

Beyond the Lens Model and Direct Perception: Toward a Broader Ecological Psychology

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Despite sharing the label *ecological psychology*, Brunswikian and Gibsonian research programs are virtually independent scientific activities conducted by a virtually independent pair of scientific communities. The purpose of this article is to provide a theoretical integration of these 2 lines of work. The lens model and the theory of direct perception can each be viewed as specific versions of a more general research program that distinguishes between distal structure (i.e., “thing”) and proximal structure (i.e., “medium”) and that is based on the metatheoretical commitment to understanding human behavior by focusing on adaptation to functionally significant environmental regularities. The lens model deals with probabilistic relations between proximal and distal that require judgment and decision making, whereas direct perception deals with direct specification between proximal and distal that permits an intimate coupling with the environment. By showing how these 2 lines of work can be integrated theoretically, a number of important benefits can be obtained, including the furthering of the primary aim of science: the development of more unified and cumulative knowledge.

This article provides a novel theoretical integration of the work of two founders of ecological psychology: Egon Brunswik and James Gibson. By doing so, researchers can broaden the scope of ecological psychology as a whole—addressing a much wider set of psychological phenomena than would be possible by relying on either

Brunswik's or Gibson's theories alone—without sacrificing the core ecological belief that knowing consists of adaptation to functionally significant environmental regularities (Heft, 2001; Reed, 1996).

WHAT COUNTS AS THEORETICAL INTEGRATION?

There are several forms of cumulative knowledge that could fall under the label of *theoretical integration*. A very modest form that is perhaps scarcely deserving of the label occurs when an author of one tradition merely cites work from another tradition. A barely more ambitious form would occur when the findings of one tradition are compared and contrasted with those of another. A more advanced form of theoretical integration would involve the development of an “umbrella” theory that would subsume two existing theories that had existed in isolation (i.e., the relation between the two theories was unknown or perhaps even perceived to be incommensurable). Einstein's development of special relativity theory to subsume Newtonian mechanics and Maxwellian electromagnetics is a well-known example. The integration I propose here is of the same type, although obviously far less important and sweeping. For the record, I would also be in favor of any type of theoretical integration between Brunswikian and Gibsonian research because, as I show later in this article, even the most modest type is rare.

WHY BRUNSWIKIAN AND GIBSONIAN RESEARCH SHOULD ALREADY HAVE BEEN INTEGRATED

There are several reasons why one would expect that Brunswik's and Gibson's theories would have been integrated under a common framework. First, both are prominent figures in the history of psychology whose ideas have received a fair amount of attention. Thus, integration has not been hampered by a lack of notoriety. Second, Brunswik and Gibson both adopted an ecological approach to psychology. As a result, one would think that there would be considerable common ground between their ideas. Third, their careers overlapped to some extent. In fact, they held discussions when Gibson went on a visiting fellowship to the University of California, Berkeley, in 1955, where Brunswik was on the faculty (Reed, 1988, p. 206). Fourth, there are several indications that Brunswik influenced Gibson. According to Reed (1988), “Gibson took the term ecology from Brunswik” (p. 207). Gibson's sympathy with some of Brunswik's ideas is also clear in a relatively obscure publication that is of great historical significance, namely J. J. Gibson's (1957) review of Brunswik's (1956) posthumous monograph. Fifth, the ideas developed by Brunswik and Gibson have been pursued to this day by a very active group of neo-Brunswikians (e.g., Brehmer, Gigerenzer, Hammond, Bjorkman, and Juslin) and, of course, neo-Gibsonians (e.g., Neisser, Shaw, and Turvey). Unlike many other theoretical approaches in psychol-

ogy, these two traditions have endured over several decades of sustained theoretical and empirical inquiry. Thus, one would expect that there would be ample time for cross-fertilization of ideas to occur.

EVIDENCE SHOWING THAT BRUNSWIKIAN AND GIBSONIAN RESEARCH HAVE NOT BEEN INTEGRATED

Despite this rather long list of factors to induce integration, the ideas developed by Brunswik and Gibson are virtually isolated from one another in the psychological literature and therefore usually fail to satisfy any of the criteria for theoretical integration just outlined (see Zebrowitz & Collins, 1997, for an exception). There are several points of evidence to support this claim. First, each group has its own professional society: Brunswikians have founded the Brunswik Society, and Gibsonians have founded the International Society for Ecological Psychology. These two societies do not communicate or collaborate; in fact, for quite a few years, most members of each society were not aware that the other even existed. Second, each society has its own meetings. Brunswikians have held an Annual International Invitational Meeting of the Brunswik Society since 1985. This meeting takes place at the same time and place as annual meetings of the Psychonomic Society and the Judgment and Decision Making Society. Gibsonians, on the other hand, have held a biennial International Conference on Perception and Action since 1981. Despite the fact that both groups deal with ecological psychology, an informal poll of members from both societies taken a few years ago indicated that only three people had attended both the Brunswikian and Gibsonian meetings at least once. Of these three, two were engineers, not psychologists. Third, this journal, *Ecological Psychology*, has been published since 1989 and, given its title, one would think that it would naturally include both Brunswikian and Gibsonian research. However, the journal, founded by the International Society for Ecological Psychology, contains virtually no Brunswikian research, primarily because many Brunswikians do not know that the journal exists.

Several anecdotes can be offered to document the fact that there is a lack of integration between Brunswikians and Gibsonians. In 1989, I first met one of the most prominent neo-Brunswikians and showed him a copy of the journal *Ecological Psychology*. He was surprised that a journal with such a title could exist without his knowledge. After all, he was a very strong proponent of ecological psychology, having made seminal contributions to the field for several decades. In 1994, when I discussed my idea for writing this article with one of the most prominent neo-Gibsonians, the latter was surprised to hear that there were still Brunswikians around. He was also curious as to where they published, as he was not aware of their work. I pointed out that Gigerenzer, a neo-Brunswikian, had recently published two articles in *Psychological Review* (Gigerenzer, 1991; Gigerenzer, Hoffrage, & Kleinbölting, 1991), a fact that gave the neo-Gibsonian colleague pause. To-

gether, these facts and anecdotes clearly indicate that Brunswikian and Gibsonian research are largely independent and in need of theoretical integration—even of the most modest type.

It could be that such integration has not occurred for some very good reason having to do with conflicts or differences in metatheoretical approach, theories, or phenomena. It is possible, for instance, that Brunswik and Gibson actually meant something very different when they each referred to “the ecological approach.” Perhaps there is a different set of metatheoretical commitments behind the work of each researcher. It is also possible that Brunswikian and Gibsonian theories are irreconcilably in conflict. Brunswik’s (1952, 1956) emphasis on probabilism (e.g., the lens model), and J. J. Gibson’s (1966, 1979/1986) emphasis on determinism (e.g., direct perception) might lead one to think that this is in fact the case. A third potential reason for the lack of integration is that Brunswikians and Gibsonians have studied very different types of psychological phenomena, and so there may not be any common ground between their respective theories, methods, and findings. The fact that neo-Brunswikians have focused almost exclusively on problems of judgment and decision making, whereas neo-Gibsonians have focused almost exclusively on problems of perception and action, might reinforce this view.

INTEGRATING BRUNSWIK AND GIBSON

In this article I show that none of these reasons for lack of integration are persuasive. Although Brunswikians and Gibsonians have focused on different phenomena, have adopted different methods, and have certain theoretical conflicts that must be addressed, it is still possible to integrate them under a common theoretical framework while keeping intact the essence of each set of ideas. This is possible because Brunswik and Gibson shared a metatheoretical approach to psychology that cuts across, and goes well beyond, the specific details of the theories, methods, and findings that they and their respective followers have generated. To date, psychologists have focused on the differences between Gibson and Brunswik and have not seen the forest through the trees.¹

WHY BOTHER?

There are several benefits to be obtained by pursuing a theoretical integration of Brunswikian and Gibsonian research. First, it would help achieve the primary goal of science: the development of cumulative, unified knowledge. Psychology researchers have focused on conducting experiments and obtaining more data but

¹In the cognitive engineering literature, Kirlik (1995) proposed one way to integrate Brunswikian and Gibsonian views, which has greatly influenced the ideas in this article. The differences between my ideas and those of Kirlik are evaluated later.

have devoted less attention to developing satisfactory explanations for those data. Staats (1981) summarized the implications of this imbalance: "Our field is constructed of small islands of knowledge organized in ways that make no connections with the many other existing islands of knowledge" (p. 239). Given this state of affairs, putting even just two islands on the same map, as I aim to do here, represents scientific progress.

Second, theoretical integration would also help reduce the number of contentious arguments in psychology that shed a great deal of heat but very little light. As Heft (2001) rhetorically asked: "Has there been a moment since its formal founding in the late 19th century when experimental psychology was not in a state of theoretical conflict?" (p. xxi). Of course, such conflicts could conceivably serve a constructive purpose if they lead to a resolution, but instead they frequently lead to a blanket rejection of opposing viewpoints and thus a lack of progress in achieving the primary purpose of science (Meehl, 1978). For example, Heft stated that Brunswik's theory (described later) is not only "unnecessary" but also "illogical" (p. 230), which, if true, would mean that the dozens of researchers currently working in the Brunswikian tradition have nothing to offer psychology—a situation that is unlikely, given that some of their articles are being published in *Psychological Review*. By adopting the tack of theoretical integration, researchers may be able to spend less time criticizing other researchers' theories and more time constructing new, broader theories that do a better job of explaining the mounds of existing data.

Third, theoretical integration could also help reconcile what appear to be incommensurate facts. For example, Jacobs and Michaels (2002) obtained data that appeared to present a paradox, given the assumptions of direct realism. As I show later, their findings have a straightforward explanation from the integrated perspective proposed here—there is no appearance of inconsistency, and thus no paradox to explain, when a broader theoretical perspective is adopted.

Finally, theoretical integration could also lead to new empirical research that draws on more than one tradition and thus would likely not be conducted without such integration, thereby fueling the engine of scientific discovery (see Runeson, Juslin, & Olsson, 2000, for an exceedingly rare example). In short, there are many legitimate reasons why all ecological psychologists should be interested in pursuing a theoretical integration of Brunswikian and Gibsonian research.

OUTLINE

The remainder of this article is organized as follows. First, I provide a brief theoretical overview describing Brunswik's and Gibson's primary contributions to psychology. Second, I put forward a critical analysis of these ideas with an eye toward identifying common ground and resolving theoretical differences, the result being a novel proposal for how the two lines of research can be linked theoretically. Finally, I present a review of previous work to show the novel and significant contributions of this integration.

THEORETICAL OVERVIEW: BRUNSWIK AND GIBSON

What makes research Brunswikian or Gibsonian? There is no simple, comprehensive answer to this question, because Brunswik and Gibson both made many important contributions to psychology. However, each researcher is best known for a particular theory that has been adopted by most followers. Thus, as a first-order approximation, Brunswikian research is largely based on the *theory of probabilistic functionalism* (see Gigerenzer et al., 1991, for an exception), and Gibsonian research is largely based on the *theory of direct perception* (see Vicente & Wang, 1998, for an exception). In this section I summarize these theories.

Brunswik: Probabilistic Functionalism

The basic premise of Brunswik's theory of probabilistic functionalism is that psychology should be concerned not just with the human organism but, more importantly, with the interrelations between the organism and its environment (Brunswik, 1957). This general premise took a specific concrete form in the now well-known *lens model* (Brunswik, 1956), shown in Figure 1.² The left half of the lens describes the structure of the environment, whereas the right half of the lens describes the organism's adjustment to that environment.

The lens model is based on a number of theoretical constructs. Brunswik adopted the distinction between *distal stimuli* (objective descriptions of the state of the organism's ecology) and *proximal stimuli* (sensory input that the organism can obtain from its ecology). As shown in Figure 1, these concepts are represented in the left-hand side and the center of the lens model, respectively. Brunswik believed that an organism is not able to perceive distal stimuli directly but instead must infer what is going on in the ecology from the imperfect (i.e., probabilistic) cues provided by proximal stimuli. As a result, he introduced the term *ecological validity* to refer to the correlation between the proximal cues available to the organism and the distal stimulus of interest. The ecological validities of the cues provide a normative description of how diagnostic the available cues are with respect to the actual state of the world (i.e., the distal stimulus) and, as a result, represent an optimal weighting scheme for combining the various cues.

Whereas the left side of the lens model describes the structure of the environment, the right side shown in Figure 1 describes the organism. The extreme right shows the organism's perception or judgment of the state of the world. This perception or judgment is said to be achieved by combining the proximal cues in some manner, so as to infer the status of the distal stimulus. This inferential process is demanded by the probabilistic view adopted by Brunswik. The actual weights that

²The lens model has been operationalized mathematically (see Tucker, 1964, for details). It is referred to as a "lens" because of its symmetrical shape (see Figure 1) and because it takes a variety of pieces of information and "focuses" them (via a linear weighting function) on a single judgment outcome.

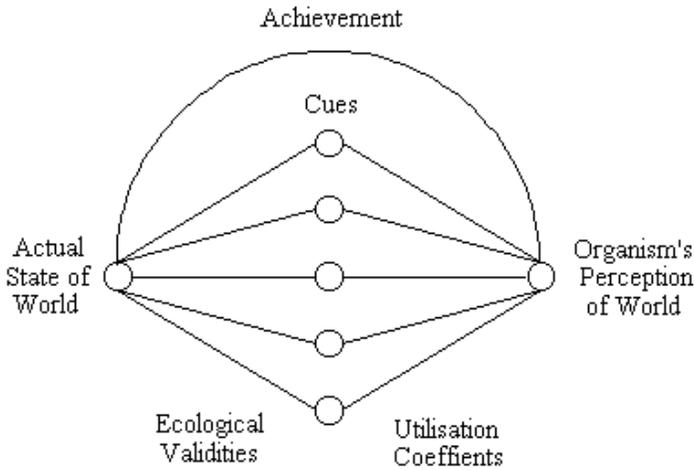


FIGURE 1 Brunswik's (1956) theory of probabilistic functionalism, instantiated in the lens model.

the organism places on the available proximal cues are termed the *utilization coefficients*. Because these are descriptive, they may differ from the optimal weights defined by the ecological validity of the cues.

The lens model has several interesting and important characteristics. First, it takes the organism–environment system as the fundamental unit of analysis, as indicated by the dual nature of the lens. Second, it describes the environment and the organism using a common language (i.e., probabilities or correlations), as evidenced by the symmetric nature of the lens. Brunswik took this parallelism between the organism and environment very seriously. For each concept describing the environment system, there is a parallel concept in the cognitive system. Third, the lens model begins by analyzing the environmental constraints on behavior, and only then does it address the organism's response. For example, it is important that the ecological validities be established first because these provide an upper limit on achievement. If an organism is faced with a situation in which the cues available are not very diagnostic, then performance will be poor, regardless of the strategy that is adopted. Fourth, and as a result of all of the preceding, the lens model provides a way of measuring the degree of adaptation between the organism's behavior and the structure of the environment. This is possible because the environment side of the model provides a referent for evaluating the fitness of behavior; to the extent to which the utilization coefficients reflect (or mirror) the ecological validities, behavior is adaptive.

Brunswik (1956, 1957) used the lens model to tackle a relatively broad set of topics in psychology, ranging from the perception of objects and space to judgments of other people's personality traits from external appearance. Since then, the lens model has been applied and refined primarily within the more specific context

of judgment and decision-making tasks. In fact, an entire literature, known as *social judgment theory*, has developed from the application of Brunswik's lens model to problems of this type (Hammond, 1996; Hammond, Stewart, Brehmer, & Steinman, 1975).

Gibson: Direct Perception

Gibson also believed that psychology should be concerned with the interaction between organism and environment; however, unlike Brunswik, he thought perception can be direct, that is, that people can directly perceive meaningful properties of the environment, without having to resort to mediating inferences. As a result, in Gibsonian ecological psychology, the general principle of organism–environment duality is instantiated in the theory of direct perception (J. J. Gibson, 1979/1986), graphically represented in Figure 2.³

On the extreme left of Figure 2 is the natural environment (as opposed to a description of that environment), which is the starting point for any theory of perception. The most important concept in J. J. Gibson's (1979/1986) theory is that of an *affordance*. As shown in Figure 2, affordances represent a way of describing the distal structure of the environment independently of the stimulation available to inform perception—in Heider's (1926/1959) terms, the “thing,” not the “medium.”⁴ This description is not in the terms of physics (e.g., mass, length, time) but in functional terms that are psychologically relevant. Thus, affordances are goal- (or action-) relevant descriptions of the environment. They are a way of measuring or representing the environment with respect to the action capabilities of an individual. For example, rather than describing a chair in terms of its physical dimensions (e.g., height), one can also describe it with respect to the possibilities for action that it offers to an organism with certain capabilities. A particular chair may afford sitting to an adult but perhaps not to a toddler. It is for this reason that there is a one-to-many mapping between the environment and affordances in Figure 2; the same object, event, or place not only can have different affordances to different organisms but also can have multiple affordances for the same organism. Note also that an affordance is just as “real” or objective a description as the traditional metrics used in physics (Runeson, 1994). For example, a chair's affordance is just as real or objective a property as its

³Although Figure 2 is drawn for the specific case of vision, the formulation presented in this article is agnostic as to whether there are several perceptual systems (see Stoffregen & Bardy, 2001).

⁴As I discuss later, J. J. Gibson (1960) rejected the distinction between distal stimuli and proximal stimuli with, I believe, good reason. However, as Heft (2001) recently pointed out, he did not reject Heider's (1926/1959) distinction between *thing* and *medium*. On the contrary, he used that distinction as an organizing principle for Part II (“The Environment to be Perceived”) and Part III (“The Information for Visual Perception”) of his final book (J. J. Gibson, 1979/1986); the distinction continues to play a central role in contemporary Gibsonian research (Turvey & Shaw, 1995). However, rather than use Heider's awkward, albeit apt, terms, I instead use the term *distal structure* to refer to “thing” and the term *proximal structure* to refer to “medium.”

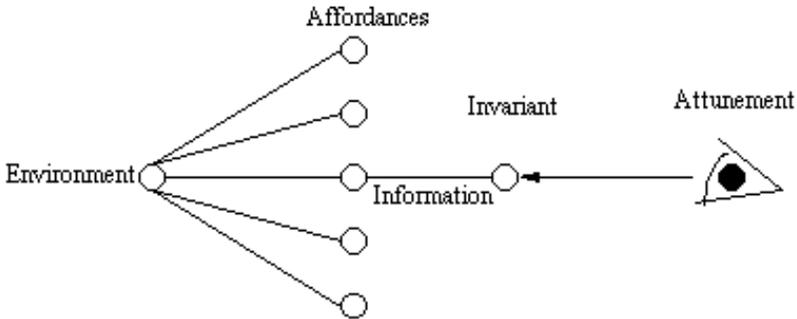


FIGURE 2 A graphical depiction of the primary concepts in J. J. Gibson's (1979/1986) theory of direct perception.

height, the only difference being the frame of reference that is adopted for measuring. The concept of affordance plays a crucial role in Gibson's theory because it provides a way of bridging the physical and psychological worlds or, alternatively, the object and the subject. This elimination of dualism is accomplished by measuring the objective properties of the environment using a frame of reference defined by the organism's action capabilities.⁵

Once the distal structure of the environment has been described, it is then possible to move on to describing the proximal structure of the environment (i.e., the stimulation available to specify the state of the ecology)—in Heider's (1926/1959) terms, the *medium*, not the *thing* (see footnote 4). Gibson developed the concept of *invariants*, shown in Figure 2, to describe the structure in a visual scene—or, in Gibson's terms, the *ambient optic array* (in the case of vision). A simple example is the *focus of expansion* (i.e., the central, singular point from which the optical flow expands). During forward movement, the focus of expansion specifies the direction of locomotion (J. J. Gibson, 1958). This variable is a higher order property of light that exists regardless of whether the organism knows it and whether the organism attends to it. Its existence is a matter of physics—or, better, ecological physics—and can be demonstrated analytically rather than experimentally.

Perception can be direct only if there is a one-to-one relation between an invariant and an affordance (see Figure 2). In other words, the invariant (a higher order property of the stimulus array) must directly specify the affordance (a goal-relevant distal property of the environment). This one-to-one mapping is referred to as

⁵It is interesting that the concept of affordance seems to have been anticipated by Tolman and Brunswik (1935), who referred to the *manipulanda* properties of objects (e.g., grasp-ability, sit-on-ability). Brunswik, being a coauthor of that article, presumably endorsed this concept, although he did not seem to have made much use of it in his subsequent work.

information, a theoretical construct that has a unique and important meaning in Gibsonian ecological psychology that differs from the normal usage of the term (J. J. Gibson, 1979/1986; Turvey & Kugler, 1984). To be clear, neither the affordance nor the invariant carries information; rather, information is the one-to-one mapping between the two. For example, in a prey–predator context, the focus of expansion can be directly used by one organism to pursue another (J. J. Gibson, 1958). All the predator needs to do is to move so that the focus of expansion is aimed at the prey. Such an action will ensure that forward movement of the predator will be in the direction of the prey being pursued. Thus, the focus of expansion invariant is information regarding the affordance of pursuit for an organism that is capable of locomotion. In short, the existence of information provides for the possibility of direct perception because it potentially allows functional meaning (i.e., affordances) to be perceived directly.

Returning to Figure 2, the question still remains whether the organism can pick up on the information and thereby use it to guide action effectively. Just because an invariant specifying an affordance has been identified does not necessarily mean that people can, or do, attend to such information. Information pickup must be demonstrated empirically. Direct perception occurs when organisms are actively attuned to an invariant in the environment, thereby allowing them to perceive an affordance directly (J. J. Gibson, 1979/1986). Because attunement is an active process, it is illustrated in Figure 2 with an arrow from the organism to the invariant in the optic array. It is important to point out that perception is of the affordance, although it is made possible by information; that is, people can perceive the possibilities for action that the environment has to offer because structure in light specifies those possibilities, but people do not perceive light itself (the medium is completely transparent).

Like probabilistic functionalism, the theory of direct perception has several interesting and important characteristics. First, it takes the organism–environment system as the fundamental unit of analysis, as indicated by the fact that the action capabilities of the organism are used as a frame of reference for describing the environment. Thus, the organism and environment are seen as a single system. Second, and as a result, direct perception describes the environment and the organism using reciprocal terms. There is no clean distinction between object and subject, or environment and mind, because one cannot exist without the other. Third, direct perception also begins by analyzing the environmental constraints on behavior. The first step is to describe the distal structure of the environment (i.e., its affordances). The second step is to identify the proximal structure in the environment (i.e., an invariant in the ambient optic array). If direct perception is to be possible, this invariant must directly specify the affordance of interest. The third step is to determine whether people can pick up this information and use it to guide action effectively. Fourth, direct perception is based on the notion that the organism is adapted to the distal and proximal structure (i.e., regularities) in the environment as well as the relation between the distal and proximal. This exploitation of

structure makes direct perception possible. Fifth and finally, direct perception also treats perception and action as a coupled system by describing what is perceived (affordances) in terms of action possibilities. As a result, perception is viewed as a means of selecting the appropriate action to attain a goal.

J. J. Gibson's (1979/1986) theory of direct perception has generated a productive body of research, primarily on perception and action (e.g., Kugler & Turvey, 1987; Mark, 1987; Savelsbergh, Whiting, & Bootsma, 1991; Turvey, 1990; Warren & Hannon, 1988), including substantial work on developmental issues (e.g., E. J. Gibson, 1969, 1991; Thelen, 1995). There have also been some forays into cognitive psychology (e.g., Neisser & Winograd, 1988; Vicente, 2000; Vicente & Wang, 1998) and social psychology (e.g., McArthur & Baron, 1983; Zebrowitz & Collins, 1997), but such studies are much fewer in number.

CRITICAL ANALYSIS

It is clear from the previous section that there are both similarities and differences between Brunswik's and Gibson's theories. The similarities provide a basis for integration and are therefore discussed first. The differences must be resolved for integration to be feasible and are therefore discussed second.

Similarities: A Foundation for Unification

In comparing two lines of research, one can focus on any of several levels of abstraction, including findings, methods, theories, and metatheoretical commitments. There is no doubt that there is little overlap and several significant differences between the theories, methods, and findings generated by Brunswikians and Gibsonians. However, at the level of metatheoretical commitment, there is a great deal of consensus between the two views.

First, both Brunswik (1957) and J. J. Gibson (1966, 1979/1986) explicitly adopted a systems approach to psychology. This similarity, although seemingly ethereal, is probably responsible for the other points of overlap between Brunswik and Gibson. Second, both were concerned with the interaction between organism and environment, rather than solely with the organism. This feature is quite evident in the two theories described in the previous section, both of which pay as much attention to the environment as to the organism (see Figures 1 and 2). Third, both emphasized the primacy of perception. J. J. Gibson (1979/1986) believed that direct perception was a fundamentally important and powerful way of knowing the world (although by no means the only way; see later). Although his theory of perception differed from Gibson's, Brunswik (1956) also acknowledged the power of perception: "Considering all the pros and cons of achievement, the balance sheet of perception versus thinking may thus seem seriously upset against thinking, unquestioned favorite of a culture of rational enlightenment as the latter has been"

(p. 93). Fourth, both Brunswik and Gibson emphasized the importance and value of starting the analysis of behavior by analyzing the environmental constraints on action. Again, this is very clear in the lens model and the theory of direct perception (see Figures 1 and 2). Fifth, and relatedly, both focused on the organism's achievement. Rather than evaluating the organism's thought processes against some context-free norm, Brunswik and Gibson instead focused on evaluating the functional value of behavior in representative environments.

All of these points of similarity stem from the fact that Brunswik and Gibson, being ecological psychologists, were influenced by a pragmatic, evolutionary perspective. Much of Brunswikian and Gibsonian psychology can be viewed as a search for understanding the extent to which the organism has adapted to the structure that exists in the environment, a feature that is being increasingly recognized as the core belief of ecological psychology (Heft, 2001; Reed, 1996). This basic insight will provide the foundation for the theoretical integration proposed later. First, however, the significant differences between the two viewpoints must be addressed.

Differences To Be Resolved

There are five issues that must be resolved before Brunswikian and Gibsonian ideas can be integrated into a common perspective. These issues, which result from differences between the two sets of theories, follow:

1. The problem of scope,
2. The problem of how to describe the environment,
3. The problem of how to define the stimulus,
4. The problem of probabilism versus determinism, and
5. The problem of coupling perception and action.

I discuss these issues in turn and propose a resolution for each. These resolutions will lead to a novel theoretical integration that provides a broader view of ecological psychology than could be obtained from the lens model or direct perception alone.

The problem of scope. As important as they are, the scope of the phenomena that have traditionally been emphasized in Brunswikian and Gibsonian research is quite narrow compared with the broad range of activities in which people engage on a daily basis. Neo-Brunswikians, for instance, have dealt almost exclusively with static, multiattribute judgment and decision-making tasks of the type captured by the lens model. Although this research has led to very important insights, it does not address many other types of judgment and decision-making tasks that are characterized by a dynamic, closed-loop feedback structure (Rasmussen, 1993), not to mention psychological phenomena that are not judgment and deci-

sion-making tasks. Although some of these limitations are beginning to be addressed (e.g., Brehmer, 1992; Hammond, 1996; Hammond, Hamm, Grassia, & Pearson, 1987), it still remains the case that Brunswikian research can be operationally defined as approximately equivalent to lens model research. The meta-theoretical commitments described earlier clearly accommodate a much broader set of phenomena. Therefore, one could argue that neo-Brunswikians have yet to realize and demonstrate the full potential of the vision for psychology laid out by Brunswik.

What about the scope of Gibsonian research? As already mentioned, the vast majority of research conducted by neo-Gibsonians has focused on problems of perception and action. In fact, in a rare review article assessing the state of the Gibsonian program, Michaels and Beek (1995) descriptively defined ecological psychology as "the branch of science dealing with the coordination of activity with respect to perceptual information" (p. 259). Moreover, there has been a deliberate reticence to address other types of psychological phenomena, particularly cognition. For example, Turvey and Shaw (1995) stated that

grammar, problem solving, remembering, expert knowledge, and the like, are too far beyond the pale of the current stock of scientific tools by which nature's phenomena are understood in general law-based terms, reducing thereby their potential as a basis for substantial progress. (p. 154)

Some have worked toward changing this state of affairs, most notably Neisser (1978/1982, 1987, 1994). However, as is the case with neo-Brunswikians, it is safe to say that the vast majority of the research being conducted by neo-Gibsonians is focused on a relatively narrow set of phenomena and therefore does not do justice to the broad vision for psychology put forth by Gibson (see Reed, 1996, for another exception).

These observations should not be interpreted as criticisms because one cannot expect relatively small communities of scientists, as Brunswikians and Gibsonians are, to comprehensively tackle all of the problems in experimental psychology within the span of a few decades. Put into this perspective, the lack of breadth is not surprising. The more important question is whether, in principle, there is anything preventing each group from addressing other types of psychological phenomena. A related question is whether these scientists acknowledge the fact that there is a wealth of other phenomena that can, and should, be addressed. As for the first of these questions, the breadth of the metatheoretical commitments discussed in the previous section shows that no such obstacle exists (cf. Vicente & Wang, 1998).

The second question is important to address, particularly in the case of Gibsonians, because many researchers seem to believe that Gibson claimed that direct perception is intended to explain all psychological phenomena (cf. Ullman, 1980).

If this belief is true, then it is a major obstacle toward integrating Brunswikian and Gibsonian research without destroying either of the viewpoints. This factor fortunately is not an obstacle to integration.⁶

According to Reed (1988), the widespread opinion that mediated perception or cognition is inconsistent with Gibson's view of ecological psychology is "simply mistaken" (p. 305). One does not have to rely solely on Reed's word. As early as 1951, J. J. Gibson (1951) distinguished between different types of psychological phenomena that needed to be explained:

At least three separate levels [of theorizing] will be required: first, a theory of how we perceive the surfaces of objects ...; second, a theory of how we perceive representations, pictures, displays, and diagrams; and third, a theory of how we apprehend symbols. There is no reason to suppose that the physiological concomitants of all these experiences will be the same; in fact, since pictures and symbols presuppose objects, their physiological explanations will probably have to be found at increasing levels of complexity. (p. 413)

Although it is undeniable that Gibson subsequently focused much more on the first of these three categories, this quotation makes it clear that he did not deny the existence of other psychological phenomena, including those involving symbols. Moreover, Gibson briefly but explicitly discussed different kinds of mediated cognition in an obscure note (J. J. Gibson, 1977/1982) and more prominently, but still briefly, in his final monograph (J. J. Gibson, 1979/1986, pp. 258–263). It is clear from these sources that Gibson did not consider his theory of direct perception to be the final word in psychology. It is equally clear that he intended concepts, such as affordances, to provide a foundation for problems of indirect perception and other psychological phenomena such as remembering and the apprehension of symbols. More recently, Turvey and Shaw (1999) pointed out that cognitive phenomena, such as inference, language, and the use of symbols eventually need to be accommodated in a more mature ecological psychology, and even went so far as to make room for the possible theoretical need to include mental representations to accommodate such psychological phenomena.

Similarly, Hammond et al. (1975) clearly acknowledged that people have a variety of cognitive capabilities that they can use to know the environment (e.g., perception, learning, and thinking) in addition to the judgment and decision-making processes that have been the focus of neo-Brunswikian research. They even went

⁶Unfortunately, there is no clear, widely accepted definition of the Gibsonian research program. As Michaels and Beek (1995) pointed out in their review of the field, "an overall research program with a direction that is clear to a large portion of the ecological community seems to be lacking" (p. 264). This lack of consensus creates a problem for this article because it is highly likely that some Gibsonians will disagree with my characterization of their research program. The approach I have adopted to deal with this dilemma is to quote from the most prominent neo-Gibsonian researchers and from Gibson himself, whenever possible.

so far as to write that “human judgment is a cognitive activity of last resort” (Hammond et al., 1975, p. 272) that must be relied on only when people are not allowed, or able, to manipulate the environment and observe the results to determine the true state of the world (in Gibsonian terms, one would say that judgment is required when active exploration of the environment is not possible or permitted). Therefore, when people cannot engage in such exploratory behaviors “they must do the best they can by passive rather than active means to arrive at a conclusion regarding a state of affairs clouded by causal ambiguity” (Hammond et al., 1975, p. 272). These quotes make it clear that neo-Brunswikians admit that other types of cognitive phenomena exist. Some efforts by Brehmer (1992) and especially Hammond (e.g., Hammond, 1996; Hammond et al., 1987) have been directed at expanding the scope of Brunswikian psychology.

Brunswikian and Gibsonian empirical research has been focused on a different set of relatively narrow psychological phenomena. However, at least some researchers in each camp have acknowledged that there are other important psychological phenomena that need to be tackled. Moreover, there does not seem to be any principled reason why the metatheoretical commitments described in the previous section could not also be applied to phenomena not captured by the lens model and the theory of direct perception (e.g., Vicente, 2000; Vicente & Wang, 1998). The possibilities for ecological psychology go well beyond the confines of these two specific theories. Some researchers in each camp have already tried to expand the scope of their respective approaches. However, as mentioned in the beginning of this article, the two communities still exist in almost complete isolation from one another.

The problem of how to describe the environment. Another issue that must be tackled before integration is possible is that of describing the distal structure of the environment. Brunswikians and Gibsonians have represented the distal regularities in the environment in different ways. Brunswik (1956) used the context-free language of physics (e.g., length) to describe distal stimuli (although see footnote 5). In contrast, J. J. Gibson (1979/1986) used the organism-dependent concept of affordances to describe the environment. Neither of these approaches is “more correct” or “truer” than the other; they merely represent two different frames of reference for measuring the same entity (the environment). Thus, any choice between them must be based on the criterion of utility. The choice of frame of reference for measurement is a very important one, however; if an observer examines a perfectly deterministic system from an inappropriate frame of reference, then the behavior of that system can appear to be completely chaotic, despite the underlying regularities (Ashby, 1956). Therefore, for the purposes of psychology, the more useful frame of reference for representing the distal environment is the one that best reveals the regularities in human behavior.

One prominent Brunswikian acknowledged that the concept of an affordance provides a more psychologically useful way of representing the environment than

the context-free approach advocated by Brunswik (1956): “The study of the environment cannot be a prolegomenon to the study of psychology as Brunswik (1956) thought. The description of the environment has to be made for a given organism” (Brehmer, 1984, p. 394). Brehmer’s opinion finds empirical support in the work of, among others, Warren (1984), who studied the visual perception of one particular affordance, namely, the climbability of stairs. Warren asked both short and tall participants to judge whether stairs of varying riser height were climbable or unclimbable. When the results are plotted using the traditional (context-free) frame of reference used by physicists to measure length, the data reveal that the perceptions of the two groups differ. There do not appear to be any regularities in behavior. These results are what one might expect from a Brunswikian analysis because Brunswik clearly advocated using the context-free units of physics to describe the distal environment. However, when the data are plotted using an affordance-based, action-relevant frame of reference—the ratio between riser height and each participant’s leg length—the perceptions of the two groups are virtually identical, with the 50th percentile judgment discriminating climbable from nonclimbable occurring at 0.88 for the short group and 0.89 for the tall group. Warren’s study therefore shows that the organism-specific frame of reference suggested by the concept of affordance can uncover regularities in behavior that cannot be observed using the context-free frames of reference adopted by Brunswik.

A skeptic could argue that the utility of affordances is strictly limited to revealing regularities in the perception of physical properties, such as climbability. This objection is refuted by Vicente and Wang’s (1998) theoretical account of expertise effects in memory recall, which shows that regularities in cognitive phenomena that had not been previously identified can also be revealed by adopting affordances as a frame of reference. These and other data suggest that people view the world in terms of possible actions (or goals). Therefore, if one is to capture regularities in human behavior, then one should describe the distal structure of the environment in an action-relevant manner, as J. J. Gibson (1979/1986) proposed, rather than in the context-free manner suggested by Brunswik (1956).

One might think that this resolution to the theoretical conflict between Brunswik and Gibson does not accommodate a Brunswikian perspective, but this is not the case. As Kirlik (1995) pointed out, adopting the concept of affordance to describe the environment does not commit one to any particular position regarding how much proximal structure there is in the environment to specify that affordance (i.e., whether there is 1:1 information, or whether there are merely probabilistic cues). This important insight opens up the possibility of combining the concept of affordances with the lens model in the following manner: “An affordance space can in some cases play the role of the criterion in the Lens model, thus shifting the emphasis from passive judgment to the identification and selection of opportunities for action” (Kirlik, 1995, p. 91). With this approach, the left side of the lens model (see Figure 1) would consist of one or more affordances, even though the perceptual cues that are available in the en-

vironment to specify that affordance could still be probabilistic.⁷ One of the advantages of such an approach is that it illustrates the relation between direct perception and the lens model. Direct perception represents the special case where the ecological validity of a particular “cue” is 1 (i.e., there is direct specification of the affordance).

A concrete example can help make the value of this point more obvious. One of the prototypical judgment and decision-making tasks studied by neo-Brunswikians is medical diagnosis (e.g., Wigton, 1996). The typical experimental task is to determine what disease the person has, based on a set of probabilistic cues (e.g., demographic information and symptoms). In many medical decision-making contexts, however, the physician’s goal is not to make an accurate diagnosis but instead to select one treatment among a set of possible alternatives (Rasmussen, 1993). In this case, the patient is the environment for the physician, so in Gibsonian terms, one could say that the physician’s task is to determine whether a given patient affords being cured by Treatment X or Treatment Y.

Consider the following episode, based on an actual interaction between patient and physician. The patient, a male in his late 20s, was experiencing severe back pain. After observing the patient and conducting some simple tests, the physician suspected that the patient either had a problem with one of his discs or that he simply had a strained muscle. The physician explained that the only way to determine which of these two diagnoses was correct was to conduct an MRI examination, and that the only way to cure a disc problem was with surgery. However, he also pointed out that, even if the MRI indicated a disc problem, he would not recommend an operation because the patient was relatively young. Instead, he would just recommend that the patient perform exercises to strengthen, and reduce the load on, the back muscles. Therefore, rather than conducting an MRI (which would cost the patient several hundred dollars, even with insurance), the physician recommended that the patient perform the aforementioned exercises.

Note that the goal of this decision-making process was not to perform an accurate diagnosis. In fact, the patient left the physician’s office without knowing whether he had a disc problem or a muscle problem. Instead, the process is more accurately described as selecting among the alternatives available for action, and thus is amenable to being described in terms of affordances. A lens model formulation of the task can still be adopted, but the cues and the weightings would change because the task is no longer to diagnose the ailment. This provides an intriguing possibility for combining Brunswikian and Gibsonian concepts, in the form of the lens model and affordances, respectively. Therefore, adopting an action-relevant frame of reference to describe the distal structure of the environment seems to provide a good foundation for integrating Brunswikian and Gibsonian research.

⁷This possibility was also anticipated by Tolman and Brunswik (1935), who noted that the manipulanda properties of objects (see footnote 5) could be probabilistically specified—a provocative and promising idea that does not seem to have been pursued in psychology.

The problem of how to define the stimulus. Another issue that must be dealt with is that of describing the proximal structure of the environment (i.e., the stimulus for perception and cognition). Here we find two substantial differences between Gibson and Brunswik. First, Brunswik (1956) relied on the retinal image as the stimulus for perception, whereas J. J. Gibson (1966, 1979/1986) rejected this notion entirely in favor of invariants in the ambient optic array. The second difference arises from Brunswik's adoption of the distinction between distal and proximal stimuli. As J. J. Gibson (1960) pointed out in a poignant critique of the concept of the stimulus in psychology, stimuli are energies, not objects. Consequently, it is important to make a clean demarcation between "medium" and "thing" (Heider, 1926/1959), that is, the stimulus energy about something and the something itself, respectively (cf. Turvey & Shaw, 1995). For example, a chair and the light reflecting off of a chair are qualitatively different entities. The human eye is a transducer for the latter but not for the former. In other words, the distal stimulus is not a stimulus at all.

A resolution to these two differences can be found in the work of neo-Brunswikians on judgment and decision making (e.g., Hammond et al., 1987; Stewart & Lusk, 1994). These researchers have clearly distinguished between the distal and proximal properties of the environment. Proximal features are the proximal stimuli available to the organism, whereas distal features are not stimuli at all—they are the characteristics of the distal objects to be known by the organism. These distinctions are captured particularly clearly by Stewart and Lusk's expanded formulation of the lens model, illustrated in Figure 3. On the far left of the diagram is the actual state of the world (as opposed to a description of that world). Next are the true descriptors, distal variables that describe the true state of the world. These are followed by the cues that are available to an organism, whether it

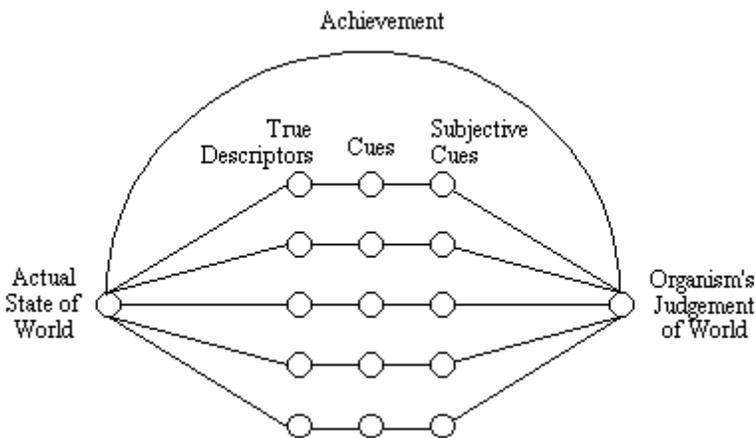


FIGURE 3 An expanded lens model, adapted from Stewart and Lusk (1994).

TABLE 1
Correspondence Between Gibsonian and Neo-Brunswikian Concepts

	<i>Gibsonian</i>	<i>Neo-Brunswikian</i>
1. Distal structure of the environment	Affordances	True descriptors
2. Proximal structure of the environment	Invariants	Cues
3. Modes of knowing	Attunement to information	Judgment of subjective cues

be by some type of artificial display (e.g., text on a computer screen) or by the natural environment (e.g., sounds and visual cues). Next are the subjective cues that are actually perceived or picked up by the organism, which of course need not correspond to the objective cues that are available to be picked up. Finally, these subjective cues are somehow integrated by the organism into a judgment about the state of the world.

Stewart and Lusk's (1994) example from weather forecasting can be used to illustrate their model. The actual state of the world could be the wind rushing through a particular town. A true descriptor of this world could be the current wind speed measured at a ground station. A cue could be the display of the measured wind speed on a color computer screen. A subjective cue could be the wind speed that a forecaster perceives on the basis of such a cue. Finally, the judgment could be a forecast based on this, and other, subjective cues.

Table 1 summarizes the conceptual correspondence between the Gibsonian view in Figure 2 and the neo-Brunswikian view in Figure 3. Although the concepts developed by each group differ, they can both be accurately captured by a higher order level of description. From this unifying perspective, one can see that each group has developed concepts that are tailored to the phenomena that it has focused on investigating. For example, if perception is to be direct, there must be invariants in the optic array to which organisms can become attuned. Conversely, in situations requiring judgment and decision making, there must be probabilistic cues that the organism can use to make an inference.

The formulation in Table 1 serves three important purposes. First, it resolves the apparently contradictory ways in which Brunswik and Gibson defined the stimulus. By incorporating the insights of the neo-Brunswikians, one sees that different proximal descriptions are required to account for different psychological phenomena. Direct perception requires invariants, whereas judgment and decision making require probabilistic cues. Second, and perhaps more important, this formulation puts Brunswikian and Gibsonian psychology on a single, common map. Table 1 suggests that the theory of direct perception and the lens model can be viewed as two exemplars of a single, broader theory, exemplars that have been instantiated for two particular classes of psychological situations. Third, the formulation in Table 1 accommodates various kinds of mappings between the proximal and distal descriptions of the environment. For example, in direct perception there is a one-to-one mapping between proximal and distal descriptions (i.e., invariants and affordances, respectively). In the lens model, on the other hand, there is a probabil-

istic relation between proximal and distal descriptions (i.e., cues and affordances, respectively, if the suggestion made earlier is adopted).

The problem of probabilism versus determinism. Perhaps the biggest impediment to integrating Brunswikian and Gibsonian perspectives is the fundamental conflict between probabilism and determinism. Brunswik's adherence to a probabilistic worldview is very clear in the label he chose for his approach (probabilistic functionalism), his theory (the lens model), and the methods he used (correlation coefficients). Gibson's adherence to a deterministic worldview is equally clear in his insistence on a lawful, one-to-one relation between invariants in the ambient optical array and affordances in the environment. One might think that such a disagreement would be irreconcilable. However, progress toward a resolution can be made by examining the nature of this difference in more detail.

For Brunswik (1956), the assumption of probabilism is a starting point rather than an empirical finding. His works, and those of his followers, often start off by asserting that there is a probabilistic relation between perceptually available stimuli and the true state of the world without providing any empirical evidence to back up the assertion. In fact, the assertion of probabilism can never be proven empirically because it is always possible that unknown deterministic relations exist. However, if one assumes probabilism, then those deterministic relations will be less likely to be found.

This point can be fleshed out by examining the Gibsonian perspective in more detail. Turvey and Carello (1981) explicitly pointed out that direct perception is based on a "*commitment* [italics added] to the principle of ecological realism" (p. 318). This notion of commitment is subtle yet important. The claim is not that direct perception is the only kind of perception or the only way of knowing. As mentioned earlier, such a belief is inconsistent with J. J. Gibson's (1951, 1977/1982, 1979/1986) own writings. Instead, the claim is that scientists should try to identify situations where perception is direct. As Turvey and Carello (1986) stated, the guiding question is "What must be true at nature's ecological scale for perception to be direct?" (p. 154). Note that this approach does not rule out probabilistic relations; rather, the approach simply means that Gibsonians wish to avoid resorting to Brunswik's assumption of probabilism. Consequently, they seek out cases of information, in the Gibsonian sense (i.e., one-to-one specification between invariants and affordances). Several examples of such one-to-one relations have been discovered, so Brunswik's global claim to probabilism has been repeatedly falsified.

Of course, this does not mean that one can, or should, do away with probabilism. On the contrary, there are many situations where it seems clear that information, in the Gibsonian sense, does not exist. An obvious example is the behavior of the stock market. As far as anyone knows, there are no deterministic rules or laws that govern changes in the prices of stocks. This is a prototypical example of the type of situation that cannot be captured by direct perception but could be described using the lens model (cf. Hammond, 1996).

In other cases, such as perceptual learning, information may be available but not perceived. For example, Jacobs and Michaels (2002) found that novices relied on probabilistic cues and become attuned to information only with experience, leading to the conclusion that “the assumption of realism cannot be maintained if one considers short-scale [i.e., learning] phenomena” (p. 136). Jacobs and Michaels wisely cautioned ecological psychologists not to apply and evaluate the theory of direct perception beyond the scale at which it applies, but they did not offer a satisfactory theoretical framework that can explain novice behavior, let alone a single integrated theory that can explain both novice and expert behavior. From the perspective of Table 1, one can account for all of Jacobs and Michaels’ findings in a coherent theoretical fashion: The distal structure of the environment can be described in terms of affordances, and there is information available to which experts have become attuned (a Gibsonian view), but novices rely instead on judgment based on probabilistic cues (a neo-Brunswikian view). The proximal–distal distinction, with its corresponding modes of knowing, provides the theoretical glue with which to subsume these two modes of behavior (cf. Runeson et al., 2000).

Therefore, whereas Brunswik’s global assumption of probabilism is demonstrably false, Gibsonians’ commitment to direct specification is essential but incomplete. Without such a commitment, Gibsonian information is unlikely to be discovered (cf. Runeson, 1995; Runeson & Vedeler, 1993). Nevertheless, there is still a need for other theories that can accurately describe behavior in the many situations in which specification is not direct.

The theoretical formulation in Table 1 provides a way of summarizing this discussion. Direct perception is possible only when there is a one-to-one mapping between proximal and distal structure. The lens model, on the other hand, is well suited to situations in which this mapping is, or is perceived to be, probabilistic. The key point is that both theories can be subsumed under a single framework that identifies the nature of the mapping between proximal and distal structure in the environment.

The problem of coupling perception and action. Another difference between Brunswik and Gibson is that the former focused on perception to the exclusion of action, whereas the latter focused on the coupling between perception and action. This difference becomes clear when one compares Figures 1 and 2. The lens model ends with a perception or a judgment. In contrast, direct perception claims that the world is perceived in terms of opportunities for action (i.e., affordances), thereby bootstrapping an intimate coupling between these two psychological functions.

The lens model has been extended by the addition of another lens describing the cognitive activities leading from a perception or judgment to an action in the environment (Petrinovich, 1979). Nevertheless, this is a static view of perception–action because there is no feedback loop, and thus the continuous, dynamic nature of perceiving–acting in the world is not well captured by the model (Rasmussen, 1993).

These limitations have been recognized by some neo-Brunswikians. For example, in his review of medical judgment, Wigton (1996) pointed out that the performance of physicians in lens model studies is highly variable. In contrast, studies of physicians' judgments conducted in actual practice have frequently shown a very high level of performance. Wigton convincingly argued that one reason for this discrepancy may be that lens model experiments comprise "one-shot," static decision-making tasks, whereas physician judgment in practice is more of an iterative, dynamic process with judgments followed by actions (e.g., medical tests), followed by revised judgments (cf. Hogarth, 1981). The lens model does not capture this dynamic coupling between judgment and action.

Given the resolutions proposed earlier in this section, this difference between Brunswik and Gibson seems relatively straightforward to work out. The deep theoretical and empirical problems in viewing perception and action (and other psychological phenomena) independently from each other were recognized more than 100 years ago in a seminal article by Dewey (1896). By adopting a goal-relevant frame of reference to describe the distal structure of the environment, these problems are avoided because perception and action are viewed in a holistic fashion, as duals of each other. Therefore, adopting affordances to describe the distal structure environment automatically deals with the problem of whether, and how, to couple perception and action. People try to find information in the world that can directly be used to achieve their goals.

Summary

At the beginning of this section I outlined the metatheoretical commitments shared by Brunswik and Gibson. These similarities, arising from a view of the organism as struggling to adapt to the structure that exists in the environment, provide a foundation for unification. In the remainder of the section I identified and resolved the five primary conflicts between Brunswikian and Gibsonian approaches. For the problem of scope, I suggested that both groups need to address a broader set of psychological phenomena than they have in the past. For the problem of how to describe the environment, I suggested that goal-relevant descriptions were more likely to reveal regularities in behavior than more traditional context-free frames of reference. For the problem of how to define the stimulus, I argued that the concept of proximal structure in the environment is broad enough to encompass different definitions of stimulus that are demanded by various classes of psychological phenomena. For the problem of probabilism and determinism, I suggested that the mapping between the proximal and distal structure of the environment covers both types of situations. Finally, for the problem of how to include action, I argued that the concept of affordances provides a way of theoretically unifying perception and action into one framework. The end result is a theoretical integration of Brunswikian and Gibsonian perspectives.

RELATED WORK

In this section, I highlight the novel contributions of this theoretical integration by comparing it to three previous efforts to broaden the scope of ecological psychology.

Reed (1996)

Reed (1996) outlined a broad view of ecological psychology that could include not just perception–action but also language and other forms of cognitive phenomena. He adopted a Darwinian perspective, viewing the functionally specific adaptation of behavior to the environment as a core metatheoretical commitment. Affordances played a key role in his formulation because they create a selection pressure and thus serve as a referent for the regulation of behavior. It is clear that the perspective described here shares these features. The primary novel contribution is to point out how the work of Brunswik could be integrated under this Darwinian perspective, an issue that Reed did not address. Indeed, Brunswik was not cited in Reed's monograph.

Kirlik (1995)

Kirlik (1995) also presented a framework that has many similarities with, and has greatly influenced, the one proposed here. He too argued for the value of the concept of affordances, the importance of coupling perception and action, and the necessity of accommodating cases of direct specification and probabilistic functioning. Nevertheless, there are some important differences between the two approaches. Perhaps the most significant difference is that Kirlik did not describe the degree of goal-relevant distal structure in the environment, independently of the degree of proximal structure. Instead, he focused primarily on the different types of mappings that can exist between distal and proximal. Moreover, Kirlik's mappings seem to be based on a definition of proximal structure that is dependent on the organism's expertise. For example, he stated that a 1:many mapping between proximal and distal structure can be transformed into a 1:1 mapping with experience. These differences may be attributable to the fact that Kirlik's framework was developed for a different purpose than the framework proposed here. Rather than developing a broader view of ecological psychology, Kirlik's primary motivation was to account for fluent and skilled perceptual–motor behavior.

Heft (2001)

Heft (2001) also proposed a theoretical framework that has some similarities with the one proposed here. Some of the primary points of overlap include the use of the proximal–distal distinction, the use of affordances as a relational frame of reference for understanding behavior, and a view of knowing as adaptation to functionally significant environmental regularities.

At the same time, there are a few critical differences with the ideas described here. First, Heft's (2001) framework does not appear to accommodate any situations in which the proximal cues are only probabilistically related to the distal structure in the environment because it is based on the belief that "perception is direct" (p. 188). Second, and relatedly, Brunswik's views are interpreted in a narrow fashion because it is claimed that "perception of the structure of objects in the environment is a much more direct process than these theories [e.g., Brunswik's lens model] *permit* [italics added]" (p. 230). As I have tried to show here, Brunswik need not be interpreted in this manner. If the ecological validities in the lens model are 1.0, then the proximal specifies the distal, opening the door for direct perception. Thus, the framework proposed here shows that Brunswik's life work and that of his followers need not be left out of a broader view of ecological psychology. Third, Heft's framework does not devote a great deal of attention to cognitive phenomena where there is a need to "go beyond the information given." Indeed, fundamental psychological phenomena, such as decision making and problem solving, do not appear in the index of his book. I believe that this difference follows from the first two; by emphasizing direct perception and not accommodating situations of impoverished specification, Heft's framework appears to leave out important psychological phenomena that need to be explained. In contrast, the framework proposed here accommodates the entire range of environmental conditions, from direct specification to no relevant proximal structure at all.

Finally, Heft (2001) spent a great deal of effort reviewing and integrating the work of Barker (1968) with that of J. J. Gibson (1979/1986), whereas the focus here has instead been on integrating Brunswik (1956) and J. J. Gibson (1979/1986). Future research should work toward a theoretical framework for ecological psychology that integrates the important contributions of all three of these ecological psychologists.

Summary

Like any other theory, the one proposed here is far from completely original. Many insights have been borrowed from existing theories, particularly that of Kirlik (1995), but there are significant differences as well. The result, therefore, is a unique and significant contribution to ecological psychology.

CONCLUSIONS

Both Brunswik and Gibson had broad visions for psychology as a discipline, but the temporal limitations imposed by a lifetime demand focus; there is not enough time to do it all. Thus, it is important not to equate the current outputs of a vision, which are necessarily limited, with the full potential of a vision, which can be much broader in scope. The lens model does a good job of accounting for static, one-shot judgment and decision-making tasks; other psychological phenomena—and there

are many—do not fall under its purview. Similarly, direct perception does a good job of accounting for tight coupling to information in the environment; other psychological phenomena—and again, there are many—do not fall under its purview. This is not to minimize the importance of these theoretical contributions because they are both landmarks in the history of psychology. My point is that the ecological perspective has far more to offer psychology than either of these theories alone would have one believe (Vicente, 2000).

As a step in this direction, I have argued that it is possible to integrate Brunswik's and Gibson's theories into a common perspective. This theoretical integration shows that these ideas are not in irreconcilable conflict. It also shows how the chasm that currently separates these two communities of psychologists could be bridged, pointing the way to a more cumulative and unified knowledge base—a goal that is the hallmark of scientific activity, but one that has been excruciatingly difficult to achieve in psychology (Staats, 1981).

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