TRACING THE ORIGINS AND USAGE OF AFFORDANCES IN HUMAN-COMPUTER INTERACTION: EPISTEMOLOGICAL ASSUMPTIONS AND IMPLICATIONS FOR DESIGN

by

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ABSTRACT

ADAM TREVOR HESS. "Tracing the origins and usage of affordances in human-computer interaction epistemological assumptions and implications for design". (Under the direction of PROFESSOR ERIC SAUDA).

This thesis questions the use of the theory of affordance, a psychological theory of perception, as the basis for a symbolic design methodology in human-computer interaction. By comparing the psychological writings on affordance of James J. Gibson, James E. Cutting, and Edward Reed, with the design-oriented writings of Donald Norman, William W. Gaver, and Paul Dourish, the thesis identifies key differences in the writers' underlying assumptions. Despite the distinction in their goals, these ideas about affordance are often used interchangeably, allowing designers to justify formalized decisions that remain unsupported by the psychological discourse.

In an effort to highlight the disagreement between the two definitions of affordance, this thesis traces each definition back to a set of underlying epistemological and ontological assumptions. While existing literature has established a connection between the James J. Gibson's writings and the philosophical tradition of phenomenology, little work has been done to uncover the assumptions of Donald Norman's definition of affordance. By associating his symbolic and formalized conceptualizations with those of early artificial intelligence work, the thesis relates Norman's definition with neo-Kantian ideas that fundamentally oppose the phenomenological ideas that form the basis for human-computer interaction. Based on these findings, this thesis questions the validity human-computer interaction's current symbolic design methodology.

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INTRODUCTION

The power of observation, and recently the rise of data collection, as a form of long-term quantitative observation, has brought increasing attention to empiricism as a methodology for design. Interest in evidence-based design in architecture and the prominent position of ethnography in the field of human-computer interaction has given designers the ability to study the effects of their designs and respond to issues that may otherwise go unresolved without observation and conscious effort to resolve. With both design methodologies in architecture and human-computer interaction allow for the study of design products after completion, the ability to predict behavior through simulations and formalized rules closely follows the efforts of data collection and observation. To support this predictive endeavor, human-computer interaction has turned towards the theory of affordances (Gibson 1979), an idea emerging from ecological psychology that explains the mechanism through which perception occurs. The design community adopted the theory to formally explain the relationship between the perception and meaning ascribed to designed objects, and the ways that people interact with the objects and world around them (Norman 1988/2; 1999). While it has been recognized that the design-oriented definition of affordance falls outside of the scope of the psychological definition (Norman 2002, 219), it has served as a foundational concept behind the field's approach to the design of physical objects (Maier and Fadel, 2005), computer interfaces (Gaver 1992) and the virtual environment (Gaver 1991). While recent literature has examined the increasing breathe of the definition of affordance (Kaptelinin and Nardi 2012), and the misuse of the term (Burlamaqui and Dong 2014), the fundamental conflict between psychological and design-oriented definitions has yet to be identified. As a

result, the theory remains a foundational concept in the human-computer interaction design methodology.

In an effort to determine the essential distinction between the two prevailing definitions of affordance, this thesis will compare the disagreement to the development of human-computer interaction as a reaction to the failings of early artificial intelligence efforts, and to a split in the neo-Kantian traditions epitomized in the 1929 disputation between Ernest Cassirer and Martin Heidegger. Through an alignment of the psychological definition, human-computer interaction and the phenomenological tradition of Heidegger it is possible to contrast the epistemological assumptions to the design-oriented definition that can be linked to artificial intelligence and the symbolic discourse of Cassirer. While phenomenology supports the discourse on human-computer interaction, and previous literature recognizes the corollary relationship between the assumptions of artificial intelligence and the work of Cassirer, a connection to the discourse on affordances has yet to be established.

By aligning the series of discourses, this thesis uncovers a fundamental conflict between the two definitions of affordances. Considering human-computer interactions reliance on phenomenology and its alignment with the original, psychological definition of affordance, this thesis concludes that Donald Norman's definition of affordance significantly contributes to the continued expansion and misuse of the theory of affordances. Since the conclusion does not eliminate affordance from the discourse, only limits their predictive abilities, it is possible for the current design methodology to support the psychological definition without significant alteration. The conclusion, however, does suggest a re-evaluation of the current symbolic approach to design.

HISTORY OF AFFORDANCES IN DESIGN AND HUMAN COMPUTER INTERACTION

The Definition of Affordances from Ecological Psychology

The theory of affordance emerged in 1979 from the writings of ecological psychologist James J. Gibson, whose previous work focused on visual perception (Gibson 1950). The theory comes out of a need to describe the act of perception without an understanding of how the brain processes and interprets light, so that researcher can begin to explain how visual features in the environment can affect and shape the way that we interact with it. From driving a car (Gibson 1950) to landing on a plane on an aircraft carrier (Reed 1988), the theory of affordances allows for an examination of the direct connection between visual perception and physical relationship with the world.

As a term, an affordance refers to an action made possible through the mutualistic relationship between an individual's bodily ability and the physical features of the environment (Chemero 2003, 184). The theory, as such, states that perception occurs when an individual recognizes one of these action possibilities. The theory builds on previous work by gestalt psychologists that discussed the relationship in regards to behavior (Koffka 1935) through "demand character," stating that once perceived, the environment encourages or demands interaction. Gibson's theory of affordances, however, eschews a relationship between perception and behavior; it is a theory of perception, not a theory of action.

The non-relationship between affordances and behavior is reified by the work of James Cutting that uses the affordances of a piece of paper as an example:

> *"A piece of paper affords equally writing gibberish and sonnets; it affords writing a shopping list or a note to a colleague; it affords making a map; it affords*

> *writing nothing upon; it affords wadding up and throwing away; it affords making paper airplanes; it affords shredding, cutting into pieces, making paper dolls, making a montage, making Mobius strips; it affords pasting on the wall; if affords coloring green or fingerpainting upon; if affords photocopying and photocopying onto; if affords stapling to other pieces of paper or clipping them into an album; if affords bookmarking; it affords wrapping a package or making into an envelope; it affords cleaning the gaps between teeth; it affords cleaning up after your dog or wiping your hands; it affords burning; it affords filtering particulates; it quite simply affords all the possible things I can do with it. My behavior is virtually unconstrained by its affordances." (Cutting 1982, 216)*

The example is important because it establishes that an individual-object relationship possesses an almost infinite number of affordances. While not denying the possibility that a relationship between perception and behavior exists, the example of a piece of paper establishes that the mere existence of an affordance does not possess a correlation to behavior.

Since the theory of affordance cannot account for the relationship between perception and behavior, it requires a complementary theory of agency to explain the intention and motivation behind the selection of specific affordances (Withagen 2012). Edward Reed an ecological psychologist building on Gibson's work, describes intention as an observable pattern of behavior that draws on prior experience, similar to an evolutionary process, to aid the selection and usage of specific affordances (Reed 1993, 65). The theory offers a description of agency (Reed 1996, 19), but stops short of offering a deterministic or predictive relationship between affordances, perception, and behavior.

With theories describing the relationship from the environment to behavior, however, it is possible to discuss a relationship between affordances and observable actions without returning to the arguments of Gestalt psychology. Writing on this subject suggests that affordances can invite behavior, but do not invite or suggest behavior through their existence. Rather, invitation relies on the affordances evolutionary, cultural,

or personal importance to the individual (Withagen 2012). In contrast to the invitations described by Gestalt psychology (Koffka 1935, 353) invitations can always be ignored, in keeping with James Cutting's critique (1982) of affordances as the prime motivator of behavior. Thus, the definition of affordances as elucidated by the ecological psychology discourse allows for an explanation of the relationship between the environment, perception, motivation, and behavior, it does not provide a predictive or deterministic explanation that would allow these theories to be used outside of the field.

An Operative Definition of [Perceived] Affordances for Design

Following early work on affordances, the theory of affordances was leveraged as a tool that could be used by designers. The original publication for designers, "The Psychology of Everyday Things," (Norman 1988) predates the theory of agency (Reed 1993), and discussions about the possibility for invitation (Withagen 2012), and thus constructs an alternate framework for relating the environment, perception, interpretation, and behavior.

Initially described (Norman 1988) and revised (Norman 1999; 2002) through a series of publications, the design-oriented definition of affordances consists of three major components: conventions, constraints, and a mental model. In the framework, conventions are recognizable and repeated physical features of the environment or design products. Door handles, for instance, possess a variety of dissimilar decorations, but possess a number of similar features such as a circular shape and a lever to aid rotation. Due to cultural and logical similarity, these similarities prior experience suggests a mode of interaction: pulling, turning or grasping. Within the framework, these features constrain our behavior through suggestion ultimately giving rise to a pattern of behavior

across a population, akin to intention, as described by ecological psychology (Norman 2002, 81-91). Design literature unifies the environment, perception, interpretation, and behavior through the conceptual model. The conceptual model (Norman 2002, 12-29) refers to the learned connection between conventions, constraints, and the behaviors allowed by these features of the environment. With the knowledge of the conceptual model, designers can manipulate the physical features of the environment to predict and alter the behavior that occurs through interaction with their products.

The relationship created by conceptual models, however, was used by the design community as a deterministic relationship, prompting the publication of "Affordance, Convention, and Design," (Norman, 1999) to clarify the terminology. In the article Norman writes that the definition refers to a subset of affordances called to perceived affordances. Perceived affordances in contrast to affordances circumvent Cutting's (1982) critique by narrowing the action possibilities of an object to those recognizable and learned by the individual. Norman further states that constraints, which serving as a guide to behavior may be ignored, and it is only physical constraints, or the lack of affordance, that unconditionally restricts behavior. Thus, a conceptual model provides predictive relationship between the environment and behavior, rather than a deterministic relationship as adopted by the design community.

Both definitions of affordance and perceived affordance form associations between the environment and behavior, the psychological definition only offers an explanation of the relationship, while the design-oriented definition of perceived affordances offers a predictive description. Revisions to "The Design of Everyday Things" make a note that the definition of perceived affordance deviates from the theory

of affordances (Norman 2002, 219) but lacks a comparison between both definitions and the implications of those differences. By separating itself from the psychological definition of affordances, perceived affordances remove the psychological support it supposedly offers design. Besides the potential for misuse, the lack of comparative analysis between the theory of affordances and perceived affordances allows for the continued use of perceived affordances, without a complete account of the environment-behavior relationships that remain supported.

The Use of Perceived Affordances in Human-Computer Interaction

Given the ability to formally evaluate affordances through the predictive abilities of perceived affordances, use of the theory gained quick acceptance in the design community. As a collection of symbols, pieces of successful products and interfaces could be reused in new creations without the need to debate or critique their potential success since it had already been "proven." While the difference between the two definitions of affordance were still recognized (Kannengiesser and Gero 2012, 2), the predictive power of perceived affordances served as a useful tool for designers, thus differences between the two definitions were largely ignored. As use of perceived affordance increased, the definition was expanded to accommodate all design needs (McGrenere and Ho 2000; Kaptelinin and Nardi 2012) from the design of objects (Maier and Fadel 2002) to descriptions of context (Turner 2005) as needed for context-aware applications in ubiquitous computing (Schilit et al. 1994; Abowd et al. 1999).

Of great interest were the affordances that technology provided (Gaver 1991). As tools designers could create new affordances, and through spatial metaphors in computer-supported collaborative work applications (Gaver 1992), affordances could be used to

describe the relationship between the virtual environment and behavior. While claims about an environment-behavior relationship are supported by empirical research on the relationship between form an interaction of physical objects (Ju and Takayama 2009) and the perception of affordances in stair-climbing these ability to predict perception and behavior comes under increasingly specific conditions related to leg length (Warren 1982), age (Konczak and Meeuwson 1992), and physical ability (Cesari et al. 2003). As the basis for a design methodology (Maier and Fadel 2002, 2009) the formalization of constraints, conventions, and conceptual models remains grounded in a theory possessing a tenuous relationship to the psychological theory from which it is derived.

As a consequence, ideas built on the conflation of the two definitions of affordance must be carefully considered to separate the description of action possibility from claims about the ability to predict behavior. Forming the basis for social and tangible computing, the idea of embodied interaction (Dourish 2001), serves as a prominent example. The idea draws from the philosophical tradition of phenomenology to describe the body's role in cognition (Dourish 2001, 99-117) and uses affordances to establish a connection to scientific literature (Dourish 2001, 117-121). By citing both psychological and design-oriented literature on affordances, the idea of embodied interaction allows make formal claims about how specific technologies extend and aid cognition. While the discourse on phenomenology makes clear epistemological claims about the nature of humanity, the conflicting definitions of affordance may create internal conflicts within the supporting ideas behind embodied interaction. To fully understand the conflict between definitions of affordances and ideas grounded in affordance require an analysis of the elemental beliefs that support both theories of affordance.

CONFLICTING ASSUMPTIONS

The Symbolic Assumptions of Perceived Affordances

In the conception of perceived affordance, Donald Norman offers the designer a set of perceptual mechanisms that can be used to communicate intention between the designer and the individual grounded in cultural, logical, and personal experience. As the term convention refers to the development of shared understandings of the environment across logical groups and cultural populations, designers may reuse these features to suggest proper use of an object. Conventions are not affordances, as Gibson describes, they are representations of affordances that possess similar meaning across a group of people. Through the development of similar mental models, a predictive relationship is formed between convention and behavior, representation and the actions of an individual. To be useful to designers, perceived affordances require this predictive relationship that allows the designer to anticipate reactions to the existence of a perceived affordance.

In part, these ideas are supported by a Gibson's theory of affordances. In an oft overlooked passage, Gibson states that classification or labeling is not required for the perception of an affordance, thus rescuing "us from the philosophical muddle of assuming fixed classes of objects, each defined by its common features and then given a name" (Gibson 1979, 134-135). Perceived affordances, therefore, do not refer to all affordances that are perceived in a psychological sense. Instead, perceived (design-oriented) affordances refer to a subset of perceived (psychological) affordances that are classified from a perspective external to experience.

To describe the difference between the internal perspective of psychological affordances and the external perspective of perceived (design-oriented) affordances, we

turn to the ethnographic terms emic and etic. These terms refer to the difference between how local people think about the world, and how external observers describe the world through observations. The distinction between local and external thought comes out of the recognition that when the world is experience in first-person, it is often hard to present an unbiased account of what is going on. Thus, an emic "approach to ethnography investigates how the local people think," (Kottak 2006, 53) how they categorize the environment, how they explain behavior, and how the apply meaning to the world. An etic approach, by contrast, refers to the description of a culture from the outside perspective of anthropologists, applying their own categories, explanations, and meanings of the culture (Kottak 2006, 53). Taking an etic approach to the description of perceived (design-oriented) affordance, an external observer is able to categorize objects into conventions that is not possible from the emic experience of psychological affordances.

In general terms, a convention is a symbol, used to communicate meaning to another individual. These symbols can relate across a category of objects, such as door handles, and used by the designer to suggest appropriate behavior. While the ability to label and categorize affordances should be acknowledged, it should be recognized that symbolism is not an *a priori* property of an affordance. Rather, labels and classifications are applied from an etic perspective as a form of analysis. Through analysis it is possible to craft the formalization of convention, constraint and conceptual model that implies a predictive relationship between environment and behavior when understood as an explanation of perception and agency. Due to its conflicts with psychological theories of agency, however, Norman's writings on perceived affordance should only be considered as an analysis of an observed phenomenon.

The Phenomenology of Affordances

Given James J. Gibson's clear statement that affordances exist irrespective of intention (Withagen 2012) and his rejection of former gestalt principles of 'demand character' and 'invitation character' hypothesized by Gestalt psychology (Gibson 1979, 138), the conclusion should be that not all affordances alter behavior. While Donald Norman clarified his position on agency later work (Norman 1999) his theory of perceived affordances has lead to a widespread misuse of the concept in the design community (Burlamaqui & Dong 2014). Therefore, when considering the invitational quality of affordances, one must consider the invitational quality of affordances cannot be considered the cause of an action (Withagen 2012). When viewed from an invitational perspective, affordances do not retain the predictive qualities necessary to complete a mental model.

Now that the invitational quality of affordances has been established it is essential to understand when affordances invite. While work has been done regarding the quantified relationship between people's abilities, and the physical dimensions of stairs, these are representations of affordance, but do not account for the invitational quality of the affordance, these experiments show that the action possibility exists. From Warren's stair-climbing experiment (1984) we distinguish between critical points and optimal points at which the height of the stair is optimized to the leg length of the person. Thus, we should be able to say that ease of use affects the invitational character of an affordance from an evolutionary or developmental standpoint. From a cultural perspective perception and invitation are affected through the shared cultural understanding of the environment. While a chair affords many behaviors, it is most likely

that the affordance of sitting will be utilized based on the shared cultural understanding of the function of a chair. Lastly, personal history affects our perception of the world. While some people are addicted to chocolate (which widely affords eating across a population) the degree to which a person will be drawn to it varies widely (Withagen 2012, 256).

Through Gibson's definition of affordances as action possibilities, he defines affordances as a relation occurring between an animal and their environment. To create an action possibility the environment must possess a physical quality, and an animal must possess the ability to interact with that physical quality. Without the mutual relation between form and ability and affordance cannot exist. The body plays a vital role in perception as it allows the relationships to exist.

In the human-computer interaction discourse, the mutualistic relationship between the body and the environment is used to support the development of social and tangible computer. Support comes from the phenomenological tradition in philosophy with a primary focus on the writings of Merleau-Ponty, who focused on the inseparable relationship between the body, the environment and our understanding of both. Interest in Merleau-Ponty began with Lucy Suchman, whose book "Plans and Situated Actions" (1987) critiqued the planning model of human behavior, and served as the primary text that encouraged the development of human-computer interaction as a field. In the book she notes that we can always create a *post hoc* representation of situated actions (behavior understood through context) through the indexical use of language (Suchman 1987, 53) but the representation or formalization is not indicative of an a priori plan. Instead, it must be considered that actions occur in situ (Suchman 1987, 51). Since behavior occurs without an a priori plan and people react to the environment around them, actions should

be considered to as situated in the environment, thus establishing the relationship between human behavior and the environment; the same relationship that Gibson creates through the definition of affordance. Without considering the context in which actions occur, or the environment in which the body resides, neither can be wholly understood or accurately described.

Interest in the phenomenological discourse continues, as previously discussed, in Paul Dourish's book "Where the Action Is," which defines the term embodied interaction. Like Suchman, Dourish cites Heidegger's idea of ready-to-hand that notes objects tendency to "disappear" when utilized for some other action (Suchman 1987, 53). Dourish identifies the relationship as an embodied one, where the object becomes a tool that extends ones body Dourish utilizes this conception of embodiment in support of a direction for social and tangible computing, where the computer becomes an extension of the body, rather than an object that operates independently.

While these writings should not be consider a complete account of the importance of phenomenology in the field of human-computer interaction it is clear that the discourse plays an important role in divining a direction for human-computer interaction research. Since the computer cannot replicate the phenomenological experiences that humans experience, phenomenal artificial intelligence can only be accomplished when accompanied by some human interaction. When taking this view of the discourse, computers become tools that move from Heidegger's "present-at-hand" to "ready-at-hand" to utilize as an extension of our existing capabilities as humans.

James J. Gibson touches on the role of tools in his theory of affordances, stating that tools "Tools are a detached objects of a special sort" that have their own affordances

"graspable, portable, manipulate-able" (Gibson 1979, 40) in relation to a human, but objects that, though use, serve as "a sort of extension of the hand, almost an attachment to it, or a part of the user's own body" (Gibson 1979, 41). Though this description of tools, Gibson allows us to draw comparisons, like Suchman and Dourish, to the phenomenological states of "present-at-hand," "ready-at-hand" and embodiment philosophy (Fallman 2011).

Without recognizing the connection between "present-at-hand," "ready-at-hand" and Gibson's views on tools as extensions of the body, it is possible to construct an understanding of tools and computers as detached objects that can utilize affordances themselves (Maier 2002). What occurs here is a subtle distinction; while tools do indeed expand the affordances or action possibilities available to people, the tools themselves do not create action possibilities with the environment, thus, without being "ready-at-hand" a tool or object does not relate to the environment in the same way that an affordance relates animals to the environment.

The Continuation of Assumptions from Early Artificial Intelligence

The predictive ability of Donald Norman's perceived affordances can be deconstructed into a few component parts. The first is a symbol, the feature of the environment that represents one or more affordances. The second is an action, a physical movement or interaction performed by the individual. Finally, the third component is the relationship between the physical feature and the action (Norman 1999). In the case of a mental model, the relationship between the environment and appropriate interaction is built from experience (Kannengiesser and Gero 2012). Once established the relationship can be applied to similar environmental features such as door handles. While individual

door handles rarely look exactly the same, the basic physical features have a latch and turn-able lever across all door handles. In Norman's writing these objects with similar features, or in his writing, conventions, the idea of reduce-able understanding is remarkably similar to Emmanuel Kant's description of categories found in artificial intelligence literature (Dreyfus 1972, 176) and Ernest Cassirer's ideas about man as a symbolic animal (Cassirer 1972). When understood through symbols and the formalization of a mental model, the relationship between environmental feature and action is transferable across categories. When a designer creates a new door handle that utilizes the same conventions of a turn-able lever; they expect that people will understand how to interact with their new door handle. The existence of common experience across the category of a door handle only strengthens his position that designers need to pay attention to the familiarity that people have with the existing products they use.

The allowance of the transferable claim requires that we tackle the relationship between environmental feature and action that exists in the mental model. In the predictive relationship between convention and action, the mental model in much the same way as the information processing of a computer. As Hubert Dreyfus describes, "A digital computer is a machine which operates according to the sort of criteria Plato once assumed could be used to understand any orderly behavior" (Dreyfus 1992, 192). When actions are interpreted as a predictive response to an environmental feature, they can be seen a corollaries to Emmanuel Kant's reasons which are "rules in the mind applied by the mind to input" (Dreyfus 1992, 178). By describing a predictive relationship between the individual, their actions, and the environment that can be represented as conventions and constraints, the theory of a mental model exists as a formalization of Gibson's theory

of affordances and Reed's theory of agency. Granting the formalization the ability to predict the interactions that occur, however, differs from Reed in that his theory of agency. While theory states that intention is built on prior experience, it does not state that these experiences exist across affordances, or in Norman's case the categorical objects and conventions of perceived affordances. Thus, the formalism of a mental model contains two assumptions also made through behavior formalization in artificial intelligence: "(a) that all non-arbitrary behavior can be formalized, and (b) that the formalization can be used to reproduce the behavior in question" (Dreyfus 1992, 190), a key assumption of early artificial intelligence.

Following a model of human behavior that relies on formalization, Donald Norman's theory of perceived affordances should be viewed as a corollary to the planning model of human behavior prevalent in the same artificial intelligence work that Dreyfus critiques (Dreyfus 1992). While computers, being information and symbol processing machines, require a formal theory (McCarthy and Hayes 1969) an adequate theory of perception requires only a description of a mechanism through which the phenomenon occurs (Gibson 1979). As a corollary to the planning model, perceived affordances should be open to the same critiques. Since the field of human-computer interaction emerged primarily in response to critiques of the planning model of human behavior, the theory of perceived affordances should be approached with the skepticism as the basis for a computational design methodology.

Identifying the Epistemological Conflict

Given the oppositional relationship between artificial intelligence, a symbolic conception of the world, and human-computer interaction, a phenomenological conception of our relationship with computers, it should not be hard to imagine the opposition between semiotics and phenomenology. This opposition came to bear in 1929 during a disputation between Ernest Cassirer and Martin Heidegger, leading to a split between analytic and continental philosophy (Friedman 2000, 156). While both philosophers grounded their work in neo-Kantian ideas (Friedman 2000, 25-37), their disagreement occurred over the question "What does it mean to be human?" While Cassirer established his position on humanity, "Man is a symbol making animal," in is essay on man (Cassirer 1972); Heidegger rejected that notion by grounding humanity in experience of phenomena (Friedman 200, 39).

What must be recognized is that the disputation between Cassirer and Heidegger emerges out of the neo-Kantian tradition rather than the Kantian tradition identified by Dreyfus as a key source of the epistemological assumptions that arise throughout early artificial intelligence research. Thus, the difference between the two positions must be recognized. The neo-Kantian tradition seeks to resolve a deficiency of Kant's work. With Kant's account, there is no way to explain how an external perspective of knowledge and judgment can be achieved. Kant establishes that the external perspective exists as an *a priori* structure. The neo-Kantian tradition contends that the external perspective cannot exist independently of an internal perspective. This is where the term "transcendental logic" emerges, as a way to bridge the external and internal perspectives (Friedman 2000, 27). While the distinction between the Kantian and neo-Kantian traditions is relatively

important to the success and failures of early artificial intelligence work as in the Chinese Room Critique of strong artificial intelligence (Searle 1990) the distinction relative to affordances only reinforces the shared relationship between Norman and Gibson. Each begins from an interpretation of the relationship between the environment, perception, and behavior, but through differing epistemological assumptions, each interpretation arrives at different understandings of human behavior that conflict with each other.

This thesis will not claim humanity as innately symbolic or experiential. As the debate began in 1929 and has yet to be resolved, it is far outside the scope of the disagreement between two definitions of affordance. What can be claimed, however, is that human-computer interaction as a field grounds itself in the phenomenological tradition. As a mechanism to explain the phenomenon of perception, affordances, as defined by James J. Gibson, are inherently phenomenological, in agreement with the philosophical grounding of the human-computer interaction discourse. Perceived affordances, as defined by Donald Norman, ground themselves in a formal and symbolic description of the world. While the formalism of perceived affordance may be acceptable as a description of phenomena, its use as a description of humanity is fundamentally at odds with the human-computer interaction discourse. Through the interchangeable use of the definition of affordance, the HCI community allows itself to accept the failings of artificial intelligence that it claims to reject. The use of mental models as a basis for design allows HCI to base its design on rationalist and planned models of human behavior which Lucy Suchman critiques, and the symbolic interpretation of the world that Norman proposes, allows design to make predictive claims [about the consistent interpretation of symbols] that remain unsupported by psychological literature. While

Norman identifies the relationship a relationship between perception and behavior, he does so without considering Cutting's critique of affordances as constraining behavior (1982), and Edward Reed's writing on a theory of agency (1996). These psychological theories tackle the same problem that Norman claims to have solved through the formalization of a mental model, but can only conclude that affordances can invite behavior, and that when agency is considered, these invitations can always be ignored. This phenomenological conclusion aligns with Norman's frustration with British faucets (Norman 1999, 39) where cultural experience and personal history conflicted with the design. While millions of people successfully use these faucets everyday, Norman's failure to understand them what not a failing of his mental model, but a misperceived invitation. While computers, built on a binary symbolic logic, innately require a symbolic and deterministic relationship with the environment, the ability to describe a formal relationship between an "intelligent" being and the environment does not mean that humanity exists within the same oncologic condition.

ALTERNATIVES

Implications for Design

While the dismissal of the mental model restricts the ability of HCI designers to predict the behavior that will occur in response to their design, it frees them from the need or ability to prove the validity of their design. In the world of perceived affordances, designers could argue that one interface was empirically better than another based on the symbols it used, an invitational understanding of affordances, allows designers to reject optimized interface elements if they can imagine a situation in which the interface and the computer's affordances are not culturally or personally important to the people who will use the interface.

What the rejection of perceived affordances gives designers is freedom from empirical proof. When faced with a unique design challenge or original technology, they are free to come up with new interface paradigms without being restricted to existing examples. The designer in this case can successfully argue why a symbol was perceived as intended in one situation, but not in another, and is allowed to come up with new ideas that do not require proof. It is within this new design paradigm that human-computer interaction should focus. Instead of creating a set of generalizable symbols that can be reused across different technologies, study should focus on the differences between each and the need for original ideas for each new technology.

Interpreting the Handlebar Metaphor

A subtle but effective way of altering the relationship between the people and the environment comes, like Norman identified, through symbolic representations of the

world. Given the findings of this thesis, that symbolic representations of reality can not provide a full account of experiential phenomena, we should not consider that symbols have an analogous relationship with reality. Through their indexical relationship to reality, symbols can only claim to relate through the existence of a metaphor in which the individual understands reality by integrating their own personal and cultural experience. Given Norman's previous use of symbolic representation as a basis for design, however, these symbolic metaphors have a high likelihood of being misused as the meaning of the symbol is often understood as analogous across the physical and virtual environment of the screen. As an example of the distinction between Norman's symbolic assumptions and G

A particular challenge when constructing interfaces to be used with free-air gestures is the fact that users have nothing to guide their movements, and no distinct basis for the actions they are performing. In tandem with the significant potential for misrecognition of gesture in gesture recognition platforms, the inability for user to have reference that guide their behavior becomes a significant challenge for interface designers. Thus, the handlebar metaphor was introduced as a way to explain possible movements to users by creating a metaphor relationship between the gestures needed to manipulation onscreen objects and a physical object that users would be familiar with.

The methodology of the experiment was quite simple. Users were presented with an interface showing an onscreen cube and were asked to manipulate the object. A straight line was placed on one of the axes of the cube to represent a handlebar. Prior to interaction, the experimenter explained the purpose of the metaphor and demonstrated the way the interface was used. Results from these interactions showed that using the

metaphor as a way to explain and visually represent the mode of interaction significantly increased the user's ability to manipulate the object and remember how the gesture related to onscreen movement.

From an external perspective, the definitive conclusion of this experiment was that the use of a symbolic metaphor was a useful tool that allowed experimenters to explain the gesture required to interact with the interface. The important point, however, is that the experimenter demonstrated how to use the display prior to user interaction, thus the use of a symbolic metaphor did not mean that the user intuited or learned the mode of interaction themselves, the metaphor in this case served only as a way to explain how the onscreen object should be interpreted.

Thus, the use of a symbolic metaphor is not supported by the findings of Kannengiesser and Gero (2012) in which the user will learn how to use an object because it is unfamiliar to them. While Kannengiesser and Gero suggest that users will intuit and experiment with unfamiliar symbols, Norman claims that once a mental model is established (in this case through the experimenters demonstration) that the symbols can be reused across a number of different interfaces and situations since users will interpret the symbol in the same way. If we consider the invitational character of affordances formerly established (Withagen 2012) then the existence of prior experience only suggests that the affordance or symbolic representation of it will invite if that prior experience is important to the user. Even then, the invitation can be ignored. Thus, the use of symbolic metaphors needs to be met with measured skepticism. While interface objects can utilize a metaphoric relationship to physical objects to explain the interaction

method to users, the metaphor does not guarantee that the user will understand the relationship between physical and virtual interaction without and outside explanation.

Similarities the Computational Discourse on Context

This conversation between symbolic and phenomenal understandings of the environment plays out most evidently in the discussion of context (Dourish 2004). To create applications that respond to the environment, computers need a numeric description of context that can be manipulated and processed (Schilit et al. 1994; Abowd et al. 1999). Descriptions of context for context-aware applications focused on the measurable qualities of context: location, time, identity and activity (Abowd et al. 1999, 5). The human-computer interaction discourse, on the other hand, identified two different understandings of context. Ubiquitous computing, in its focus on measureable and empirically testable representations of context required a positivist understanding of context. Given a positivist perspective, achieving an accurate portrayal of context is a representation problem, solving the problem simply requires the identification of the correct indexes of context (Dourish 2004, 21-22). In contrast a phenomenological understanding of context carries a different set of assumptions. From the phenomenological perspective context is a relational property that dynamically changes as the relationships between person and environment change. Context therefore is an occasioned property that arises from activity, which creates and changes relationships (Dourish 2004, 22). A phenomenal understanding of context allows the problem to be framed as an interaction problem, where the challenge lies in capturing relationships and dynamically altering their meaning. The epistemological assumptions held in both conflicts on context and affordance can be traced back to the same philosophic discourse.

CONCLUSION

In conclusion, this thesis separates the discourse on affordances between the phenomenological claims of psychological literature and the formal semiotic claims of design-oriented literature. While the basis for design-oriented literature on affordances grounds itself in the validity of psychological literature, the perspective it takes on human behavior deviates from that of ecological psychology. Instead of adopting the description of psychology that creates an invitational relationship between the environment and observable behavior, it builds on the rationalist and computational understandings of humanity utilized by artificial intelligence. As this thesis has shown through a comparison to the 1929 deputation between Cassirer and Heidegger (Friedman 2000), these symbolic assumptions directly conflict with the phenomenological discourse that human-computer interaction aligns itself with. These conflicts with the human-computer interaction discourse, both in the interpretation of human behavior and its epistemological assumptions, show that for perceived affordances to remain a integral part of the design-oriented discourse, the term, and the discourse that supports it, need to be completely re-evaluated.

While the conflict between symbolic and phenomenological discourses is an important distinction, this is only highlighted to identify the fundamental differences between the assumptions of psychological and design-oriented discourse. A realignment of discourses does not require a complete evaluation of behavioral and epistemological conflicts. Instead the consideration that must be made is the disagreement between predictive and invitational understandings of affordances, as defined by design-oriented and psychological literature respectively. The existence of a symbol or representation of

an affordance can no longer determine the type of interaction that will occur with a designed interface. Instead the designer must contend with the fact that people can ignore their designs and objects. This accomplishes the original intent of *The Design of Everyday Things* (Norman 1988/2001); to shift responsibility of the misinterpretation of design onto designers instead of blaming the people objects are designed for. With the predictive relationship between the environment and behavior provided by perceived affordances, designers can blame users for not understanding their products and interfaces. When the designer assumes that users will understand their design, users can always be blamed for understanding or interacting the object correctly.

The value of identifying this conflict can be found in creating a more honest approach to design. When designers do not think they can control how people interact with their products, they must approach problems by creating original solutions that cannot be proven through prior studies. The designer must think through the metaphoric relationship of previous products and a user's understanding of their own products. By aligning with the invitational qualities of affordances provided by psychology, the design community is free to utilize prior examples as they do now, but can not rely on them as prove of the validity and success of their own work. Ultimately, the conclusion of this thesis is that aligning the design-oriented definition of affordance with the psychological definition of affordance will create a design methodology that allows for a greater variety of design solutions since they do not need to be based on prior example or proof.

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