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Two ecological perspectives: Gibson vs. Shaw and Turvey

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An ecological perspective on psychology views the proper unit of analysis as the organism in its natural environment. In this manner, it is said, one can discover the ways in which animals and environments mutually constrain one another. James J. Gibson was first to bring this particular perspective to psychology, especially in the study of visual perception. Recently, others have begun to extend this idea to other areas of perception , to other areas of psychology, and to other disciplines. Robert E. Shaw and Michael T. Turvey have led this expansion. Gibson, on the one hand, and Shaw, Turvey, and their colleagues, on the other, share much in their approaches. However, it is the purpose of this essay to draw some distinctions between them in hope that neither the views of Gibson, nor those of Shaw and Turvey, will be misconstrued.

How do we perceive? How can we most effectively approach the question of how we perceive? These questions, along with several like them (What do we perceive? Who are we that we can perceive?), engage both philosophers and psychologists. It is rare that anyone proposes new answers to any of these, much less the whole set. Yet new answers were proposed by James J. Gibson. Gibson firmly believed that the study of perception was a muddle unless approached in the correct way, and the best way was to minimize domain differences between perceiver and perceived. Dualisms were banned. Gibson's procedure for establishing a nondualistic view of perception was to reassess old methodological and epistemological habits, to shriven himself of them, and to adopt a new perspective.

The new perspective that Gibson chose is that from ecology rooted in evolutionary biology. *Ecos* means house. When extended to that which "houses" an animal, ecology is the study of the relation between animals and environments. It is the study of the mutual constraints of the two on one another. But many view this perspective as

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one far removed from human beings, human perception, and the objects of human perception: How are television sets and asphalt highways products of evolutionary biology? In what way are books and computer displays to be considered fruits of the mutuality of human beings and the natural environment? Gibson was beginning to tell us the answers to these and other questions in his last book, *The Ecological Approach to Visual Perception* (Gibson, 1979).

Gibson influenced psychologists, philosophers, artists, architects, and any others who would listen. But influence is not acceptance, and he seemed to enjoy most his discussions with those who disagreed with him. Despite his tendency toward extreme postures, however, there were those who began to agree; and almost despite himself he developed a following. During his last decade the number of followers grew steadily as an invisible college. With increase in number, they became a self-organizing system (Prigogine, 1976; Soodak & Iberall, 1978), and two of the most important members of this coalitional structure are Robert E. Shaw and Michael T. Turvey. Shaw and Turvey, along with their many colleagues, have begun to characterize the ecological perspective, outline the domain of ecological psychology (and other fields), and throw down the gauntlet to the rest of us. They, like Gibson, are challenging the premises of traditional psychology. Unfortunately, they have not yet given us a full account of their viewpoint. Moreover, they are sometimes difficult to understand. Their words occasionally provoke haggling and confusion. Fodor (1980, p. 107), when speaking of one slice of the Shaw and Turvey perspective (Shaw & Turvey, 1980), echoed the sentiments of many: "I admit to understanding almost none of this. And what I think I understand I'm sure I don't like."

In clarifying the issues at stake, Claire F. Michaels and Claudia Carello have recently done us great service. Michaels and Carello, in their book *Direct Perception* (1981), present for the first time an account of the Shaw and Turvey perspective as it has grown over the first eight years of their collaboration. In this book, also presented for the first time, is hard evidence that Shaw and Turvey are not systematic followers of Gibson. They are revisionists who present a new ecological perspective. Thus, unlike the unified ecological view presented by Reed and Jones (1979), it is now clear that we have two ecological perspectives: that of Gibson and that of Shaw and Turvey. Since Gibson was first to present this general point of view, it will be useful to call his viewpoint the *ecological formulation;* since Shaw and Turvey have come later, most times building on the work of Gibson, but sometimes not, it will be useful to call their viewpoint the *ecological reformulation.*

What follows, then has three simultaneous aims. First, it is a review of *Direct Perception* by Michaels and Carello. Second, it is a contrastive essay on the ecological formulation and the ecological reformulation. And third, it is a guideline for the assessment of both.[1] But before beginning this exposition, it is necessary to place the two ecological perspectives in context.

Paradigms and world hypothesis

Science is full of sweeping views with overarching consequences. Information processing is a perspective that fits this notion, and so do the ecological perspectives. The former has the root-metaphor of the general-purpose digital computer, and the latter have the root-metaphor of animal-environment mutuality (Gibson, 1979, p. 8; Prindle, Carello, & Turvey, 1980) or animal-environment dualism (Turvey & Shaw, 1979; Michaels & Carello, 1981, chapter 5). For purposes of explanation, information-processing psychology takes out large loans on the concept of computation; ecological psychology, on the other hand, takes out large loans on the concept of evolution.[2] It is tempting to call these points of view *paradigms,* after Kuhn (1962). For example, Lachman, Lachman, and Butterfield (1979, chapter 1) suggest that information processing is one paradigm, and Michaels and Carello (1981, p. 115) and Reed and Jones (1979) suggest that the ecological perspective is another. Moreover, each set of authors suggests that acceptance of one perspective constitutes, or would constitute, a paradigm shift.

But the notion of paradigm may not be entirely applicable here. First, Kuhn (1962, 1970, 1974, 1977; see also Masterman, 1970; Percival, 1976) intended it for the mature, natural sciences, not for the social sciences. Since perception clearly straddles the two it is not clear how much of a problem this is. Second, one criterion for a paradigm is that it results from the work of a single innovator. It is not clear who the *single* innovator for information processing is; many prominent names come to mind. Gibson, of course, is the innovator for the ecological formulation, but this fact is disqualified by a third point: paradigms are followed uniformly by members of a *group.* Gibson never founded or even belonged to any such group, and the point of this essay is that Shaw and Turvey are not always direct followers of Gibson. Nevertheless, the ecological reformulation definitely has become something of a group enterprise. Of course, these are quibbles, but there are other aspects of the use of the concept paradigm that are not.

Kuhn (1970), 1974) later recast his notion of paradigm in terms of a

disciplinary matrix, which has four parts: symbolic generalizations, models, values, and exemplars. *Symbolic generalizations* are formalisms readily deployed by all members of the group. It is not clear that information processing psychologists can do this or are even interested in doing this. Gibson certainly was not. But it is clear that Shaw and Turvey are interested in symbolic representations (Michaels & Carello, 1981, p. 43; Shaw, Turvey, & Mace, 1982; Turvey, Shaw, Reed, & Mace, 1981.) *Models* are conceptual analogies that provide insight into the fundamentals of knowledge. Information-processing psychology has used many of these, and I will discuss some used by Gibson and by the reformulation in a later section. *Values* are the criteria used to justify the way research is conducted, to identify problems, and to judge between competing theories. Certain aspects of this notion of values are important in the context of separating Gibson from Shaw and Turvey, and I will return to this idea as well. Finally, *exemplars* are typical problem solutions—experiments and their data—accepted by all members of the group. Information processing has many exemplars, the ecological formulation quite a few (see Gibson, 1979), and the ecological reformulation, at least at present, fewer. For the latter group, ageing faces is very nearly the only exemplar one can find (Todd, Mark, Shaw, & Pittenger, 1980; Michaels & Carello, 1981, pp. 123–133). Thus, although there is much to recommend the notion of paradigm to this discussion, there are many ideas connected to it that are not entirely relevant.

Another cogent characterization of information-processing and ecological perspectives, I think, is that they are *world hypotheses*. Defined by Pepper (1942), these are beliefs about how the world is structured and how it should be dealt with.[3] The information-processing psychologist approaches the problem of information in the world and how any organism must interact with it—information must be processed with the aid of computations and representations. The ecological psychologist, on the other hand, approaches the problem in a different way—information must be picked up without appeal to computation or to representation within the organism. It is said that for the information-processing psychologist perception is *indirect*, but for the ecological psychologist perception is *direct*.

Direct and indirect perception

This direct perception business is tricky: "Direct perception is the activity of getting information from the ambient array of light" (Gibson, 1979, p. 147). Nothing is said by Gibson about process. But I will not try to capture the richness of debate over direct perception

(see Fodor & Pylyshyn, 1981, Gibson, 1979; Gyr, 1972; Mace & Pittenger, 1975; Shaw & Bransford, 1977; Turvey et al., 1981; Ullman, 1980). Instead, let me address it indirectly, returning to the world hypotheses and their root-metaphors. If one is an information-processing psychologist one tends to view organisms in their environments as general-purpose computers that do a lot of computation in order to interact and understand their surrounds. If, on the other hand, one is an ecological psychologist, one tends to view organisms in their environments as mutually constraining systems. The two are entrained. The organism does no more computation than does the environment (that is to say, none). The ecological psychologists view the flaw of the information processing approach as having too few constraints on the animal for efficacious interaction with its environment. Mental computation is not the normal work of perception and cognition; biological constraints guide these activities better than does calculation. The information processing psychologists however, view the flaw of the ecological approach as generally ignoring the idea that the human being is the most general-purpose entity in all of biology, perhaps structurally and functionally closer to a general-purpose computer than to any collection of special purpose devices.

What is interesting about both views is that, as world hypotheses, they cannot *in principle* reject any datum. All animal-environment situations must be addressed by both. Information processing, perhaps because it generally has had narrower goals, has not addressed issues in, say, ethology. For example, how does the male silkworm moth "process" bombykol, the female silkworm's sex attractant? No information-processing scientist that I know of has answered this type of question. The ecological perspectives, on the other hand, have broader goals. Since humans are as much a product of evolution as silkworm moths, an account of humans must have the same form and, insofar as possible, use the same terms as the account of moths. Just as the male silkworm moth has been designed by nature (constrained by the coevolution of itself and its environment) to pick up bombykol and fly up a density gradient, so too human beings are designed to pick up information about the world and act upon it.

But who admits of direct and indirect perception, and when? Michaels and Carello suggest (1981, p. 183), I think correctly, that even from a traditional view in perceptual psychology *some* perception is direct – that of touch, for example. This is undoubtedly a residue of the Berkeleyan idea that touch educates vision. For symmetry's sake,

one must ask how much the two ecological perspectives admit of indirect perception. The answer proves interesting. For Gibson there are several kinds of indirect perception. According to the ecological formulation, indirect perception occurs when humans view human-generated displays—pictures, written-on surfaces, and what can be seen through microscopes, telescopes, and the like (Gibson, 1979, p. 42). However, according to the ecological reformulation, no indirect perception occurs; it is all direct (Michaels & Carello, 1981, chapter 3, especially p. 55; see also Shaw & Bransford, 1977).

For Gibson, the perception of pictures is indirect because what is perceived is not the object but only a depiction of the object—magnified, preserved on paper or rocks. These depicting media are clearly artifacts that represent something in the world. Thus, we perceive what the depictions refer to (that is, pictures mediate perception of what they depict) and *also* perceive them as objects themselves. This dual character makes picture perception particularly interesting (Gibson, 1979, chapter 15). Since we did not evolve to look at pictures or televisions, and since what we see through telescopes and microscopes is out of scale with our normal environment, we must be perceiving what these present to us indirectly. Michaels and Carello disagree: all is direct, and the pick-up invariants are functionally the same in all cases.

As a world hypothesis, the ecological reformulation must eventually address picture perception and similar phenomena. Shaw and Turvey, or Michaels and Carello, are even obliged to give us, for example, an account of the direct human perception of tachistoscopic displays.* One typically hears about the avoidance of this kind of animal-environment setting by dismissal; they are something less than completely valid types of animal-environment settings (e.g., Neisser, 1976, pp. 33–37). But this seems less principled than one might like. Dismissal certainly bespeaks the *values* of the group perspective as to what constitutes a proper research domain, but it is also a withdrawal from the root-metaphor of the world hypothesis. Fodor (1980, p. 107) has addressed this dismissal problem when discussing going to the cinema: "If someone now says that flicking out is not 'ecologically valid,' I think that I shall scream." A human being in front of a tachistoscope and one in front of a movie screen are no less animal-environmental transactions than any others, even though the organism may be more passive than normal in both. Since the ecological reformulation seems not to permit indirect perception for human-generated displays, as Gibson does, it must eventually deal with these displays in a principled way as a type of direct perception. That it

hasn't yet is a clear example of value in problem choice.

In addition to these analyses from a world-hypothesis perspective, there are several aspects of a Kuhnian analysis that are useful. For example, consider the models of these disciplinary matrices. Both Gibson and the ecological reformulation have presented models of perception. Gibson (1966), for example, once proposed a radio model: we, as perceivers, simply resonate when exposed to information in the environment as the transistors and circuitry of a radio resonate to radio waves. Gibson was not entirely happy with this idea (Gibson, 1966, p. 271) since, for the radio to work, something must first turn it on and tune it, implying a homunculus. In his last book (Gibson, 1979, p. 249), he barely even mentioned the term resonance, and he certainly did not return to the radio model. The reformulation, however, has adopted a new model from Runeson (1977). As we will see, it has the same problems as does the radio.

The model of the polar planimeter

One model proposed by the reformulation is the polar planimeter (Michaels & Carello, 1981, pp. 66–69), although a hatchet planimeter would do as well. A planimeter is a device that, through the movements of gears and a tracer pin, can be used to measure the area of any figure regardless of shape. Analysis of this device demonstrates how a higher-order stimulus property might be detected without the prior computation of lower-order properties (Runeson, 1977). The planimeter registers the area (a higher-order property) of any figure with any shape without first registering length (a lower-order property) and without performing, through *digital* computation, the calculus that would be necessary to perform the task. Area simply falls out as a consequence of moving the tracer pin around the perimeter of a figure. The planimeter is a special purpose device that performs no other function. Moreover, it performs this function over time with no discrete, decomposable steps.

The argument, then, generalizes to perceptual systems. Perceptual systems might, like the planimeter, register higher-order stimulus properties without prior registration of lower-order properties. These systems might be specially attuned to pick up certain stimulus properties, not others, and do so without computation. Our perceptual systems might be special-purpose biological machines that perform limited sets of functions. If they were "smart" in the way that a polar planimeter is "smart," they too would not need to compute in order to pick up information. They simply register information over time, without decomposable steps.

The planimeter model is a rich one. It does indeed demonstrate that there may be alternative ways to obtain higher-order properties other than composing them from typically construed lower-order properties. In particular, the planimeter is an excellent model for how analog processing can be different from digital processing. What it is *not*, however is a metaphor that provides support for the direct perception view from the root-metaphor of animal-environment systems. It has problems beyond those mentioned by Michaels and Carello (1981, p. 68n). As I see it, they are twofold.

First, like the radio, the polar planimeter has no evolutionary history.[5] This is rather more than a quibble. It would seem that if this model were cogent it should have some semblance of the root-metaphor of animal-environment synergy that Shaw and Turvey (1980; Michaels & Carello, 1981) speak of. Yet to speak of planimeter-figure synergy makes little sense. Animals and their environments are usually neither products of human intention nor of human design[6]; planimeters and figures are both. The difference is crucial because it centers on intentionality. We, as human perceivers, construct neither our perceptual systems nor many of the objects in the world that we perceive. Intentionality can play no clear role in evolutionary biology and in discussions of animal-environment ecology.

Second, the polar planimeter does not measure area, its user does. The planimeter registers area. By backward analogy to perception we are confronted with the following view: the perceptual system gives to the perceiver some information in the manner that the carriage gear gives area to the planimeter user. The perceiver then "reads off" the perceptual system the higher-order sense data in the manner that the planimeter user reads off the revolution recording dial, the measuring wheel, and the vernier scale. Thus, the planimeter analogy is a good one for *indirect* perception; it requires a homunculus in order to be complete. Gibson would not like this. It is why he was uncomfortable with the radio model.

On two grounds, then, that of evolution and that of the necessity of a homunculus, the polar planimeter model proves uncomplementary to the root-metaphor of the ecological reformulation. Pepper (1942, p. 113) suggests that concepts or analogies that have lost contact with their root-metaphor are empty. This model, as part of the disciplinary matrix of the reformulation, is incoherent with respect to its goals. The nice thing about models, however, is that they can be discarded. One can be sure that the polar planimeter will be discarded, just as Gibson discarded the model of the radio. New models are sure to appear in the next few years, as some already have: airplanes and

their ailerons (Kugler & Turvey, 1979), termites building arches (Michaels & Carello, 1981, pp. 146–151), pendulum clocks (pp. 51–52), electricity detecting sharks (Turvey et al., 1981, pp. 276–277), and even slime molds and potatoes.

Some differences between the ecological formulation and reformulation

To highlight differences between the ecological perspective of Gibson on the one hand and that of Shaw, Turvey, and their colleagues on the other, I will focus on three areas: terms and concepts, the status of perceptual error, and attitudes about dualisms and formalisms. These do not exhaust the differences; for example, I have already mentioned the difference in construals of the notion of indirect perception, and I will later discuss differences in categories of invariants. Nevertheless, these three are representative and instructive. And it will also be useful to discuss Kuhn's notion of value for each.

Terms and concepts

Ecological perspectives are as much concerned with words as they are with reality. This, of course, is as it should be, because words are the tools from which ideas are made.

Gibson liked the discussion of words. Beyond his many empirical researches, he more than earned his keep during the middle of his career as one who kept psychologists honest about the words they used. He first warned us about the concept of *set* (Gibson, 1941), suggesting that it meant virtually all things to psychologists. He warned us next, a decade later, about the concept of *form* (Gibson, 1951) and gave us a taxonomy to deal with the multiplicity of the term. He finally warned us, a decade later still, about the concept of *stimulus* (Gibson, 1960), and gave us its many interpretations. Beyond these admonitions, he chose his own words carefully. He liked gerunds instead of static nouns: *perceiving, knowing,* and *remembering* instead of *perception, knowledge,* and *memory.* The rationale is that a "verbal" form connotes action; a noun connotes a thing and may lead one into reification of that thing as a construct, box, or cluster of tissues within the organism. Gibson was reluctant to make up words. His famous neologism, *affordance,* was carefully crafted. And even here, the concept has a history in psychology through Lewin's *aufforderungscharakter* (Gibson, 1979, chapter 8). In sum, Gibson cared about words and when he found none that would fit his ideas, he made them up, *slowly* and *carefully.*

This is in contrast to Shaw and Turvey. They certainly like the discussion of words, but their generation rate borders on logorrhea. Every chapter they write—singly, together, or in concert with other colleagues—has a new term, a new concept that we must grapple with.[7] This is not necessarily bad; it is simply difficult and sometimes annoying. Again, one of the many strengths of the Michaels and Carello volume is that they have put together many of the reformulation terms in as coherent a manner as they can be placed.

It is instructive, then, to compare the terms used by Gibson in *The Ecological Approach to Visual Perception* (1979) and those used by Michaels and Carello in *Direct Perception* (1981). Since the books are nearly contemporaneous, since both are about perception, since both are about ecological perspectives in psychology, and since the latter book is dedicated to the author of the former, one would expect much that is held in common. In fact, there is much commonality. There is, for example, ample discussion in both of the central concepts of invariances and affordances. But surprisingly, there is much that is not held in common. One way to demonstrate this is to peruse the index of each book and look for the terms that are not found in the other. Some terms in the index of Gibson but not in that of Michaels and Carello are: *accretion, clutter, concavity, convexity, corner, deletion, dihedral, gradient, horizon, illumination, information pick-up, layout, looming, occlusion, perspective, picture, point of observation, proprioception, shadow,* and *visual kinesthesis.* Some of those in the index of Michaels and Carello but not in that of Gibson are: *algorist, attensity, coalition, coordinative structure, dissipative structure, effectivity, grain of analysis, structural invariant,* and *transformational invariant.* For the most part, the terms that Gibson uses (and that Michaels and Carello don't use) refer to aspects of or relations to the optic array. For the most part, the terms Michaels and Carello use (and that Gibson doesn't use) refer to nonperceptual constructs, new to psychology.

It is not easy to know how to interpret these differences in terms.[8] My interpretation, however, is that Gibson has a deeper commitment to perceiving, and perhaps to ways of doing justice to the organism and to its environment. Shaw and Turvey, on the other hand, seem to be working harder on broader issues across many disciplines. They import terms from mathematics, physics, biology, and philosophy. This makes assessment of their program difficult. Gibson was trying to forge a new domain of ecological psychology out of the terms largely from traditional psychology and common parlance. Shaw and Turvey, while trying to forge an ecological science of approximately the same type, use key concepts from domains outside those of traditional psychology and of common parlance.

Values. Values, remember, are the part of Kuhn's (1970, 1974, 1977) disciplinary matrix that are responsible for choice of methodology, choice of research problems, and choice of criteria to assess theories. Values are, in essence, the force behind scientific style. There is much that is shared in values between Gibson and the reformulation by Shaw, Turvey, and their colleagues. But there is also much that is not.

Differences in terms and concepts are an example. Gibson chose his terms so as to create a self-consistent, relatively closed theoretical system (Reed & Jones, 1978). All terms were rooted in his own empirical research, in traditional psychology, or in common usage. He made sure that these words had strong connotative roots because he was aware that borrowed terms are deracinated; they are cut off from the roots of their own disciplinary matrix. At worst they shrivel and die; at best they grow to be something different than they were. Shaw, Turvey, and colleagues, at least so far as one can determine at present, have a more open theoretical system. Many of their terms are rooted in other disciplines, seldom in their own empirical research, and not often in common usage. These terms are cut off from the disciplinary matrix in which they grew.

This is not to say that the reformulation terms and concepts are necessarily inconsistent—to the contrary, Shaw and Turvey work hard at deriving a consistent world view (see, for example, Turvey & Carello, 1981). What it means is that even if we could educate ourselves in the domains from which the reformulation draws, we have no guarantee that we can understand Shaw and Turvey better. As a case in point, consider their fascination with Klein's Erlangen program for the specification of geometries by invariant relations (Michaels & Carello, 1981, pp. 30–37). One can recognize Klein's program as elegant, but once recognized one does not have a deeper understanding of invariants as they are used, for example, in perception. Thus, for my money, the Erlangen program is dazzling, but not compellingly relevant to the task at hand.

The status of perceptual error

Most approaches to perception are chock full of error analyses. Error is the very meat of their methodologies. Not so for the ecological approaches: error plays no central role in discovery of how perceptual systems work. It is argued that the traditional line of reasoning in experimental psychology is not sound: we should not infer from what people cannot do in unusual circumstances (e.g., errors in tachistoscopic stimulus conditions) to what people do in everyday life. My purpose is not to address the assertions about this inference line. In-

stead, I wish to compare the roles of perceptual error in the ecological formulation and reformulation.

For Gibson, perceptual error is rare. Animals and their perceptual systems have evolved because they are correct an overwhelming proportion of the time. If they erred too often, the animal would not survive. But errors do occur: "An adult can misperceive the affordance of a sheet of glass . . . the affordance of collision was not specified by the outflow of optical texture in the array, or it was insufficiently specified" (Gibson, 1979, p. 142). Such a statement allows for error in perception. And there is more: "Errors in the perception of the surface of support are serious for a terrestrial animal. If quicksand is mistaken for sand, the perceiver is in deep trouble" (p. 142). It is sometimes claimed that Gibson believed that things look the way they do because they are what they are (Mace, 1977, p. 64; see also Kolers, 1978, p. 228). In fact, this is not quite correct. What Gibson (1979, p. 143) did believe is that: "When Koffka asserted that 'each thing says what it is,' he failed to mention that it may lie. More exactly, a thing may not look like what it is" (see also Gibson, 1971). In this manner and others, Gibson admits that perceptual error can occur: " . . . that innocent looking leaf is really a nettle" (p. 142) and we are mistaken to treat it as an innocent leaf.

For the ecological reformulation, error is nonexistent (Michaels & Carello, 1981, pp. 88–97). Instead, borrowing in part from Gibson (1966, chapter 14), there are situations where information is inadequate (as is many experimental settings), where adequate information is undetected (as in the glass door example), where various illusions depict unreality, where the human perspective is used inappropriately, and where arbitrary limits have been placed on the scope of perception. But none of these is error according to Michaels and Carello: "Perception cannot be in error because no one moment in that event must stand as the last word on pragmatic truth" (p. 95).

Now this seems odd. Why, for example, are not *some* examples of undetected adequate information considered as perceptual error? Consider the aftermath of Gibson's example of an adult running through a glass door. Surely, lying in a hospital bed with 219 stitches stands as a moment of pragmatic truth in that event that issues the call "Perceptual error! Perceptual error!" To say otherwise goes against common sense.[9] The denial of perceptual error by the ecological reformulation seems to belie interest in the consensual reality of human experience and bespeak more an interest in words and relations between certain ideas. It suggests a difference in value from that of Gibson.

Values. To err is human, and error can be integral to certain adaptive processes. For Gibson, errors are not particularly common. But when they occur, and when they are not so severe as to be harmful, perceptual errors or misperceptions (however they shall be called) are opportunities to learn. When we misperceive things and the consequences tell us that we have erred, we are forced to reevaluate and learn more about these objects of our attention. When we do not directly perceive the affordances of objects and events, we sometimes make mistakes, and these mistakes are typically chances for us to become *more attuned* to our surrounds. Learning from errors broadens what the environment affords us. To deny perceptual error, as the reformulation does, is to adopt the position that instances of misperception, even in the real world, are not proper research problems. Moreover and more deeply, it seems to deny the fact that the human animal and its environment can ever be out of perfect harmony.

Dualisms, dualities, and formalisms

In the ecological formulation dualisms are anathema. In particular: "The theory of psychophysical parallelism that assumes that the dimensions of consciousness are in correspondence with the dimensions of physics and that the equations of such correspondence can be established is an expression of Cartesian dualism" (Gibson, 1979, p. 306). Gibson fervently believed that dualisms were not efficacious approaches to perception. He spoke instead of the mutuality of animal and environment (Gibson, 1979, p. 8) and expressly stated that the terms animal and environment are complementary. An affordance is a statement about the mutuality of the two: it is "equally a fact about the environment and a fact about behavior. It is both physical and psychical, yet neither. An affordance points both ways, to the environment and to the observer" (Gibson, 1979, p. 129).

In the ecological reformulation, this attitude towards dualism is maintained. But the distinction becomes more difficult to grasp properly: *dualisms* are banned in their usual form, but *dualities, dispositional duals,* and *dual isomorphisms* are fully embraced. Duality is the general term here and is similar to the *mutuality* of Gibson (1979, p. 8). It differs from some construals of dualism in that a duality is symmetric, but neither reflexive nor transitive (Shaw & Turvey, 1981, pp. 380–382). Perhaps the most important dualities of the reformulation are the terms *affordance* and *effectivity*. The first term is used by both Gibson and the reformulation, but the latter only by the reformulation.

To understand these terms a few formalisms may help (and I will

return to them later): "A situation or event *X* affords action *Y* for animal *Z* on occasion *O* if certain relevant compatibilities between *X* and *Z* obtain. . . . An animal *Z* can effect action *Y* on an environmental situation or event *X* if certain relevant mutual compatibilities between *X* and *Z* obtain" (Michaels & Carello, 1981, p. 43; Shaw, Turvey, & Mace, 1982). Except for the fact that the occasion variable *O* is left out of the formal description of an effectivity in the Michaels and Carello account, the effectivity and affordance are symmetric. To the reformulation, then, an affordance is something that is directional from environment to animal, and an effectivity directional from animal to environment. But Gibson didn't need the latter term: an affordance is something that *points both ways* and is equally a fact of the environment *and behavior.*

Now the duality approach of the reformulation may turn out to be a more efficacious approach to perception and action, but there are some other concepts presented by the reformulation that seem out of step with dualities and mutualities, and seem very close to dualisms. For me the most problematic case is that of the *algorist* (Michaels & Carello, 1981, pp. 72–76; Shaw & McIntyre, 1974). It is very difficult *not* to construe the algorist as homunculus, although claims are made to the contrary. The algorist is somehow not simply the perceiver (otherwise that word would do). The algorist is "the nonalgorithmic and noninformational constraints on perception. . .[it] is not something or someone inside the animal. Rather the algorist is better thought of as those aspects of the animal—the whole animal—that render certain algorithms cost-effective, certain environmental objects useful, behaviors as intentional, and so on" (pp. 74–75). To paraphrase Fodor, I admit to understanding almost none of this, and what I think I understand smacks of dualism. Michaels and Carello attempt to deontologize the algorist, but one is left with the following view: the algorist is *certain* aspects of the whole animal (which I can read only as part of the animal) and it deals somehow with the information in the world through *algorithms.* Anyone who proposes this seems hardly to be presenting a solid front against the information-processing perspective; in fact, this *is* information processing.

Values. Gibson never proposed schemas or formalisms for his concepts. One can only suppose that he thought they would be uninformative and not useful. The reformulation, however, does propose formalisms, and the two for the concepts affordance and effectivity are cases in point. It is interesting that Shaw, Turvey, and Mace (1982); Michaels & Carello, 1981, p. 43) propose that these are informative. To rearrange them in predicate-calculus form from Michaels

and Carello, they are: *Afford*(X, Y, Z, O) and *Effect*(Z, Y, X), where X is the situation or event, Y the action, Z the animal, and O the occasion. Now formalisms are useful only to the degree that they constrain possibilities. A phrase is added to each—"if certain relevant compatibilities between X and Z obtain"—that is supposed to do all the work of constraining, but one wonders if any semblance of a system for determining what these compatibilities are for all Xs and Zs will be forthcoming. In short, these formalisms are a guise for the proposition that affordances and effectivities constrain perception and behavior.

Of course, we must wait and see if the reformulation delivers on their promissory note concerning dualities. My concern here is with these formalisms. Formalisms in many sciences pretend to be more than they are. My fears with regard to formalisms in ecological science are best captured by Hayek, who presents his views of formalisms within economic science:

> I want to avoid giving the impression that I generally reject the mathematical method in economics. I regard it in fact as the great advantage of the mathematical technique that it allows us to describe, by means of algebraic equations, the general character of a pattern even where we are ignorant of the numerical values which will determine its particular manifestation. . . . It has led to the illusion, however, that we can use this technique for the determination and predication of the numerical values of those magnitudes. . . . Indeed, the chief point was already seen by those remarkable anticipators of modern economics, the Spanish schoolmen of the sixteenth century, who emphasized that what they called the *pretium mathematicum,* the mathematical price, depended on so many particular circumstances that it could never be known to man but was known only to God (Hayek, 1978, pp. 27-28).

Diety or not, I doubt that we shall never know the values of the variables—and the "certain relevant mutual compatibilities"—shown in the formalisms of Shaw and Turvey. The values displayed by use of formalisms are that they will make the ecological perspective more constrained, more rigorous, more scientific, and more acceptable. Yet these do not necessarily follow.

The idea of constraints needs more attention. Here, I will deal with it in the context of two other terms: invariants and affordances.

Invariants, affordances, and constraints

Three terms are crucial for understanding the force of the

ecological approaches to perception. The first term is *invariance.* Since Berkeley, many views of perception have assumed that stimuli are impoverished and do not have adequate information in them to trigger, full-blown, a percept. The demonstration by Gibson (1950) of the existence of invariants, though not the first such demonstration, is a landmark in the study of perception. To Gibson, and to many of us more recently, the world is a plenum of invariant information as well as variant information. Given that the world is trustworthy in this regard, the ruliness of perception has come to make a lot more sense. Invariants unburden computational requirements on the perceiver.

Invariants are formless and timeless. They can be represented as mathematical-like expressions, but they are properties of information in the world. They are also animal-neutral. What remains invariant in the world does not necessarily depend on the type of perceiver that is present; in fact, in many cases no perceiver needs to be present at all (for example, see the invariants described by Cutting, 1981; Cutting, Proffitt, & Kozlowski, 1978; and Proffitt & Cutting, 1980). Gibson, Shaw and Turvey, as well as many others, use the concept of invariants in essentially the same manner.

There seems to be some question as to whether the appropriate invariants relevant to ecological psychology are *higher-order* invariants or not (Gibson, 1979, p. 141; Kolers, 1978, p. 228; Michaels & Carello, 1981, p. 178), but this seems to be a small matter. Higher-order invariants are simply invariants, like any others. Levels of order is a value-laden concept: order is relevant only when one finds some invariants useful and others not.

The reformulation parts with Gibson when it comes to specifying classes of perceptual invariants. They admit to only two classes of invariants, transformational and structural (Michaels & Carello, 1981, pp. 25–26; Shaw, McIntyre, & Mace, 1974). Transformational invariants are the style of change that an object may undergo—sliding, spinning, growing, and many other gerunds. Structural invariants are the properties of the object that remain constant while undergoing change—flatness, roundness, humanoidness, and many other physical-property nouns. Gibson, in contrast, admits to four types of invariants (Gibson, 1979, appendix 2): those under change of illumination, those under change of point of observation, those across samples of the optic array (when looking around), and those that are due to local disturbances of structure in the optic array. Gibson's invariants refer directly or indirectly to both the transformational and structural invariants of Shaw and Turvey. The two systems do not intermix; in fact, they are orthogonal. Moreover, their differences

again suggest a difference in emphasis. Gibson was interested in the reality of the optic array; Shaw and Turvey are interested in the mathematical constructs that may underlie the reality of the optic array. I, personally, find the reformulation set of terms more helpful (see Cutting, 1981).

To make the concept in invariance mesh with perception, something more is needed. Gibson proposed a new concept, *affordance*. The concept of an affordance is nothing less than brilliant. It is the invariance of an object or event in the environment geared to the particular animal. We don't perceive invariants; we perceive the affordances of the objects and events around us. Those objects and events are meaningful to us because of what they afford for us as individuals—what they allow us to do. To perceive an affordance is to perceive meaning. Of course, different objects and events afford different things to different people and to different organisms, but this is seen to be no problem. The affordance is part of the animal-environment mutuality, and it points both ways between a particular animal and a particular environment.

Perhaps the nastiest issue in psychology and philosophy is that of meaning. What Gibson has done is to cut through the pretzel-shaped logic with which most of us have dealt with this issue and simply has assumed that what we perceive is meaningful. Rather than solve the problem of meaning rationalistically, Gibson re-poses the problem to promote empirical analyses. Meaning is not something to be attached or contributed by the organism during the process of perception. It is simply there in the affordance. The bold simplicity of this idea is its best attribute. To be sure, not all people agree on the efficacy of the concept. Fodor (1980, p. 107), for example, says, "The category 'affordance' seems to me to be a pure cheat: an attempt to have all the goodness out of intensionality without paying any of the price."

In addition to reformulating the problem of meaning, Gibson intended that the concept of affordance also *constrain* perception and behavior. We perceive an object to be what it is because it affords few alternatives, and we behave with respect to an object the way we do because its affordances offer a narrow domain of possibilities. For example, a tree stump sawed off at the height of 18 in. affords sitting for most human beings. It also affords standing on for a better view, picnicking on when one sits beside it, and so forth. And it also affords reminiscence of the tree that used to be there. Our perceptions of, and behaviors with, the stump are few though not necessarily stereotyped.

My own problem with the concept of affordance is not that it begs the question of meaning. To the contrary, I am quite happy to

assume meaning in the manner that Gibson has. What troubles me is that the concept of affordance does not constrain perception and behavior nearly enough.

Human beings have remade their environment so that it affords more (Gibson, 1979, pp. 129–130). Our artifacts in particular are multiply affording. Consider a piece of paper. A piece of paper affords equally writing gibberish and sonnets; it affords writing a shopping list or a note to a colleague; it affords making a map; it affords writing nothing upon; it affords wadding up and throwing away; it affords making paper airplanes; it affords shredding, cutting into pieces, making paper dolls, making a montage, making Mobius strips; it affords pasting on the wall; it affords coloring green or fingerpainting upon; it affords photocopying and photocopying onto; it affords stapling to other pieces of paper or clipping into an album; it affords bookmarking; it affords wrapping a package or making into an envelope; it affords cleaning the gaps between teeth; it affords cleaning up after your dog or wiping your hands; it affords burning; it affords filtering particulates; it quite simply affords all the possible things I can do with it. My behavior is virtually unconstrained by its affordances. To be sure, it does not afford flying to Baghdad upon, but the exclusion of a large domain of behaviors does not diminish the fact that an infinity remain. To apply to adult human beings, it would seem that the theory of affordances needs full-blown theories of personality and of choice. And I am sure Gibson would have agreed. The question, then, is how much is gained, other than having dissolved the problem of meaning, by the concept of affordance? The answer is, I think, little.

Shaw and Turvey certainly realized this insufficiency by which affordances constrain behavior. Their postulation of a complementary term *effectivity* is an attempt to eliminate the problem of too few constraints. But the addition of this new term may bring in a wash of new problems. For example, where do all our effectivities come from? Since affordances belong to the environmental half of the duality, effectivities must belong to the animal. But how did the animal acquire them? Natural selection seems woefully remote in accounting for our effectivities of reading text, driving cars, writing poetry, going to concerts, and programming computers. Thus, the inclusion of effectivities may superficially appear to constrain behavioral possibilities, but until we have a principled way to determine and delimit their origin in a human biological context, the system of affordance-effectivity duals seems almost ad hoc, nearly circularly defined, and not particularly informative.

Summary statement

James Gibson presented a new perspective on psychology and on psychological phenomena. He called that perspective the ecological approach. Over the past decade many have followed Gibson. Robert Shaw and Michael Turvey are two salient examples. Yet, in what I believe to be crucial details, Shaw, Turvey, and their many colleagues are presenting a different viewpoint than that of Gibson. To be fair, I think that Shaw and Turvey share much more with Gibson that they do not share, and that both the ecological formulation of Gibson and the ecological reformulation of Shaw and Turvey fully deserve to be classified as kindred perspectives on psychology. Yet too many psychologists are unaware of differences between the two views. I have tried to point out that construals of indirect perception and of perceptual error separate the two, as do the differences in values and styles of using terms and formalisms, and that these differences have important ramifications.

Notes

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1. Three things should be noted. First, the Michaels and Carello volume, *Direct Perception,* is by far the clearest presentation of the ecological reformulation to date. The perspective that Michaels and Carello present is due in essentials to Shaw, Turvey, and other colleagues, but in detail to their own hard work. But except for a small section on stereopsis (pp. 116–122), what Michaels and Carello present is not new to them; they, in essence, have translated Shaw and Turvey into plain English. Since it is impossible to review *Direct Perception* without reviewing the perspective that Shaw and Turvey present, I have tried to do both. Second, in drawing my distinctions between Gibson on the one hand and Shaw and Turvey on the other, I am necessarily relying only on the published record and emphasizing the most recent material. The reformulation acknowledges great debt to Gibson, has gone far in explication of some of his ideas, and notes few differences between Gibson and themselves; Gibson is relatively silent on the reformulation, acknowledging some debt (Gibson, 1979, pp. xiv and 305) and never mentioning differences or acknowledging that any exist. Thus, the distinctions that I draw stem from my reading of the available material and from

my inferences about Gibson, Shaw, and Turvey. Third, one may wonder why I bother drawing distinctions in positions between a mentor (Gibson) and students (Shaw and Turvey). Certainly the best of students can be expected to disagree with mentors in some details. The answer centers on construal by others. It is my belief that what the reformulation says is not always consistent with what Gibson said, and that few people currently recognize this. This is not to say that Shaw and Turvey misrepresent Gibson. I think that they generally have not; they simply use Gibson as a backdrop to present their views. But I believe that their extensions of Gibson occasionally become hyperextension and become inconsistent with Gibson. It is my belief that both views of Gibson and of Shaw and Turvey should be known, and be known to be different in some important areas.

2. The first part of this phrase is due to Michael Turvey (see Turvey & Carello, 1981; Turvey, Shaw, Reed, & Mace, 1981), and the addition of the latter to Michael Studdert-Kennedy.

3. Pepper (1942) delimits six world hypotheses, four of which are reasonably coherent: formism, mechanism, contextualism, and organicism. Neither information processing nor ecological percpectives fit snugly within any of the four, but information processing is somewhat close to mechanism, and ecological perspectives less close to organicism and contextualism. In fact, at present neither information processing nor ecological pespectives are full world hypotheses, but I contend that they could easily be extended to become them. Most importantly, however, it is the essence of a world hypothesis that it have a root-metaphor. These perspectives clearly do.

4. In fact, Michaels and Turvey (1979) have addressed problems of tachistoscopic masking, but their footnote 2 (p. 3n) dismisses that set of studies as not relevant to normal perception. In fact, their studies date in execution from before either author became a fully committed ecological psychologist.

5. The planimeter was invented in the mid-19th century, but interestingly, the mathematics of how it works—by integrating in analog fashion over positive and negative polar areas—was not understood until much later.

6. Domestic animals and the potential fruits of recombinant DNA are counterexamples. For a discussion of intention and design see Hayek (1967) and Ullman-Margalit (1978).

7. For example, in Kugler, Kelso, and Turvey (1980) we learn about order-grains, scaling effects, coordinative and dissipative structures, and geometrodynamic perspective.

8. There is much indication that the reformulation uses Gibson's terms to go beyond Gibson. Gibson, for example, talks about affordances; Shaw, McIntyre, and Mace (1974, pp. 281-283) talk about affordance structure. It was Gibson's intent to have affordances point both ways between objects and animals; it is Shaw and Turvey's to have this relation, and also have affordances relate to one another. This difference—between affordances and affordance structure—may serve as an example of how the reformulation ex-

tends Gibson. Gibson, for example, would certainly note that a piece of wood can afford both splitting and burning, and that its affordances can run only in that order: one cannot burn, then split, wood. Given that affordances can often be ordered in this way, asymmetrically, one can say that they have structure—that affordances not only relate object and animal but also to other affordances. In this particular case, after the wood is burnt, it is no longer wood; it is ash. Thus, some affordances, when fulfilled, destroy the essential character of an object—burning destroys the wood-like quality of a piece of wood. Other affordances, on the other hand, preserve essential character—splitting wood leaves the wood-like quality intact. Thus, the concept of affordance structure seems to be embedded in Gibson's thought, but the term is not.

9. One may argue that common sense should not be the final court of appeals for scientific concepts. For example, it may seem commonsensical to speak of *élan vital,* but it is also scientifically vacuous since vitalism was purged from biology in the 19th and early 20th centuries. But *élan vital* was an empirical concept found to have no content; perceptual error is a definitional concept that one can neither prove nor disprove. The court of appeals for such concepts, I believe, is consensual: if the organism perceived something in a manner different from the way it *ought* to have perceived it (where *ought* is defined by the social convention of the organism's conspecifics) then it perceived erroneously. The term *error* stems from 16th century usage, meaning to wander and to be misguided. Perceptual error, then, is misguided perception, and this construal is attuned to current usage. One cannot, contrary to the assertions of Humpty Dumpty, have terms mean whatever one chooses.

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