

Discussion: The Roots of Emerging Ecological Psychology

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I briefly trace the topics presented in the 4 symposium papers in a cyclic order. Sheena Rogers' (this issue) paper discussing an example of J. J. Gibson's sense of 'information' (the horizon ratio) and Eleanor J. Gibson's (this issue) paper discussing affordance learning bring together the 2 core concepts of ecological psychology (information and affordance). Robert Lickliter (this issue) and Gene C. Goldfield (this issue), along with E. J. Gibson, discuss skill development in context utilizing comparative psychology and human infant research. For the recent history that holds these topics together, the early contributions of E. B. Holt and J. J. Gibson are emphasized.

As stated in the introduction by Rogers (this issue), the purpose of assembling these short reviews of empirical research was to illustrate the breadth and growth of the field of ecological psychology. Ed Reed organized the symposium but died before it was held (Mace, 1997). Sheena Rogers carried on with the plans so that the symposium could be held at the 1997 meeting of the Eastern Psychological Association and then the papers printed here in revised form.

To further illustrate the emergence of ecological psychology, I cite some noteworthy collections of articles presented in this journal. These include sets on (a) ergonomics or human factors psychology, organized by John Flach (1990); (b) comparative psychology, introduced by Owings and Coss (1991); (c) situating action (Costall & Leudar, 1996); (d) a diverse set from the third European workshop on ecological psychology (Guski & Heine, 1995); and (e) the special issue on visually controlled locomotion (Warren, 1998).

EXTRACTING INVARIANTS IN THE CYCLE OF THEMES

In ecological psychology, stress is placed on the need for variation to extract invariants and the role of that variation in isolating invariants. As E. J. Gibson (this issue) described it, what emerges does so with increasing specificity. Imagine that the topics of the four papers printed here are arranged in a circle and that we can enter at any point but that as we move around it, the cycling will allow us to perceive the emerging ecological psychology.

Lickliter to Rogers

Ecological psychology always has opposed preformationism in all its guises. It resists homunculi, Platonic forms, cognitive maps, retinal images, and "internal programs" as explanatory. Admittedly, such entities can stand for important facts that need to be explained, but there has long been a suspicion that they obscure explanation. J. J. Gibson's teacher, E. B. Holt, complained about "verbal magic" (Holt, 1931). In his book on animal drive, Holt sought to "present the outline of a non-faculty psychology in terms wholly of physical and physiological processes" (p. 7). He was unhappy both with widespread uses of the concept of purpose, which he regarded as an example of verbal magic, and with its denial by behaviorists: "Now exorcism by verbal denial is a form of word magic that seems to me more primitive and rather cruder than the other." (p. 7).

What Holt (1931) presented in that book looks like a blueprint for the position that Lickliter (this issue) described in his paper. Not only did Holt sketch an epigenetic position, but he cited the early 20th-century portions of the same literature that Lickliter used to make his points (e.g. Child, Coghill, Kuo):

The notion of growth as a mere unfolding of potentially contained characters is to be abandoned. And further, the process of functional construction which is so largely sustained by outside, environmental agencies is *not different in principle* from the process that we call "learning." (Holt, 1931, p. 12)

The compatibilities of spirit that Lickliter saw between modern work in animal behavior and ecological psychology do not have to be argued from analogy but may be traced to recent common ancestors.

J. J. Gibson (1950) actually used one of these common ancestors to help argue for the plausibility of the importance of gradients in optical patterns:

According to the evidence of C. M. Child and his students (Child, 1941), all living tissue is characterized by *physiological* gradients. Along the axes of an organism, from head to tail, from front to back, or from the apex to the base of a limb, there exist gradients of metabolism, excitability, and growth. Now these gradients of ac-

tivity are not merely spontaneous self-generated phenomena but are also reactions of the living cells to their environment. Although conditioned in part by the genes within each cell, these reactions are primarily determined by differentials of temperature, light, chemical concentration, or electrical activity—that is to say, by gradients of these kinds of energy. The proposal that the light-sensitive cells of the retinal mosaic and the neural tissue in the brain connected with them can react to gradients of stimulation, therefore, is not without analogy in other kinds of organic tissue. (p. 73)

The texture gradient concept allowed J. J. Gibson (1950) to open up and expand on what could count as a stimulus for perception. This enrichment of the notion of stimulus led to the development of his concept of information, the subject of Rogers (this issue) paper. This is pleasing because the distance between the Lickliter (this issue) and Rogers papers seems to be the greatest of any pair of this set. The day-to-day and week-to-week laboratory and teaching activities of Rogers and Lickliter surely do look quite different. Lickliter is surely correct that there are many ecological psychologists not following the animal literature, but he is also correct that there are commonalities that justify alertness to developments in that area and that it always should have a prominent place in any comprehensive treatment of ecological psychology. The book edited by Johnston and Pietrewicz (1985) was included in the series *Resources for Ecological Psychology* for this reason.

Rogers to E. J. Gibson

Although ecological psychology has a unifying core in the concepts of affordance and information, this is not a reductive core. (Reed, 1996, p. 185)

Rogers' (this issue) paper explores an archetypal topic in ecological psychology, information. The horizon, which she investigated in the case of picture perception, is a concept that as a concept that links that environment and a point of view in a single well-defined entity, sets the stage for J. J. Gibson's (1979/1986) concept of affordance. The development of J. J. Gibson's ideas from information to affordances is one framework for viewing the papers by Rogers and E. J. Gibson (this issue).

The sense of the term *information* as J. J. Gibson used it was contrasted with the term *stimulus*, especially *proximal stimulus*. For vision, it means optical structure specific to its sources. The specificity allows one to say that an observer detecting the structure is informed of its source; hence, the structure is informative. J. J. Gibson (1960) published a careful review of the uses of the term *stimulus* in psychology, showing that the meanings were vague, contradictory, and misleading as applied to perception. Although he did not do so immediately, he eventually dropped the term *stimulus* from his own usage, insisting on *information* in its place.

Experimental optics (e.g., perceptual psychophysics). More important than the term *information* itself was what it signified in J. J. Gibson's research efforts. By 1950, he had realized how much might be gained by examining, through empirical and theoretical work, what informative structure might be found in nature. The most renowned example, of course, was the texture gradient. Instead of accepting current textbook lists of cues (e.g., for size and depth), J. J. Gibson showed that commonly accepted lists of cues could be questioned. As a result, finding relevant new optical structures, such as texture gradients, became goals of research. Compared to an isolated visual angle, a texture gradient could seem complicated, but J. J. Gibson (1950) argued that there was no reason to forbid structures like gradients from behaving as units themselves. New alternatives to count as stimulus structure for vision or any other modalities made it possible to suppose that putative gaps between what is given in a medium and what is experienced might reflect a mistaken hypothesized stimulus not intervening hypothetical processes. A better hypothesis about what is given might improve the match between what the scientist supposes is given in some instance and what the observer experiences. Thus, the mismatch between the two dimensionality of a retinal image and the experience of depth might be overcome, as J. J. Gibson maintained, by restating the situation as one of seeing a slanted surface given by an optical texture gradient. Depth would be implied in the slant of the surface, but there would be no special mystery in the correspondence between the texture gradient and surface slant. This kind of research formed the backbone of the program J. J. Gibson called *perceptual psychophysics*: questioning, reformulating, and testing potential instances of informative stimulus structure (in the earlier terminology).

J. J. Gibson's (1959) last account of the perceptual psychophysics program was his chapter in the Koch series. By the time it was published, he had abandoned the program as one cast far too much in the stimulus-response mold. The insights derived from pondering the case of visually guided locomotion (J. J. Gibson, 1958) marked the main point of departure for the next phase of the development of J. J. Gibson's ideas. The previous prime example of the texture gradient was replaced by optic flow. Like all of his new concepts, there was ample warning in his previous work. There are flow fields in J. J. Gibson's (1950) book, but the emphasis changed and implications were worked out more fully in J. J. Gibson (1958). The seminal role of this paper was honored by its being reprinted twice, once in Reed and Jones (1982a) and once in Warren (1998). The articles in the latter collection all were written in reaction to and appreciation of J. J. Gibson's (1958) article in honor of the 40th anniversary of its publication.

Experimental ontology. Earlier, I mentioned that the concept of texture gradient allowed J. J. Gibson to reinterpret the traditional problem of depth perception as one of surface slant perception. Depth is abstract and does not reflect light. Slanted surfaces do reflect light. In that earlier paragraph, the emphasis

was on the texture gradient as a newly proposed optical structure. However, the corresponding surface at a slant is also a new player. In J. J. Gibson's theorizing, it played an ontology-like role to the texture gradient's epistemological one. J. J. Gibson not only proposed to hunt for new optical structure but also introduced the option of selecting new candidates for what the proper objects of perceiving might be. Hence, surfaces and not immaterial abstractions were the new order of the day. Indeed, even before 1950, he was stressing that his new approach was a *ground theory* (J. J. Gibson, 1950) in contrast to traditional approaches, which he called *air theories*.

Perspectival ontology: From occluding edges to the horizon to affordances.

The final aspect of the previous examples that must be mentioned here is at the heart of J. J. Gibson's (1979/1986) concept of affordance and leads back to E. J. Gibson's (this issue) symposium paper. This aspect is perspective or, less formally, point of view. J. J. Gibson brought observer-relative entities into his theories of what there was to be perceived in addition to their usual place in patterns of optical structure. Prime examples of entities that depend on a point of view for their definition are surface slant, the occluding edge, and one limiting case of an occluding edge, the horizon. Slant may be defined relative to a point of view (optical slant) or relative to the surface of the earth (geographical slant). Early in his psychophysical program, J. J. Gibson presumed a kind of primacy for optical slant but later rejected that and defined slant only relative to the earth. The occluding edge, however, is unambiguously observer relative.

J. J. Gibson did not invent observer-relative concepts (cf. Tolman & Brunswik, 1935), but he did have the insight to stop and wonder about them. Is an occluding edge objective or subjective? He concluded that these were misleading alternatives. To have an occluding edge requires a surface in the world and a point of observation. However, the role of the observer here is not one of strict subjectivity. What might or might not happen in an observer's brain or consciousness is beside the point. There is a subjective side to the concept but only in the sense that a point (or place) of observation is part of the definition of the entity. An occluding edge is a real part of the world but only with respect to points of view. The horizon is not a fixed place on the earth but it is fixed geometrically relative to a point of observation.

J. J. Gibson's (1979/1986) concept of affordance is formally the same kind of thing, except the perspective that is used in the definition includes a full range of biological and psychological capabilities of a living, sentient animal and is not merely a geometric point. "The *affordances* of the environment are what it *offers* the animal, what it *provides* or *furnishes*, either for good or ill" (J. J. Gibson, 1979/1986, p. 127).

Once affordances have entered the theoretical picture, many familiar questions reemerge but in a new context. For E. J. Gibson and her students, these are primar-

ily the questions of learning and development compactly described in her symposium paper (E. J. Gibson, this issue).

Pictures. If one follows developments in the study of optic flow and active perception, one might wonder if traditions have not been turned completely on their head for J. J. Gibson. Whereas traditional theories emphasize that vision begins with the retinal image (which is what, if not a picture?), J. J. Gibson (1979/1986) stressed that it had to begin with information in the flowing optic array. Then could there be information in his sense in pictures at all? J. J. Gibson regularly stepped back and used an analysis of pictures as a way to test his ideas and also (deliciously to him) to add distance between pictures as environmental objects and images as putative bases for perception. He stressed that pictures were challenging and interesting as derivative sources rather than fundamental sources. In his 1979 book (J. J. Gibson, 1979/1986), he put the material about pictures at the end, not at the beginning. Reed and Jones (1982b) wrote an excellent account of J. J. Gibson's work on picture perception accompanied by reprintings of articles representing the full history of J. J. Gibson's thinking about pictures.

E. J. Gibson's contributions (represented early in E. J. Gibson, 1969) might further underscore the need to be sure the concept of information can accommodate pictures. It is obvious that even frozen arrays can contain enough information to support unlimited amounts of perceptual learning. Examples from E. J. Gibson's research as well as from artist's studios throughout history show us that even in fixed samples of information, structure can be rich enough to reward repeated and intensive scrutiny. It is, therefore, most fitting to have the Rogers (this issue) paper drawing attention both to information and to pictures as ecological subject matter.

E. J. Gibson to Goldfield

E. J. Gibson's longstanding specialty, carried over into the title of her paper (E. J. Gibson, this issue) here, is perceptual learning. Goldfield's interest, in traditional terms, is motor development. As ecological psychologists, both are acutely aware of the limitations of these categories, especially when exploration is studied. Because perceiving requires a full motor system for proper exploration and controlling motor systems requires properly attuned perceiving for control, one cannot have one without the other. It certainly cannot be the case that perceiving is input and behaving is output. Ed Reed (1982), following J. J. Gibson, argued for action systems, and this is the scheme that Goldfield (this issue) explicitly followed in his paper.

Some of Ed Reed's (Reed & Bril, 1996) last work provides an excellent perspective for looking at the potential interplay of the themes presented by E. J. Gibson (this issue) and Goldfield (this issue). Goldfield rightly pointed to the importance of Nicolai Bernstein's work in theories of motor development (taking the term

loosely and colloquially). Mark Latash, a student of Bernstein's from Moscow, translated Bernstein's *On Dexterity and Its Development* (Latash & Turvey, 1996), to be published with commentary chapters. This book looks specifically at the refinements of motor activity as one becomes highly skilled, whether the skill is an everyday activity or an athletic accomplishment. The attitudes and principles dovetail nicely with E. J. Gibson's descriptions and analyses reported in her paper. Characteristically, Ed Reed (Reed & Bril, 1996) wrote a commentary seeking to frame the topic of action development in an even broader context, in this case a variable cultural context. By looking at research on cultural variation in motor expectations, the Reed and Bril chapter allows us to reflect back on Lickliter's (this issue) equifinality through a different comparative route. To what extent do we see a variety of means (some nonobvious) to the same ends, and to what extent do we see real variation in development as a result of differing cultural expectations and practices? How do some cultures achieve toilet training before a child is 1 year old?

Goldfield to Lickliter

The properties of development that Lickliter (this issue) presented from comparative psychology, probabilism, equifinality, nonlinearity, and distributed control look most similar to the ideas behind Goldfield's (this issue) work. In his paper, Goldfield kept his accounts close to those of Reed (1982) and Bernstein (Latash & Turvey, 1996), but elsewhere (Goldfield, 1995) he presented the more explicit connection to the work in dynamical systems from Thelen and Smith (1994) and Kelso (1995). As with Lickliter's work, one can look at the developments that Goldfield documented and ask, "Is this learning or is it development?" With Holt (1931), we should probably wonder if it matters. If one finds order and good reason for that order in the interplay between biological materials and processes and organismic experience in an environment, it probably matters less what one calls it.

CONCLUSION

And so it goes. Readers may expand the discussion by inserting other ecological subtopics into the cycle. It is presumed that the emerging knowledge will become increasingly differentiated, clear, specific, and even economical.

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