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What Animals Can Do: Agency, Mutuality, and Adaptation

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Abstract
The endeavor to naturalize the philosophy of biology brings the problem of agency to the forefront, along with renewed attention to the organism and organicism. In this article, we argue for a mutualist approach to agency that starts to unravel layers of this complex issue by focusing on perception and action at the core of all biological agency. The mutuality of animals and their surroundings is seen as distinct from the typical concepts of organism, preexisting environment, and their interactions. Mutuality means a deep ontological and epistemological compatibility between the organism and its surround. We suggest that the concept of direct perception developed and empirically researched in the tradition of the ecological approach, launched by James J. Gibson, offers a promising path to approach agency within an ecological–mutuality framework. At the core of our definition of agency is the animal's ability to self-initiate actions and activities. Animals are the source of their own actions and activities within the mutual, co-defining relation to their surround. The place of agency related to mutuality has not been elaborated sufficiently thus far, in either biology or ecological psychology. In this article, our goal is to argue for the necessity of placing agency into an ecological–mutuality framework and of further research in this direction in line with Marjorie Grene's call to assimilate Gibson's theory of knowledge into biology.

Keywords Agency · Animals · Direct perception · J. J. Gibson · Marjorie Grene · Mutuality · Naturalized philosophy of biology · Organicism

Introduction

> *…no one has yet assimilated [J. J.] Gibson's theory of knowledge as it needs to be assimilated if the triviality of most epistemological discourse and the futility of the so-called evolutionary alternative are to be overcome.*
> --Marjorie Grene (1993)

Within naturalized philosophy of biology questions of the existence of agency in nature inform an active area of inquiry (e.g., Moss 2024). If naturalized philosophy includes taking into account questions that arise in biology (cf. Godfrey-Smith 2003), and if, as some philosophers claim, ecological psychology is a branch of biology (Chemero 2009), then it is possible to develop a philosophy of biology that applies to animal perception/action. As an ecological approach to perception has developed based on the earlier work of James Gibson (Gibson 1966, 1979) which concentrates on the animal as the organism that directly perceives its surroundings, and, therefore, is in mutual relation with the surround, there exists a foundation for a naturalized philosophy of animal perception that begins from an ecological point of view. On this view, perceiving takes place by means of resonating to structure in the ambient energy array (for example, in steady-state light reverberating in a transparent medium such as air), structure that exists because it is formed by the layout of surfaces in the surround over time in relation to the perceiving/acting organism, including the changes in surfaces that constitute events. On this type of view, agency consists of acts and activities in, with, and on the surround

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(including other organisms), *rather than* in forming representations of the surround, which are then "processed." (See Godfrey-Smith (2003 p. 222) for an example of a naturalized philosophy of cognitive science that takes mental representation as a given: "Our perceptual mechanisms are used to form judgments about the objects in the world around us even though these mechanisms are only directly affected by stimuli like light and sound waves.").

Mutuality in direct perception means that the organism and its surround are in mutual existence with each other; each brings the other about, and any intermediary mental representation is not only unnecessary, such representation entails an infinite regress of knowing (cf. Fultot et al. 2016; Read and Szokolszky 2020). Van Woerkum (2023), for example, details examples of animal navigation and direct perception. It is important to note that perceiving/acting is, therefore, not based on prior judgments, either for "daily life" or for specialized perceiving, such as in scientific work. Direct perception is radical in stepping outside of a Kantian perspective that focuses on judgment and, at the same time, has the potential to transcend neo-Darwinian concentration on an independent "environment" and hypothesized "natural selection." As Grene and Depew (2004) point out, the ecological approach to perceiving/acting has consequences both for our understanding of science and for the philosophy of science, especially in biology. "We can finally forget the picture of Mach counting his sensations and try to understand the situation of scientific workers as engaged, each in his or her discipline, in an ongoing dialogue with reality" (2004, p. 328). And a further implication is that philosophers can "strive, like scientists, though in a different style, to find ourselves, as we hope, in a dialogue with reality" (Grene and Depew 2004, p. 360). We will return to these points after explicating direct perception and organism/surround mutuality. As Honenberger has pointed out: "Grene appealed to Gibson to preserve realism by enabling a link between a philosophical account of perception and the facts of biology, ecology, and other empirical scientific fields that must variously be informed by or supply evidence for philosophy" (2022, p. 57).

In this article, we develop the idea that a core type of agency, that is, acts and activities, applies only to animals as the organisms that can perceive and act (cf. McGhee 2023). At the core of our definition of agency is the ability to self-initiate actions and activities. Our argument is neutral concerning other types or levels of agency in nature. The difference between movement and action is key to our approach. Experimental psychologists assume without reflection that animals act (behave, respond, react). Plants move, for example in response to light, and aggregate colonies of plant cells, for example, in the case of volvox algae, move toward the light, but these movements are not initiated by the plant, they are metabolic processes. Animals have the possibility to initiate their own action, of course, in coordination with their surroundings. (Sessile animals have a motile stage in their development.) In other words, it is possible for an animal *not* to act; it is impossible for a plant not to metabolize.[1] (See Plessner [1975]2019 on the difference between animals that have specialized organs for metabolism "turned to the inside" and plants as organisms whose organs of metabolism are "on the surface," pp. 202–209). A detailed differentiation of plants and animals either conceptually or empirically is beyond the scope of this article. We hope that some of the ideas laid out here might further future work on the distinction.

We will argue that within the mutuality of animal and surround, agency applies only to the animal and is, therefore, asymmetric with surround in the "organism–environment system," rather than emerging in a symmetrical way from such a system, as is argued by others (e.g., Malfouris 2013; Hodges 2023). The animal as an agent is a core assumption of the ecological approach which builds on the acting–perceiving organism (Gibson 1966, 1979). The theory of agency has been tackled from various points of view within the ecological approach (e.g., Reed 1992; Shaw and Turvey 1999; Segundo-Ortin 2020; Segundo-Ortin and Kalis 2023), but it has not been developed systematically, although the ecological approach could significantly contribute to the biological concept of agency. The contrast between agency and general adaptation (as studied in current biology and philosophy of biology) is an ongoing area of research (e.g., Rosslenbroich 2011, 2014). The ecological approach, because it is based on mutuality of organism and surroundings rather than on interaction of organism and environment, develops a different type of relation between animal organism and surround than is usually assumed in biology. Specifically, instead of assuming a preexisting "environment" that the organism must adapt to in order to maintain its life, the ecological approach posits a mutuality of animal organism and environment such that the ambient energy array is brought about mutually by the organism and the surround, but only the animal organism *acts* (is an agent) in bringing about the array that is the basis

[1] Some plants function without light (Smith 2018), but they still require certain conditions to which they respond. Also, some single-celled plants form multicellular collections in phases of their development, for example the *Volvox* genus of fresh water green algae (Umen 2020) that move toward the light. Although there is no accepted division of the kingdom Monera, that is, prokaryotes, into protoanimal or protoplant, *E. coli* bacteria have been analyzed according to direct perception (Pittenger and Dent 1988), and as exhibiting "quorum sensing" in forming colonies depending on the concentrations of cells (e.g., O'Malley 2014, p. 192). Perhaps definitions of perceiving/acting could in the future be an aid to systematic biologists. One might ask: is multicellularity a requirement for animal agentive perceiving/knowing? (cf. Keijzer and Arnellos 2017).

of ongoing intentional adaptive action. This buttresses the asymmetric relationship that privileges the agent in dealing with the environment.

Our argument proceeds in three steps: First, we argue that agency is important in biology and the philosophy of biology because the science of living organisms must deal with the locus of change or development. Biological "forces," such as natural selection have been posited as the source of changes in populations and, therefore, in evolution; emergence processes that arise out of systems have been posited; but individual organisms can also be sources of change. Animals, as they are separated from direct metabolic contact with their surroundings and are more independent, must establish a new kind of contact, which is done through perception and action (see Plessner [1975]2019 for a gestaltist account and Rosslenbroich 2014 for a modern usage). We propose that the process of perceiving/acting is direct, as theorized by J. J. Gibson in his ecological approach to perception. The implication is that it is only as *agents* that organisms (animals) pick out, for attention or action, aspects of their surroundings with which they are in direct perceptual contact. It is this type of functional relation of animal organism and surround that supports the animal's continued health and existence. As Gibson stated: the animal perceives what the surroundings afford it, for good or ill (Gibson 1979).

Second, we suggest that a biological theory of agency can find a foundation in direct perception/mutuality as laid out by Gibson (1979) and elaborated by Grene and Depew (2004) and placed in an organicist context (Read and Szokolszky 2018). Our starting point is Gibson's ecological approach that entails direct perception, unmediated by cognitive representation. The mutuality of animal and surroundings is a key concept in the ecological approach to perceiving/acting. Mutuality refers to the idea that animal organism and surround co-define and co-form each other. There is no "environment" separate from the organism, and no organism separate from environment. This does not mean, however, that organism and environment "interact," only that they are complements. Alley (1985), based on previous work by Shaw and others (Turvey and Shaw 1979; Shaw and Turvey 1981; Turvey et al. 1981), characterizes the relation of organism and environment based on the mathematical idea of a "dual" (e.g., set/subset or lines and points in projective geometry), but these mathematical ideas do not cover the case of *living* organisms which are different in kind from their surrounds. They are different in kind because they are alive, and the surroundings, even though they can contain living organisms, are "outside" the living organism (see Plessner [1975]2019, pp. 202–209). We claim that to be consistent, one must make direct perception the core of the definition of mutuality, in Gibson's sense. Although it is beyond the scope of this article to give a full explication of direct perception, basic tenets will be discussed and some familiarity with Gibson's work is central.[2]

Third, the place of agency within the phenomenon of mutuality must be elaborated in further work to clarify the role of animal agency in biology and in ecological psychology (ecological cognitive science). John Dewey's work (Dewey 1896) is a classical source in this direction, although from a pragmatist, rather than a realist, position. The ecological approach to perceiving/acting is a realist theory, but only in the sense that it claims that the relation between animal agent and its surroundings is real. Distinctions in types of animal movement, that is, among actions, acts, and activities, is central to both ecological psychology and animal biology.

Organicism and Agency: Organisms as Sources of Change

The Focus on the Organism

Current developments in biology include a renewed attention to the organism and organicism at large (Goodwin 1988, 1989; Grene 1995, 2002, 2022; McDonough 1997; Gilbert and Sarkar 2000; Hunneman and Wolfe 2010; Denton et al. 2013; Nicholson 2014; Amrine 2015; Sheets-Johnstone 2016). Goodwin (1988) states that "ontogeny and phylogeny will not be understood until we have an exact description of the type of dynamic organization that characterizes the living state" (p. 103). With the renewed interest in organicism in 21st century biology (e.g., Nicholson 2014), the organism once again comes to the fore compared with either the molecular or the population level of analysis. A focus on organisms as the level of analysis solves several problems in evolutionary theory. For example, the molecular level of analysis in evolution, the Modern Synthesis, has been critiqued as incapable of explaining how the chemical level of living organisms can be used to explain inheritance, development, and adaptation in organisms, or even populations (Moss 2003, 2020; Jablonka and Lamb 2006; Nicholson 2014). Instead, "inheritance, development, and adaptation are all unified because they are all consequences of the distinctive capacities of organisms" (Nicholson 2014).[3]

[2] James Gibson studied the functional relation of organism to surround based on the organism's perceptual systems. This type of function should be distinguished from mathematical functions that relate quantities, formal functions such as those developed in behaviorism, and mechanical functions based on laws of physics. Living animal organisms have their distinct way of functioning in relation to their surroundings, and that distinct way is direct perception.

[3] The word "organism" was first used in English, and in the 19th century. "Organism" refers to a living body as a unity of organs or

We make the somewhat more radical claim that a correct account of the ecology of perceiving/acting is a constraint on any theory of evolution. That is, the ecological approach to direct perception constrains *what* evolves, viz., organisms with the perceptual systems to perceive directly what their surroundings afford, for good or ill. If animals function in relation to their surroundings by using their perceptual systems to resonate to energy patterns structured by the layout and, thereby, to perceive what the surroundings afford for their life processes, then a functional basis of taxonomy is a possibility (cf. Alley 1985). We argue that recent work on the evolution of autonomy (Rosslenbroich 2014) and animal experience (Walsh 2015) are examples of such evolutionary theory based on function, in the biological sense, as opposed to genes, anatomy, or phylogeny. Single-celled organisms and plants would then be the organisms that evolve based on direct metabolic contact with their surroundings, without the need for perceiving. We do not claim to have a general theory of evolution; the difference between plants and animals, and between protists and multi-celled organisms, is a rich field of ongoing inquiry.

The focus on the organismic level raises the possibility of developing the epistemological connection between the animal organism and its surround, providing a bridge between biology and cognitive science. Marjorie Grene (Honenberger 2023) was a pioneer in biological epistemology who realized the significance of the direct perception/action approach to animal life. Selecting animals as the starting point of theory and research allows foregrounding questions of agency in accounts of central topics in biology. A formal or even sufficient delineation of animals from plants is beyond the scope of this article. But it is possible that the functional account of directly perceiving/acting animals who detect what the surroundings afford might contribute to such a project in the future.

We focus on a certain type of agency, that of animals (including humans), who directly perceive their surround by means of ambient energy flows and can act accordingly in light of their own needs/goals/intentions. Direct perception allows perception to be in the service of action and, simultaneously, for action to be in the service of perception. Animals are the *source* of their own actions and activities within the mutuality relation to their surround. Even some simple prokaryotic organisms have been analyzed in terms of direct perception (see Pittenger and Dent 1988 for an example of the direct perception of chemical gradients by *E. coli* bacteria).

As organicism maintains a focus on the organism, it is consistent with ecological psychology's emphasis on the animal organism, but the former is a broader concept in that it includes all living organisms, and is not restricted to animal organisms (e.g., Baedke 2013, 2018; Peterson 2016; Brooks 2019). Here we will constrain the topic to animal organisms, as they are the organisms capable of acting, and therefore, of perception and agency.

Animals and Humans as Agents, in the Framework of the Ecology of Perceiving/Acting

Our starting point on the question of the role of agency in nature is J. J. Gibson's work on the ecological approach to perception as laid out in his books *The Senses Considered as Perceptual Systems* (1966), and *The Ecological Approach to Visual Perception* (1979). His starting point is the category of organisms that perceive and behave, that is, animals (Gibson 1979, p. 1).

> Depending on the locomotor capacities of the animal, this terrain provides definite possibilities or impossibilities for crawling, walking, climbing and the like. And if the animal can discriminate the textural variables it can discriminate among potential paths for locomotion. A potential path is a stretch of surface extending away from the animal which affords the kind of locomotion for which the animal is equipped. (Gibson 1958, p. 192).

Given this starting point, we present our perspective that agency is a quality or aspect of a subset of living organisms, that is, animals including humans, and that it is not a quality of all living beings, or all of nature. If a naturalized philosophy of biology focuses on the processes of the science of biology (Giere 2005; Rysiew 2016), and if those processes apply to organisms that perceive and behave and, therefore, know, then a philosophy of biology that encompasses the cognitive science of perceiving/knowing is a possibility. Our work lies within this possible intersection.

The ecological approach to perception, in which the perceiving/acting organism, the animal, is in direct contact over time with its surround, including other organisms, is the core of the idea of the mutuality of the animal and its

specialized parts, that is, an individual animal or plant. It is related to the term organization, with its Greek root "organon" or instrument, tool. "Organismic" was a term used by gestalt psychologists and systems biologists to mean organized into levels and encompassing part–whole relations (e.g., Kohler, 1969). Organicism in biology is a scientific approach that involves analyzing and researching at the level of the organism (as opposed to the molecular level of the genes, or the reductionist level of chemistry or physics) (Oyama 2010; Denton et al. 2013; Nicholson 2014). The basic ideas originated from Conrad H. Waddington in Edinburgh and the Theoretical Biology Club at Cambridge (see Peterson 2016), but this "third way" between mechanistic and vitalistic approaches in biology never became an established approach or theory in the field. One of the basic ideas in organicism did continue and that is the idea of epigenesis or emergence of structure (see Baedke 2013).

surroundings. The surround of an animal organism is a more circumscribed idea than what is usually covered by the term "environment" in biology. The usual approach to theory and research in biology begins by distinguishing "organism" and "environment" as two distinct components of the biosphere and that these components can "interact" or form a system.

Mutuality, however, encompasses a deep ontological and epistemological compatibility between the organism and the "environment." Mutuality exists at the level of the animal; therefore, this level is of distinct importance in the ecological explanation. On the ecological approach developed by Gibson, the animal and its surround are not separate and, therefore, do not have to be "coupled" or "conjoined," especially not by some kind of code or mental representation. "[T]he terms 'affordance' and 'ambient optic array' bridge the gap between animal and environment, because they point both ways" (Gibson 1982, p. 234). To support this idea, we refer to Dewey's concept of unity of function (see Costall 2004, p. 191; Read and Szokolszky 2020). That is, the animal and its surround have different qualities: animals adapt and surrounds do not. If we apply Dewey's idea to animals in particular, i.e., if we exclude plants, we can develop the idea of agency as a characteristic of animals. That is, animals act over time, and in so doing, they affect their particular surrounds, but surrounds do not act, unless they are also animals. The ambient array that specifies "acting" to a perceiver, either self-acting or other-acting (see Grene 1993; Zukow-Goldring 1997) is open to analysis and description.

The organism (human or nonhuman animal) and its environment are co-defining and inherently form each other; environments are animal referential, and organisms are environment referential. Mutuality is defined at the ontological level as codependence, coregulation, codetermination, and coevolution of the organism–environment whole. Mutualism in ontology entails mutuality in epistemology. The organism–environment relationship necessarily is based on reciprocity, agency, and functional significance (see, e.g., Alley 1985; Heft 2014; Read and Szokolszky 2018, 2020; Szokolszky and Read 2018). Gibson worked out his ecological approach to perception based on the idea that the environment to be perceived should be analyzed at the level of the (animal) organism (e.g., 1966, 1979). On this view, perceiving is an ongoing process of resonating to energy that is directly structured by the layout and surfaces of the environment (which includes other acting organisms) and, therefore, directly perceivable as the organism goes about its activities, some of which change the surround. Perceiving and acting are continually mutual. Note that direct perception entails a functional analysis of animal organism-and-its-surroundings, but this function is not a mathematical one of related variables or set/subset or geometric complements. And it is not a polarity of qualities as are physical variables, such as heat and cold, or even dynamic physical variables, such as state changes. In ecological direct perception mutuality is defined by the organism's perceiving of what the surroundings provide for its organismic functions, in fact, its ongoing life.

Still and Good (1998) list three requirements for a theory of mutuality and the language used to describe it: (1) the concepts and descriptions are not primarily about either the organism or the environment, rather they relate to activities that necessarily involve both; therefore, the terms are interdependent; (2) units retain properties of the whole; and (3) explanations are diachronic rather than synchronic. How does the concept of agency, that is, of the animal as purposive actor, fit into these requirements? We propose that there is an asymmetry of agency in the mutuality of animal and surround: the animal acts, but the surround does not. The human or nonhuman animal is not just any organism, and the animal–surround mutuality is not just any system, even a dynamic system. Still and Good (1992) maintain that *visual kinesthesis* is an example of mutuality. We propose that it is an example that fits with the animal as an agent. Specifically, optical structure "guides locomotion by specifying both the invariant surrounding surfaces and the movement of the organism within them" (Gibson 1966, p. 163). Still and Good point out that,

> Visual kinesthesis retains the flow of activity; it links organism and environment dialectically,…; it applies directly to the whole organism; and, by being a part of activity necessarily extended over time it is a foundation for diachronic rather than synchronic explanation. (Still and Good 1992, p. 114)

Along the same lines, the principle of mutualism has been described as a relational thinking encompassing nondisjunctive distinctions, for example, organism and surround (Costall 2001). Without this type of thinking, dualisms persist, of subject and object, of agent and world, and of the intentional and the material (Costall 2001, p. 481). For example, when one attends to the view from one eye, one can always perceive one's nose in any act of (unrestrained, natural) visual perception. Therefore, even when one is holding still (which is an act), and nothing else of one's body is in view, part of one's own body is always in view. If we include two eyes, we have two opposite views of the nose and, in a way, a midline is formed, even in a static view of a static scene. Even this reduced case is an example of *visual kinesthesis*.

Agency, Mutuality, and Adaptation

The Concept of Environment in the Ecological Approach

Ecological psychology has been critiqued for tendencies to overemphasize the environment, and even to think of the environment as preceding the organism (cf. Costall 2004). There is, however, nothing in the ecological approach to perception that requires this view of the environment; in fact, such a view is counter to the theory. Ecological research benefits from efforts to counter the idea that the environment exists before the organism, and the organism is the one that "adapts" to a preexisting environment. As Dewey (1898, pp. 283–284, cited in Costall 2004) points out, the environment of an organism is a product of the process of development: it has developed *along with* the organism. *Mutuality is not interactionism*, that is, the interrelating of two ontologically separate entities. Organisms inherit environments as much as they do genes, and environments exist because of organisms. The organism is different from the environment, from its surround, but this distinction "presupposes their relation, just as riverbeds and rivers, and beaten-paths and walkers imply one another's existence" (Costall 2004, p. 191).

If the environment is seen as something that the organism has to adapt to in order to stay alive and to reproduce, as it is in almost all work in biology, then adaptation is the response of the organism to the "active" environment, or to the active process of "natural selection." Responses are reactions and, therefore, a weakened form of agency. If perception is the direct resonance to the ongoing flow of the ambient array as the perceiving animal lives and acts, then it is *not* a response to stimuli. (See Read and Szokolszky (2020) on the contradictions between direct perception and stimulus–response approaches to animal knowing.) If perceiving/acting is direct, then strong intentional agency on the part of the animal is possible. On our view, strong intentional agency refers to the possibility of intentional, autonomous action in the process of perceiving directly. We argue for an explanatory framework that understands agency—defined in the broadest sense as the capacity to act—based on the closely related concepts of ecological mutuality and direct perception, and suggest that strengthening the ecological framework with an elaboration of agency and mutuality is necessary. This elaboration must distinguish mutuality of organism and surround from the idea that being and acting in the world is a capability of the mind (as opposed to the organism) (e.g., Popova and Raczaszek-Leonardi 2020). Mutuality must be distinguished also from interactionism which dichotomizes organism and environment, the "usual" stance in modern biology, even organicist biology.

Agency and Mutuality

The role of agency within mutuality has yet to be explored and defined. Mutuality as opposed to interactionism is a new concept in biology and psychology and is still being worked out. But the agentive aspect of animals and humans cannot be ignored if theory, research, and the coordinated philosophy of biology are to be developed. The idea of dynamic systems and emergence from dynamic systems has predominated in cognitive science and the philosophy of biology for the last 50 years, but mutuality of animal and surround is not just another dynamic system. The concept of dynamic systems, whether mathematized or not, is too broad to capture what agency is, in our view. The self-perception and self-initiation of action and of acts must be included in an ecological approach to perception, and in the philosophy of biology that is consistent with this approach (Grene 1993).

Our mutuality approach to animals posits that all animal organisms (including single-celled organisms) perceive directly; for example, *E. coli* perceive gradients of nutrition directly without an "internal" comparison process (see Pittenger and Dent 1988). Cells within organisms do not perceive; they are not organisms, but, rather, subcomponents of organisms. All animal organisms are agents in the sense that they act; all perceiving entails and is coextensive with acting (note that holding still is an act, so acting is not coextensive with movement; cf. Byers 2006) and, therefore, agency. On this view, nonanimal entities cannot be agents (algae that form colonies are not animals, e.g., *Volvox*; see Umen 2020 for a description). One somewhat radical (in the context of some ecological research) consequence is that an organism–environment *system* cannot be an agent, as it is not an animal organism. From the ecological organicist point of view, the physics of dynamic systems (a well-developed branch of mechanics in physics) does not capture the phenomenon of animal organisms that perceive directly.[4] But the organism–environment mutuality is necessary to carry out agency. Of course, there are extensive differences in the capabilities of various animal organisms from single-celled animals to human beings. We only point out that all perception is continuously perception of self-in-surround—ambient arrays co-specify self (body) and surround, that is, proprioception or "self-kinesthesis." "Self" for *E. coli* is obviously very different from "self" for a human being (see Grene 1993), but in all cases, the animal organism always co-perceives its (almost always purposive) movements and its surround. Gibson described the ambient array available to any perceptual system as "pointing in two directions,"

[4] If organicism in theoretical biology had continued to be developed from the 1930s we would now have an alternative to physical systems thinking in biology (Peterson 2016). Such an alternative is one motivation for the present essay.

that is, as pointing to the perceiving/acting organism and to its surround. One might say that the active organism and its surround "co-create" the flowing, changing ambient array. For example, van Woerkum (2023) describes different cases of animal navigation based on direct perception (as opposed to the cognitive approach which appeals to mental representation for animals).

As direct perception is a process of selectively resonating to structure in the media available to the organism's perceptual systems (e.g., air and light are transparent to the structure of the layout, which structure is resonated to by the visual/body system of an organism), such structure is being co-formed by the acting organism. Direct perception *is* resonance at the fundamental *biological* level. Physical resonance, as when the strings of a musical instrument resonate in octaves, is basically bidirectional. But biological perceptual resonance is directional in the sense that the structure specifies the surround to the perceiving/acting organism, so the organism resonates (that is, perceives) its surround, but the inanimate surround does not resonate to the organism. The inanimate surround is acted upon; it does not act.[5] The animal surround, however, does co-resonate, as animal beings in the "surround" of an animal entity are perceiving/acting themselves. As I walk through a room toward a doorway, avoiding furniture along the way, flow gradients of texture (expansion around a point, or accretion/deletion) specify the surface of support, the open pathway, and the opening of the doorway. If another person, or a pet, is walking toward me in the same space, we co-resonate to the layout and coordinate our acts and actions (cf. Gibson 1979; on the environment of all perceivers). On this account, the organism is agentive, the inanimate surround is not.

It is the animal organism that is the agent: all perception is of *"self" in the surround* (Grene 1993; McConnell and Fiore 2017; Honenberger 2023) even when the surround includes other agents. In other words, animal organisms are always perceiving both self and surround. Note that as perception is direct and in resonance with structured arrays that always include the perceiver's self/body as well as the surround, there is no solipsism, even with regard to "higher thought process" or "cultural variables" (cf. Costall and Still 1989). Within this direct-perception ecological view of the self, though, there are important distinctions related to agency to be made that have not so far been elaborated within ecological psychology. Namely, we should distinguish among the phenomena of acts, actions, and activities. In this brief essay, we only begin this discussion by provisionally defining acts as behavior originated by the organism that is goal-directed, actions/interactions as complexes of acts, and activities as complexes of actions/interactions. In other words, acts are nested within actions, and actions are nested within activities.

[5] See Saborido and Heras-Escribano (2023) for an alternative view that the inanimate environment is an active "agent" of change. This contrasting analysis grows out of an emphasis on the "organism-environment system" as opposed to our emphasis on the living animal organism.

The Mutuality Principle Elaborated

We develop the idea of mutuality in line with Gibson's treatment of the topic (1979, 1982) thus:

> aspects of an object or set of surfaces have unity relative to the posture and behavior of the animal being considered. If it is sit-on-able it should look sit-on-able and can be perceived visually. If the surface properties are seen relative to body surfaces, the self, they constitute a seat and have meaning. (1982, p. 128)

What other persons afford is the whole realm of social significance for human beings. "Exteroception and proprioception must be complementary" (1982, p. 183). Seeing oneself is not a complex intellectual exercise, but a basic foundational one. (Here Gibson touches on a topic central to agency, i.e., the self. Grene (1993) has elaborated his ideas in describing the primacy of the ecological self.) Gibson uses the word "unity" for the animal's posture/movement/acts and the surrounding surfaces and events. This unity he characterizes as mutuality.

We first note that *mutuality* must be distinguished from *mutualism*, a term in biology that is synonymous with symbiosis, and refers to distinct species that live in an interdependent manner that is advantageous to both. Mutuality, on the other hand, refers to the fact that organisms and their surrounds entail each other, and cannot exist independently (either ontologically or epistemologically).

The idea of the mutuality of organism and surround is also distinct from epigenetic ideas in evolutionary theory, which concentrates on the species level, and has maintained concepts of an environment that demands and an organism that adapts (cf. even Lewontin 2000, p. 126 on "natural selection").

To further clarify the idea of mutuality we begin with statements from Gibson (1979). The environment is what animal organisms perceive, and this is not the world of physics. The observer and its environment are co-defining, as are the set of observers and their common environment (1979, p. 15). For example, for terrestrial animals, water is a substance, not a medium (1979, p. 21) (but note that water is a medium when we look through it to the bottom, as opposed to looking at it as a surface that reflects images). Gibson did tacitly accept that adaptation and natural selection model for

organisms, but to the extent that he did, he contradicted his own idea of mutuality (cf. Read and Szokolszky 2020).

Enactivist approaches in philosophy and psychology have also emphasized action in context. Popova and Raczaszek-Leonardi (2020) ask whether ecological psychology and enactivism are compatible, and they focus on the enactivist concept of the "lived body" to describe how in social events individuals learn how their body should move, and how their body should feel (p. 354). Here the body becomes the "agent/actor," rather than the organism, the individual. On the enactivist view (which accepts indirect perception based on sensation; see Read and Szokolszky 2020), agency is important, but it is ascribed to embodied minds rather than perceiving organisms.

Some ecological approaches have chosen to "distribute" agency across the organism and the environment by describing the affordances of the surround as "inviting" the organism (Withagen et al. 2017). We take a different ecological approach that locates agency as an aspect of the animal organism, and affordances for action, knowing, or feeling as specified to the agent in the ambient arrays. Thus, the agent acts out of "interest" and perceives affordances that are related to the organism, that is, have meaning for the organism. Mutuality in the case of animal organisms is the bedrock of agency. That is, the organism–environment relationship necessarily is based on reciprocity and agency.

The mutuality principle as presented herein is consistent with homeorhetic theories in ecology that emphasize the maintenance of flow or change as a biological process (Chuang et al. 2019). By concentrating on the balance of flow as opposed to relatively static (although living) organisms, we can emphasize and clarify the idea of mutuality as an ongoing balanced flow of action on the part of animal organisms and relevant aspects of the surround. Mutuality goes beyond the idea of niche construction, which is still essentially dualistic and separates the organism and environment into parts that interact.

Action, the Body, and Perception

Most research in biology and the philosophy of biology share the common assumption that the contact between the organism and its environment can only take place through sensations (such as the retinal image) and some connection of these sensations to "sensorimotor" schemes or programs (citations). But what are the consequences if we do not make these basic assumptions? What if the senses are not purveyors of sensations but detection systems that are used to coordinate the organism with the surround and consist of "sense-body systems" (Gibson 1966, 1979; Grene 1971)? Grene points out that one consequence is a set of existential choices that coincide with the ecological approach to perception (Grene 1971, p. 35). These choices include: the denial of sensations as universally existent, the acceptance of immediate contact with the external world, and the acceptance of the structures of ambient light (i.e., ambient arrays) as real aspects of the natural world (see also Fultot et al. 2016; Read and Szokolszky 2020; Turvey and Carello 2020). We point out that an additional consequence is that agency is located in the animal organism. (Organisms that have no brain, e.g., bacteria, are able to perceive and act, e.g., Pittenger and Dent 1988; and amoeba such as *Physarium polycephalum* form their own surround to navigate toward nutrition, e.g., Crippen 2020.)

A theory that begins with the animal organism that directly perceives and acts in/on its surround, indeed, co-defines and co-creates its surround (as opposed to adapting to a previously given, independent "environment") begins with the organism as agent, that is, as an active intentional being (Gibson 1966, 1979). This ecological approach to perception begins where systems biology endeavors to find consensus, as it assumes the existence of animal organisms as a starting point and proceeds from there. And the ecological approach to perception can be seen as an example of the use of "systemic or relational" techniques in biological theory (Grene 1971, p. 33).

One possibility is to begin with Gibson's theory and observations and the endeavor to work out the consequences for areas of cognition and epistemology that he did not explore (e.g., Costall 2008). Ours is the latter approach, as Gibson did not elaborate the idea of agency. Some researchers in the ecological line have defined intention in formal mathematical terms (Shaw 2002), and others have argued that Gibson's idea that organisms perceive what the surround, especially the sociocultural surround, affords inherently makes perceiving intentional (Heft 1989).[6] Reed (1988), in writing in answer to the question "What is an animal?" explicated Gibson's account of the animal organism as one that moves autonomously. Reed described ongoing direct perceiving/acting in several species and included the human capacity to directly perceive animal movement. The latter has been studied with displays of human movement showing only the movement of the joints, for example, by Johansson and colleagues (see Szokolszky et al. 2023), and in abstract displays (e.g., Michotte 1963). But none of these approaches is organicist, that is, is centered on the biology of organisms. We endeavor to develop an organicist approach to agency

[6] Enactivists who have defined perception as detecting the "spatial-temporally extended patterns of stimulation that lawfully correspond or specify the environmental properties that are relevant for the system's sensorimotor repertoire" (Segundo-Ortin 2020) place agency in the coordination of "sensori-motor habits" to intentions carried out in actions (see Read and Szokolszky 2020 and Heft 2020 for critiques of theories that base perception on sensation).

in ecological psychology that focuses on animal action and activity *in the context of* biological organicist theory and research. One potential outcome of this focus is a differentiated and detailed understanding of how animal organisms from prokaryotes to primates (including humans) directly perceive/act intentionally. Our approach has the potential to link biology and ecological psychology in a way that avoids the logical conundrums inherent in the usual cognitivist/representational theory of animal knowing (cf. Grene 1993; Heft 2020; Read and Szokolszky 2020).

It is clear that there is a long way to go to differentiate central concepts such as *act*, *action*, and *activity* for the wide variety of animal organisms in their various life spans. This is where ecological psychology and biology can support each other in developing consistent, general accounts. If perceiving/acting can be seen as direct, as worked out in ecological psychology, and the wide variety of animal organisms as studied and documented by biologists can be brought together, perceiving will be much better understood, and organisms' life possibilities will be better understood. Are acts embedded in actions which are embedded in activities? Does that organization hold for all animals? How can these ideas be studied empirically for a wide range of species? These are large overarching questions that require a reorientation in thinking from the usual cognitive/representational approach in psychology and from the neo-Darwinian interactionist thinking in biology.

Conclusion

Our approach to agency draws on work in organicist biology which endeavors to define and study life at the level of the organism. We propose that direct perception is a contribution to this effort in that it provides a model-based method of approaching animal organisms as active perceiving agents that explore and change their surroundings. This theoretical turn allows for specific definitions of key ideas in ecological and evolutionary biology that have to do with the concept of active agency. Specifically, agency is local to the individual organism in its surround, and is actively maintained by the organism in conjunction with its surround. Acting is an ongoing process over time, rather than consisting of anatomic or physiologic or behavioral features; i.e., perceiving/acting is adapting to the environment and, at the same time, changing the environment.

Agency is not a "problem" in ecological psychology (contra Fowler and Hodges 2016; Popova and Raczaszek-Leonardi 2020; Segundo-Ortin 2020), but it is a neglected topic. To remedy this neglect, we have proposed herein that direct perception is the key to active exploration of an open-ended world that includes other agents, and those that are active in creating new surfaces (e.g., architecture and art; see Grene 1980; van Dijk 2021) (see also Read and Szokolszky 2018, 2020). An open-ended world that is explored actively by animal organisms moving through, and producing a flow of affordances (cf. Jones and Read 2023) is crucial to both organicist and ecological accounts of agency in biology and in psychology.

The role of direct perception in relation to concepts of agency is only beginning to be explicated.[7] We have made a beginning in answering Grene's call to assimilate Gibson's theory of knowledge into biology with our use of the idea that agency is a characteristic of animal organisms in mutual existence with their surroundings. The mutuality-based account of animals, for which direct perceiving provides the core, could provide the basis to challenge interactionist accounts of biological functioning, taxonomy, and evolution in many different types of models and empirical studies. The challenge is based on an understanding of animal organisms as inseparable from their surroundings and, therefore, as necessarily not merely something that "adapts" to the "environment," where the latter is conceived of as preexisting the organism. This latter assumption is antithetical to mutual, agentive, direct perceiving/acting, and yet is a basic assumption in most biological theory and empirical rationales. Coordinating work by Gibson and Grene provides a radically different approach to animal organisms, one that is consistent with organicism and provides a theoretically consistent basis for focusing on the organism as the locus of change in the development and evolution of, at least, animal organisms.

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[7] See the thematic section "Concepts of Agency" guest edited by Lenny Moss, *Biological Theory* 19(1), pp. 3–36.

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