology and computer science departments, and schools of information or informatics. Many of these workers are outside of academia, practicing their skills in industry where they call themselves interaction, human–computer interaction, or user experience designers. They engage in an uneasy but productive dance with people from design who call themselves interaction, user experience, graphical, or industrial designers. All areas make use of the word “affordance,” but often meaning quite different things. This mélange of disciplines and terms leads to ontological chaos. Read this essay with tolerance.

My major interest in the concept aligns with the interests of the authors of this Special Issue: the use of affordances as a practical tool for design. The question these papers address is how we can design objects and systems that are practical,

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reliable, affordable, functional, usable, and understandable. Affordances play critical roles in all of these aspects. Whether the designer comes from the traditional background of art and architectural schools; the modern background of a human-centered systems analysis with an iterative prototype, test, and revise philosophy; or from engineering design with its more powerful set of formal design methods and tools, the end goals are the same.

Affordances can be the bridge between the traditional engineering focus on efficiency and function with the goals of fitting people's needs, desires, and emotions. Engineering design quite often focuses upon the technical requirements. Human-centered design often focuses on the impact upon people in terms of understandability, providing appropriate conceptual models, and feedback, but adding the requirement that the results be beautiful and enjoyable. These different emphases are complementary: both are required. We build things for people, yet how we can study, understand, and design appropriately for the way people actually think, act, and behave (as opposed to the logical manner in which engineers wish they would behave) is seldom studied within engineering curricula.

Affordances are part of designers of all types, from Design, from computer science, engineering, and the social sciences. The term affordance has spread itself all over, with people using the concept in the design of urban planning, landscapes, interior design, architecture, and in spaces both real and virtual. Tools are now characterized by their affordances (or lack), so the printed medium has one class of affordances, social interaction another, hammers and saws yet another, and each of the new communicative technologies comes with its own forms of affordance.

This bridgelike component of affordances was clearly one of Maier and Fadel's intentions when they introduced artifacts into engineering design (see the discussion in this volume in the paper by Mata, Fadel, & Mocko). An affordance is a relation, specifying the possible interactions of one thing with another, where the things can be animate or inanimate; intelligent or not; human, animal, or manufactured object or system. Because affordance is a relation, it is a powerful, context-sensitive design concept. However, different disciplines are interested in affordances in different ways, using the concept to focus upon the relationships and systems of most interest to that discipline. Thus, psychologists are most concerned with interactions between people and other people and their environment, both natural and artificial. Designers are most concerned with interactions between people and designed objects (i.e., artifacts). Engineering designers tend to be concerned with the interaction of machines: sometimes machines to machines; sometimes machines with the environment; and sometimes machines with people or artificially intelligent or automated systems. Other disciplines use affordances to enhance the study of the objects of their concern. It is rare to find that these different approaches overlap.

One of the important aspects of this Special Issue on affordances is its attempt to bring many of these disciplines together, in one publication, spanning engineering, philosophy, psychology, and design. This is especially important because of the differences among the disciplines. For example, the concept of affordance has proven difficult for some groups to understand. Many people, especially those from the arts and humanities, have had difficulty with the idea, possibly because they are more used to designing objects rather than relationships among things. Designers like to do things, to make physical items or graphic displays. For them, the item is the critical focus. As a result, they might say, "I put an affordance there," or perhaps, "people were having difficulty knowing what part of the screen to tap, so I added an affordance to help them—that red circle." "No," I would silently shout, "that circle is not an affordance. It is a signal. It communicates where the tap should take place."

Design practitioners have had so much difficulty understanding the concept of affordance that I have at times complained that "the problem with affordances, and the reason designers have so much trouble understanding them, is that they are relations, not things." For engineers, however, as Jonathan Maier points out in his paper "On the Computability of Affordances as Relations," the opposite is true: the power of affordances is that they are relational.

Design practitioners have had numerous difficulties with the concept of affordance, in part because they need practical tools and the concept of affordance seemed to offer solutions for some of their problems. The result, however, was to simplify the concept, treat an affordance as an object rather than a relation, and extend its use far beyond what the scientific community had intended. One result was confusion between the communicative component of a perceived affordance and the affordance's support of various interactions between person and object. The term *affordance* was frequently applied to the signaling component.

The communicating component provided by the physical appearance of an object and the set of potential actions specified by the affordance itself are very different concepts, but they were confused because the perceived affordance was both a signal of possible action and the enabler of those actions. As a result, people often thought the affordance was the signal. I tried to eliminate this confusion by naming the signaling component of the affordance as a "signifier," borrowing the term from semiotics, much as many years ago I borrowed the term affordance from Gibson's perceptual psychology (Norman, 2010, 2013). The communicating, signifying component can be realized by the form of the affordance, by its placement, or where necessary, by words and diagrams.

Distinguishing between the signifier and the affordance eases the task of designers, especially within the realm of screen and gesture-based interactions, where there may be limited or no physical devices. In the absence of physical devices, the concept of affordance is weakened, so the signifier concept becomes dominant. When machine parts interact, the physical affordance is important and the signifier component is weak or nonexistent, although as machines become more perceptive, adaptive, and intelligent, they too are apt to rely upon signifiers.

Note that all the possible affordances of an artifact are seldom known by the users of the artifact. Moreover, they may not even be known by the designers of the artifact. Consider many hotel rooms in Europe that have a room power switch inside the room, adjacent to the entry door. When the hotel key card is inserted into the slot, it enables all the room power. When the guest leaves the room, taking the key, all the room power is turned off. Therefore, when the occupant leaves the room even for a brief errand (perhaps to get ice from the hall ice machine), the act of taking the room key card turns off all room power. I have a simple workaround: I insert a small hair comb into the slot. Did the designer of the slot, the room power, or the comb ever contemplate this usage? It is subsidiary issues like these that concern several papers in this collection, including the function, affordance, and use plan analyses discussed by Pols. This and related issues are nicely discussed by Shu et al.

One major difference in the approaches by psychologists and designers from the engineering designers of this issue is the way human needs, abilities, desires, emotions, and so on, are treated. Thus, Cormier and Lewis state that "[a] consumer purchases a system because of the affordances it provides them (i.e., the benefit or set of benefits)" and they go on to represent user characteristics in a $1 \times p$ vector. Although I use Cormier and Lewis as my example, this is a common theme in engineering design, allowing for rigorous treatment of design elements.

Human-centered practitioners will rebel, however, with the notion that affordances alone are sufficient. Yes, they represent many of the functional and use requirements (but not all), some of the properties of signifiers (but not all), but none of the aesthetic, emotional, and economic factors that are so critical in the purchase decision, let alone the eventual satisfaction. Their example of stroller design illustrates these concerns: in this analysis, these issues are not only absent, but it is assumed that all the components are independent, with no confounding dependencies. This leaves out the opportunity for emergent properties that can sometimes overwhelm the effects of the individual elements. Thus, it is well known in the design and marketing communities that after carefully listing the desired characteristics of the item they wish to purchase, people will sometimes exit from the store with quite a different item, one that violates their stated requirements but whose aesthetic or self-image components were so overwhelmingly attractive that they knowingly contradicted their own stated needs (and remain happy with the product ever after, I might add). Here is where more collaboration is needed between the engineering design community and the human-centered component of the design community.

The articles in this Special Issue present a valuable contribution to our understanding of the use of affordances in engineering design. The weaknesses are the result of the traditional, well-known lack of information across disciplinary boundaries. This is especially true with respect to knowledge about the work being done within the field of traditional Design in the development and design of artifacts. Thus, the papers by Shu et al. and by Stoffregen and Mantel present engaging examples of the discovery and exploitation of affordances by people, but without any reference to the huge literature in Design research where the basic premise of the entire field is to discover and exploit just these properties: this has long been a staple of the work of design practitioners. Stoffregen and Mantel explicitly address their paper to the design community, but the only references in their paper to the work of the design community are to my 1988 book (they reference the 2002 reprinting) and to a paper that I coauthored in 1986. However, the vast literature within design already knows these things: the design community does not need to be told. These are well embedded in design practice. Perhaps it is the engineering design community that needs them.

My reservations concern the disconnect between the engineering and design communities, a disconnect that goes in both directions. This collection of papers presents an excellent treatment of affordances from the point of view of engineering design, moving the engineering understanding forward in valuable ways. Now it is time to integrate this research with the existing practices within the design community. One problem is that engineers and designers publish in different journals and attend different conferences. Designers publish in journals such as *Design Issues*, *Design Studies*, and the *International Journal of Design*. In this collection of papers on affordances and design, the only design journal that is referenced is *Design Studies* and in only one paper, that of Pols. In turn, the design community is ignorant of the work in engineering design. Thus, these papers are published in a special issue of *AI EDAM*, a name that will be foreign to people from the design community even if spelled out as *Artificial Intelligence for Engineering Design, Analysis and Manufacturing*.

Note that this kind of problem is not restricted to the gulf between the design and engineering communities. I recently attended a conference on the psychology of design, but I observed that there were few people who could be characterized as designers. Most were psychologists employed by schools of business. I asked the audience about their knowledge of design conferences and journals: IASDR, IDSA, ICED, CHI, SIGCHI, ASME, *Design Issues, Design Studies*, and *Journal of International Design*. Most had never heard of these societies, conferences, or journals. How about you? I presume readers of this issue will know about ASME and ICED. What about the others? How many of you know of the journal *Ecological Psychology* or its society? I had never heard of the journal *Artificial Intelligence for Engineering Design, Analysis and Manufacturing* before I was asked to write this essay. I am similarly ignorant of conferences that sound highly relevant, such as Design Computing and Cognition, a conference I only heard of from comments from the editors of this issue in their review of my first draft of this paper. Our communities are so separate that even when attempts are made to bridge them, it is difficult to get the word out to all the relevant parties. This is everyone's loss.

All communities make valuable contributions from their perspective of the issue. I continue to look forward to a merging of disciplines, where the insights of all fields can be brought together to form a new, harmonious whole, with many new and exciting emergent properties.

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