TECHNOLOGY AFFORDANCES

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ABSTRACT

Ecological approaches to psychology suggest succinct accounts of easily-used artifacts. Affordances are properties of the world that are compatible with and relevant for people's interactions. When affordances are perceptible, they offer a direct link between perception and action; hidden and false affordances lead to mistakes. Complex actions can be understood in terms of groups of affordances that are sequential in time or nested in space, and in terms of the abilities of different media to reveal them. I illustrate this discussion with several examples of interface techniques, and suggest that the concept of affordances can provide a useful tool for user-centered analyses of technologies.

KEYWORDS: ecological perspectives; human interface design; input/output design; multi-media

INTRODUCTION

There is a real tension between tasks and technologies in interface design. Designs based primarily on the features of a new technology are often technically aesthetic but functionally awkward. But equally, designs based primarily on users' current articulated needs and tasks can overlook potential innovations suggested by new technologies. We must understand the needs and abilities of prospective users. But equally, we must understand the capabilities and limitations of technologies in order to know the possibilities they offer for design.

In this paper, I explore the notion of *affordances* as a way of focussing on the strengths and weaknesses of technologies with respect to the possibilities they offer the people that might use them. The term "affordance" comes from the perceptual psychologist J. J. Gibson [9, 10], who developed an "ecological" alternative to cognitive approaches. The cognitive approach suggests that people have direct access only to sensations, which are integrated with memories to build up symbolic representations of the environment and its potential for goal-oriented action. This account has recently come under attack, particularly for its decontextualized approach to design [e.g., 4, 17, 19]. In focussing on perception, action, memory and problem-solving "in the head," its descriptions of action in the world, tool-use, perceptually-guided learning, etc., often seem baroque and overly complicated.

In contrast, the ecological approach stresses relevant human-scaled objects, attributes and events and the patterns of energy that provide effective perceptual information about them. It eschews detailed accounts of information processing as being unnecessary products of the abnormal situations found in laboratories. In focussing on everyday perception and action, the ecological perspective may offer a more succinct approach to the design of artifacts that suggest relevant and desirable actions in an immediate way. Cognitive approaches, from this perspective, are best reserved for artifacts which are complex, difficult to use, and error-prone.

The notion of affordances is in many ways the epitome of the ecological approach, encapsulating ideas about ecological physics, perceptual information, and the links between perception and action. In this account, affordances are the fundamental objects of perception. People perceive the environment directly in terms of its potentials for action, without significant intermediate stages involving memory or inferences. For instance, we perceive stairways in terms of their "climbability," a measurable property of the relationship between people and stairs. The work required to climb a flight of stairs can be described by a U-shaped function relating work to riser height and leg length. Warren [18] showed that people's visually-guided judgements of the climbability of different staircases reflect this function with great accuracy: people perceive the affordance of stairclimbing.

An affordance of an object, such as one for climbing, refers to attributes of both the object and the actor. This makes the concept a powerful one for thinking about technologies because it focuses on the interaction between technologies and the people who will use them. However, the concept raises issues from many different domains: perception and action, metaphor and learning, and techniques for input and output. A simple example from everyday life can illustrate the sorts of issues that must be addressed before the notion of affordances can be made precise and useful.

WHAT ARE AFFORDANCES?

The concept of affordances is not a new one for design. Most notably, Norman [15] applied the concept to everyday artifacts. For instance, thin vertical doorhandles afford pulling, while flat horizontal plates afford pushing (Figure 1).

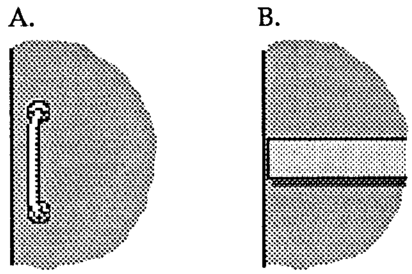

Figure 1. Different door handles suggest affordances for different actions.

The interaction of a handle with the human motor system determines its affordances. When grasping a vertical bar, the hand and arm are in a configuration from which it is easy to pull; when contacting a flat plate pushing is easier. We can perceive the affordances of doorhandles because the attributes relevant for grasping are available for perception. Finally, the course from perception to action seems a direct one, implying an ease of learning desirable for artifacts. However, perceptual information may suggest affordances that do not actually exist; while those that do may not be perceivable. For instance, vertical doorhandles suggest pulling, but doors may be locked. In general, when the apparent affordances of an artifact matches its intended use, the artifact is easy to operate. When apparent affordances suggest different actions than those for which the object is designed, errors are common and signs are necessary.

This example illustrates several important aspects of affordances. Below I develop the idea of affordances as properties of the environment relevant for action systems, consider how they might be perceived, and note the effects of culture on their perception. In the end I offer a definition that seems broad enough to be interesting for design, yet narrow enough to be useful.

Complementarity of Action

Affordances imply the complementarity of the acting organism and the acted-upon environment. Most fundamentally, affordances are properties of the world that make possible some action to an organism equipped to act in certain ways. Whether a handle with particular dimensions will afford grasping depends on the grasper's height, hand size, etc. Similarly, a cat-door affords passage to a cat but not to me, while a doorway may afford passage to me but not somebody taller. Affordances, then, are properties of the world defined with respect to people's interaction with it.

Tools afford different actions. For instance, mechanics use a myriad of different tweezers, pliers and clamps to take advantage of the variations in their affordances for grasping. In interfaces, a similar diversity of input devices (e.g., keyboards, mice, touch tablets) and onscreen cursors (e.g., arrows, brushes, hands) offer various affordances for interaction [1].

Perception and Inter-referentiality

Affordances *per se* are independent of perception. They exist whether the perceiver cares about them or not, whether they perceived or not, and even whether there is perceptual information for them or not. For example, a glass of water affords drinking whether or not I am thirsty, a ball affords throwing whether or not anybody sees it, and a pit affords falling even if it is concealed by brush. Affordances exist whether or not they are perceived, but it is because they are inherently about important properties that they *need* to be perceived [9, p. 143].

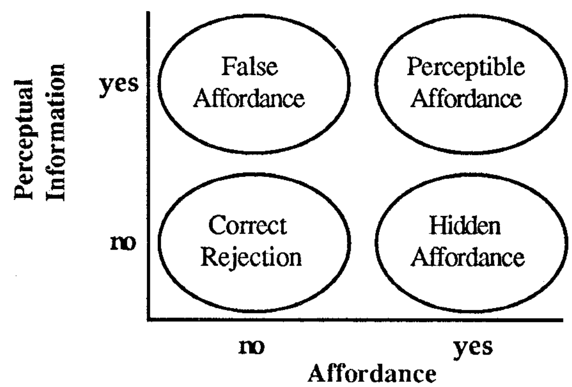

Figure 2. Separating affordances from the information available about them allows the distinction among correct rejections and perceived, hidden and false affordances.

Distinguishing affordances from perceptual information about them is useful in understanding ease of use. Common examples of affordances refer to *perceptible affordances*, in which there is perceptual information available for an existing affordance (Figure 2). If there is no information available for an existing affordance, it is *hidden* and must be inferred from other evidence. If information suggests a nonexistent affordance, a *false* affordance exists upon which people may mistakenly try to act. Finally, people will usually not think of a given action when there is no affordance for it nor any perceptual information suggesting it.

Making affordances perceptible is one approach to designing easily-used systems. Perceptible affordances are *inter-referential*: the attributes of the object relevant for action are available for perception [cf. 6]. What is perceived is what is acted upon. This situation contrasts with one in which perceived attributes must be related to those relevant for action by a mediating representation. Perceiving that a doorhandle affords pulling does not require a mediating concept because the attributes relevant to pulling are available for perception. Knowing that a key should be turned inside a lock does require mediation because the relevant attributes are not available.

From this point of view, interfaces may offer perceptible affordances because they can offer information about objects which may be acted upon. We can understand displays in terms of the subset of normally available perceptual information various media make available for various actions [cf. 9, 10]. For instance, the onscreen buttons shown in Figure 3 appear to be raised from the background, to have depth. This is not arbitrary, but the result of refined methods for conveying certain sorts of information. In semiotic terms, the marks are nomically (causally) related to their referents, rather than symbolically or metaphorically. In a sense, nomic mappings do not need to be interpreted, because they do not rely on convention or analogy. Their meaning is directly available to the perceiver [16, 8]. Nomically mapped graphical objects can provide information about affordances when the information conveyed graphically corresponds to attributes of the system that are relevant for action.

Culture, Experience and Learning

The actual perception of affordances will of course be determined in part by the observer's culture, social setting, experience and intentions. Like Gibson I do not consider these factors integral to the notion, but instead consider culture, experience, and so forth as highlighting certain affordances. Distinguishing affordances and the available information about them from their actual perception allows us to consider affordances as properties that can be designed and analyzed in their own terms. Learning can be seen as a process of discriminating patterns in the world, as opposed to one of supplementing sensory information with past experience. From this perspective, my culture and experiences may determine the choice of examples I use here, but not the existence of the examples themselves.

Affordances Are...

The concept of affordances points to a rather special configuration of properties. It implies that the physical attributes of the thing to be acted upon are compatible with those of the actor, that information about those attributes is available in a form compatible with a perceptual system, and (implicitly) that these attributes and the action they make possible are relevant to a culture and a perceiver. Artifacts may be analyzed to see how close they are to this configuration of properties, and thus what affordances they convey.

For instance, MacLean et al. [13] discuss a user-tailorable system of onscreen buttons and their experiences introducing them to non-technical users (Figure 3). Users intuitively understood that these buttons could be "pressed" using the mouse, but their tailorable attributes were not spontaneously manipulated. MacLean et al. interpret this as implying the need for a "tailoring culture" to support users [see also 5]. But consider *what* needed to be supported. Buttons appear to afford pressing but not moving because they appear to protrude from the underlying surface. They do not appear to afford tailoring because they don't suggest decomposition. They appear and act as unitary objects – one of their advantages as an interface metaphor – with the drawback that they do not afford much *except* pressing.

Figure 3. Onscreen buttons seem to protrude from the screen; they afford pushing, but not moving or editing.

Just as the affordances of door handles imply the complementarity of handles and the motor system, so do the affordances of onscreen buttons imply the complementarity of buttons and mouse-driven cursors. Various graphical techniques allow us to perceive the pressability of an onscreen button, and the course from perception to action seems as direct as it does for doorhandles. And again, perceptual information may be misleading about the affordances of buttons; in this case the ability to move or edit buttons is not supported perceptually.

AFFORDANCES FOR COMPLEX ACTIONS

The account above emphasizes perceptual information for affordances that can be obtained via relatively passive perception. But there often seems to be too little information available for the perception of more complex affordances. How do we know to turn a pivoting door handle? Do scrollbars afford scrolling?

The notion of affordances may be extended to explicitly include exploration. For instance, the pivoting door handle shown in Figure 4 may appear to afford grasping, but passive observation will probably not indicate the affordance of turning it or using it to open the door. However, once grasped (B), a random or exploratory press downwards will convey tactile information revealing the affordance of turning the handle. When the handle is fully turned (C), the new configuration is one from which pulling is natural. The results of a pull will indicate whether the door affords opening or not.

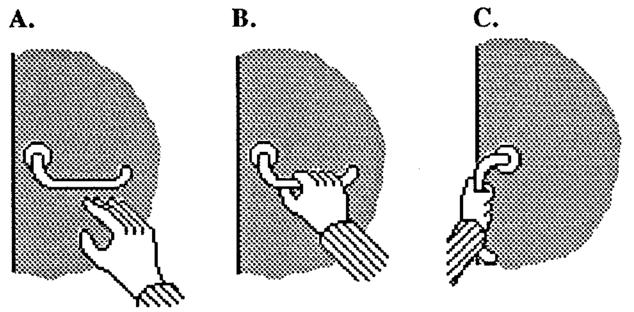

Figure 4. Sequential affordances: one affordance leads to another. Visual information indicates grasping (A & B); tactile information indicates turning (B & C).

What is true for door handles again seems true for interfaces. For instance, the Macintosh scrollbox (Figure 5A) may appear to afford grabbing, but visual information probably does not indicate an affordance of dragging it or using it to scroll a window. However, just as grasping a door handle is likely to lead to tactile information indicating turning, so is grabbing the Macintosh scrollbox likely to move it, leading to visual information about its affordance of dragging. In addition, the vertical grey shaft which encloses the scroll box perceptibly affords one sort of dragging – up and down – but not others, such as side to side.

These are examples of *sequential affordances*, a concept I introduce to refer to situations in which acting on a perceptible affordance leads to information indicating new affordances. The Macintosh scrollbox offers a sequence of affordances – dragging is a natural progression from grabbing. In contrast, Smalltalk 80 scrollbars do not; the scrollbar cannot be grabbed. Instead, scrolling requires moving the cursor over the scrollbar to change the cursor into an arrow pointing up, down, or sideways, and pressing one of the mouse's buttons (Figure 5B). The Smalltalk scrollbar lacks inter-referentiality: There is nothing to coordinate perception and action with the device, no way to take advantage of obvious affordances to explore others.

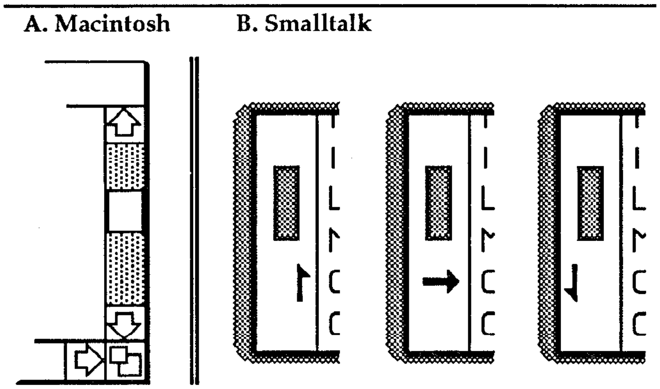

Figure 5. Two kinds of scrollbar. Which affords scrolling?

Sequential affordances explain how affordances can be revealed over time; *nested affordances* describe affordances that are grouped in space. For instance, a handle alone only appears to afford pulling. A door alone may suggest an affordance for manipulation due to its partial separation from the wall, but not what sort of manipulation will be effective. Only by seeing the affordance of pulling the handle as nested within an affordance of pulling the door can opening the door be a perceptible affordance. Similarly, an onscreen window may appear to afford uncovering if the occlusion of its contents is apparent, and a scrollbox may afford dragging. A perceptible affordance of scrolling the window relies on seeing the affordance of dragging the scrollbox to uncover the window. In each case, the nested affordance offers itself both as an end in itself, and as a means towards realizing another affordance.

In general, the affordances of complex objects are often grouped by the continuity of information about activities they reveal. Affordances are not passively perceived, but explored. This point of view leads to a reconception of metaphor which emphasizes its role as a design tool for importing consistent affordances from one domain to another. From this perspective, users need not know metaphors explicitly. Exploration of afforded actions leads to discovery of the system, rather than knowledge of the system metaphor leading to expectations of its affordances. Learning is seen as a matter of attention rather than inference. The role of a good interface is to guide attention via well-designed groups of sequential and nested affordances.

MODES, MEDIA, AND AFFORDANCES

Gibson [9] focuses almost exclusively on affordances which may be seen. But affordances may be perceived using other senses as well. As the pivoting handle example suggests, tactile information is a rich source of information for affordances. We can often feel what can be done with something – that it is hot enough to fry an egg, sharp enough to slice a tomato, and so on. Similarly, input devices may make use of tactile affordances. For instance, pressing onscreen buttons is reinforced by pressing mouse buttons, and force-feedback joysticks allow users to feel simulations. We might imagine redesigning three button mice with two of the buttons on the sides; this would offer the affordances of squeezing and pushing.

We can also hear some affordances. Typical examples of affordances depend on attributes of the environment such as the size and orientation of surfaces; such attributes are those about which vision provides information. Sound, on the other hand, conveys information about affordances related to the size, material and internal structure of objects, the location, nature and forces of interactions, and the status of occluded processes [8, 12]. For example, when door handles are turned the sound of the latch may reveal the affordance of moving the door. The sound conveys information for an affordance which can not be seen.

Sounds can similarly reveal affordances of interfaces. For instance, selecting an object in a direct manipulation system might make a sound indicating its size and type, and thus reveal affordances which depend on these attributes (e.g., whether the object can be copied or the results of activating the object) [8]. As with the pivoting door handle, visual information leads to a sequential affordance; consequent auditory information suggests new possibilities. Sounds may also convey information for affordances in ways which supplement graphics. For example, sounds which indicate ongoing processes can reveal affordances for using other interdependent tools, sounds indicating the activities of others can suggest affordances for collaboration, and so on [7].

Just as different modalities can reveal information about affordances, so might we characterize various media in terms of the affordances they make available. For instance, researchers at EuroPARC have been exploring remote communication via computer-controllable audio and video links [2]. Video may support many aspects of face-to-face communication, but it does not seem well-suited for supporting the use of gestures as a communicative tool [11]. An account relating the characteristics of video as a medium for conveying information, the attributes required for effective gesture, and the information necessary to perceive these attributes might allow us to redesign the system to emphasize this desirable affordance.

In general, understanding the affordances offered by media other than graphics can aid in designing transparent systems. When visual affordances can not be designed in systems, the tendency is to turn to symbolic means of conveying information. A more fruitful approach may be to explore other modes as means of communicating affordances for actions.

CONCLUSIONS

The notion of affordances is appealing in its direct approach towards the factors of perception and action that make interfaces easy to learn and use. As a means for analyzing technologies, affordances should be useful in exploring the psychological claims inherent in artifacts [3] and the rationale of designs [14]. More generally, considering affordances explicitly in design may help suggest ways to improve the usability of new artifacts.

In providing an integrated account of a complex configuration of attributes, the concept provides a simple but powerful means of addressing a broad range of interface issues. This paper lays out a framework for developing ways to apply the notion to design. At the level of detail explored here, the concept provides a valuable way to think about transparent interfaces. It encourages us to consider devices, technologies and media in terms of the actions they make possible and obvious. It can guide us in designing artifacts which emphasize desired affordances and de-emphasize undesired ones. Perhaps most important, it allows us to focus not on technologies or users alone, but on the fundamental interactions between the two.

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