Affordances in HCI: Toward a Mediated Action Perspective

Victor Kaptelinin [1,2] and Bonnie Nardi [3]

[1] Department of Information
Science and Media Studies
University of Bergen
Postboks 7802, NO-5020,
Norway

[2] Department of Informatics
Umeå University
SE - 901 87 Umeå
Sweden

[3] Department of Informatics
School of Information and
Computer Sciences
5088 Bren Hall, UC Irvine
92697-3440, USA

ABSTRACT

Interpretations of the concept of "affordances" in HCI are becoming increasingly diverse, extending well beyond the original Gibsonian meaning. We discuss some of the key analyses of affordances in HCI research and make three related claims. First, we argue that many current interpretations of the concept are essentially incompatible with Gibson. Second, we hold that the Gibsonian concept of affordances, conceptualized as interaction between animals and their environments, provides some important insights, but is, in the end, of limited relevance to HCI research. Third, we call for adopting *a mediated action perspective* on affordances as an alternative to Gibson's ecological psychology. We outline a view of technology affordances as possibilities for human action mediated by cultural means conceived as a relational property of a three-way interaction between the person, mediational means, and environment. We conclude with a discussion of prospects for future conceptual and empirical explorations of the meditational perspective in HCI research.

Author Keywords

Affordances, technology affordances, ecological psychology, mediated action.

ACM Classification Keywords

H5.m. [Information interfaces and presentation (e.g., HCI)]: Miscellaneous;

General Terms

Design, Human factors, Theory.

INTRODUCTION

Affordance is currently one of the most fundamental concepts in HCI and interaction design. The term was originally proposed by Gibson [17, 18] within his ecological approach to perception. It was introduced to HCI by Norman [22] in the late 1980s and quickly became one

of the field's key concepts, widely used by researchers, educators, and practitioners. Such a prominent status for the concept would suggest that the field should have a well-defined and generally accepted meaning of affordance. However, this is not the case. The exact meaning of the term continues to be a subject of ongoing debate. Numerous attempts have been made throughout the history of HCI to more clearly define what affordances are and to develop the concept further to better meet the needs of HCI research and practice (e.g., [1, 3, 20, 23, 32]). Arguably, however, the meaning of "affordance" in HCI and interaction design remains vague.

The aim of this paper is to contribute to clarifying the confusion surrounding affordances. We start out by exploring the relationship between some of the most influential analyses of the notion in HCI research and the original notion proposed by Gibson.

Of particular interest are the inherent limitations of Gibson's concept of affordances. A common position explicitly or implicitly expressed in many HCI discussions is that Gibson did not exploit the full potential of the notion he proposed, and that his understanding of affordances should be further elaborated to include a broader range of issues and phenomena. Such phenomena include functionality, development, motivation, communication, culture, and context (e.g., [1, 3, 16, 20, 23, 24, 26]). An underlying assumption is that Gibson's theory of affordance does allow for such extensions.

The analysis in this paper questions that assumption. We argue that the notion of affordance as it was understood by Gibson has a distinct and rather limited focus, determined by the role of the notion in Gibson's conceptual framework as a whole. Accordingly, the concept of affordance has a number of fundamental inherent limitations and cannot be directly extended beyond its original scope. We argue that a concept of technology affordances which would adequately serve the needs of HCI research and practice can only come about through theoretical re-grounding, that is, constructing the concept on a different theoretical foundation. We propose that a socio-cultural framework be employed for understanding technology affordances as possibilities for human actions mediated by cultural means.

GIBSON'S THEORY OF AFFORDANCES: ANIMALS, ENVIRONMENTS, AND DIRECT PERCEPTION

The first step of our analysis is to identify the basic assumptions underlying the original concept of affordance within Gibson's ecological approach to perception [12, 13].

The approach challenged the prevalent view of perception as a sequence of information processing stages. Gibson asserted that animals directly pick up significant information about their environments from the ambient optic array. The information that is picked up is information about *affordances*—what the environment "offers the animal, what it provides or furnishes, either for good or ill" [12]. In other words, animals directly perceive affordances as possibilities for action in the environment, which are determined, on the one hand, by the objective properties of the environment and, on the other hand, by the action capabilities of the animal.

Gibson defined affordances as independent of the current needs and goals of the perceiver. He acknowledged that the concept was heavily influenced by precepts from Gestalt psychology, especially Koffka's "demand character" and Lewin's "invitation character" and "valence" [12]. At the same time, Gibson emphasized that there was a substantial difference between these concepts and affordance:

> The concept of affordance is derived from these concepts of valence, invitation, and demand, but with a crucial difference. The affordance of something does *not change* as the need of the observer changes. The observer may or may not perceive or attend to the affordance, according to his needs, but the affordance, being invariant, is always there to be perceived. An affordance is not bestowed upon an object by a need of an observer and his act of perceiving it. The object offers what it does because it is what it is. ([12], original emphasis)

The independence of affordances from the situational needs of the animal does not make them value-free aspects of the environment. Affordances are always meaningful. They can be positive or negative, even affordances of the same object. A knife, for instance affords slicing a sausage but also cutting a finger; water may afford drinking but also drowning.

While affordances exist irrespective of whether or not they are perceived by the observer, in general there is a close connection between affordances and perception. Perception is a key factor defining the action capabilities of the animal. For instance, a dark forest may afford stumbling because the person cannot see tree roots clearly enough (which affordance may or may not be noticed by the person).

Gibson was very clear about not being particularly interested in affordances *per se*. To him, affordances were relevant to his larger ecological theory of perception only to the extent to which they could help provide an account of how actors perceive their environments:

> The central question for the theory of affordances is not whether they exist and are real but whether information is available in ambient light for perceiving them. [12]

Finally, Gibson made virtually no distinction between human beings and other animals. As follows from his general theoretical stance of considering the mutuality of the animal and the environment as a conceptual point of departure, as well as the concrete examples of affordances he provided, the approach was intended to be general enough to be applicable to all animals. While some examples of affordances described by Gibson are related to specifically human objects (e.g., knives, mailboxes, staircases), these affordances are considered as similar to affordances provided by "natural" objects to non-human animals, e.g., affordances for physical manipulation (piercing, inserting) or locomotion (climbing). Gibson maintained that it would be a mistake

> … to separate the cultural environment from the natural environment, as if there were a world of mental products distinct from the world of material products. There is only one world, however diverse, and all animals live in it, although we human animals have altered it to suit ourselves. [12]

The key underlying assumptions of Gibson's theory of affordances can be summarized as follows:

- affordances are perceived directly; their perception is not based on an interpretation of initially meaningless "raw" sensory data,

- affordances are relational properties; they emerge in the interaction between the animal and environment: the same environment may offer different affordances to different animals,

- affordances are independent of the situational needs of the perceiver,

- natural environments and cultural environments should not be separated from one another, and

- the theory of affordances is concerned with how affordances are perceived rather than affordances *per se*.

These assumptions define the original scope of the notion and set the stage for the discussion below.

THE AFFORDANCE DEBATE IN HCI: SELECTED KEY POINTS

The introduction of the concept to HCI

When introducing affordances to HCI, Norman described them as

> …the perceived or actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used… A chair affords ("is for") support and therefore affords sitting. A

chair can also be carried. Glass is for seeing through, and for breaking. [22].

Affordances, according to Norman, provide strong clues to the operations of things and, therefore, can be fruitfully employed in design:

> When affordances are taken advantage of, the user knows what to do just by looking: no picture, label, or instruction is required. [22].

A systematic exploration of the notion of affordances in HCI was done by Gaver [10, 11], who identified three types of affordances depending on the relationship between affordances and perceptual information: visible, hidden, and false affordances. In addition, Gaver analyzed hierarchical and temporal dependencies between simple affordances, which led him to introduce the concepts of nested and sequential affordances [10].

The Ecological Interface Design (EID) approach by Vicente and Rasmussen [34] is another early attempt to employ Gibson's theory as a foundation for the design of interactive technologies and work environments. The approach differentiates between various types of affordances by mapping them to levels of cognitive control and a means-ends abstraction hierarchy[1].

Separating affordances from perception

McGrenere and Ho [20] present a thorough discussion of the notion of affordances in HCI including a detailed comparative analysis of the original Gibsonian concept and its interpretation by Norman. The authors maintain that the key difference between Gibson and Norman is in how they understood the role of perception. For Gibson, affordances exist independently of whether or not they are perceived by the actor, while for Norman affordances can be not only real but also just perceived. McGrenere and Ho [20] argue strongly for separating affordances from their perception (the position they ascribe to Gibson) because, as they claim, the separation would help researchers and practitioners more clearly differentiate between two aspects of design, namely: designing the utility of an object (its affordances) and designing usability (the information that specifies the affordance). Tornvliet [31] makes a similar argument.

In addition, McGrenere and Ho argue that there is a need to further develop Gibson's original notion. In particular, they call for moving beyond a binary view of affordance as something which either exists or does not exist, toward a more nuanced interpretation of the "possibility for action", that would, for instance, take into account the difficulty of using an affordance.

The key points of the analysis are summarized by the authors as follows:

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[1] A thorough discussion of EID can be found in [1, 20].

Returning to a definition close to that of Gibson's would solidify the concept and would also recognize that designing the utility or functional purpose is a worthwhile endeavor in its own right. In order for the *affordance* concept to be used fully in the design world, however, Gibson's definition needs to incorporate the notion of varying degrees of an affordance. [20]

On the one hand, McGrenere and Ho claim that HCI needs to return to the true, authentic Gibsonian interpretation of affordances. On the other hand, they imply that the original notion is not sufficiently developed and must be further evolved.

Moving beyond operational affordances: affordances as emerging in activities

Baerentsen and Trettvik [3] outline an activity-theoretical perspective on affordances. The structure of their argument is not dissimilar to that of McGrenere and Ho [20]; they point out that HCI research has deviated from Gibson's notion, criticize the deviation, and suggest that the original notion be further developed to overcome its shortcomings. However, their disagreement with the way HCI interprets affordance is of a more philosophical nature:

> The concept of affordance was meant to cut though the subjective-objective dichotomy of traditional psychology and philosophy, but its interpretation in HCI often retained this dichotomy. [3]

The main shortcoming of Gibson's concept of affordances, according to Baerentsen and Trettvik [3], is that the underlying notion of activity is simplistic and undeveloped, and essentially limited to low-level interaction between the actor and environment:

> … it seems to us that Gibson's… focus was on the operational side of activity in his treatment of "behavior". His focus was on the perceptual requirements of the operational realization of activity, the information that is available in the environment that lets the organism control locomotion and simple forms of object related activities. Perhaps his behaviourist "upbringing" blinded him to the non-identity of motivational-goal-directed aspects of activity... [3]

Adopting a more advanced notion of activity developed in activity theory (e.g., [4]), would mean understanding affordances as contextualized in unfolding activities and emerging in concrete interaction between the actor and the environment:

> The features of the physical environment and its objects provide affordances when they are related to the needs and requirements of organisms.…Although affordances are in a sense constituted by objective physical features of the environment, these objective features only become affordances when some organisms relate to them in their activity. [3]

The main points made by Baerentsen and Trettvik have been taken up in further discussions of affordances (e.g., [35]).

Selected interpretations of affordances in HCI history: A summary
Table 1 presents a brief (and somewhat simplified) summary of the relationship between selected analyses of affordances in HCI with respect to the five basic assumptions of Gibson's theory, discussed above.

The first two assumptions, with few exceptions, are adopted by nearly all the interpretations. Concerning the remaining three assumptions, however, there is an opposite tendency: most interpretations clearly deviate from Gibson. The only one that appears fully consistent with the original Gibsonian framework regarding these three assumptions is Norman's.

Gaver's reference to affordances as suggesting "relevant and desirable actions in an immediate way" [8] implies an understanding of affordances as dependent on user needs. This understanding makes his interpretation similar to some Gestalt psychology concepts, such as "invitation character", from which Gibson explicitly distanced himself [12]. Separating affordances from their perception as McGrenere and Ho [20] do foregrounds issues of utility and functionality which are not of direct relevance to Gibson's original research agenda. The position advocated by Baerentsen and Trettvik [3] essentially abandons all three of these assumptions.

GIBSON'S THEORY AND CURRENT HCI DEBATE: THE NEED FOR RE-GROUNDING THE CONCEPT OF AFFORDANCES
Undeniably, explorations of Gibsonian affordances in the HCI research discussed above have contributed to further development of the concept. The notions of nested and sequential affordances [10] and degrees of affordances [20], levels and types of affordances [34, 14] enrich the concept and make it a more useful conceptual tool for analysis and design. At the same time, as suggested by Table 1, interpretations of the concept in HCI research tend to transcend its original scope and become inconsistent with the basic assumptions of Gibson's theory.

This trend is even more apparent in recent research. A growing number of studies in HCI and related areas call for re-defining the notion of affordances to include social and cultural aspects of human interaction with the world. For instance, Rizzo [26] maintains that "… Gibson's account does not yield sufficient insight for affordances that are culturally determined through individual history". Zhang [39] introduces the notion of "motivational affordances" which includes, for instance, "leadership and followership". Turner [32] contrasts Gibsonian "simple affordances" to "complex affordances", the latter embodying history and practice. Similar claims were made in other studies (e.g., [6, 16, 19, 24, 26]).

In general, the work that advocates the need to move beyond Gibson to "social affordances" is characterized by extreme diversity. The aims, research agendas, and arguments put forward in individual studies are sometimes only loosely related to each other. Concrete examples of social affordances range from articulation [35] to imitative learning [26] to competence and achievement [39].

	Aspects of affordance according to Gibson				
	Relational property	Directly perceived	Independent of actor's needs	Same in natural and cultural environments	Theory's concern with perception, not affordances *per se*
Norman (1989, 1999)	—/+	+/—	+	+	+
Gaver (1991, 1992)	+	+	—	+	+
McGrenere & Ho (2000)	+	+	+	+	—
Baerentsen & Trettvik (2002)	+	—	—	—	—

Table 1. Gibson's theory of affordances vs. selected interpretations of affordances in HCI research

Despite their diversity, many current interpretations of affordances have one thing in common: they typically criticize Gibson for introducing a powerful concept but excessively limiting its scope (e.g., [4, 16, 26]). It is averred, implicitly or explicitly, that Gibson failed to exploit the full potential of his own brainchild. This criticism, in our view, overlooks that Gibson's point of departure was "the mutuality of *animal* and environment" ([12], emphasis added). Gibson provides a deliberately delimited perspective on humans and how they make sense of their environments. Gibson's theory views humans as, essentially, animals acting in their natural habitats. Gibson's notion of affordance as "natural affordances", such as those for manipulation and locomotion, is consistent with the overall aims of his research project which centered on perception. It would be unfair to criticize Gibson for not developing the notion of affordance beyond natural affordances, i.e., to criticize him for not choosing a different research agenda.

Therefore, while current debate clearly indicates that Gibson's original notion is too limited to properly serve the needs of HCI research and practice, the notion has its own inherent contours, and cannot be "upgraded" without being transformed into something it is not.

The strategy for constructing a richer notion of affordances advocated in this paper is different. We posit that HCI needs a non-Gibsonian concept of technology affordances, and suggest a *re-grounding* the notion. Re-grounding means preserving the general understanding of affordances as action possibilities, but constructing the concept on a different theoretical foundation, one more suitable for analysis and support of human uses of technology. In this respect our position is different from calling for a radically redefined notion of "extended" affordances (e.g., equating affordances and context, see [32]).

A limitation of Gibson's framework, particularly critical for HCI, is that it lacks an appropriate conceptual apparatus for understanding technologies as a special type of objects, that is, tools mediating human interaction with the environment. This is not to say that Gibson did not consider tools. Affordances of tools were of special interest to Gibson, who provided revealing insights into what makes an object a good candidate for being a tool. For instance Gibson describes a club as "an elongated object, [which] especially, if weighted at one end and graspable at the other, affords hitting or hammering" [12]. These insights were further developed in more recent studies within the ecological approach. In particular, Wagman (e.g., [33]) argues that the whole "user-tool-environment" system needs to be taken into account to understand how users choose a grip on simple hand-held tools, However, owing to the main focus on the "animal-environment" interaction, the analysis of tools in the Gibsonian tradition is incomplete in several respects.

First, while it is implied that tools have two facets (corresponding, for instance, to "graspability" and "impactability"), the integration of the facets has not been systematically analyzed. Indeed, in natural objects, such as sticks, the facets are inherently inseparable aspects of a tool. However, with the advancement of technology, they progressively become more independent of one another, and their integration can be an issue that should be addressed in design. For instance, power-driven tools are operated by controls, which may take various shapes and have different locations. Digital technologies allow for even greater dissociation of the facets. Second, Gibson's theory does not deal with the social aspects of the use and production of tools, such as the support of collective action and the historical development of tools based on the transition of experience from generation to generation. Third, the use of tools is not related to action capabilities of the actor: a tool is just an object in a natural environment, which provides certain affordances without changing the nature of the actor.

Therefore, Gibson's theory of affordances is limited in its support for understanding mediated human actions. Given that HCI as a field is primarily concerned with advanced, rapidly developing mediational means that make deep impact on both individual humans and the society, this limitation of the framework significantly undermines its ability to serve as a theoretical foundation for studying action possibilities offered by technologies to humans. To address this problem, we propose a mediated action perspective on technology affordances.

AN OUTLINE OF A MEDIATED ACTION PERSPECTIVE ON TECHNOLOGY AFFORDANCES

One of Gibson's fundamental insights is that it is our *basic nature to see the environment in terms of the range of action possibilities* (i.e., affordances) offered to us by the objects in the environment. This means, in particular, that a *natural* human way to perceive a technological artifact is to actively pick up information in order to establish the affordances provided by the artifact. Gibsonian theory suggests that successfully conveying the possibilities for meaningful action offered by a technology to the user should be a top priority in the design of interactive systems (cf. [1, 34]).

The mediated action perspective we propose retains the general Gibsonian understanding of affordances as action possibilities offered by the environment to the actor. However, the notion is conceptually "re-grounded" and not merely extended. Instead of Gibsonian ecological psychology's concern with how animals perceive and act in their natural environments, we adopt the Vygotskian socio-cultural approach (e.g., [36, 38]) concerned with humans acting in cultural contexts. According to the approach, the most characteristic feature of human beings, differentiating them from other animals, is that their activities and minds are mediated by culturally developed tools, including technology. The socio-cultural view of technology as a mediational means has been introduced to HCI through activity theory [4, 21] which is a particular framework within the general socio-cultural approach.

It should be noted that in the discussion below, "human action" is understood as action carried out by an individual human being rather than a "collective subject". While the latter is an important issue to consider, it is beyond the scope of the present analysis as we move to re-conceptualize and re-ground the foundational concept of affordance for HCI.

The mediated social action perspective on technology affordances is outlined below in three steps. First, we describe the basic structure of an *instrumental technology affordance* as an integrated unit comprising two components: handling affordance and effecter affordance. Second, we identify a set of *auxiliary technological affordances* determined by the embeddedness of a technology in "webs of mediators" [5] typical of real-life

uses of technology. Third, we discuss how technology affordances develop over time.

As immediately follows from adopting a mediated action perspective, technology can be considered a mediational means, an instrument through which the person interacts with objects in the environment. The person directly interacts with a technology by handling it and, indirectly, by causing an effect on an object. Therefore, action possibilities provided by a technology, considered as an instrument, comprise two related facets (Figure 1): (a) possibilities for interacting *with* the technology (P-T), i.e., *handling affordances*, and (b) possibilities for employing the technology to make an effect on an object (T-O), i.e., *effecter* affordances. Together, they define instrumental technology affordances as possibilities for acting *through* the technology in question on a certain object ((P-T)-O).
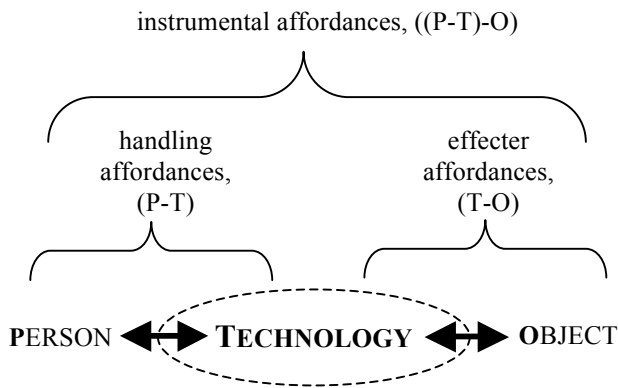
instrumental affordances, ((P-T)-O)

handling
affordances,
(P-T)

effecter
affordances,
(T-O)

PERSON ◄——► TECHNOLOGY ◄——► OBJECT

Figure 1. Two facets of instrumental technology affordances: handling affordances and effecter affordances

The distinction between handling affordances and effecter affordances is obvious in case of traditional instruments, discussed by Gibson, such as knives. Such instruments usually comprise two distinct parts, responsible, respectively, for handling (e.g., a handle) and affecting objects (e.g., blade). Apparently, the distinction also applies to digital technologies. For instance, common user interface widgets, such as the scroll bar, enable two types of actions [2]; operating on the widget (e.g., dragging the scroll box) and operating on the object of interest (e.g., displaying in the window a certain portion of the document). These two facets correspond, respectively, to handling and effecter affordances of a widget.

The basic structure of instrumental affordances shown in Figure 1 is a simplified abstraction, which does not reflect the diversity of action possibilities associated with human mediated action. Bødker and Andersen [5] observe that real-life mediation seldom involves a single mediator. Instead, it typically consists of "web of mediators", which are organized in chains (i.e., the object of one action becomes a mediator of the next one) or levels, depending on the purpose of the activity. Accordingly, the possibilities for action offered by technologies embedded in real-life

contexts include not only direct, instrumental affordances, but also a variety of generic types of indirect, auxiliary affordances emerging in the complex relations within webs of mediation. Examples of such auxiliary affordances are maintenance affordances and aggregation affordances (see Figure 2).
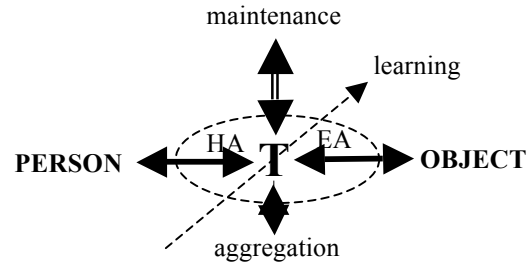
maintenance

learning

PERSON ◄——► HA T EA ◄——► OBJECT

aggregation

Figure 2. Technology affordances: Instrumental, maintenance, and aggregation (T – technology, HA-handling affordances, EA-effecter affordances)

Maintenance affordances. Technologies need to be taken care of to work as effective mediators. It is essential, therefore, that a technology provide appropriate affordances for carrying out maintenance routines and troubleshooting (understood in a broad sense, as including necessary modifications of the technology). For instance, a mobile phone must enable the person in changing the battery or inserting SIM cards (see Figure 3 for an example of an affordance provided by the back cover of a mobile phone).

Figure 3. Auxiliary affordances of a mobile phone. A: back cover removal slot (maintenance); B: headset jack slot (aggregation).

Aggregation affordances. Technological artifacts can be combined with other artifacts (digital and non-digital) to constitute larger-scale compound mediators, both ad hoc assemblages of tools needed for a specific task and interoperable technologies designed from the start to work in unison. For instance, a mobile phone can be connected to a headset to comprise a personal music player (see Figure 3). If such an aggregation is an essential condition of

successfully employing the technology, the possibilities for achieving that should be ensured and conveyed to the person.

Learning affordances. The instrumental and auxiliary technology affordances discussed above (shown in Figures 1-3) are embedded in the context of development and learning. Many technologies cannot be used until at least some learning occurs. A second order mediation is needed to access a tool's instrumental, maintenance, and aggregation affordances. In many common situations, instruction is necessary. For instance, to turn to a non-digital example, while shoe laces admirably afford keeping a shoe snug to the foot, a child (and most adults) could not figure out on their own how to tie the appropriate knot to attain the instrumental affordance. The laces lack a learning affordance. But other tools, especially digital technologies, accomplish the second order mediation of learning by embedding learning affordances within themselves. Tooltips, help screens, standardized icons, and coded signs are typical digital learning affordances. The USB icon inscribed on a computer, for example, demonstrates for the user where it is possible to attach a USB device. (The same sign also appears on the connector signaling the proper orientation of the connector.) The pairing of instrumental and learning affordances is an instance of Wartofsky's typology of mediating means that specifies "primary and secondary artifacts". Primary artifacts get the job done, while secondary artifacts tell us how to use primary artifacts [37].

Recursively, learning affordances may form their own aggregations. When encoded in software, learning affordances can readily be combined in multiple configurations, e.g., hyperlinks, mouseovers, and so on. It may thus be difficult to definitively establish the boundaries of "a technology" or "an artifact" as the generativity and malleability of software enable the rapid appearance and disappearance of cues and information through easily replicable and configurable combinations of signifiers (see [17]).

Bødker and Andersen's notion of webs of mediators [5] is also pertinent; learning affordances entail a chain of linked actions that lead, seriatim, to the completion of the user's goals. Learning affordances thus further render Gibson's notion of direct pick up of invariant cues less relevant for understanding how humans encounter designed artifacts. Learning affordances highlight Gibson's reflection that "we human animals have altered [the world] to suit ourselves."

PERSPECTIVES ON AFFORDANCES: GIBSON'S VS MEDIATED ACTION

The analysis above allows us to discuss how the mediated action perspective on technology affordances is related to the original concept proposed by Gibson. The mediational perspective bears a number of similarities with Gibson's

	GIBSON'S THEORY vs MEDIATED ACTION PERSPECTIVE		
	Similarities	**Differences**	
		Gibson's theory	**Mediated action perspective**
General notion *Affordances are understood as…*	action possibilities offered to the actor by objects in the environment	possibilities for animal actions in natural environment	possibilities for human actions in cultural environments
Relational property *Affordances emerge in interaction between …*	the actor and the world	the animal and natural environment	the person, tool(s), and cultural environment
Dynamics Action capabilities of the *actor are…*	a result of the develop-ment of a coupling between actor and the environment	relatively stable, formed by biological evolution, maturation, and long-term learning	dynamic, can quickly change as a result of tool switching
Role of perception *Quick extraction of information about affordances…*	is critically important for successful acting in the world	occurs as an immediate outcome of placing a certain animal in a certain environment	can be an outcome of learning
Needs *Affordances and actor's situational needs are…*		independent of one another	interrelated: tool affordances can be adjusted to situational needs

Table 2. Perspectives on affordances: Gibson's theory vs. mediated action perspective

theory. It adopts the general notion of affordance as a possibility for action offered by the environment and understands affordance as a relational property defined by the coupling between the actor and the world.

There are also significant differences between the perspectives. The mediated action perspective is concerned with how humans act in their cultural environments, rather than with how animals act in their natural habitats. Accordingly, affordances are understood as emerging in a three-way interaction between actors, their mediational means, and the environments. Therefore, action capabilities of the actor can quickly change as a result of switching to a different tool.

A major disagreement between the approaches is in how they view the relationship between affordances and needs. For Gibson an object "is what it is"; its affordances do not depend on actors' needs. The mediated action perspective points that the dynamic nature of tools make it possible to adjust a tool to a situational need: a knife can be sharpened, a battery charged, a computer application upgraded, and so forth. Another aspect of the relationship is that understanding tool affordances includes recognizing their predefined purposes, which can influence how agents experience their own needs. Finally, some technologies manifest something similar to needs: to function properly they need to be taken care of, which means that the agent should act in a certain way to meet the demands of a tool (e.g., look for a Wi-Fi hotspot).

The mediated action perspective questions Gibson's assumption of the direct perception of affordances. A necessary condition for direct perception is a stable relationship between an actor and the environment. Since modern humans often live in frequently changing environments, the development of direct perception of affordances may be problematic. In general, however, the mediated action perspective also assumes that there is a close connection between perception and action. In particular, extensive learning often results in "almost immediate" pickup of information about action possibilities offered by objects in the environment (e.g., see [8]).

The similarities and differences between Gibson's theory of affordances and the mediated action perspective are summarized in Table 2.

IMPLICATIONS FOR ANALYSIS AND DESIGN OF INTERACTIVE SYSTEMS: A FEW ILLUSTRATIONS

There are several ways in which the mediated action perspective on technology affordances can be relevant to analysis and design of interactive technologies. In this section we present a few simple examples of how the two-facet model of instrumental affordances, introduced above (see Fig. 1) can be employed in HCI. The examples are intended to provide simple illustrations rather than give a complete overview of potential applications of the mediated action perspective.

A straightforward way to use the model is to employ it for identifying potential usability problems. The model predicts that usability problems can be selectively related to handling or effecter affordances of a technology. For instance, the effecter affordances of an alarm clock (i.e., time setting and alarm activation/ deactivation) can be efficiently conveyed to the person but the handling affordances (i.e., how exactly to use the clock controls to achieve that) can be confusing.
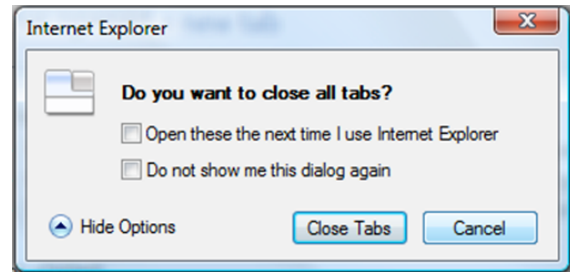

Figure 4. Immediately obvious handling affordances, but not effecter affordances.

The opposite problem is experienced when handling affordances are clear but the outcomes of user actions (effecter affordances) are not immediately obvious. Fig. 4 shows an example of a dialogue box illustrating such case. The user can see that they can select the checkboxes and click the buttons but the effects of these actions are not directly apparent.

The two-facet model of instrumental affordances also suggests that integration of handling affordances and effecter affordances is a design issue that needs to be addressed. If these affordances are not coupled tightly enough the user may be confused (if temporarily) by the instrumental affordance as a whole. Figure 5 and Figure 6 show examples of dialog boxes that differ in the degree to which the clues conveying the handling affordances and effecter affordances are coupled to one another.
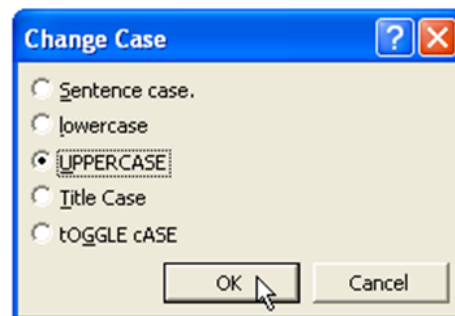

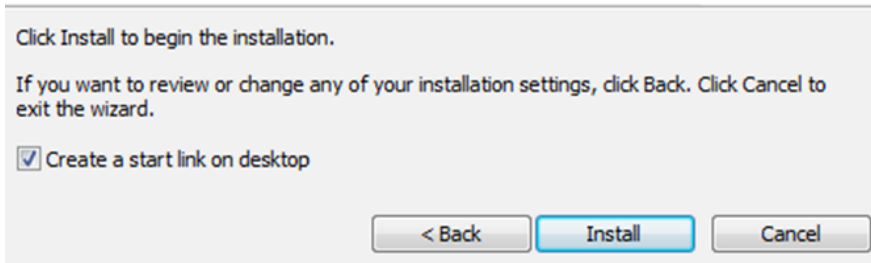Figure 5. Tight perceptual coupling of handling and effecter affordances.

Figure 6. Loose perceptual coupling of handling and effecter affordances.

A number of strategies can be used by interaction designers to ensure proper integration of handling and effecter affordances. Some of the basic properties of interaction instruments, indentified by Beaudouin-Lafon [2], such as degree of indirection (spatial and temporal offsets) and degree of compatibility (similarity between user actions and object transformations), provides useful insights on how handling and effecter affordances can be successfully integrated. Empirical evidence also suggests that a sound design strategy can be supporting the user in exploring the relationship between handling and effecter affordances (cf. [24]).

CONCLUSION

In no way do we intend to question the value of Gibson's approach and the importance of its contribution to HCI. They are enormous. Undoubtedly, understanding how animals interact with their natural environments provides some very useful insights for HCI researchers and practitioners. We are all animals and our ability to physically interact with the immediate environment is to a large extent determined by the capabilities of our bodies, formed in biological evolution [8]. Understanding technological affordances for physical manipulation (cf. [25]) and locomotion has been and continues to be of direct relevance to a wide range of approaches in the analysis and design of digital technologies (e.g., [7, 19, 24, 28]).

At the same time, there is a growing realization in HCI that the field needs a broader concept of affordances that would help understand distinctly human uses of interactive technologies. Building on previous analyses of affordances we argue in this paper that Gibson's research agenda does not include studying some phenomena which are central to HCI.

Contrary to most other analyses we posit that Gibson's theory of affordances cannot be extended beyond its original scope to meet the conceptual needs of HCI. The theory was developed to provide an account of animals' action and perception in their natural environments and, essentially, it delivers all it promises. We claim that to understand the possibilities for specifically human action offered by technology, we need to employ another theory, with a different research agenda. We turned to the

Vygotskian socio-cultural approach [36, 38] to re-ground the concept of affordances..

The most fundamental insight of the socio-cultural approach is that human action and mind are inherently mediated. Our action capabilities to a large extent depend on socially developed mediating means, first and foremost tools, including technological tools (e.g., [38]). Accordingly, we propose understanding technology affordances as possibilities for *mediated human action*, and argue that adopting a mediated action perspective on affordances has direct implications for understanding specifically human uses of technology. We differentiate between instrumental, auxiliary, and learning affordances and introduce a two-facet model of instrumental affordances.

The paper presents an initial outline of the mediated action perspective on affordances which deliberately focuses on *individual* human action. A necessary next step is to extend the analysis to include mediated *collective* actions. The step is necessary because social and technological mediation are often inseparable. For instance, Sambasivan et al. [29] found that in lower income households in India mobile phones are used by some people through the "intermediation" of other people, e.g., a grandmother needs her grandson to place a call for her. In this case the tight coupling between user and tool is altered and the handling affordance is separated from the purposeful agent, which is important to take into account in design.

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