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Understanding affordances:
history and contemporary development of Gibson's central concept

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Abstract

Gibson developed the affordance concept to complement his theory of direct perception that stands in sharp contrast with the prevalent inferential theories of perception. A comparison of the two approaches shows that the distinction between them also has an ontological aspect. We trace the history and newer formalizations of the notion of affordance and discuss some competing opinions on its scope. Next, empirical work on the affordance concept is reviewed in brief and the relevance of dynamical systems theory to affordance research is demonstrated. Finally, the striking but often neglected convergence of the ideas of Gibson and those of certain Continental philosophers is discussed.

Keywords: affordance; Gibson; perception-action; dynamical systems theory; phenomenology.

An affordance cuts across the dichotomy of subjective-objective and helps us to understand its inadequacy. It is equally a fact of the environment and a fact of behavior. It is both physical and psychical, yet neither. An affordance points both ways, to the environment and to the observer.

(Gibson 1979: 129)

At the end of the 1970's, the American psychologist James J. Gibson introduced the concept 'affordance'. It was meant to help complete the ecological theory of direct perception, of which he was the main proponent. On the one hand, affordances are a very easy thing to explain; they are the possibilities for action that an environment allows to an animal. On the other hand, the affordance concept can become obscure when one tries to exactly define it along with the notion of direct perception.

On the following pages, we explain the concept in detail. In particular, we introduce it in the historical context in which it appeared. Then, subsequent attempts for formalization and extension of the concept are discussed, followed by an empirical review and a discussion of comparable notions in the work of other scholars.

Preliminaries: two-term and three-term theories of perception

Perception has long been a central topic of study in philosophy, psychology and more recently in neuroscience—perhaps because an understanding of perception would answer not only the question of how one gets about in one's daily life, but also how the attainment of knowledge is even possible. The central assumption underlying the theoretical framework of the received view follows from the work of Herman von Helmholtz (1878/1971) but can be traced further back to Plato's ideas (see the last sections for more on the relation between Gibson and the philosophy of perception). The assumption is that perception is a *three-term relation* among a subject, an object, and something internal to the subject that stands in for the object (e.g., a representation). For example, one can construe visual perception such that the projected images on the retina play the role of that third term, and introduce a process of *unconscious inference* that disambiguates the images on the basis of previously acquired knowledge. This is necessary because the images on the retina are only deformed projections of the perceived object.

Gibson disagreed strongly with such a conception of perception. In his early work, he strove to show the weaknesses in three-term explanations. For example, how can knowledge from previous experience inform the current situation without the perceiver already having knowledge about the current situation? And why does one need to presuppose that vision is based on static images on the retina? The retina always moves (between saccades too), presumably in order to sample the optic array in its *transformation*. For that matter, static stimulation is not even defined. When the image on the retina is immobilized with a special apparatus, the study participants cannot even tell whether light is present or not. Hence, the eye is better conceived of as a 3D apparatus (two-space plus time) of the visual system, not a 2D camera. The motivation behind the snapshot (2D) model that requires a three-term theory of vision is problematic. For such reasons Gibson rejected the view that animals perceive indirectly objects in their environments by way of perceptual mediators such as retinal images that refer to these objects. He posited that perception is direct, that is, it is a two-term relation between animal and environment.

Origin

Gibson realized that if the notion of indirect perception is abandoned, the traditional ontology of perception needs to be altered too. Therefore, in addition to his first claim, that perception is a two-term and not a three-tern relation between animal and environmental properties, he proposed that perception is not of Lockean qualities such as the length of an object expressed as the Euclidean distance between points but of possibilities for action. Note that in traversing a gap, length itself does not qualify as a possibility for action but 'shorter than my step' does.

It is generally accepted that Gibson's two claims necessarily imply each other (but see Vicente 2003). Suppose that only the first claim is true. If *only* things such as surfaces were perceived directly – Gibson's early work focuses on the perception of surfaces (Mace 2005) – then the possibilities for action that these surfaces afford would have to be inferred. Because the main function of perception is to enable action, it would follow that most perception is indirect.

Supposing that only the second claim is true turns the affordance concept into a mere buzzword. One can study possibilities for action as conceptual possibilities in the framework of the received view (e.g., designing algorithms that infer gap length from distance cues and compare it to an internal representation of maximum step length). One can call the product of such an algorithm affordance perception, but this would not make any difference to the computational theory. In other words, the affordance concept has a special meaning and hence, is *necessary*, only in the context of Gibsonian theory.

What was Gibson's original exposition? In contrast with the ontology of the received view, e.g., "[o]rthodox psychology asserts that we perceive these objects insofar as we discriminate their properties or qualities", Gibson (1979: 134) proposed "... that what we perceive when we look at objects are their affordances, not their qualities". What are affordances? "The affordances of the environment are what it offers the animal, what it provides or furnishes, either for good or ill. I mean by it something that refers to both the environment and the animal in a way that no existing term does" (Gibson 1979: 127).

What is it about the environment that allows affordances to be perceived? "Perhaps the composition and layout of surfaces constitute what they afford. If so, to perceive them is to perceive what they afford" (Gibson 1979: 127). In order to understand what this layout might be, it is useful to refer to his earlier insights about the *occluding edge*, which follow a similar logic (Mace 2005). As I move my head leftwards, an edge (the right side of the computer screen) progressively erases a portion of the visual array (the wall that serves as background). This is enough to show in a definite way that the screen is *between* me and the wall. It is crucial to realize that the occluding edge does not only define the locations of surface A (here) and surface B (there) but also their spatial order *relative to me*, the point of observation. Later in his career, Gibson realized that the occluding edge provides even more information – it specifies to a per-

ceiver that she can reach the one surface directly and needs to make a detour to reach the other. In short, things such as occluding edges can specify not only spatial order but also affordances (e.g., *reachability*).

Effectivities complement affordances

Gibson put enormous effort into understanding what it is about the environment that allows one to directly perceive it. Consequently, his work says much more about the environment, especially the visual environment, than about the animal. The term *effectivity* was introduced in order to help compensate for this inequality (Michaels & Carello 1981; Shaw et al. 1982). The animal's effectivities are directed to the environment in the way that the environment's affordances are directed to the animal. An affordance dispositional and an effectivity dispositional; the concepts complement each other and, thus, make a dual.

This move has attracted some criticism because one could possibly understand it as a step backwards. Gibson's affordance "*points both ways*, to the environment and to the observer" (Gibson 1979: 129, italics added); there is no need for two terms. In the "reformulation", however, affordance and effectivity point unidirectionally (Cutting 1982: 212). Accordingly, one abandons what is most important and original about affordances by dispensing with the double arrow in their formalization.

The apparent discrepancy between Gibson and Shaw-Turvey-Mace stems from the different ways in which the word affordance is used in the two formalisms. What Gibson calls an affordance is what Shaw-Turvey-Mace call an affordance-effectivity dual. Gibson's double-sided arrow is replaced with something like a field with two poles. In order to see how the two formulations are similar, consider that instead of an 'affordance-effectivity dual' one could say 'environment pole and animal pole of the affordance dual.' The latter version fits more literally with Gibson's expression and would not change the Shaw-Turvey-Mace formalism. Furthermore, dispositions necessarily come in complementary pairs. Hence, the relational character of affordances that Gibson was aiming for is also part of the definition (Turvey et al. 1981; Turvey 1992). Michaels (2003) provides an evaluation of the gains and losses related to the notion of effectivities. Shaw and colleagues (1988, 2001) aim to develop a systematic theory of effectivities.

Formalism and ontology

Gibson's second claim, that perception of affordances is understood as *real* and not as *conceptual possibilities* for action, implies that affordances are an *ontological*, not an *epistemological* category (Shaw et al. 1982; Turvey et al. 1981; Turvey 1992). Additionally, affordances exist as properties of the environment independently of the perceiver. As long as squirrels exist, a particular tree affords climbing to a squirrel regardless of whether there is a squirrel around. Hence, affordances are prior in logic to their actualization. One way to summarize a lot of what has been said so far is through the

definition "A situation *X* affords action *Y* to an animal *Z* on occasion *O* if certain relevant compatibilities between *X* and *Z* obtain" and, analogously, "An animal *Z* can effect action *Y* on an environmental situation or event *X* if certain relevant compatibilities between *X* and *Z* obtain" (Shaw et al. 1982: 196-197).

What are these compatibilities? In any particular situation, what is dynamic and what a psychologist would focus on is not *every* potential affordance and effectivity, but the match of *particular* affordances and effectivities that got *actualized* by the experimental situation. Turvey (1992) accommodates this fact by explicitly assigning a role to the environmental properties and animal dispositions supporting an affordance. An animal *Z* with the disposition to perform an action *q* (same as *Y* above) and an environment/situation *X* with a property *p* that complements the disposition *q* form an environment-agent system $W_{pq} = j(X_p, Z_q)$. The dispositionals *p* and *q* actualize each other once being made available to each other, what Turvey calls the juxtaposition function *j*. In this manner they select each other out from the larger arrays that contain all potential properties and actions of the particular environment and agent, respectively.

Kadar and Effken (1994) develop an approach to the ontology of affordances and effectivities that is more of a critique of Turvey's formalism (1992) than a self-sufficient proposal. Specifically, they would like to replace the metaphysics that Turvey's work relies on with Heidegger's. Turvey is led to build his ontology out of things with properties. Conversely, adopting Heidegger's metaphysics, the authors argue, would lead to assigning ontological primacy to fields. The question is, which of the two metaphysics fits better with Gibson's understanding of affordance? Kadar and Effken argue that, first, Heidegger and Gibson thought the same way about many issues (see the section Relations between Gibson and some philosophers of perception) and, second, fields can be made consistent with both Gibson and Heidegger, but things cannot.

Recent developments

In contrast to some of the earlier formalizations (Turvey 1992; Michaels 2003) and somewhat comparable to Kadar and Effken (1994), Chemero (2003, 2009) argues against understanding affordance as a property of the environment. Instead, it is a *relation* between an animal's ability to act and aspects of the environment. For instance, the affordance "stair-climbability" *is* the relation between riser height and climbing ability of the observer, and is not in the layout of the surfaces alone. This move, Chemero argues, solves the philosophical problems associated with properties and dispositionals while keeping Gibson's approach intact (2003, 2009). The situation is similar to the explication made earlier of how both Gibson's and Shaw-Turvey-Mace's accounts fit the same abstract theoretical model.

Regardless of whether affordances are understood as duals, dispositional properties, or relations, all the formalizations listed so far treat affordances in a timeless domain. The field of ecological psychology, however, is heavily influenced by the advent of dy-

namical systems theory. Chemero (2009) therefore argues that the coupling between affordance and ability (effectivity) should be treated not only as an instantaneous match (lock and key) but as an unfolding system that in the longer time domain converges with niche construction.

Chemero's (2003, 2009) real break with traditional Gibsonian theory is with respect to the issue of specificity of information. Usually, one takes it that perception can only be direct if information exists that *specifies* what is possible; otherwise ambiguity exists, and a process of inference is necessary. However, building on the work of Barwise and Perry (1981) and Milikan (2000), Chemero argues that information need not be specific as long as there is a *constraint* that connects (non-specifying) information with what is present in the environment in a way that is reliable enough to guide behavior (see also, Withagen & Chemero 2009, 2011). For instance, to a prey animal the shadow of a flying predator informs it about the presence of a predator, but the constraint between the predator and the shadow is merely correlational. On a cloudy day, the flying predator will not produce a shadow moving across the ground. And if the shadow is present, the possibility exists that it was produced by a non-predatory animal or a flying object of a similar shape (example taken from Millikan 2000). This position thus explicitly addresses perceptual error (see Gibson 1979: 142-143 on misinformation for affordances). It also fits well with empirical findings of perceivers' use of non-specifying information, such as those by Michaels and de Vries (1998). For a critique and extension of Chemero (2009) see Withagen and van der Kamp (2010).

The scope of the concept

Turvey (1992) abides by Hume's touchstone; action-based affordances at a level that applies to all animals are to be taken as "propaedeutic to any extension of affordances to other domains" (Turvey 1992: 174). Conversely, Shotter (1982) emphasizes the historical character of affordances. In a human world one *must* consider the sociocultural affordances. For Gibson, mailboxes afford sending letters to a human *enculturated* in letter-writing in the same way that chairs afford sitting. Stoffregen (2004) also argues for a broader scope of affordances. This is appropriate in the context of his understanding of affordance as *emergent* properties of the animal-environment system. Heft (2001) attributes affordances to the intrinsic properties of features, objects and events that tie us together in relations. Therefore, values and motivations that are intrinsic to affordances also constitute a proper domain of study.

Equating affordances with just anything that is "meaningful" might trivialize them (Michaels 2003). Still, Gibson's theory of perception was meant to address the human world in its full complexity. For instance, the mailbox example refers to a network of human activities. A full-fledged theory of affordance should be able to take heed of the richness within any action. How to balance these requirements? Maybe affordances can be organized by taking into account the different capacities of different organisms since these, taken as effectivities, actualize an affordance.

Classical experiments

Eleanor Gibson must be the pioneer of affordance research with her work on child development, which even preceded the formal introduction of the concept (in: Adolph & Berger 2006). Her *visual cliff* paradigm shows that human babies and self-locomoting animals perceive that the cliff affords falling and injury, whereas the non-self-locomoting ones do not until they learn to locomote. A methodologically more optimal design, however, consists of an adjustable *locomotory slope*. Instead of a cliff one uses a declining surface and as a result there is no need for a glass plate that may or may not be as transparent as the experimenter would like (Adolph & Berger, 2006). A novel finding there is the *motor-specificity* of learning. After having learned to perceive which slopes afford crawling and which do not, infants fail at the task once they start walking and, hence, have to go through the learning process again.

Warren (1984) was among the first to test the animal-relative character of affordances. He examined participants' perceived ability to step on the flight of a stairway. In particular, the transition from ability to inability was measured as a function of riser height. Participants from both the "short" and "tall" groups transitioned when the ratio of riser height to individual leg length had reached a value that was the same across groups. Such ratios are known as dimensionless π-numbers (the units cancel out because they are the same in both the numerator and denominator) and can also index critical transitions in certain purely physical systems. For instance, the Rayleigh number for a given fluid predicts heat transfer transitions from conduction to convection (as in the onset of boiling).

The hypothesis that body-scaled information specifies affordances was tested further using judgments of the passability of a vertical aperture (Warren & Wang 1987). The layout of an Ames-like room was manipulated in a way that demonstrated that participants relied on body-scaled (eye height) information and not on extrinsic cues of object size and distance. Similarly, a study of sitting and stair-climbing found that an eye-height-based π-number specifies the affordance boundaries (Mark 1987). Interestingly, participants adjust to the eye-height changes induced by platform shoes only if allowed natural posture and mobility patterns during the learning phase (Mark et al. 1990).

Some recent studies

Empirical π-numbers for affordance boundaries such as those found in the stepping and sitting studies need theoretical justification. Otherwise, one could speculate that a higher-order homunculus is monitoring the use of information and flipping on-off switches in accord with memorized threshold values. Self-organizing systems theory naturally handles these transitions, formally called phase transitions. Nonlinear dynamical modeling extends the previously merely conceptual use of this theory by giving an explicit mathematical account of affordance transitions (Fitzpatrick et al. 1994; Frank et al., 2009; Lopresti-Goodman et al. 2011; Richardson et al. 2007).

The intrinsic metric for affordances may include variables such as *effort*. Participants tend to overestimate the slant of a perceived slope when their response is verbal or pictorial but are relatively accurate when the response is in the form of a coordination task (Proffitt et al. 1995). Importantly, the overestimation is amplified after exercise implying that participants are not merely perceiving slant but a surface to be climbed. A similar paradigm has shown that the effect of prospective effort appears if the participants actually intend to perform the action corresponding to the distance being estimated (Witt et al. 2004; but see Woods et al. 2009).

Generalizing the intrinsic metric even further, one can simply use *abilities* as the scaling factor (Chemero 2003). Fajen studies abilities in the context of visually guided actions (Fajen 2005; Bastin et al. 2011). For instance, braking behavior while driving depends on the car's maximum deceleration (Fajen 2005) and subjects turn toward a target when the ideal speed required to intercept it is less than maximum possible speed, and ahead of it when ideal speed is greater than maximum (Bastin et al. 2011). Thus, observers adjust such that the intended action is always possible within the limits of their action ability.

Relations between Gibson and some philosophers of perception

Ever since the classical Greek period, most philosophers and, later, psychologists would assume as a starting point in their studies of knowledge and perception what appears to be an obvious truth—here I am, a subject, looking at something over there, an object. How does a subject get to know a detached object? This question has been formalized as Cartesian skepticism. Asking this question leads to a representational account of knowledge and perception. In contrast, some of the most important 20th century philosophers (e.g., Carnap, Wittgenstein, Dewey, Davidson, Heidegger) argued against even considering the skepticism problem and instead sought to "dissolve" it (Blattner 2006: 109). Heidegger's particular strategy is illuminating; scholars need to stop relying on bare intuition to formalize their foundational problem and start using a systematic phenomenological analysis. The conclusion of his analysis is that the subject-object dichotomy only appears in what is called the present-at-hand mode. This mode exists only in isolated cases of experience that do not warrant the presumed fundamental character of the dichotomy.

The similarity between Gibson and Martin Heidegger and Maurice-Merleau-Ponty has been pointed out a number of times (Dreyfus 1996; Heft 2001; Kadar & Effken 1994). Compare their ways of bridging the subject-object divide: "An affordance is neither an objective property nor a subjective property; or it is both if you like." (Gibson 1979: 129) and "Perceivedness … is in a certain way objective, in a certain way subjective, yet neither of the two" (Heidegger 1982: 314).

What other commonalities can one obtain? First, the Heideggerian word for affordances could be *equipment* (Kadar & Effken 1994), but *ready-to-hand* is a possibility too. The latter stands for the function, the *for-what,* that a tool promises (Dreyfus

2007). Consequently, an affordance structure that defines a niche (Chemero 2009) would correspond to Heidegger's functional totality, the structure of *towards-which* or *in-order-to* relations (Blattner 2006: 59). Second, Heidegger (Dreyfus 1991) just like Gibson assigned his respective construct the status of ontological primacy, more fundamental than Lockean properties which themselves have a derived character. Third, for both scholars possibilities for action cannot be cast in terms of propositional knowledge characterized by truth conditions (Blattner 2006: 94; Turvey 1992: 176). Finally, both the concepts of equipment/ready-to-hand and affordances are fundamentally temporal. Dasein is historical and the kind of being that projects itself ahead of itself (Dreyfus 1991: 186), it is always "pressing forward into possibilities." And on Gibson's side, affordances are prospective by nature (Turvey 1992).

Gibson's own abandonment of the subject-object assumption is probably most directly influenced by the American *pragmatism* tradition of William James and John Dewey of which he was part through his advisor Edwin Holt, who was a student of James. See Dewey's famous critique of the *reflex arc* concept for an entry point in the pragmatist tradition, and Heft (2001) for a detailed exposition of this lineage.

Who else can be found in Gibson's anti-representationalist camp? According to Lombardo, Aristotle anticipates Gibson in opposing the mind-matter dualism of his mentor Plato and in arguing that the world itself and not the world of appearances is the object of perception. Additionally, Aristotle's "correlative objects" are similar to Gibson's notion of affordances as perceived opportunities for action in the environment (Lombardo 1987).

The umwelten, the perceiver-centered animal-relative worlds of von Uexküll (1957), also converge with Gibson's thinking—more specifically with the way an affordance-structure defines an animal's niche (Chemero 2009). We do not know if Gibson was familiar with von Uexküll's work but both Merleau-Ponty and Heidegger read von Uexküll, and Gibson was familiar with Merleau-Ponty (Heft 2001: 161). There are several other theorists whose ideas were closely related to Gibson's affordance concept but who were representationalists. These include Egon Brunswik and the Gestalt psychologists.

Conclusion

What are some of the underlying themes in the sections presented above? Ecological psychology carefully examines the assumptions that sit behind research in perception-action. It has exposed fundamental problems with the subject-object dichotomy that is taken for granted by the received view. Affordance research is not just about how knowledge is acquired but about what there is to be known to begin with. It is thus applied research as much as it is theoretical. It is an active field, both in terms of theoretical development and in terms of the amount of empirical work that is being done. It has also become extremely interdisciplinary. Just in this short review we have touched upon experimental psychology, physics, dynamical systems theory, self-organization, and stuck phenomenology in between.

What are some of the outstanding challenges that affordance research faces? The concept was developed in the context of an ongoing dispute between the ecological and cognitivist traditions within psychology. Nowadays, however, the domains of perception and action are arguably dominated by the neurosciences. These retain the information processing metaphor of cognitivism (at least superficially) but are different enough to be considered a movement on its own. Thus, there is a new and very powerful player on the scene and proponents of the ecological approach should determine their stance. It would be easy for a cognitive neuroscientist to appropriate the word affordance but miss its substance by simply talking about "action representations" stored in some cortical area. Although more thoughtful attempts to develop an ecologically-motivated neuroscience do exist (see for example Cisek & Kalaska 2010), it is yet to be seen if such attempts have any prospects.

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