An affordance-based approach to architectural theory, design, and practice

Jonathan R. A. Maier and *Georges M. Fadel,* Clemson Research in Engineering Design and Optimization (CREDO) Laboratory, Department of Mechanical Engineering, Clemson University, 135 Fluor Daniel, EIB, Clemson, SC 29634-0921, USA
Dina G. Battisto, Department of Architecture, Clemson University, Clemson, SC 29634-0921, USA

The idea of affordance, borrowed from perceptual psychology, is applied to the domain of architecture. As to architectural theory*, affordances can be used as a conceptual framework to understand the relationship between environments and occupants, especially with respect to form and function. Regarding architectural* design*, the concept of affordance allows for a common theoretical basis to improve the design process. Concerning architectural* practice*, affordances can be used as a tool to explore the connection between the intentions of the design with how the artifact is actually used, leading to archived knowledge, and the potential for avoiding common design failures.*
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'Architecture and design do not have a satisfactory theoretical basis,' wrote psychologist James J. Gibson three decades ago. He then asked 'Can an ecological approach to the psychology of perception and behavior provide it?' (Gibson, 1976). Clearly his opinion was yes, and we agree. In this article we expand upon this idea by applying Gibson's concept of *affordance* to the design of artifacts in general and in particular to the domain of architecture. In previous work we have applied the concept of affordance more specifically to the field of engineering design, where we have argued that the concept of affordance is more fundamental than other extant concepts, particularly that of *function* (Maier and Fadel, 2001, 2002; cf., Brown and Blessing, 2005). In this article we argue that, as in engineering, the concept of affordance is more fundamental to architecture than other often studied concepts, particularly that of *form*. One of our goals in this paper is therefore to show how the idea of affordances applies to a theoretical basis for architecture, in an answer to Gibson's provocative question.

Corresponding author:
Jonathan R. A. Maier
jmaier@ces.clemson.edu

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Our application of affordances to architecture rests upon three main propositions, which we explore in the remainder of this paper. First, as to architectural *theory*, we assert that affordances can be used as a conceptual framework to understand the relationship between built environments and humans over time, especially with respect to the form, function, and meaning of architectural elements. Second, regarding architectural *design*, we propose that the concept of affordance allows for a common theoretical basis to improve the design process by offering a shared language among those involved in a design project, particularly architects and engineers. Third, regarding architectural *practice*, we believe that affordances may be used as an evaluation tool to explore the connection between the initial intentions or objectives of the design with how the artifact is actually used, leading to archived knowledge for use in future projects, and the potential for avoiding an array of common design failures.

In this regard we echo and expand upon some points made by Koutamanis in his application of the idea of affordance to building elements and spaces. He states 'Affordances promise integration of different viewpoints (architects, engineers, clients, users) and continuity, i.e., compatible expressions of functionality and usability throughout the lifecycle of a building (briefing, design and use). This holds promise for the codification of design knowledge: affordances could support direct matching of an existing building or type to a specific brief, thus allowing for early evaluation and refinement of design or briefing choices' (Koutamanis, 2006). Before expanding upon these ideas further, the concept of affordance needs to be explored and understood, as presented in the next section.

1 A generalized theory of affordances

1.1 History of the idea of affordance

The perceptual psychologist James J. Gibson first put forward the theory of affordances. In other work, the present authors have expanded upon this theory, and identified new application areas (Maier and Fadel, 2001, 2002, 2003, 2005, 2007, in press). Following our introduction of the concept into the engineering design community, other authors have also begun using the concept of affordance within engineering design and industrial design research (e.g., Galvao and Sato, 2004, 2005, 2006; Brown and Blessing, 2005; Kim et al., 2007). In this section, we briefly review our generalized theory of affordances (see Maier, 2005, Maier and Fadel, in press, for a more complete discussion) with a focus on its applicability to architecture. We begin with Gibson's original definition. Gibson coined the term 'affordance' as follows (all emphases are his):

> The *affordances* of the environment are what it *offers* the animal, what it *provides* or *furnishes*, either for good or ill. The verb *to afford* is found

handles, and proceeds to apply affordances to architectural spaces in which he introduces the technique of 'affordance mapping' to help architects think about the affordances of their architectural designs. In a similar vein, Kim et al. (2008) study the actual affordances of a building lobby and how they vary between different users. Whereas the above authors tend to focus on techniques for using the concept of affordance in architecture, our focus in this paper is a thorough application of affordances on a theoretical level which should underlie subsequent practical applications.

1.2 Examples of affordances

The concept of affordance is perhaps most easily understood through some simple examples. Gibson gives the following examples:

- 'If a terrestrial surface is nearly horizontal (instead of slanted), nearly flat (instead of convex or concave), and sufficiently extended (relative to the size of the animal) and if its substance is rigid (relative to the weight of the animal), then the surface *affords* support'
- 'Terrestrial surfaces, of course, are also climb-on-able or fall-off-able or get-underneath-able or bump-into-able relative to the animal. Different layouts afford different behaviors for different animals'
- 'Air affords breathing, more exactly, respiration. It also affords unimpeded locomotion relative to the ground… when illuminated and fog-free, it affords visual perception. It also affords the perception of vibratory events by means of sound fields and the perception of volatile sources by means of odor fields'
- 'Solids afford various kinds of manufacture, depending on the kind of solid state. Some, such as flint, can be chipped; others, such as clay, can be molded; still others recover their original shape after deformation, and some resist deformation strongly' (Gibson, 1979)

Pertaining to architecture specifically, the following examples of affordances may be helpful:

- Buildings have many high-level affordances, including affording shelter to occupants from the exterior environment, affording aesthetics to occupants and passers-by, affording storage of goods, affording comfort to occupants through climate control, etc. More detailed affordances can better be analyzed by looking at specific building elements.
- Windows afford the transmission of light, and hence illumination of the interior environment as well as a view of the exterior environment. Operable windows may also afford the exchange of air, and in extreme cases even defenestration.
- Floors afford the support of occupants' weight, as well as furniture, the attachment of finish materials, the routing of utilities, and in some cases even drainage.

Notice how some of the above affordances are positive, i.e., beneficial to the user, such as the lights, air and views through windows. Other affordances are negative, i.e., harmful to users, such as defenestration through windows.

With both Gibson's and our examples of affordances in mind, for both environmental things and architectural elements respectively, we can now generalize the concept in order to apply it to the design of artifacts in general and architecture in particular. This is accomplished in the context of two distinct classes of affordances, artifact-user affordances and artifact-artifact affordances, as discussed next.

1.3 About artifact–user affordances (AUA)

Affordances always express a complimentary relationship between two separate systems. In Gibson's original formulation, one is the environment, and the other is an animal situated in it. For design, and especially for architecture, we can view the environment as the built environment, i.e., artifacts, and consider the typical animals in them to be in fact human users. Hence the usual affordances of interest exist between artifacts and users. We call these 'artifact-user affordances' (AUA).

Affordances are distinguished from other types of interaction by the potential usefulness of the relationship. Other types of relationships, such as ownership, or even the artifact's actual use by the user are not affordances. An affordance indicates the potential for a behavior, but not the actual occurrence of that behavior. As Gibson pointed-out, individual properties of either the artifact (color, density, size, etc.) or the user (strength, age, height, etc.) are not in and of themselves affordances, but taken together can determine whether a specific affordance exists, such as the ability of a specific person to walk on a specific floor. Note also that an affordance must first exist before the behavior afforded can ever be exhibited. For example, the affordance of visibility through a window is one type of interaction, while the behavior of a person looking through the window is a different type of interaction, but the two are related because the window must (first) afford visibility before it can (second) ever actually be gazed through.

1.4 About artifact–artifact affordances (AAA)

An affordance does not need to be perceived for that affordance still to exist. This means that the human user does not need to even be present for the affordance to exist. Taking another step of abstraction, we recognize that an affordance expresses a relationship between two (or more) subsystems in which a behavior can manifest between the two subsystems that either subsystem cannot manifest in isolation. Examples exist of course between artifacts and users (e.g., turnability of a door-knob, readability of a sign) between multiple users (e.g., conversations, mating, fighting, etc.), and finally between multiple artifacts (e.g., walls affording support to roofs, sprinklers affording suppression of fires). We call the latter relationships 'artifact-artifact affordances' (AAA).

Obviously buildings must be designed to afford desired uses to its occupants and other stakeholders, however, the components of the building must be designed to have affordances as well. The behaviors of these affordances may be realized in practice, such as walls supporting roof loads, or may be designed simply as contingencies that may never be realized, such as fire suppression, or extreme loading by snow, hurricanes, or floods.

It is important to note that whereas an AUA expresses a relationship that is *directly* useful to users (including the meaning of architectural elements as discussed in Section 2.3), an AAA expresses a relationship that is *indirectly* useful to users. Floors must support users walking on them, however, walls must support roofs, but this is ultimately to protect users within the building.

1.5 Affordances and system behavior

Whether an affordance exists, and what quality the affordance is, depends upon the structure of both of the subsystems involved. A thicker, stronger floor affords support to heavy occupants better than a thinner, weaker floor. However, a thinner, weaker floor may be adequate to support lighter users, such as children. In the case of AUA, designers have control over the structure of the artifacts they design, and thus over what affordances exist with respect to specific users, over whom they usually do not have control. In the case of AAA, designers have control over both artifacts, but still need to design the affordance and resulting behavior ultimately to benefit or to protect human users.

At this point three basic categories can be identified as essential to any affordance relationship. The first is structure (of artifacts and/or users), the second, behavior (again, or artifacts and/or users), and the third, purpose. The fundamental relation between these categories is that *systems afford behaviors via their structure for a purpose*. This is a more detailed adaptation of the dictum from general systems theory that ‘structure influences behavior’ (cf., Senge, 1990). Essentially, we have used the generalized concept of affordances to describe *how* structure influences behavior, and to what ends.

Structure determines what *affordances* exist. The *affordances* indicate what *behaviors* are possible, whether or not they are ever expressed. The ultimate usefulness of the affordance to users (directly in the case of AUA, or indirectly in the case of AAA) is the *purpose* of the system and its organization. In the next subsection we offer a specific architectural example, using the theory of affordances to understand some well publicized failures of modern architecture.

1.6 A motivating example using the concept of affordance to understand building failure

Hermetically designed concepts for high-rise housing towers provide an example of how unintentional social behaviors develop in structures that inherently afford those behaviors. Modern masters such as Le Corbusier, in his austere high-rise multi-family housing projects, significantly influenced a generation of housing schemes in urban environments in the International Style. Modernist ideals were evident in the design of the failed public housing developments such as Pruitt-Igoe in St. Louis and Cabrini Green in Chicago, although the lessons learned following the occupation of the buildings by the tenants clearly show that there was a gap between the intentions of the design and the ensuing behaviors of the tenants (cf., Hillier, 2007). The building achieved its intended affordances of providing high density, inexpensive housing. Its failure was due to the multiple macro-scale unintended negative affordances that resulted in such bad actual living conditions.

Although it is a myth that Pruitt-Igoe ever received any kind of architectural prize, some of its design features that were initially praised, such as the design of the elevators and hallways (Figure 1a), soon 'proved to be opportune environments for violent crime' (Bristol, 1991). Due to a variety of factors, including demographic shifts within the city, poor management and maintenance, as well as actual design flaws, three of the high-rise towers of Pruitt-Igoe were intentionally demolished in 1972 by the St. Louis Housing Authority (Figure 1b), just 18 years after their completion in 1954. We suggest that if the affordances of the proposed buildings had been better understood in the design stage, then the building design could have been modified so the building would not afford the undesirable behaviors later experienced by the tenants. Recently developed strategies for identifying and understanding affordances in the design process are discussed in the next section.

1.7 Strategies for identifying and understanding affordances in the design process

Two design tools have recently been developed to help designers identify and manage affordances with respect to user behaviors and artifact structures in the design stage. The Function Task Interaction Matrix (FTIM) proposed by Galvao and Sato (2005) identifies affordances as the intersection between artifact structure and user tasks. While Galvao and Sato (2005, 2006) originally demonstrated the FTIM with consumer products such as cell phones and digital cameras, Kim et al. (2007) have applied the FTIM to identify 28 affordances to guide their design of the interior of a conference room. They conclude 'It is more systematic and effective to use these relationships in the design of [a] conference room to meet specific needs of users rather than to only rely on designer's experience and knowledge'.

Another matrix based design tool to aid designers in understanding and managing the impact of artifact structure on affordances is the Affordance Structure Matrix (ASM) which is being developed by the present authors (Maier et al., 2007b, 2008). Using an ASM, changes to artifact structure can be traced to the affordances that depend on each structural element. Thereby

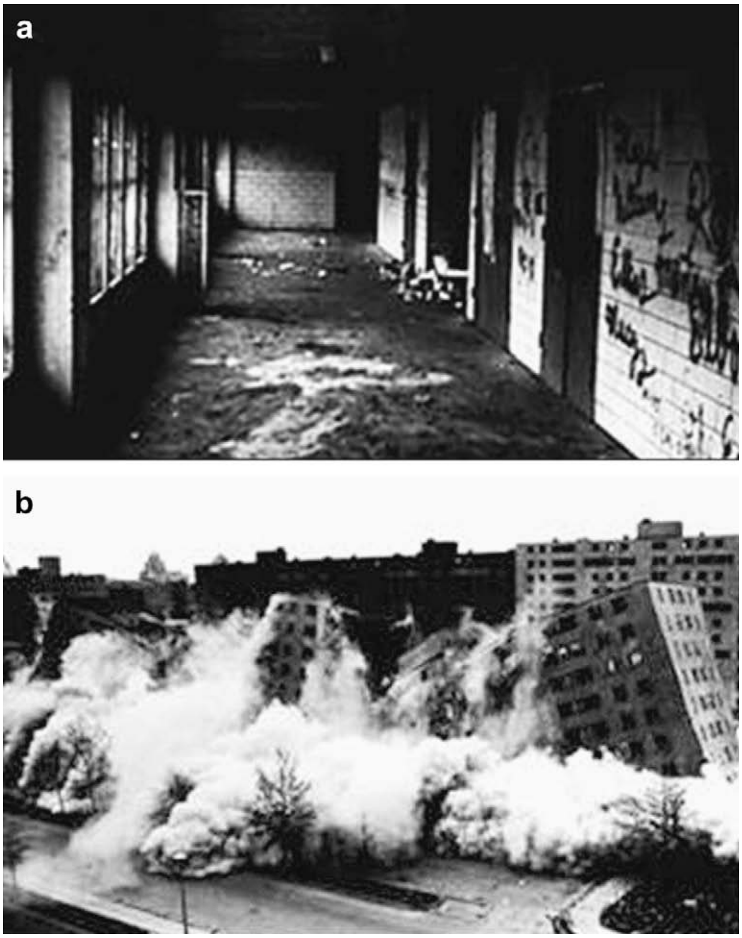

Figure 1 Demolition of Pruitt-Igoe housing project (© Newman, 1996)

possibilities for improving positive affordances and mitigating negative affordances can be explored during conceptual design. Methods for designing individual affordances have also been introduced by the present authors (Maier and Fadel, 2003).

Finally, Tweed (2001) has begun investigating explicit representation of affordances in computer-aided architectural design software. Although research into applying affordance-based design theory to the design of architectural elements is on-going, as discussed further in Section 3, we suggest that the careful application of even these early concepts and tools can produce better architecture with better affordances and less tendency for failure.

2 Application to architectural theory and design

2.1 Historical separation of form and function in architecture

As the preceding example illustrates, an understanding of the relationship between form (or more generally, structure) and function (or more generally, other stakeholders involved in the design process. According to Hamilton (2003), architects are accustomed to casual investigation as opposed to scientific rigor, i.e., not establishing any clear hypotheses with subsequent claims that can be measured to build a knowledge base. When the design intentions are not clearly articulated in the design process, it makes it difficult to conduct a post-occupancy evaluation to determine if the design is meeting measurable objectives, e.g., with regard to safety, comfort, productivity, flexibility, aesthetics, etc.

To respond to clients' expectations, those involved with designing environments are seeking ways to advance their thinking and position themselves as leaders capable of blending the creative arts and a credible knowledge base. The appropriate application of the concept affordances may help to build this knowledge base, by providing a means for comparing actual behaviors with the intended affordances of a structure, and documenting solutions to problems encountered in practice, so these problems can be avoided in future projects. Such is the approach taken by the authors in the recent design of a community wellness center (Battisto et al., 2006).

3.4 Applying affordance-based design to understanding architectural failures

There are numerous examples of unintentional consequences that may be discovered after an artifact is built. These consequences may be revealed after the people begin to use the building, or as programs and operations evolve, and they may change throughout the lifecycle of the artifact. Unintentional design consequences within the domain of architecture include unexpected behaviors, adaptation, interpretation error, signage, and obsolescence.

Unexpected behaviors occur when the affordances of designed structures were not correctly understood, or when structures create an environment in which novel behaviors can occur. Consequently, users interact with the designed building in ways the designers either did not or could not anticipate. Just as jumbo-jet air-liners were not designed to be missiles, but unfortunately afford this use in the hands of terrorists, spectacular and symbolic architectural landmarks such as the World Trade Center in New York and the Pentagon building in Washington, D.C. afford targets for terrorism. The hallways of Pruitt-Igoe were designed to foster community interaction but instead afforded a haven for criminals through which their prey had to traverse.

Adaptations are needed when a building structure does not afford desired behaviors, or affords undesired behaviors. Levy and Salvadori (1994) provide many examples of adaptations to buildings over time due to unintentional design consequences.

Interpretation error occurs when a building is designed to afford one behavior, but in practice affords a different behavior. The external influences that shape how an artifact is used over time may also alter the interpretation of that artifact. For example, the symbolic front door in American homes has changed over time with the introduction of the automobile; meanwhile new entryways to the house have influenced the reading of the house within the contemporary culture. The physical nature of the front door has not changed, although the pathway to the house is now viewed in terms of the automobile and has been emphasized with the garage. The door still affords entry to the house, but is now rarely used for that.

Signage is often used to compensate for the lack of properly designed affordances. Within any large institutional, educational or commercial building one can see signs placed all over these facilities for the purpose of orienting the user, e.g., 'watch your step', or 'do not enter'. Better designs are those that do not need signs because they indicate by their structure how they are to be used. For example, the front entry doors to the Cooper Library at Clemson University were recently changed. In the old design, the exterior handles afforded both pulling and pushing, although the doors only opened inward. To remedy the problem of patrons' consternation over frequently trying to pull the door open, signs were installed instructing the user to 'PUSH' (Figure 2a). However, the handles themselves were much larger than the signs, and users continued to try to pull the doors open. Recently, the problem was resolved by replacing the handles with push plates that only afford pushing and not pulling (Figure 2b). Note that with the new push plates the signage for 'PUSH' is in fact redundant because the plates only afford pushing, not pulling.

Obsolescence in artifacts may result when buildings afford specific uses, but do not afford change. Often times, it is too expensive to rectify or to modify the design of an artifact and it becomes prematurely demolished. In many cases, these buildings are built with (i.e., to afford) a specific intended purpose, for a temporary time period.

3.5 Additional ramifications of affordance-based design for architectural practice

The concept of affordance-based design also suggests a natural metric against which various designs may be compared. Any design that affords its intended purpose may be called a successful design. However, a design that affords that same purpose while affording other desirable features (such as user comfort, safety, durability, recyclability, etc.) may be viewed as better. Furthermore, a design that does afford everything it is supposed to do, while also affording something it is not supposed to do, is worse than a comparable design that only affords what it is supposed to do. It is also important to remember that affordance is not always a clear 'has' or

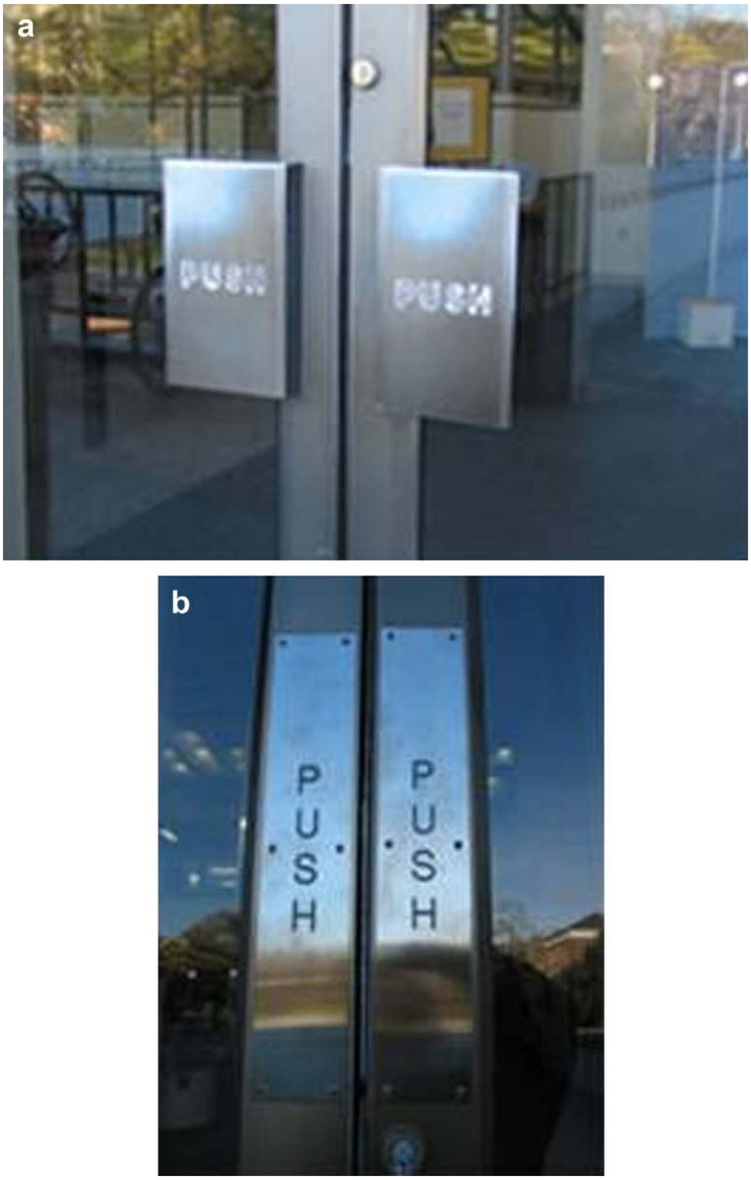

Figure 2 Front entry doors to the Cooper Library at Clemson University

'has not' distinction. One artifact may afford a desired use better than another.

Moreover, the affordances of the artifact can differ with respect to different users. The concept of 'environmental role' developed by the British psychologist David Canter clearly supports this premise. Building from his general theory of place as mentioned earlier, 'environmental role' is a particular set of associated behaviors and rules within a particular place that vary according to the relationship between an individual and place (Canter, 1977). He argues for architectural design and practice. We commend the concept of affordance as an important tenet within such a theory.

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1. Lewin argued that behavior in general could be viewed generally as a function of the interaction between people and the environment. Based on his research a formula was derived: $B = f(P, E, P \times E)$, where behavior (B) is a function (f) of person (P) and environment (E) and the interaction between the two ($P \times E$).

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