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Gibson's Reasons for Realism and Gibsonian Reasons for Anti-Realism: An Ecological Approach to Model-Based Reasoning in Science

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Abstract

Representational views of the mind traditionally face a skeptical challenge on perceptual knowledge: if our experience of the world is mediated by representations built upon perceptual inputs, how can we be certain that our representations are accurate and our perceptual apparatus reliable? J. J. Gibson's ecological approach provides an alternative framework, according to which direct perception of affordances does away with the need to posit internal mental representations as intermediary steps between perceptual input and behavioral output. Gibson accordingly spoke of his framework as providing "reasons for realism." In this paper I suggest that, granting Gibson his reasons for perceptual realism, the Gibsonian framework motivates anti-realism when it comes to scientific theorizing and modeling. If scientists are Gibsonian perceivers, then it makes sense to take their use of models in indirect investigations of real-world phenomena not as representations of the phenomena, but rather as autonomous tools with their own affordances.

Keywords: perception; ecological psychology; affordances; representation; philosophy of science; scientific modeling

Introduction: Representationalism and Skepticism

Representationalism concerns, roughly speaking, the thesis that the mind operates by generating, storing and processing representations of the world. In this view, as traditionally understood, perceptual input is transformed into internal representations or "information-bearing structures" (Pitt 2013) which in turn are utilized to create behavioral output. Recent representationalists differ in how they define 'representation', distinguishing between internalism and externalism about both the "content" of representations and the "vehicles" that carry representational content (see, e.g., Clark and Toribio 1994, for a rejection of the representationalism/anti-representationalism dichotomy and the suggestion that representation comes in different degrees and types; along similar lines, Hurley 2001 provides a comprehensive taxonomy of externalist views, defending a distinction between what- and how-externalism). Representational theories of the mind, in particular the internalist varieties, are intimately connected to the threat of skepticism: if our knowledge of the "external world" is indirect and mediated by "internal reconstructions" of our surroundings—if, that is, we only have direct experience of our mental representations, not of the world itself—then it is reasonable to wonder about the accuracy of such representations and, consequently, about the reliability of our knowledge.

Epistemological consideration of the problem of perceptual knowledge dates back at least to Plato, who likened input from the senses to the shadows on the dark cave wall, imperfect reflections of the outside world (cf. Newman 2014). A classical example of skeptical doubts resulting from a more explicitly representational approach to the mind is found in the work of René Descartes, who took there to be "reasons for which we may, generally speaking, doubt about all things and especially about material things" (Descartes, Weissman, & Bluhm 1996, p. 55). In his *Meditations* Descartes discusses skeptical threats involving dreams and evil demons. We sometimes have dreams that seem so realistic that we have the impression that the dream is indeed real. Based on this common experience, Descartes asks: how can we be sure that we are not currently dreaming? Further, how can we be certain that our entire lives were not a dream? A second skeptical doubt for Descartes concerns the possibility that an evil, deceitful demon or deity gives us misleading sensory inputs such that we believe in the existence of an external world when in reality none exists. Different versions of these skeptical threats have persisted since Descartes and influenced philosophical theorizing. A variation of the evil demon argument that has been influential in recent analytical philosophy, for example, concerns the idea that if one were a disembodied brain in a vat and were fed representations of the external world, one would be unable to know that those were not real (Harman 1973, Putnam 1981).

The thesis that the mind operates by generating, storing and processing mental representations—particularly internal structures that encode information about the world—has been labeled "the central hypothesis of cognitive science" (Thagard 2014). But that is not to say that there are no alternatives. Major examples of anti-representationalist accounts are found in dynamical systems theory (van Gelder 1998), situated robotics (Brooks 1991; Webb 1995, 2005), and radical enactivism (Hutto and Myin 2013). Ecological psychology has informed and motivated much of this anti-representationalist work (see, e.g., van Gelder and Port 1995 on the its influence on the dynamical systems approach), and will be the focus of the present paper.

Ecological Psychology Revisited

Ecological psychology, as articulated by J. J. Gibson in his 1979 book *The Ecological Approach to Visual Perception*, was founded on three precepts. First, Gibson suggested that perception is *direct*: rather than having to reconstruct the world by generating representations built upon sensory input, we have unmediated perceptual access to what is present in our surroundings. Second, for Gibson perception is inherently *action-oriented*, and we always perceive in order to do something. Gibson claims that “perceiving is an act, not a response, an act of attention, not a triggered impression, an achievement, not a reflex” (1979, p. 149). In his view, as active explorers of the world, we are in constant engagement with our environment, such that perception is in principle and in practice indissociable from our acting and preparing for action. Third, Gibson proposed a radically novel account of what the objects of perception are. Rejecting the idea that we perceive discrete properties such as an object's size, shape and composition and then have to analyze those properties in order to determine how to relate to the object, Gibson proposed that perception is of “*affordances*” or “action possibilities.” Ordinary examples include the possibility to sit on (in the case of a chair), to pass in between (in the case of an aperture), or to cut with (in the case of knives). Gibson's proposal is that the descriptions favored by mainstream psychology and cognitive science are mistaken when they take perception to be the first stage in a process that involves the generation and internal processing of sensory inputs in order to produce external behavioral outputs (similar to what Hurley 2001 calls the “sandwich view” of the mind). Instead, for Gibson we simply and directly perceive *how* we can engage with objects and *what* we can *do* in the environment, such that perception-cognition-action become an indissociable unit. In light of this, the title of Gibson's 1979 book and its emphasis on visual perception can seem misleadingly simplistic: in reality, by treating perception as necessarily action-guided and of action possibilities, Gibsonian ecological psychology collapses perception, cognition and action, at once providing a unitary account of the three.

Gibson's concept of “affordance” has generated considerable controversy. His own description was that affordances are what the environment “offers the animal, what it provides or furnishes, either for good or ill” (1979, p. 127). This somewhat obscure formulation was later interpreted as referring to the *dispositional properties* of the objects themselves (Scarantino 2003). Another interpretation, one that seems to be more faithful to Gibson's proposal, frames affordances in *relational* terms as the interplay of subjective skills and environmental properties, or “relations between the abilities of organisms and features of the environment” (Chemero 2003, p. 189). A more recent adaptation of this relational interpretation attempts to account for social and cultural differences by defining affordances as “relations between aspects of a material environment and abilities available in a form of life” (Rietveld and Kiverstein 2014). Regardless of the particular variety, similar relational interpretations have in the past couple of decades influenced expansions of the Gibsonian framework, which, paired with the explanatory tools of dynamical systems theory (Kugler, Kelso, & Turvey, 1980), have led to the use of non-linear modeling to investigate systems that exhibit “interaction-dominant dynamics” (Van Orden et al. 2003). These additions and applications have secured to the Gibsonian framework a place as a successful approach in contemporary experimental psychology and cognitive science. As for the concept of 'affordances', it has taken its own life in the domain of design research (see, e.g., Norman 1990) as well as in neuroscience, where it has been framed in terms of neural representations of object-related motor intention (Jeannerod 1994, Craighero et al 1998, Tucker and Ellis 2001) and linked to the mirror systems believed to be associated with social cognition (Bach et al 2011, Brincker 2015).

Gibson's Reasons for Realism

Framed in relational terms, as seen above, affordances can be interpreted as undermining the distinction between subject and object: action possibilities exist objectively regardless of subjective awareness, and still they are subjective in that they change according to the individual organism and its characteristics. Gibson himself seemed unbothered by the dichotomy, claiming that “an affordance is neither an objective property nor a subjective property; or it is both if you like” (Gibson, 1979, p. 129). An anti-dualist in many respects, Gibson rejected also the existence of any difference between the natural and the artificial, and, accordingly, between “affordances in general” and the affordances of human artifacts. Psychologist Alan Costall has questioned this point, proposing that artifacts have what he calls “canonical affordances,” that is, conventional and normative action possibilities: even if other uses can be found, chairs, for example, are *for sitting on*. Costall considers this expansion of the conceptual framework to complement Gibson's own interests by taking analysis beyond the subject-object dyad: “The object needs to be understood within a network of relations not only among different people, but also a “constellation” of other objects drawn into a shared practice” (Costall 2012, p. 92). Whether this is a reasonable suggestion and particularly whether it provides additional insights into scientific modeling qua affordance-based practice is something to be explored elsewhere. For now, with the basic outline of the Gibsonian approach in place, let us consider what conclusions it motivates for philosophical discussions about realism.

In a paper published a decade before his explicit articulation of the ecological approach in the 1979 book, Gibson argued that the view of perception he was developing provided the basis for a kind of naïve realism, one that justified the confidence we ordinarily have in (the reliability of) our epistemic access to the world around us. He summarized his account at the time saying that it was based on: “(1) the existence of stimulus information, (2) the fact of invariance over time, (3) the process of extracting invariants over time, and (4) the continuity of perception with memory and thought” (1967, p. 167-168). Despite the difference in terminology, the spirit of the theory seems similar enough to the 1979 book, particularly with respect to the assumption that information is available perceptually, as well as to the merging of perception and cognition. Again, Gibson's view, even in this earlier stage, is that perception is of publicly available information; this is a direct approach, with no intermediary steps between perception and action that involve the generation and manipulation of mental representations. If there existed such representations, there would be a risk that they are inaccurate, that they *misrepresent*. But Gibson does away with the need to posit representations—he claims: "I am quite certain that there is no such thing as a phonograph record in the ear and no such thing as a picture in the eye—no reproduction of an external event or object that the organ transmits to the brain" (1967, p. 169). Accordingly, Gibson concludes that his ecological approach provides answers to traditional epistemological concerns by substantiating a kind of direct naïve realism: taking the senses as perceptual systems, he says, offers "sophisticated support for the naive belief in the world of objects and events, and for the simple-minded conviction that our senses give knowledge of it" (1967, p. 168)—that is, since perception is a process of actively and directly picking up ecological (publicly available) information, skeptical threats do not even get off the ground and we can rest assured—as non-philosophers tend to—that we stand on solid epistemic foundations.

Scientific Models and Representation

Assuming for the sake of argument that Gibson is right both in the basic ecological framework and in the interpretation that direct perception provides the basis for a realist outlook, this paper is concerned with whether Gibson's reasons for *perceptual realism* translate into reasons for *scientific realism*—i.e, realism about the unobservable entities postulated in scientific theorizing and about the relationship between scientific products and the "real world." Taking the recent debate about scientific modeling as a starting point for this investigation, and assuming that scientists are Gibsonian perceivers, the question here concerns what conclusion Gibson's reasons for perceptual realism motivate with regards to the epistemic import of the use of models in scientific research.

In recent years, philosophers have increasingly acknowledged the role played in contemporary science by *mediated* or *indirect* forms of investigation through the construction and manipulation of models like mathematical equations, computer simulations, and robotic replicas. A widespread view in this literature is that scientific modeling is a *representational* activity (Giere 2004, 2010; Morrison and Morgan 1999; Morrison 2015; Suarez 2003, 2004; van Fraassen 2008; Weisberg 2013). The *representational view of models* amounts to the assumption that models are *representations* of the target systems or phenomena they simulate, and that the epistemic value of model-based scientific research is grounded on the supposedly *representational* relationship between a model and its target. Even while acknowledging that models often neglect some details from the target phenomena and include known distortions and simplifications, the representational view of models takes it that models *represent* the target—that is, that despite containing purposeful deviations from "veridical representation[s] of real-world phenomena," a model is a representation of the phenomena (Weisberg 2013, p. 98). And in addition to taking the relationship between models and their targets to be *representational*, the representational view of models assumes further that this representational relationship is what secures the epistemic value of modeling, or what allows scientists to learn about a target through indirect experimentation with a model: models can teach us about the world "precisely because (…) they fulfill a representative function" (Morrison & Morgan 1999, p. 24-25). Recent contributions to this literature have put forward different accounts of scientific representation, providing distinct views of how a model represents its target: some have framed representation in terms of *isomorphism* or one-to-one structural correspondence (van Fraassen 2008) or in terms of *resemblance* or *similarity* (Giere 2004, 2010); other accounts suggest that, beyond the properties of the model-target dyad, scientific representation involves drawing *inferences* (Suarez 2003, 2004) and active *interpretation* (Contessa 2007), or that it is best understood through the lens of *semiotics* (Knuuttila 2010). Despite the variety of takes on how scientific representation works, the representational view of models presupposes that scientists build and use models to learn about some target phenomenon because models represent their target.

An Ecological Approach to Scientific Modeling

What would an alternative to this representational view of model-based scientific research look like? More specifically, what would a *Gibsonian* alternative to representationalism about scientific modeling look like? The account I outline here builds upon the ideas of treating models as "autonomous agents" and "instruments of investigation" (Morrison & Morgan 1999) and as "epistemic tools" (Knuuttila 2011). Morrison and Morgan emphasize how models are partially independent both from theory (the scientific conceptual framework within which models are built) and from the phenomena they are intended to simulate, such that experimenting with a model can shed light both on the relevant scientific theory and on the target of investigation. Like Morrison and Morgan, Knuuttila highlights the manipulability of models as central to their epistemic contribution in science—researchers need to be able to manipulate, intervene on, and otherwise experiment with a model in order to learn something from it. But Knuuttila further adds that the manipulability of models implies their concreteness or "materiality," based on which she proposes that models can play the role of an external scaffolding that, in the sense suggested by Hutchins (1995) and Sterelny (2004), *extends* the scientists' cognitive processing. This last, stronger claim about cognitive extension, while interesting and worthy of further exploration, actually complicates the issue at hand more than is necessary: the notion of cognitive extension is not one Gibson included in his framework, and can be set aside for present purposes. Accordingly, the working hypothesis to be considered here is simply that the creation and manipulation of models in the context of scientific research can be understood in comparison with how we create and engage with instruments, artifacts and tools more generally.

From a Gibsonian perspective, the ordinary objects we encounter in daily life afford a variety of uses, depending on various properties such as shape, size, and composition. For example, "a pointed elongated object affords piercing" while "a rigid object with a sharp dihedral angle, an edge, affords cutting and scraping" (Gibson 1979, p. 133). Indeed, we manufacture objects with those properties (such as spears and needles in the first case and knives in the second) *because* they afford such uses. Importantly, however, affordances are not reducible to the properties of objects or the environment. In the *relational* framework reviewed above, action possibilities are relations between organism and environment. Thus, in any situation, affordances will vary according to not only what the environment is like, but also *who* is engaging with it: the actions that are possible or not, are possible or not *for* some entity. The characteristics that make a surface climbable for a fit adult of average height are not the same that make it climbable for a child, for a dog, or for a climbing plant, and the differences are not simply a matter of body scale but of the general abilities and skills that the organism has.

Applying this framework to scientific modeling allows us to recognize that models are designed and built by modelers and scientists *so as to* afford some use(s) of interest. Whether it is a robotic model that is built to display some particular behavior, or a computer simulation that is designed to allow interventions of some sort, or a mathematical model that is specified in order to generate predictions based on some data input, scientific models are indissociable from the research context in which they are built. The guiding questions of a model-based project thus determine what the features of the model need to be so that it can be useful in that context. But usefulness is not an absolute value, which means that, from the early stages, model-building is a matter of constructing a tool that will provide relevant action possibilities *for someone*. This specificity imposed by research context and intended uses/users makes it so that no model is ever a perfect representation of its target: in fact, rather than accurate or inaccurate *descriptions* of some target phenomenon, the suggestion here is that models are, at best, the most useful tool available for a given *task*. The affordances of a model, then, are the action possibilities the model offers or makes available to model-builders and intended users.

An interesting consequence of Gibsonian ecological psychology is that it blurs the distinction between the subjective and the objective: affordances are subjective, or "relative to the animal" and "unique for that animal" (Gibson 1979, p. 127), but they are also "objective, real, and physical" (p. 129) in the sense that an "opportunity for action" exists for an animal even if that animal does not act upon it. First, which action possibilities an object affords an organism is a fact irrespective of that organism's awareness of it, that is, "*independent of the individual's ability to perceive this possibility*" (McGrenere & Ho 2000, p. 179). And additionally, the particular affordances of any object can vary across individuals at a given time as well as for the same individual over time: "knee-high for a child is not the same as knee-high for an adult, so the affordance is relative to the size of the individual" (Gibson 1979, p. 128), varying also, as seen above, according to what kind of organism it is —whether it is a human, a dog, a plant, and so on.

In this view, the affordances of a scientific model are objective in that they exist independently of their being perceived by an individual scientist, but they are also subjective in that the same model may not afford the same action possibilities to different individuals. This is significant because it illuminates both the differences between scientists and non-scientists, as well as, within science, the different practices that characterize distinct scientific disciplines. On the one hand, the variability of affordances resonates with the fact that in order to become a scientist one has to go through years of training and arduous work—it requires learning, or in Gibson's terminology, the "education of attention" (1979, p. 254); it is only through serious intentional effort that the novice can learn to perceive certain affordances that are already present and also develop new ones, as is evident in the case of highly complex mathematical models, which are gibberish to the uninitiated. On the other hand, the variability of affordances also sheds light on the differences that exist between scientific disciplines: training with the methods and tools of a particular discipline attunes an individual to the particular approach favored in that discipline, making more salient specific features of the world (both the phenomena of investigation and the models that are built and used to investigate them). The effect of specialization over time is thus present also collectively, shaping how disciplines develop differently from one another, so that, for example, the modeling techniques which appear essential to a behavioral ecologist may seem dispensable to a molecular biologist and entirely useless to a physicist, and vice versa. Members of the same species surely share many of the same affordances (as in the example of cutting objects); yet, oftentimes a lot of effort is required for individuals to become aware of certain affordances or even to develop new ones (as in the cases of training to become a scientist, and of intra- and interdisciplinary methodological differences).

Gibsonian Reasons for Anti-Realism

As seen above, Gibson took his direct-perception approach to substantiate a realist stance: our perception of the world is reliable because it is not based on the production of "internal representations" that could be wrong about the "external world," but rather perception is the very process by which we actively and directly pick up ecological information. Now even if in this Gibsonian perspective we can be realists about our perception of the world, the ecological view of models sketched above motivates a more nuanced conclusion for realism about scientific knowledge generated from model-based research. Applying to scientific methodology the insight that perception is direct and of action possibilities, we conclude that the models and simulations used in science are *tools* to whose affordances we also have direct perceptual access. Just like any organism perceives in its surroundings opportunities to act in particular ways, some scientists perceive in aggregates of silicon and synthetic compounds, or in simulation softwares, or in mathematical equations the action possibilities that enable them to study the phenomena they are interested in. The point, however, is that this ecological approach to modeling also articulates the model-target relationship in anti-representational terms. That means that rather than taking the resulting robotic, computational or mathematical model to be an accurate or inaccurate representation of some target, the model is an independent *tool* that is *useful* insofar as it offers the manipulability that is considered relevant in the given research context.

In the 1979 book, Gibson briefly speaks of a kind of "second-hand" perceptual knowledge in which ecological information is somehow mediated. This is the case, for example, in the use of instruments like telescopes and microscopes, and in pictures and verbal descriptions. He claims: "The reality-testing that accompanies unmediated perceiving and that is partly retained in perceiving with instruments is obviously lost in the kind of perceiving that is mediated by pictures. Nevertheless, pictures give us a kind of grasp on the rich complexities of the natural environment that words could never do" (Gibson 1979, p. 263). While the (partial) persistence of ecological information in these forms of mediated perception allows Gibson to remain a perceptual realist, the same does not apply to knowledge generated through model-based scientific research because models are not instruments that mediate perception, but rather autonomous tools and artifacts built for a range of action-oriented purposes.

Consider projects in situated robotics. Some robotic models are explicitly intended to simulate real-world phenomena, such as phonotaxis in crickets (Webb 1995; Reeve et al 2005) and thigmotaxis in rat pups (Schank et al 2004; May et al 2006), while others merely set out to design autonomous intelligent robotic agents for exploratory purposes (Brooks 1991; Beer and Williams 2015). It seems intuitive to say that the latter do not *represent* any particular target because the models are not designed to replicate the performance or architecture of particular types of real-world creatures. Yet, the same conclusion applies, within the present framework, to the former cases: robots do not *represent* their targets (real crickets and rat pups), but are autonomous tools whose building and manipulation lead to insights that can be applied to the targets—in other words, the models are not descriptions of *what* the target organisms *are like*, but rather they are tools that are *like and unlike* the target organisms in contextually-relevant ways. And the same idea applies more broadly to other kinds of models (whether concrete, virtual, mathematical, etc.) in different disciplines. In the Gibsonian perspective being proposed here, it is not a supposedly representational relationship between model and target that makes scientific modeling epistemically valuable—rather, it is the agent-specific action possibilities scientists exploit in building and manipulating models that enable an indirect way of learning. In some cases modeling involves the generation of predictions that are subject to empirical confirmation, but in other cases it involves simply the generation of some behavior that is importantly similar and different from what is observed in the target. In these and other cases, however, models do not yield representations of the target that we can be realists about—no description, that is, that can be *universally valid*, *independent from particular perspectives* (Chakravartty 2011) or *assumption-free* and *accurate* (Gaukroger 2012).

In the ecological view of human cognition-action-perception, the usefulness of model-based science is explained in terms of the action possibilities afforded by models and by targets. Those are necessarily action possibilities *for* someone; and in most if not all cases, they are action possibilities that are limited to trained experts in the right research context, material environment, and conceptual problem-space. The fact that this results in Gibson's *reasons for (perceptual) realism* motivating a kind of *anti-realist* stance with regards to the epistemic products of scientific modeling should not be seen as negative for either the original Gibsonian framework nor for the proposed ecological view of modeling; rather, this proves that Gibson's insights remain relevant for empirical and theoretical work alike, contributing to interdisciplinary debates where philosophical and psychological tools combined can provide a better understanding of scientific practice and methodology.

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