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Theory Psychology 2005 15: 603
DOI: 10.1177/0959354305057265

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On Ecological Conceptualizations of Perceptual Systems and Action Systems

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ABSTRACT. This article examines Gibson's concept of perceptual system and Reed's concept of action system. After discussing several assumptions underlying these concepts, the ontological status of these systems is considered. It is argued that perceptual systems and action systems should be conceptualized neither as parts of an animal's body nor as softly (temporarily) assembled devices; rather, they are best understood as animals' abilities to achieve functional relationships, that is, as dispositional properties. This conceptualization entails that these systems are relatively permanent properties of the animal that are causally supported by, though not identical to, anatomical substrates. Further, it entails that it is the animal that perceives and acts, not its perceptual and action systems.

KEY WORDS: action, action system, affordances, direct perception, disposition, information, perception, perceptual system, softly assembled device

One of the major contributions of James Gibson, the founder of the ecological approach to perception, was his conceptualization of perceptual systems. In his book *The Senses Considered as Perceptual Systems*, Gibson (1966) asserted that perceptual systems should be defined in terms of the functions they perform, that is, the detection of perceptual information. His view contrasted with the then-accepted view in two important respects. First, Gibson asserted that the detection of information is an active process. Animals are not passively receiving impoverished stimulus information, which would require inferential processing (as was and is held by many psychologists). Instead, they are actively moving and exploring, thereby creating ambient arrays that specify meaningful properties of their environments. Second, Gibson rejected the claim that perceptual systems are channels of sensation identified by a particular kind of receptor or sense

THEORY & PSYCHOLOGY Copyright © 2005 SAGE Publications. VOL. 15(5): 603–620
DOI: 10.1177/0959354305057265 www.sagepublications.com

organ. In the detection of information, he argued, many body parts can be involved:

We are told that vision depends on the eye, which is connected to the brain. I shall suggest that natural vision depends on the eyes in the head on a body supported by the ground, the brain being only the central organ of a complete visual system. (Gibson, 1979, p. 1)

Moreover, the anatomical structures involved in the detection of an informational variable can vary. According to Gibson, an animal, at least in some cases, is capable of detecting the same informational variable in several ways involving different anatomical structures. Hence, perception is not specific to anatomical structures but is, Gibson (1966, 1979) asserted, a function of perceptual information.

Inspired by Gibson's (1966, 1979) ecological psychology and the work of the Russian action theorists, who are regarded as having introduced the concept of functional system (e.g. Bernstein, 1967; Luria, 1973), Reed (1982a, 1988b, 1996) developed the concept of action systems as an analogue to Gibson's concept of perceptual systems. Adopting an evolutionary point of view, Reed (1982a, 1985) argued that behavior is a mode of resource usage—behavior is an ecological phenomenon.¹ Reed's conceptualization differed from the usual understanding of behavior. Ever since the 'mechanization of the worldview' (Dijksterhuis, 1950), behavior has been generally regarded as a mechanical response to a stimulus—behavior is specific to the mechanism generating it (see, e.g. Gallistel, 1980). Reed (1982a, 1985, 1988b, 1996) opposed this view; he asserted that behavior is not intrinsically mechanical, but intrinsically functional. Behavior, even a reflex, constitutes a mode by which a functional relationship with the environment is established:

Far from being indifferent to changes in function, movements and postures (and their underlying mechanisms) are often precisely attuned to the animal's 'motor problem'. Thus I proposed the hypothesis that behaviors are *functionally* specific (i.e. supported by resources specific to behavior, by affordances) as a counter to the traditional hypothesis that behaviors are functionally indifferent (or mechanically specific, which comes to the same thing). (Reed, 1985, pp. 362–363)

By arguing that action, like perception, is specific not to mechanism but to function, Reed followed Gibson. The concept of action system was introduced to explain how functional relationships with the environment are established. Reed (1982a, 1996) argued that in the course of evolution, selection pressures gave rise to different action systems, enabling animals to establish new functional relationships with their environments.

Gibson's concept of perceptual systems and Reed's concept of action systems play considerable roles in the ecological approach to perception and action. The concepts are referred to often, and are used as a theoretical

framework for questions regarding perception and action (e.g. Bertenthal & Bai, 1989; Goldfield, 1989, 1995; Oudejans, Michaels, Bakker, & Davids, 1999; Pick, 1989; Rochat, 1989). However, despite several attempts to elaborate the ecological concepts of perceptual systems and action systems (e.g. Bingham, 1988; Goldfield, 1995; Kugler & Turvey, 1987), some researchers have found the concepts opaque. Looren de Jong (1992), for instance, stated that, 'Reed's "action systems" approach . . . has little empirical backing and remains rather vague and programmatic' (p. 22). Similarly, the ecological psychologists Stoffregen and Bardy (2001) found Gibson's concept of perceptual systems inadequate.

Any vagueness in Reed's action-systems approach may be partly due to the lack of a clear statement of the ontological status of action systems. As has been argued over the last decade, ecological psychology may not have its 'ontological house in order' (Chemero, 2002; see also Turvey, 1992). Recent discussions on ontology among proponents of the ecological approach have been focused primarily on the nature of *affordances*, a concept introduced by Gibson (1966, 1979) to refer to the action possibilities that the environment offers the animal (see, e.g. Chemero, 2003; Sanders, 1997; Stoffregen, 2003; Turvey, 1992). Unfortunately, the nature of perceptual systems and action systems, ecological concepts that are allied to the concept of affordance, has received scant attention.² However, theoretical work addressing the ontology of these systems is, we believe, required. Reed (1982a, 1996) and to a lesser extent Gibson (1966) were not very explicit about the nature of these systems. They were clear in suggesting that these systems should not be understood as parts of the body, but they did not provide a consistent, unequivocal view of how else to conceive of them.

The main purpose of this article is to consider the ontology of perceptual systems and of action systems.³ We start our analysis by laying out Gibson's (1966, 1979) and Reed's (1982a, 1996) ideas of perception and action. These ideas form the fundamental assumptions underlying these authors' concepts of perceptual and action systems. Then, we turn attention to the nature of these systems as functional systems. Such a generic term can be used because the concepts are, we argue, based on the same assumptions and are of the same nature. After exploring and dismissing several possibilities regarding the ontological status of functional systems, we suggest that they are best understood as the animal's powers to achieve functional relationships. An animal with a functional system is an animal with the capacity to establish a certain functional relation.

The Assumptions Underlying Gibson's and Reed's Concepts

Gibson's (1966) concept of perceptual system and Reed's (1982a, 1996) concept of action system differed in important respects from the more

traditional view. Both Gibson and Reed argued against psychologies based on mechanistic metaphors. Below we briefly discuss four assumptions underlying their conceptualizations, and thereby sketch in bold strokes the ecological approach to perception and action.

Affordances: A Meaningful Environment

Both Gibson (1966, 1979) and Reed (1982a, 1996) argued that animals live in a meaningful environment. Meaning is 'out there' in the environment and the animal can perceive it. This claim was radical. Ever since the scientific revolution in the 17th century, philosophers and later psychologists have generally regarded the world as meaningless. It consists merely of matter and motion. There is no meaning or value 'out there'. Hence, the meaningful world as one experiences it is thought to be a product of the mind. In the heyday of the cognitive revolution this view was dominant. Many perceptionists took as their general goal explaining how an experienced meaningful world is constructed out of meaningless stimuli impinging on the sense organs. Neisser (1967) spoke for many when he argued that, 'Visual cognition . . . deals with the processes by which a perceived, remembered, and thought-about world is brought into being from as unpromising a beginning as the retinal patterns' (p. 4).

As noted above, Gibson (1966, 1979) argued that the environment of an animal is in and of itself meaningful, and a key concept was that of *affordances*. Affordances are the action possibilities the environment offers the animal. As Gibson (1979) put it: 'The *affordances* of the environment are what it *offers* the animal, what it *provides* or *furnishes*, either for good or for ill' (p. 127). The ground surface is walk-on-able, the chairs are sit-on-able, the cup on one's desk is graspable, and so on. The affordances, Gibson (1966, 1979) asserted, constitute the animal's environment and are the primary objects of experience.

Note that an environment described in terms of affordances is a meaningful environment. 'The meaning or value of a thing consists of what it affords' (Gibson, 1982, p. 407). Further, it is an environment described in animal-relative terms. To determine the affordances in an animal's environment, one must measure environmental properties relative to the animal's abilities. As an example, to determine whether a cup is graspable for some person, its size must be measured relative to the size of that person's hand. Being animal-relative, the environment is unique to each animal. A cup that is graspable for an adult may not afford grasping for a baby. The affordances of the animal's environment arise along with the animal's abilities—the existence of an affordance implies a fit between animal and environment. Although affordances exist by virtue of the animal's abilities, they are objective in the sense that their existence is independent of being

perceived, or, more generally, their existence is independent of mind (see, e.g. Michaels, 2003).

Information as Specification

Whereas Gibson's theorizing on affordances was primarily concerned with how they are perceived, Reed's theorizing primarily addressed how affordances are utilized, that is, action. In part this difference in emphasis is due to the fact that Gibson's advocacy of an information-based theory of perception predated his development of the affordance concept. The information-based or direct-perception theory took aim at the assumption in traditional theories that the senses passively receive impoverished stimuli from the environment. Impoverished input entails the earlier-described process of inferring or constructing a meaningful percept. Gibson's argument was that the information available to the animal is rich, not impoverished. By actively moving, the animal creates patterns in the ambient flow that specify significant properties of the environment. This specification—the one-to-one relation between information and to-be-perceived properties—also applies to action possibilities. And such specifying patterns, Gibson insisted, can be picked up. Because there is specifying information available that informs the animal, the enrichment of impoverished stimuli is not needed. Perceiving an affordance is the result of the detection of information that is specific to it.

This theory of direct perception was a significant departure within the study of perception. First, it emphasized that perception is an activity. In order to perceive, an animal actively explores and thereby creates and detects meaningful patterns in the ambient arrays. Second, Gibson's (1966, 1979) direct perception theory has yielded a search for the informational variables that animals detect. In recent decades, ecological psychologists have discovered several informational variables that animals appear to exploit as they regulate their encounters with the environment. Patterns in the ambient arrays have been discovered that inform animals about what they can do in their environment and how they can do it (e.g. Michaels, Zeinstra, & Oudejans, 2001; Savelsbergh, Whiting, & Bootsma, 1991; Warren, 1988). Thereby, ecological psychology set an important precedent for the now popular idea that an explanation for perception and action should not be sought solely within the animal, but requires an examination of the interplay of environmental and organismal factors (see also Clark, 1997). As Gibson (1979) put it, 'Locomotion and manipulation are controlled not by the brain, but by information. Control lies in the animal-environment system' (p. 225).

Perception and Action as Functional Relations

Emphasizing the environment in their theorizing, Gibson (1979) and Reed (1982a, 1996) conceptualized perception and action in a way that differed

from the then-accepted view, namely as processes of establishing functional relationships with the environment. Although functional considerations had been advocated by several thinkers in the past (e.g. Holt, 1914; James, 1890/1950; Jennings, 1906, 1908), this conceptualization has not been dominant in psychology. Instead, and as noted earlier, psychology has been dominated by the mechanistic worldview, which had done away with the idea of final cause, central to the Aristotelian worldview. All is matter in motion, and the only explanation that can be called on is in terms of causes and effects.

The mechanistic worldview led to the construction of mechanical models that simulated physiological functions. These mechanical models, in turn, inspired many psychologists. Animals, humans included, were often conceived of as (complex) machines, and their activity was understood in mechanistic terms. The influence of the mechanistic metaphor on the conceptualization of perception and action is far-reaching. Metaphors are not ontologically neutral; instead they influence the conceptualization of the phenomena to be explained and the concepts that are brought to bear to explain them (e.g. Vroon & Draaisma, 1985). Inspired by mechanistic metaphors, researchers generally conceived of animals' actions as mechanical responses: action is specific to the mechanism generating it and can be accurately described independent of the environment. Roughly speaking, action was conceived of as a change in the position of the limbs (Tamboer, 1995). Being mechanical responses, actions, so it was assumed, are elicited by stimuli, either from inside the system or from the environment. Over the years this idea was elaborated and resulted in stimulus–response psychology, arguably one of the most powerful frameworks in psychology ever since. The stimulus–response conceptualization of animal activity that was dominant at the beginning of the 20th century was still clearly rooted in a mechanistic view of animals. For instance, in 1927, Pavlov wrote, 'a stimulus appears to be connected with a given response as cause with effect' (p. 10). The idea that animal behavior can be captured in stimuli and responses was, of course, central to the behaviorists. But when in the 1960s and 1970s cognitive psychology was in its ascendancy, animal behavior was still couched in terms of stimuli and responses (see, e.g. Reed, 1997). Cognitivists asserted only that mental processes on the input are required to carry it into a response. As to perception, Fodor (1968), for instance, argued that the aim of the cognitive approach is to explain 'the disparity between the input and the percept' (p. 86), that is, how the animal gets from the stimuli to the meaningful percept.

Although the apparent wide applicability of this stimulus–response conceptualization of animals' activity might be appealing, this conceptualization, Reed (1982a, 1996) asserted, does not capture the essential characteristic of animal life. In fact, the mechanistic metaphor is misleading in several ways. First, it implies that animals are passive receivers of stimuli;

machines do not act unless put into action. This is not the case for animals; animals are ceaselessly active, exploring the environment and acting in it. Second, the mechanistic metaphor underrates the mutual influence of the animal and its environment. The mutual influence of a machine with its environment is far more limited and of a different sort than that of animal and environment. Third, and most important for present purposes, the mechanistic metaphor yields a misleading view of action. An action is arguably more than a mechanical response elicited by a physical stimulus; an action is goal-directed—it is performed for the sake of its result. Early illustrations of the goal-directedness of actions can be found in Jennings's (1906) texts on the behavior of lower organisms, which inspired Reed (1996):

The organism moves and reacts in ways that are advantageous to it. If it gets into hot water, it takes measures to get out again, and the same is true if it gets into excessively cold water. If it enters an injurious chemical solution, it at once changes its behavior and escapes. . . . In innumerable details it does those things that are good for it. It is plain that behavior depends largely on the needs of the organism, and is of such a nature as to satisfy these needs. (Jennings, 1906, pp. 338–339)

According to Jennings, actions are regulatory: action is a mode by which an animal establishes a particular relationship with its environment. By conceiving of action as the animal's adjustment of its relation to its environment so as to establish the intended relation, the goal-directedness of behavior is captured. This characteristic is not captured in a stimulus–response conceptualization of behavior. The latter portrays action not as a means to achieve a goal, but as a mechanical response that has no intrinsic function in and of itself. Only when the action occurs in a biological context in which its consequences happen to be beneficial for the animal is the action considered functional (see Hinde, 1975, for this conceptualization of function). Thus, in the mechanistic framework, behavior is intrinsically mechanical, and extrinsically functional (see Reed, 1985). Although movements as mechanical responses triggered by stimuli do occur in certain laboratory settings, an account of animal behavior, Reed (1982a, 1985, 1988b, 1996) asserted, cannot be based on the stimulus–response framework. Animals are ceaselessly active, establishing relations between themselves and their environments satisfying their needs and wants. Reed argued that an account of animal behavior should capture this goal-directedness; it should emphasize that actions are performed to establish relations with the environment; it should conceptualize actions as such, and aim at an account of how the relations between the animal and its environment are established.

As is the case in acting, perceiving can also be said to establish a functional relation to the environment, although this might not appear straightforward. In the history of psychology, a percept has often been considered as a mental state, more or less isolated from the world. A slightly

more elaborate version of the indirect perception theory described earlier is as follows: A stimulus is imposed on a receptor (or feature detector, say) and gives rise to a sensation, an awareness of the state of the receptor (or detector). Only this sensation is directly apprehended. Because the sensation is ambiguous with respect to the environmental property that induced it, the animal must infer the causes of the sensation to gain knowledge about the environment. The inferences result in a representation of the world, and it is this representation to which perception corresponds. Hence, perception resides in the head and is more or less detached from the environment. Although in somewhat different forms, this idea dominated perception theories from Descartes to Müller and Helmholtz, and is the basic assumption in many modern cognitive theories of perception (see, e.g. Meijering, 1989; Reed, 1982b).

However, there are alternative approaches to perception. In the realist tradition, perception is conceived as an ecological phenomenon—perception resides in the animal–environment system. The essence of this approach is that the object of perception is not a mental construct based on sensations; the object of perception is the environment. What animals perceive *are* the environmental objects and events; the object of perception is ‘out there’. In this approach, perception is no longer conceptualized as a mental state; rather, it is an epistemic *relationship* between the animal and an environmental property—perceiving is a being in contact with the environment. The idea of perception as epistemic contact can be traced to Aristotle (see Lombardo, 1987), is central to the work of the American functionalist Holt (1914), and is the foundation of Gibson’s (1966, 1979) ecological approach to perception (see Heft, 2001). ‘Perceiving is an achievement of the individual, not an appearance in the theatre of his consciousness. It is a keeping-in-touch with the world, an experiencing of things rather than a having of experiences’ (Gibson, 1979, p. 239).⁴

Multiple Realizability of Functional Relationships

The ecological concepts of perceptual and action systems are suggested to explain how animals establish functional relations with their environments. Reed (1982a, 1996) argued that evolving action systems enabled the animal to adjust its relations to its environment. And Gibson’s (1966, 1979) concept of perceptual systems accounts for how animals detect specifying information and thereby stay in epistemic contact with the affordances.

However, an animal can, in general, establish the same functional relationship with its environment through several means. As has long been recognized, an animal can generally reach the same motor outcome in multiple ways involving different anatomical structures, a phenomenon referred to as *motor equivalence* (e.g. Hebb, 1949; Lashley, 1930). For instance, a human being can change his or her location in the environment

by walking, crawling, sidestepping, and so on. The ability to reach the same end through different means is also omnipresent in lower organisms and, thus, does not depend on having a brain (see, e.g. Darwin, 1881). According to Reed (1982a, 1985, 1996), a mechanistic conceptualization of action is incapable of capturing this characteristic of behavior. '[The] very un-mechanistic *interchangeability of means to achieve ends of action*' cannot be understood by 'standard conceptions of psychological explanation . . . based as they are on mechanistic metaphors' (Reed, 1996, p. 12). In his *The Principles of Psychology*, James (1890/1950) also pointed out the inappropriateness of the mechanistic view to account for animals' activity. He referred to Pflüger's experiments on the wiping behavior of frogs. In these experiments, frogs were decapitated and acid was put on their backs. The spinal frog wiped the acid off with one of its hind legs. When this hind leg is amputated and the acid is again put on the frog's back, the stump moves for some time, after which the acid is wiped off with the contralateral foot.⁵ According to James, this behavior cannot be understood in a mechanistic framework. If wiping the acid off with the hind leg were just a mechanical response to the stimulus, then there is no reason to assume that the frog's contralateral foot will remove the acid when the first leg is amputated. If, on the other hand, action is intrinsically functional and the intended end-state can be reached in multiple ways, variation in the way the goal is reached is the rule.

In perception, the multiple realizability of function has been hypothesized at least at two levels. First, it has been suggested that the same environmental property can be perceived by the detection of different informational variables available in a particular sensory array. That is, the same perceptual modality might establish an epistemic relation with an environmental property by detecting different informational variables. This theory is known as *directed perception* (see Cutting, 1986). Second, the same informational variables might be shown to be detected by different anatomical structures. A particular animal can, at least in some cases, detect the same informational variable in multiple ways involving different anatomical substrates. As an example, consider the optical acceleration of a fly ball, which informs the fielder about whether the ball will land in front of, at, or behind his initial position (Chapman, 1968). This information can, in principle, be detected by several means involving different anatomical structures: one might use the retinal flow created by the ball when the eyes fixate a stationary point; one might track the ball with the eyes and use the acceleration via the eye muscles; or one might lock head movements to the ball and use the angular velocity of the head as carried by the vestibular organs (Oudejans et al., 1999). Bongers and Michaels (2004) showed that even when one restricts the movement of the eyes, the head, or both, perceivers are capable of reporting whether the ball will land in front or behind their position,

suggesting that they are indeed able to detect the optical information by any of several means.

As both Gibson (1966) and Reed (1982a, 1985) stressed, the multiple realizability of functional relations disproves the doctrine that perception and action are specific to neural mechanisms. That doctrine—that there is one-to-one mapping of psychological functions onto neural substrates—is as old as anatomy and physiology and can be found in a number of neuropsychological theories (see, e.g. Young, 1970). Two well-known examples are the Bell–Magendie law and the ‘doctrine of specific nerve energies’, each of which had a major influence on the history of psychology (e.g. Reed, 1982b). The Bell–Magendie law holds that sensory and motor functions are carried on in different sets of nerves. The ‘doctrine of specific nerve energies’ states that sensations are specific to nerves.

At the time that Gibson and Reed developed their concepts of perceptual and action systems, the doctrine of the anatomical specificity of psychological functions was widely accepted. Hence, in their texts both Gibson and Reed paid considerable attention to debunking this doctrine, and thereby making room for their own ideas of perception, action, and functional systems. Especially Reed’s texts (1982a, 1982b, 1985, 1986, 1988b, 1996) are laced with arguments against the idea that action is specific to anatomical substrates. The gists of the arguments by Reed and Gibson are basically the same: The same piece of anatomy can have different functions, and the same function can be realized by different pieces of anatomy. In his book on the perceptual systems, Gibson (1966) stated:

The same incoming nerve fiber makes a different contribution to the pickup of information from one moment to the next. The pattern of the excited receptors is of no account; what counts is the external pattern that is temporarily occupied by excited receptors as the eyes roam over the world, or as the skin moves over an object. The individual sensory units have to function *vicariously*, to borrow a term from Lashley, a neuropsychologist. (pp. 4–5)

And at the beginning of his paper ‘An Outline of a Theory of Action Systems’, Reed (1982a), following Gibson (1966), argued that a physiologist can make a clear distinction between afferent and efferent neurons, but that it is a mistake to call the former sensory and the latter motor. There is no one-to-one mapping from psychological functions onto anatomical structures; afferent neurons can serve a motor function, and efferent neurons can perform sensory functions.⁶

The Nature of Functional Systems

Now that we have laid out the key ideas underlying Gibson’s concept of perceptual systems and Reed’s concept of action systems, we can address

the ontological status of these systems. We discuss several possibilities. First, we consider, given the above discussion, whether there are ways a functional system can be understood as a piece of anatomy, that is, as a part of an animal's body. Second, we discuss the possibility that functional systems should be understood as softly assembled devices, as several ecological psychologists seem to suggest (see, e.g. Pagano, Grutzmacher, & Jenkins, 2001). We ultimately reject both possibilities, and put forward the view that functional systems are best understood as the animals' powers to achieve functional relations with their environments.

Is a Functional System a Piece of Anatomy?

In an everyday conceptualization of functional systems, one is inclined to conceive a functional system as a piece of anatomy. However, given the earlier arguments that there is no anatomical specificity in performing a function on different occasions, it seems not possible to identify a functional system with a piece of anatomy. Consider human locomotion again. Is there a part of the human body that is responsible for the function of locomotion and can be called the locomotor system? As we remarked earlier, the means of locomotion and, thus, the anatomical structures that can be involved are quite diverse. Hence, it seems that there is no such thing as *the* part of the human body that is responsible for achieving the function. This renders it impossible to identify a locomotor system with a piece of anatomy. One can point to a human's eyes, arms and legs, but is not possible to point to a human's locomotor system. Hence, it seems that functional systems have a different ontological status than anatomical substrates.

Is a Functional System a Softly Assembled Device?

Several ecological psychologists have discussed the interchangeability of the parts achieving a function in terms of the concept of *task-specific device*, also referred to as *softly assembled device* (e.g. Bingham, 1988; Kugler & Turvey, 1987; Pagano et al., 2001). The idea is that the anatomical structures of the body have particular dynamic properties. By assembling these properties, a temporary device is formed that can execute the task at hand. The devices are described as *soft* because functionally equivalent devices can be assembled over different anatomical structures, and the same anatomical structure can be involved in functionally different systems. Thereby, the concept of softly assembled device captures the multiple realizability of functions that both Gibson (1966) and Reed (1982a) emphasized.

A number of ecological psychologists have suggested that perceptual and action systems should be conceived of as softly assembled devices (see, e.g. Pagano et al., 2001). But are functional systems themselves best thought of as such devices? Although the concept of task-specific device is an illuminating one that is of help in understanding how a relatively simple,

low-dimensional system can be assembled from a myriad of diverse components, there is, we think, a problem with conceiving of functional systems as such devices: by definition, softly assembled devices are *temporary* devices. 'A soft device is temporarily organized from general dynamic properties—not specific anatomical components—to fit current task constraints' (Pagano et al., 2001, p. 216). Hence, the task-specific device exists only when the dynamic properties are assembled in a particular way so that a certain task can be performed. That is, by assembling dynamic properties, an animal *transforms* into a task-specific device. Kugler and Turvey (1987) illustrated this idea quite nicely by asking 'how a person—a very complex dynamical system composed of functionally rich components and very many degrees of freedom—can make of himself or herself a pendular clock—a very simple, dynamical system with few degrees of freedom?' (p. 406).

Although this picture of transforming into task-specific devices might be appealing, we are inclined to think of functional systems as being of a more permanent nature. Consider, again, the locomotor system. To our minds it makes sense to attribute a locomotor system to, say, a dog, irrespective of the activity the dog is involved in. Any temporary organization of the dog's anatomical parts is of no account. A dog has a locomotor system also when it is asleep. Thus, an animal with a locomotor system is not an animal with a temporary assemblage of anatomical structures. Rather, the concept of locomotor system refers to a power of the animal, namely the capacity (or disposition) to change its location in the environment. An animal with a locomotor system is an animal with the power to change its location in the environment, and an animal without such a system lacks this power. To our minds, the ecological conceptualizations of perceptual systems and action systems refer to the animals' powers to establish functional relations with their environments. This means that they refer to dispositional properties, a hypothesis we explore in the next section.

Functional Systems as Dispositions

In psychology, the concept of disposition is probably best known through the work of the philosopher Gilbert Ryle—the concept played a key role in his philosophy of mind. Trying to circumvent the problems of Cartesian dualism, Ryle (1949) asserted that psychological concepts such as belief, desire, knowledge, and the like, do not refer to immaterial causes and effects in a mental theater; rather, they refer to dispositions. 'A disposition is an ability, tendency, liability or proneness to act or react, or fail to act or react, in a certain way in certain circumstances' (Lyons, 1980, p. 46). A stock example of a disposition in the physical world is brittleness. To say that glass is brittle is to say that it will break under certain circumstances. It is

important to emphasize that dispositions are not things or occurrences. A dispositional concept does not refer to a structural entity; neither does it refer to an occurrence like breaking or dissolving. Instead, a dispositional concept refers to what an animal or object can or will do in certain circumstances—it refers to a potentiality.

Ryle (1949) asserted that many psychological concepts refer to dispositions of animals and humans. For instance, to say that someone is intelligent is not to say that he or she is in a kind of immaterial mental state; rather, it is to say that he or she is capable of solving difficult problems. The concept of intelligence refers to a power of a person. To our minds, the concept of functional system refers to a dispositional property in like fashion. This position has several implications.

First, if functional systems are conceived of as powers, then listing the animal's perceptual systems and action systems is not listing pieces of anatomy, each of which has a particular function. Rather, listing the functional systems is describing the perceptual and behavior repertoire of the animal. It is describing the functional relations to the environment that the animal is capable of establishing.⁷

Second, conceived of as capabilities, functional systems are causally supported by, though not identical to, anatomical substrates. Tissue provides the structural basis for an animal to have the power to establish a functional relation with its environment. Hence, functional systems are not occult properties of the animal; one does not appeal to vitalism when explaining a phenomenon by referring to a functional system. Our conceptualization of functional system is consonant with materialism, an ontological statement to which many ecological psychologists subscribe (e.g. Turvey, 1992). However, it is important to emphasize that a functional system is not *identical* to the tissue that supports it. A power to establish a functional relation with the environment is not something one can point to.

Third, if perceptual systems and action systems are conceived of as dispositional properties, perceiving and acting can be understood as their manifestations. That is, in the act of perceiving, a perceptual system manifests itself. And in the performance of an action, the action system manifests itself. The *manifestation of a perceptual system or action system requires* a certain assemblage of dynamic properties. For instance, to act, the 'dynamical properties of muscles and bones, along with tendons, joints, skin, and other surrounding tissues, are temporarily assembled to produce deterministic dynamics for the performance of a particular task' (Pagano et al., 2001, p. 215). And as stressed earlier, the anatomical structures involved in the executing of a task can vary (e.g. Bingham, 1988; Gibson, 1966; Kugler & Turvey, 1987; Reed, 1982a, 1988b, 1996). Thus, a functional system can *manifest* itself in different ways, through different assemblages of anatomical substrates.

Fourth, although the *manifestation* of a functional system is in general temporary, the functional system in and of itself is a relatively permanent property of the animal. Its existence does not depend on whether or not it is manifested. As Harré (1970) put it, ‘Things and materials have powers even when they are not exercising them, and that is a current fact about them, a way in which they are currently differentiated from other things and materials which lack these powers’ (pp. 84–85).

Fifth, the view that perceptual systems and action systems are dispositions implies that it is the animal that perceives and acts, not its perceptual and action system, respectively. Dispositions are causally impotent in the sense that they cannot do anything. Brittleness cannot break. The thing that acts is the thing that possesses the disposition, say, the glass that is brittle. This means that if functional systems are conceived of as powers of the animal, it is the animal, as opposed to its functional systems, that perceives and acts. This implication fits with an idea forwarded by Bennett and Hacker (2003). In their conceptual analyses of recent neuroscience, they accuse many neuroscientists of making the ‘mereological fallacy’—the fallacy of ascribing psychological attributes to the brain or parts thereof, whereas such attributes can only be sensibly ascribed to the animal as a whole. As an example, it makes no sense to say that the brain is in love, for the predicate *being in love* can only be reasonably attributed to the human as a whole. ‘Psychological predicates are predicates that apply essentially to the whole living animal, not to its parts’ (Bennett & Hacker, 2003, p. 72). Our conceptualization of the ecological concepts of perceptual systems and action systems yields an attribution of the psychological predicates *perceiving* and *acting* that is consonant with this dictum—it is the whole living animal that perceives and acts.

Conclusion

In this article, Gibson’s (1966) concept of perceptual systems and Reed’s (1982a) concept of action systems were examined. These concepts were claimed to rest upon the conceptualization of perceiving and acting as establishing functional relations with the environment. We emphasized that functional relations are, in general, multiply realizable: an animal is usually capable of establishing the same relation in multiple ways involving different anatomical structures. Therefore, an animal’s functional system could not be identified with a part of its body. We suggested that functional systems are best thought of as powers to establish functional relationships, that is, as dispositional properties. In this conceptualization, functional systems are relatively permanent properties of the animal that are supported by anatomical structures, without being identical to them.

Notes

1. It is important to note that other ecological psychologists have also sought an elaboration of Gibson's program to deal with the problem of action (e.g. Kadar & Shaw, 2000; Shaw, Turvey, & Mace, 1982; Turvey, 1992), but it was Reed who explicitly developed the concept of *action system*. Thus, it is Reed's work that serves as our departure point.
2. Attention has also been given to the ontological status of effectivity, a concept not unrelated to action systems. Just as an affordance is a functional construal of the environment taken with reference to an animal, effectivity is a functional construal of the animal taken with respect to the environment. However, its ontological status is unclear. Turvey (1992) describes both affordances and effectivities as dispositions, whereas others (e.g. Kadar & Shaw, 2000) define effectivities not as dispositions but as the actualizers of affordances.
3. The important questions of how these two systems relate to each other, and how, more generally, perception and action are related, are not addressed.
4. There is some debate about what Gibson (1966, 1979) meant when he argued that perception is direct. It has even been argued that Gibson himself used his concept of direct perception in several ways (e.g. Costall, 1989). To our reading, however, the quintessence of Gibson's direct perception theory is the claim that the object of perception is the environment (cf. Heft, 2001; Mace, 2003).
5. See Reed (1986) and Meijer (1988) for a more detailed description of these experiments, their origin, and the discussions they resulted in.
6. For the vicarious functions of neurons see, for instance, Edelman (1987).
7. In an unpublished manuscript written in the early stages of his career, Gibson (1926), too, appears to conceive of action systems as referring to the capabilities of animals: '[E]very species of the lower organisms has a characteristic *action system*—that is, every animal possesses a specific repertory of movements—a certain number of reactions which it can make, these reactions forming a coordinated *system*' (in Reed, 1988a, p. 69).

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ACKNOWLEDGEMENTS. We thank Raoul Bongers, Joost Driesens, Harry Heft, Cornelis van de Kamp, Rolf van de Langenberg, Arne Ridderikhoff, Frank Zaal and three anonymous reviewers for helpful suggestions and comments on an earlier draft of the article. This paper was written while Rob Withagen was still based at the Vrije Universiteit Amsterdam.

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