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COMMENTARIES

Processes, Acts, and Experiences: Three Stances on the Problem of Intentionality

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The concept of intentionality addresses "aboutness," how one thing can be about, or refer to, some other thing. The argument I present in this article is that intentionality is an essential ecological concept that depends equally on process (the domain of physics), act (the domain of biology), and experience (the domain of psychology). The meaning of *intentionality* does not reside in any 1 of these realms, but rests simultaneously on all 3. A case is made for intentionality being rooted in a ubiquitous cosmological scheme that underwrites all systems no less than does the universal causality scheme.

The origins and nature of intentionality is an ancient puzzle considered central to the development of a theory of knowledge and its scientific counterpart, psychology. The term *intentionality* encompasses a wide range of fundamental unanswered problems in science, the chief of which is, "How can one thing be about another thing rather than just being about itself?" A prime example of this "aboutness" or "pointing beyond itself" problem is how single objects take on symbol or signal functions so they do not mean their own circumstances or properties but refer to those of other objects with different properties existing under different circumstances. The simplest case of a situation that exhibits intentionality is ostensive specification like

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pointing or using some other convention to make something you intend to be noticed by someone else, as in having the same experience. *Experience* refers here to social context and not mental state. Consider pointing to what you believe is a cat. Under what conditions is the pointing gesture a successful intentional act, in the sense of evoking the intended experience for the other person (i.e., making that person aware of the referent intended)?

Pointing with the index finger fails if the other person does not know the convention but instead looks at your finger quizzically. (To paraphrase Wittgenstein, 1953, p. 208: Do not bite my finger; look where I point!) It fails if the pointing is inappropriate because there is no cat for the other to see. It also fails if the pointing is poorly aimed because of carelessness or is too subtle to draw attention.

Here I have assumed that the object referred to, the *reference object,* (what the pointing is about) is real and that the referring object (pointing gesture) is public and explicit—a social experience. However, what if the pointing, the *intentional act,* is private and the object intended, the *intentional object,* is not real but imaginary. Can the same conditions be used to determine the success of the intentional act? What if the person pointing hallucinates, believing there is a cat there when there is none? What could the act intend then? What is it about? Is it about a so-called mental image of the cat, or some ethereal Platonic cat form, or nothing, or something else? Does the intentional act imply that the intended objects are equally real whether they are concrete and existing or abstract and imagined? Do such different intentional objects have the same reference object, or meaning, that is, make reference to the same circumstances that allow the intentional act to succeed or fail? Is reference made to circumstances under which one could teach or learn what was intended?

One answer to these perplexing questions presupposes additional constraints on how the intentional act relates to the intended experience. The intentional act and the intended reference experience must be invariantly related by certain processes that causally support their shared context. These lawful processes must connect the "reference maker" and the "reference interpreter," and they must guarantee that invariant information exists across the shared social contexts or no common experiences of the intentional act are possible. Thus, we need to understand how intentional acts, shared experiences, and the lawful processes underwriting their interplay coalesce to make intentional reference possible. Let us look more carefully at the necessary conditions for an intentional act before returning to this point.

CONDITIONS FOR SUCCESSFUL INTENTIONAL ACTS: FIRST PASS

The word *cat,* whether spoken or written, intends, or makes reference to, a physical object that is a furry, four-legged creature who purrs, drinks milk, chases mice, and scratches. The context in which the reference is made may include the real cat, who then becomes a reference to other beliefs or actions that satisfy our expectations regarding cats—one of which has to be the word *cat* itself—or the intentional act misfires. This suggests some of the conditions under which reference is valid and intentionality is defined.

If the context does not include something to which the word refers, such as a real cat or something that looks like a cat, then the reference is invalid. Likewise if that something does not invoke the word *cat* as its reference, then the intention is again short circuited. (In such case, one might conclude that the person who said or wrote the word *cat* did not know what it meant or was joking.) In other words, for intentionality to hold, the reference made by the intentional act must be valid; for a reference to be valid, it must satisfy, first, the context condition in which the reference context must contain what is referred to and, second, the reciprocity condition in which what is referred to must refer back to that doing the referring. Logically, this latter condition asserts that p has q as an intention is true only if p entails q and q entails p is true. This has been called "inner entailment," and has been taken to be the hallmark of all living systems (Rosen, 1991). Later, I shall argue that this form of entailment may be even broader than suspected, applying in physics as well as biology and psychology.

REFERENCE TO REAL AND INTENTIONAL OBJECTS

Franz Brentano (1874/1973) was a major critic of both Wundt and Titchener's introspectionist programs for describing the contents of mind. He sought to replace their search for descriptions of the elemental contents of experience and the laws controlling their composition with a different concern. He wanted to describe the *intentional* acts by which "objects" became attached to our experiences through mental acts, such as *perceiving x*, *believing x*, *imagining x*, *inferring x*, *remembering x*, *fearing x*, *desiring x*, and so on. Here is an example of his use of the troublesome term *intention*: Our beliefs that something is a cat rather than something that just looks like a cat refers to an intentional object rather than to the reference object intended; that is to say, the experience of the appearance of something being a cat has a different ontological status than something actually being a cat. Cats have actual existence, whereas cat appearances have fictive existence or what Brentano called "intentional inexistence" (Chisholm, 1967, p. 365)—a more shadowy reality. It helps to have a convenient way to keep the two objects straight. There is the cat experience, or appearance of the cat that we are aware of, called the *intentional object;* this is to be distinguished from the cat itself, or *reference object,* which may or may not lie behind the mere appearance. The object of reference is traditionally said to be the real object, or the thing in the world, whereas the object of the intention is said to be apparent or phenomenal, a thing in our experience, a mental contrivance, which may or may not be in the world.

This traditional distinction requires us to rethink propositional logic as well. Propositions asserted about cats or other things may be extensional or intentional. *Extensional* propositions refer directly to objects or circumstances that exist in the sense of making the proposition either true or false. By contrast, *intentional* propositions refer indirectly to objects that exist and may even make reference to fictitious objects that do not or could not exist. Consider an extensional proposition: "The rain wets the grass" is either true or false. It is true if the circumstances it asserts denote an actual fact; namely, if there is rain, grass, and a wetting relation holding between the two, then the proposition is true, and it is false otherwise. The event of rain wetting the grass is the reference object. Now consider a related intentional proposition: "I hope it rains soon to wet my parched grass." This proposition is not made true or false by whether the reference object exists. The hope remains a fact about the speaker's intended meaning whether or not circumstances constituting the reference object factually occur.

What does "the hoping" refer to? It cannot be the raining-soon-and-wetting-my-grass event because it may not rain before the grass dies; we may be in the middle of a drought and my hope will be dashed. Yet the intentional proposition asserted, no less than an extensional one, must have an object (all propositions do!). The object, so Brentano (1874/1973) reasoned, must then be intentional rather than extensional, subsisting in a realm that mixes fictional objects with real objects. This led him and many philosophers after him to the conclusion that, where extensional propositions pick out potentially real objects, intentional propositions pick out only possible objects that may or may not be potential, much less actual. There are many sticky issues raised by this cursory review of the intentional–extensional object distinction that cannot be addressed here. For my purpose I need focus on just one.

Perception is a pragmatic achievement, an act, by which experiencing an intentional object is tantamount, adaptively speaking, to experiencing the extensional object that gives the intentional proposition whatever meaning it has for our actions to remain consistent. Under this interpretation, this experience I call *perceiving* is provisionally true. That is to say, the perceptual proposition "I perceive the rain" is true providing that there is indeed rain to be seen, providing that I do indeed have the ability to see rain and providing that I do indeed exercise this ability properly. Under these provisions, the assertion that I see rain is as true as anything can be true. If what I see acts like rain when I encounter it (makes me experience getting wet, makes my grass return to green, turns parched earth to mud, and even quenches my thirst), then it is more than something that just looks like rain. It is a nomological network of corroborating experiences whose meaning is pragmatically what the seeing of rain means. This is the fundamental belief that entails and is entailed by my other beliefs in the network of provisional truths and that provides the essential grounds for validating all the propositions I could assert about the putative rain event. For the pragmatic realism espoused here, and endorsed by numerous functionalists (e.g., William James, James Gibson), the existence of a nomological network of corroborating experiences is all the ontological certainty there is and all that is needed to give a scientific account of human action.

In the use of the term *experience,* one is on dangerous ground if one means that an experience is a private mode of awareness. For Gibson (1979/1986), perception is social; people may participate in the same experience as others do but from their own perspective, with their own interests and background. William James (1890) agreed that experiences may be, to a degree, either public or private, as did Dewey (1896), Angell (1907), and other functionalists (Hergenhahn, 2001). Here I opt to use the term *experience* to mean being or having been aware of something. No clearer statement can be found than Gibson's own words:

> Perceiving is an achievement of the individual, not an appearance in the theater of the mind. It is a keeping-in-touch with the world, an experiencing of things rather than a having of experiences. It involves awareness-of instead of just awareness. It may be an awareness of something in the environment or something in the observer or both at once, but there is no content of awareness independent of that of which one is aware. (p. 239)

Gibson (1979/1986) further clarified his meaning by asserting:

> This is close to the act psychology of the nineteenth century except that perception is not a mental act. Neither is it a bodily act. Perceiving is a psychosomatic act, not of the mind or of the body but of a living observer. (pp. 239–240)

AFFORDANCES: WHAT SOMETHING MEANS IS WHAT IT IS

The briefest statement of the point here is that an object of perception is what it means and means what it is. This is true and makes sense only at the ecological scale in which the object in question is functionally defined, neither at the physical scale in which the object is objectively defined nor at the traditional psychological scale in which it is subjectively defined. However, given that what an object of perception is and what it means are the same only at the ecological scale, what happens to the notions of objectively defined physical objects, as opposed to subjectively defined mental objects, which are usually at odds with one another both semantically and ontologically? Gibson's (1979/1986) answer to this important question was very explicit. Objects are perceived in terms of what they afford an animal—what Gibson called their "affordance properties." Put most simply in terms of Gibson's theory of intentionality, an *affordance* is an opportunity for action.

> What about intended movement, then? And what about the "intentionality" of perception, the active, striving nature of perception when an observer is seeking information instead of simply having it presented to him? This seems to me a question at an entirely different level. And it is not answered by supposing that the brain issues commands to the muscles, for that is the worst sort of mentalism. It is fruitless to assume that behavior develops by an increasing voluntary control of primitive voluntary reflexes. What sounds to me promising is to begin with the assumption that active perception is controlled by a search for the affordances of the environment and that

> active behavior is controlled by the perceiving of these affordances. (Gibson, 1982d, pp. 387–388)

How affordances may control behavior requires careful explanation: Affordances, being intentional, provide only the harnesses for directing causes; they are not themselves causal (i.e., they are not the horses, so to speak).

To search for affordances is to make them goals. Because there are so many of them, one must select one to be the goal over the others. This is to choose for the purpose of satisfying an intention. The choice cannot itself be controlled by an affordance but must operate at a level where reason or habit or adaptive design makes the choice for you in accordance with a policy or value. Affordances may control in the sense of being an information source for the agent, but the information source does not orchestrate or apply forces—the agent does. Hence, the agent must be a set of resources for choosing schemes of forceful control and applying them in the service of the affordance goal. The agent has its own "on-board" (metabolic) potential to power self-motivated and self-controlled actions. Control processes guided by information place this on-board potential into the service of the intended goal. The term I have adopted for such control processes that service an intention is *effectivity*.

Affordances and effectivities are dual aspects of an intended encounter with the world. They are co-occurring and cospecified. Together they define the ecological boundary conditions of the perceiving–acting cycle in that the affordance sets the boundaries on success in the environmental potentials, whereas the effectivity summons the means within the boundary conditions of the organism's capabilities for realizing the intended encounter. Without both of these concepts there would be a gaping chasm over which intentionality could never leap. The effectivity could not refer to the affordance referent to concretize the intention. Hence, it cannot be emphasized too strongly that understanding how the effectivity supplies the means to achieve the affordance goal is absolutely indispensable to a theory of intentional behavior. In short, effectivities are the means by which affordances play a role in the control of behaviors. (To continue the earlier metaphor, they are horses to be harnessed by the affordances.) Without effectivities, affordances would lie fallow.

Hence, affordances remain dormant goals unless complemented by effective means that the agent who authors the intention can bring to bear. Therefore, affordances and effectivities are dual components of the intentionality that must be exhibited by an ecosystem if it is to be adaptive; neither does the job of the other. If goal-specific information is one side of the intentionality coin, then goal-relevant control is the other. Affordances control by informing (influencing) the choices the agent makes regarding the control to apply; conversely, effectivities inform by controlling (selecting and modulating) the forces the agent applies to produce the behavior that, in the course of unfolding, changes the availability of affordances. This cycling of perceiving and acting repeats itself until the encounter intended is either successful or is aborted in favor of other means or other goals.

CONDITIONS FOR SUCCESSFUL INTENTIONAL ACTS

What are intentional objects and to what do they refer? I have already shown that, by definition, they do not simply refer to themselves. Traditional examples of intentionality phenomena in psychology are those experiences that we typically call *cognitive,* such as beliefs, hopes, fears, memories, imaginings, expectations, and inferences. Intentional phenomena however are not restricted to these Brentano-esque (Brentano, 1874/1973) examples. Presumably, we now see that information and control, perception and action, and affordance and effectivity are dual pairs of components that support the intentionality of the ecosystem (agent-environment) to which they belong.

Goal-directed behaviors make up a wide class of examples of intentional acts. Although the general problem of intentionality, as the philosopher would define it, is broader than this special problem, it has the virtue of making concrete and clear what can be very abstract and obscure in purely mental cases, such as Locke's (1706/1974) inability to see how one's own ideas might refer beyond themselves. Without intentionality being realized, crass egocentrism would be unavoidable, and our Lockean minds would remain forever locked in a black box. Intentional reference is the key to an ecological realism that opens that box and lets light in. From proper examples, I will be able to extract a summary statement of how an ecological approach must formulate the problem to avoid Locke's dilemma.

Consider the example of seeing some objects as tools that allow work to be done on other objects to change their current state to an intended state. For example, think of the wide variety of objects that can be used as levers, saws, hammers, hole punchers, and so forth. Consider how different they may be overall but still retain the functional similarities that qualify them as being tools for the same use. In spite of such structural differences, agents (even some animals) can perceive their common affordances as tools.

Now compare the intentionality ascribed to tool functions to the less concrete case of sign and symbol functions. Consider, for instance, the variety of acoustic signals that convey the same kind of speech event, as do graphic markings of written language. Written or spoken language can refer to the same objects or situations. Reciprocally, viewing these objects or situations can bring to mind the same written or spoken language, just as a tool can implicate the objects to which they apply and, reciprocally, the objects can specify what tools may apply to them. Gestures such as pointing or finger crooking intend activities other than the pointing or the finger crooking. In the first case, the act tells another person to direct his or her line of sight elsewhere than at the pointer, whereas in the latter case the act bids another person to come hither. In both cases an intentionality function is served by making reference to a goal—a situation beyond the current one. Again the intentional relation is reciprocal; the person whose actions are directed by the other person's act must recognize that the object of the act satisfies the intention.

These diverse examples of intentionality reveal the minimal conditions that intentional functions must satisfy. The first condition asserts what is logically required for intentionality to hold between two situations, the other two describe what is required psychologically for perception and action to support the intentionality function:

1. *Reciprocity condition:* There must be a first situation that refers to a second situation that then refers back to the first situation. More briefly, *X* is intentional if *X* is entailed by something that it entails.
2. *Information condition:* There must be information (for properly attuned agents) that specifies how to go from the first situation to the second either literally (as in goal-directed activities, in which an actual path is followed from the first to the second situation) or figuratively (as in perception, in which what one notices second is conditioned by what one noticed first, or in cognition, in which the meaning of one thing entails the meaning of another thing).
3. *Control condition:* There must be an agent who could, in principle, carry out the implied go to instruction that realizes the reference relation (described in Condition 1 and 2).

Although there are many profound problems of interpretation regarding these three conditions, they provide one way to distinguish psychological processes from biological or physical processes. Psychological processes exhibit intentionality, whereas biological and physical processes do not—although they play an indispensable role in the support of psychological processes that do. However, as argued earlier, physical, biological, and psychological processes are all involved in intentionality functions when they are intertwined in the adaptive acts of an ecosystem: an agent transacting the business of survival with its environment.

Later we shall argue that although physical systems as such are more causal than intentional, they nevertheless may exhibit a rudimentary form of intentionality—what might be called the prototyping of intentionality. If this argument is valid, then it undercuts any attempt for Cartesian dualists to use intentionality as the essential characteristic that distinguishes mind from matter. Indeed, a major goal of this article is to argue that intentionality and causality are co-extensive in nature. For this reason, affordance and effectivity language, as well as information and control terms, apply validly everywhere in the universe and not just where life forms exist. This claim, which is indubitably controversial, will be postponed until the end of the article.

I am now ready to give a brief statement of the role of intentionality in ecological psychology.

INTENTIONALITY AT THE ECOLOGICAL SCALE

Gibson (1979/1986) tells us the following:

> Locomotion is guided by visual perception. Not only does it depend on perception but perception depends on locomotion inasmuch as a moving point of observation is necessary for any adequate acquaintance with the environment. So we must perceive in order to move, but we must also move in order to perceive. (p. 223)

Using the preceding definition, perception, action, cognition, and emotion qualify as different modes of intentionality whenever they function adaptively because they each satisfy the three conditions. First, consider perception: When samples of structured energy distributions are detected under appropriate circumstances, they specify important properties of the environmental sources from which they emanate. Such properties, the affordances, tell animals what actions are possible. Affordance properties have adaptive significance for the agents perceiving them; however, the agent must do something with them. To do so, the agent must call on its effectivities. Affordance properties of the environment are the most fundamental building blocks for the environmental component of an ecological psychology; they supply the bricks of ontology and the mortar of epistemology—what reality is and what it means. Affordances combine to make the environment a home for life rather than just a house for lifeless particles and inert things. Gibson (1982a) elegantly summarized his theory of intentionality when he observed that, at the ecological scale of perception,

> what a thing is and what it means are not separate, the former being physical and the latter mental, as we are accustomed to believe. … The perception of what a thing is and the perception of what it means are not separate, either. (p. 408)

Next, consider action as an intentional process: Voluntary movements of the animal's body may intend consequences at some later time and place than those in which the movements were originally initiated. Actions (construed as goal-directed behaviors), like perceptions, are intentional because their meaning and significance lie elsewhere than in their causal origins. Furthermore, actions are inherently forms of true choice behavior; at each subsequent moment in its life, an animal must select from among all available affordances that particular affordance deemed most worthy to be targeted as the next intended goal.

How is it that actions can be selective of affordance goals? Because affordances are opportunities for action, they cannot be the cause of action. Affordances may motivate behavior once chosen as goals but are not self-selecting. Logically, prior to pursuing an affordance goal there must be a value or need that motivates its intention. Thirst motivates the goal-directed search for water, inclement weather the search for shelter, predators the search for safe havens, and so forth. Even more remote but equally qualifying as affordances are those abstract goals like education, marriage, insurance, and vaccinations. College degrees are often pursued because they afford opportunities for jobs; marriage with a suitable partner affords a socially acceptable way for starting a home and family; insurance and vaccinations, like contraception, afford some degree of protection against unwanted future problems.

All of these socially supported affordances are intended for happenings in the future, but how such goals are to be pursued requires choice among available methods in the present: what school is to be attended, what degree is to be sought, what classes, what teacher, on what schedule, and so forth.

The means for realizing an affordance goal in the future entails the selection of affordances in the present that are instrumental to those ends. Again, myriad possibilities exist. How such means get selected and put to successful use goes beyond the intended affordance, although the goal clearly constrains the selection process. The selection of instrumental affordances as means must be a complementary process to the selection of affordance goals. I call such effective means required to realize an affordance goal its *dual effectivity.*

Effectivities always involve goal-directed biological functions. Affordance goals have intentionality that seem to act acausally backward in time through perceiving unwanted outcomes and acting to avoid them or planning more desirable ones. Affordances dispose the agent to act in certain ways but do not cause him or her to do so; otherwise crass teleology ensues. Effectivities, the marshaling of instrumental means to achieve the affordance goal, are usually biological functions except when mechanical surrogates are used, such as tools, machines, or vehicles; they provide the efficient causes for the required behaviors under the ever present constraints of the intention to realize the affordance goal.

The affordance goal provides a global informational constraint (teleonomy) to guide the effectivity that then produces the causal steps (teleomatics) toward that goal under local exigencies. Intended affordance goals impose teleonomic constraints, or goal-specific information, which guides the goal-relevant control, or effectivities, to steer the agent teleomatically down the putative goalpath. In sum, an affordance goal acts as an intention backward in time over the goalpath to constrain the unfolding complementary effectivity—an intention that acts forward in time over the goalpath (Shaw, Kadar, Sim, & Repperger, 1992; Shaw & Kinsella-Shaw, 1988). These are but two ways that intentionality can be expressed under the ecological approach.

How many different ways can intentionality be expressed? Do *reference relations* (the relation between the referring and the referred to) belong to a well-defined system? How might we model this system? I explore these and other questions in the next and later sections of the article.

TAKING STOCK: QUESTIONS, CONJECTURES, AND DEFINITIONS

An important part of this endeavor is to provide answers to the following questions. First, assuming that natural processes are lawful and can be discovered, then what are the underlying processes by which change takes place, that is, by which phenomena arise and disappear thereby giving way to the endless march of new phenomena? Second, because processes are dynamically continuous, by what acts (performed by us or otherwise) are they parsed into events that package the phenomena and that are temporally bracketed off from other events or shade off into them? Finally, given that the basis for what we know (although not all that we know) is empirical, then what are our experiences of these events that allow us and other agents to react and act adaptively?

Adaptive living requires that such pragmatic knowledge be available even to simple creatures, whether by evolutionary design, genetic preattunement, learning, or some combination of these. Clearly, a theory of such pragmatic knowledge goes beyond the province of any single science. Before going any deeper into the problem, it would be useful to make a few definitions explicit.

Definitions

A process is the physical means by which change comes about. It can be change in properties of objects or relations among objects or the situation in which or occasion on which the change takes place. The term *process* is used here as the collective name for what all processes have in common. Acts impose constraints on process; they refer to any operations by which one process changes another process. The term *act* is used here as the collective name for what all acts have in common. Finally, experiences refer to the degree of awareness of acts and of the processes they may monitor and affect. To experience something does not necessarily entail consciousness but only that one is directly aware of that something. Indirect perception is an experience of one thing in place of another such that the first thing shares meaning with the second thing. The term *experience* is the collective name for what all experiences have in common.

The interplay of these three terms can be conceptualized as a closure of interactive constraints as shown in the diagram depicted in Figure 1. Process, connoting continuous degrees of freedom, influences and is influenced by experience through act, which carries constraints to parse or direct process. Hence, act connotes

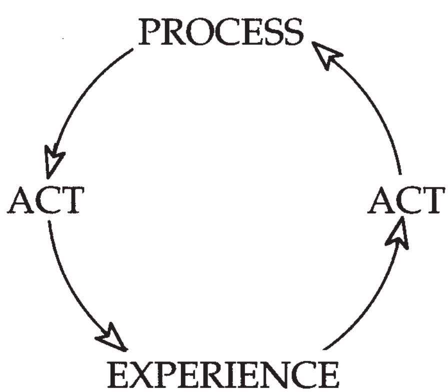

FIGURE 1 The process–act–experience cycle.

achievements in allowing experience to guide or monitor process according to intentions.

Process (*P*) is the causal foundation for all that is or comes to be. Act (*A*) delimits process according to conditions imposed by experience (*E*), but which, reciprocally, is delimited and constrained by process through act. Act is depicted twice in the diagram because it is a function that satisfies a mutual and reciprocal (duality) condition:

$$A: P \rightarrow E \text{ and } A: E \rightarrow P.$$

A serious word of caution. Act should not be thought of as being cause in the 19th-century mechanical sense; rather act is the context or playing field that reduces the degrees of freedom of what it influences—more like the rules of play for baseball (e.g., number of innings, runs, outs, strikes, fouls, and errors) and layout of the diamond and boundary conditions on play (like baselines, foul lines, outfield fences), as opposed to the pitching, hitting, or catching of the ball or running of the bases. Otherwise a mystery, much like mind–matter interaction, raises its ugly head. To make act causal in the mechanical sense is to make it part of process, and then the needed distinction is lost.

The gist of Figure 2 is that a process, whether physical or biological, flows through space–time and is continuous and uninterrupted, although it may be influenced by another process to branch, slow down, or speed up. Experience likewise flows through space–time, if not as a full-fledged Jamesian stream of consciousness (James, 1890) at least as a kind of continually updated awareness. This awareness

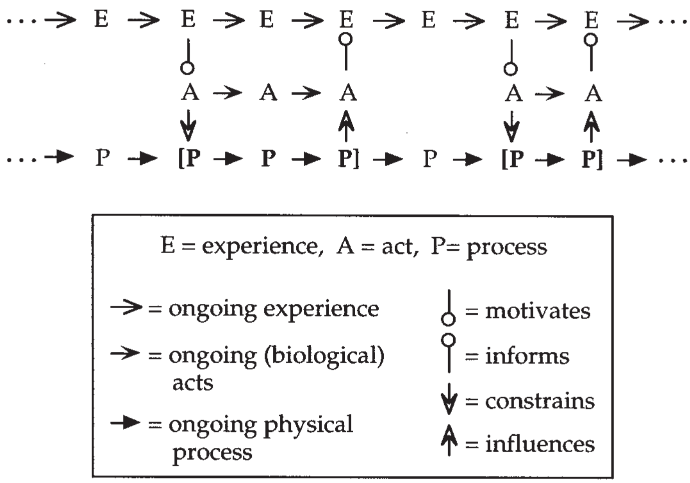

FIGURE 2 Mutual and reciprocal interaction of process and experience through act, which is the underlying scheme required on intentional agency.

ebbs and flows and is often punctuated by acts of influencing or being influenced by process. The gist of this metaphor is that it captures the fundamental assumption that has so far proven to be fact: Nothing in the universe can act without being re-acted on (law of action and reaction).

The scheme illustrated by Figures 1 and 2 is, of course, familiar to ecological psychologists. They provide one way of depicting the perceiving–acting cycle: Living systems behave (act on process) to obtain information (be acted on by process), which they then use to control further movement that generates more information and so on iteratively until the goal is reached or the attempt aborted. Without this cyclic scheme, science would not be possible because experimentation, measurement, or observation could not exist without it being schematically true. More important, animals could not accrue any knowledge; even if they could, they could not put it to use. Just as the perceiving–acting cycle is the first principle of ecological psychology, so should the more general process–act–experience cycle be the first ecological principle to underwrite all sciences.

Conjecture. One obvious interpretation of this cycle is that the three sciences of interest are deeply invested in it: Physics studies process; biology is the only mechanism known for act that influences either process or experience; and traditional psychology (like structuralism or modern day cognitivism) studies experience, either its contents or its functions.

For this reason, the process–act–experience cycle should be a common object of study for psychology, biology, and physics but with different emphases on the three terms. The most fundamental commitment of traditional physics has been to discover the dynamical laws to explain all forms of change in nature; hence, its primary aim is to study process and fashion its laws. To do so, it assumes that an empirical data basis can be obtained from which such laws might be discovered—by acts of observation and measurement—either in the field or under experimental control in the laboratory. This approach is known as the *scientific method,* and all sciences adopt it to study either the processes, acts, or experiences that are the content of their respective fields.

Therefore, the general scientific method originates in experience (empirical databases), which is obtained by a systematic and precise act (observation and measurement acts), and finally allows theories to be fashioned to explain the process (the causes of change) as experienced (usually through experiments). As a mnemonic, this interplay of the three concepts characteristic of physics is depicted in Figure 3. The scientific method identifies Experience with principle (assumed not studied), Act as method for applying explanatory principles, and Process with the problem to be studied.

On another occasion, a case might be made that process (as construed in terms of dynamical laws) is properly emphasized in the study of physics, act is properly emphasized in the study of biology (construed as process induced constraints on experience and experience induced constraints on process), and experience (con-

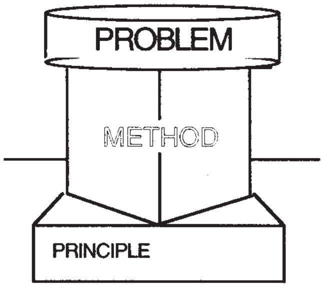

FIGURE 3 The scheme of the general scientific method.

strued contextually, not mentally) is properly emphasized in the study of psychology. The study of the interplay of processes, acts, and experiences, with equal emphases, would then fall to a truly interdisciplinary field that integrated all three sciences—a virtual hybrid psycho-bio-physics (order of suffixes arbitrary).

This is not to say that physics can ignore acts and experiences any more than biology can ignore processes and experiences or psychology can afford to ignore processes and acts; this is only to suggest that the emphases the three sciences place on these terms will be disproportionate. This point deserves careful elucidation but cannot be given here. Not only might some of the major differences among different sciences be accounted for in this way, but different schools within a science as well.

Simple combinatorics shows there are six possibilities, as depicted following. As an exercise, try to identify various schools of psychology with the schemes depicted in Figures 4a to 4f. Begin by identifying which scheme corresponds to the general scientific method. (The answer, of course, is Figure 4e.) What schemes correspond to structuralism, act psychology, functionalism, behaviorism, and ecological psychology?

PSYCHOLOGY OF BEHAVIOR

The scheme for behaviorism, perhaps, is the simplest to identify: This approach assumed behavior was the process to be explained (predicted and controlled; e.g., Watson, 1930). The experience of behavior (observed data) was assumed. The behaviorists had no real theory of perception and, therefore, none for intentionality either. Their method was to use act—the manipulation of environmental events (i.e., stimuli, the assumed determinants of behavior)—to control and predict its changes. So, if you picked Figure 4e again you were correct. This is not surprising, for behaviorism was our most mechanistic psychology (later Watson as opposed to earlier Watson, when he was a functionalist). The behaviorists so admired 19th-century classical physics that they wanted to do for psychology what Newton had done for physics. The Russian environmentalists, like Pavlov, were similar, although they had a more obvious concern for biology of behavior than did most (but not all) behaviorists. Neobehaviorists like Tolman (1928) were more subtle, allowing a minimal role to mental events such as purpose, but in the final analysis Tolman's theory is still to be identified with the mechanistic scheme of Figure 4e.

Some of the other psychologies are less familiar. A brief discussion of them might be necessary to remind us of how they differed.

PSYCHOLOGY OF EXPERIENCE

The history of psychology is a litany of controversial opinion regarding how the problem of intentionality is to be handled. It is noteworthy that the earliest brands of scientific psychology were psychologies of experience interested in the science of mental life. Wilhelm Wundt (1912/1973), the founder of experimental psychology late 19th century, repudiated the method of the physical sciences because they were materialistic, a philosophy that he vehemently opposed. Wundt eloquently summed up his argument for basing psychology in the mentalist tradition in these now famous words: "Materialistic psychology … is contradicted by … the fact of consciousness itself, which cannot possibly be derived from any physical qualities of material molecules or atoms" (p. 155).

Instead Wundt (1912/1973) offered a psychology based on a method he felt uniquely qualified to study conscious experience. His method was to use participants who were expertly trained in the use of introspective techniques to try to isolate the elements of consciousness. Because this introspective method gave a primary role to intentional acts of focusing one's attention on various aspects of

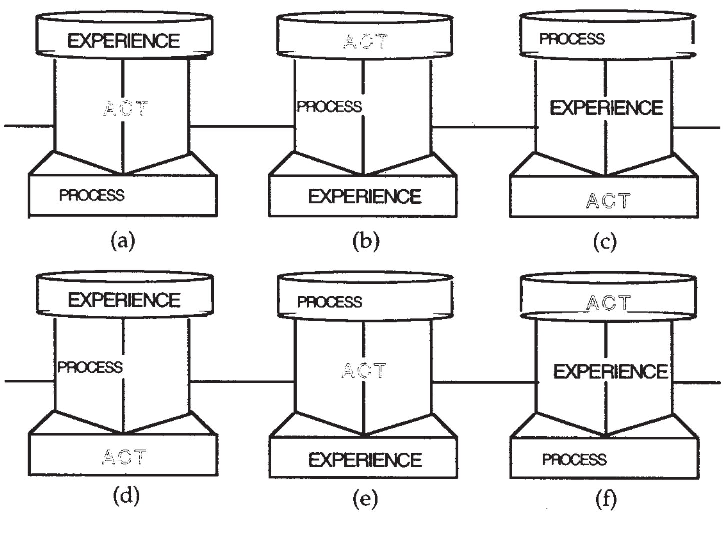

FIGURE 4 Schemes emphasizing different roles of process, act, and experience.

conscious experience, he called it "voluntarism." In this way, Wundt argued, the participant has immediate and direct access to the sensations and feelings that he believed were the elements of experience. Furthermore, by these voluntary acts of introspection, these elements might be arranged and rearranged in a variety of ways to effect a creative synthesis into whole, intact experiences. In this way he anticipated the Gestaltists' emphasis on wholes but missed their insight that such wholes could not be reduced to elements that could be added together to synthesize wholes.

Wundt (1912/1973) also claimed that whereas physical events can be explained causally in terms of antecedent events, psychological events could not. They can only be understood in terms of their purpose, or what they were about—or in the philosopher's parlance, what they intended. He went so far as to compare trying to fit psychological phenomena into the categories of physics to trying to squeeze oranges into an egg carton. For Wundt, the problem of psychology was to discover the elements of conscious experience and the laws by which they combine. The method to be used was immediate experience directed by intentional acts, and the principle assumed was the existence of central volitional processes.

Titchener's (1924) structuralism views were similar except, for him, the underlying processes were neurological, and one was prohibited from interpreting the meaning of sensation complexes (what he called the "stimulus error").

Which scheme in Figure 4 best fits this approach? If you guessed Figure 4a, you are correct.

ACT PSYCHOLOGY

William of Occam was a forerunner of act psychology and an important influence on Newton's mechanistic program (Kemp, 1998). In formulating his program, Newton in Book III of his *Principles* (1687/1995) laid down the principles of mechanism—among them being Occam's razor—the belief that extraneous assumptions should be "shaved" away from explanations and arguments. Newton's advice to scientists included the admonitions that God, the Creator, does not actively intervene in natural events, that all phenomena must obey the absolute authority of natural law, without exception, that purpose has no place in natural law, and that explanations must be as simple as possible: "We admit no more causes of natural things than such as are both true and sufficient to explain their appearance" (p. 320).

Occam was a nominalist who reduced all metaphysics to a use of language. Language has two intentions (uses) he proposes: The first intention is to allow us to talk about individual particulars in the world of our experience; the second intention of language was to allow us a convenient way to talk about language. It was this latter intention that explained the origin of universal concepts and other so-called abstract ideas. Cases of common intra-linguistic reference were, Occam thought, mistakenly taken by metaphysicists to refer to objectively reified Platonic ideas (universals), when in fact they were just a convenient way of using language to talk about language.

To be noted for our purposes is the fact that even this most parsimonious of thinkers retains the notion of intention as the simplest basis of explanations. If language is our instrument for thought, then our intentions of thought are acts by which to select one of these two uses of language. This anticipates the Act psychology of Franz Brentano that recurred a half millennium later.

Brentano (1874/1973) offered an important contrast to Wundt's (1912/1973) emphasis on the elements of mental experience. Brentano called his view "act" psychology because it focused on mental functions defined in terms of what they achieved. Mental acts were functions like recalling, expecting, inferring, doubting, loving, hating, and hoping. He called these achievements their "intentions" (hence the origin of the notion of intentional acts alluded to earlier). For instance, for him the intention of these acts always encompassed something outside of the acts themselves. Intentional acts of mind always have objects that make up the content of the experience. Seeing red is a mental act that intends red, that is, has red as its content. Acts and their experiences are as inseparable as Siamese twins. The term *intentionality* was meant to describe this fact rather than allude to purpose or goal (although these may, in special cases, be the contents of an act, such as when having the goal of recalling a date or inferring a consequence). Act psychology used the method of introspection—that is, a looking inward toward intact, whole, meaningful experiences.

It should be clear from this brief description that act psychology differs from the other psychologies of experience just described. Act psychology assumed mental processes and used introspective experiences as the method to study mental acts. The introspective method, however, was not that of Wundt (1912/1973), which was aimed at elements of conscious experience; rather it was a kind of phenomenological introspection directed toward intact, whole experiences. For this reason it is fair to say that the method of act psychology was based on experience not on act. Therefore, in Figure 4, the scheme in 4f best fits this approach.

PROCESS PSYCHOLOGY

All functionalists were directly influenced by James and his pragmatic philosophy (James, 1890, 1907). Central to James was the notion that experience is a continuous process—a virtual "stream of consciousness" as he called it, whose purpose was to allow the individual to adapt to the environment. This stream of consciousness is personal; it is the individual's subjective life. As such, James (1890) reasoned, it could not be broken down into elements; therefore, he opposed Wundt (1912/1973) and Titchener's (1924) goals for psychology but saw nothing wrong with their method of introspection, so long as it was not exclusive and observation of the behavior of others was allowed also (James, 1884). In fact, As Dewey (1896) pointed out, behavior is also a continuous process—a virtual stream—that cannot be broken down into elements. Thus, functionalists accepted both mental processes and behavioral processes as being legitimate objects of study for psychology.

It is worth noting that this holism of functionalism was even too radical for Gestalt psychologists. Although they also repudiated Wundt (1912/1973)and Titchener's (1924) elementaristic reductionism, they still believed that an intermediate level of analysis of phenomena into Gestalts (configuration) was necessary if psychology was to make progress. Gibson (1979/1986) agreed, but for him the Gestalts are affordances and therefore functionally real rather than phenomenal.

Whereas Wundt (1912/1973) and the structuralists were interested in the contents of mental process restricted to humans, the functionalists wanted to know why the mental and behavioral processes existed at all—whether in humans or animals. What good were they in helping living creatures struggle to survive? This concern led them directly to an interest in motivational principles. Where structuralism was a highly theoretical discipline with a single technique, functionalism was practical and eclectic in method. Where the structuralists looked to physiology for answers about experience, functionalists, being evolutionists, looked to biology for an understanding of how consciousness and behavior contributed to adaptive acts.

Functionalism was a loose alliance of psychologists and philosophers who opposed the rationalists' way of doing psychology, opposed mechanism, and were strongly affected by Darwin, James, and Dewey but shared few positive tenets (Hergenhahn, 2001). The core of agreement among functionalists was a belief in the following: fundamental nature of process—the flow of consciousness and behavior; eclectic in their adoption of tools for empirical investigation (experience) and analyses (introspection and external observation); and showed great breadth in the adaptive acts they were willing to study (those of animals and children, not just adult humans). They barely distinguished the subjective mental processes and objective processes of physics and biology, not in the sense of reductionism but in the sense of double aspectism—process is process. They preferred to see all processes as purposive, more like pure experience, than leave a gulf between physics, biology, and psychology as mechanists did. The basic tenet of functionalism is that intentionality is self generative; Dewey (1920/1999) expressed it this way:

> We do not merely have to repeat the past, or wait for accidents to force change upon us. We *use* our past experiences to construct new and better ones in the future. The very fact of experience thus includes the process by which it directs itself in its own betterment. (p. 95)

Because functionalists made the functions of experiential process, adaptive acts, central to psychology, the scheme that best fits them is also the one that fits act psychology: the one shown in Figure 4f. However, there are deep differences in overall theory separating the two.

Act psychology was still very much in the rationalist tradition, and closer to the philosophy behind structuralism than the functionalists' empiricism could tolerate. Here, there is a lesson to be learned: We must be wary in equating two psychologies simply because their methodological schemes are the same. Sharing a scheme is necessary for such similarity but not sufficient. The schemes are more useful in highlighting differences than in proving equivalence. It seems to me that the scheme in Figure 4f provides the one most suitable to all the sciences if only we can overcome the simplistic appeal of trenchant mechanistic attitudes that have appeal to scientists in all fields. Such appeal is not based on the virtues of mechanism but on the appeal of reductionistic thinking for experimental scientists who forget that the true purpose of experiments is not only to be fodder for more experiments but for principles of explanation.

ECOLOGICAL PSYCHOLOGY

There are modern day psychologists who embrace act but forsake its mental interpretation. They reject the elementaristic view of experience and the rationalist philosophy that motivated it. They also embrace pragmatic realism and James's (1890) process interpretation of experience and Dewey's (1920/1999) process interpretation of behavior. These modern day act psychologists who are also functionalists called themselves *ecological psychologists*.

In his article "New Reasons for Realism," Gibson (1967), like the functionalists before him, acknowledges a debt to Brentano's (1874/1973) act psychology. About this intellectual debt, Gibson (1979/1986) had this to say:

> Perceiving is an achievement of the individual, not an appearance in the theater of the mind. It is a keeping-in-touch with the world, an experiencing of things rather than a having of experiences. It involves awareness-of instead of just awareness. It may be an awareness of something in the environment or something in the observer or both at once, but there is no content of awareness independent of that of which one is aware. This is close to the act psychology of the nineteenth century except that perception is not a mental act. Neither is it a bodily act. Perceiving is a psychosomatic act, not of the mind or of the body but of a living observer. (pp. 239–240)

In the next quote, Gibson (1982a) gave the ultimate grounding of his claim that perception is not merely phenomenal—not merely about appearances but about the only reality animals have access to: ecological reality.

> What a thing is and what it means are not separate, the former being physical and the latter mental, as we are accustomed to believe. … The perception of what a thing is and the perception of what it means are not separate, either. (p. 408)

If there is one rubric for the ecological approach to the problem of intentionality, it is given in this succinct statement. Read it, ponder it, and read it again. No one can call him or herself an ecological psychologist who fails to grasp the import of this eloquent claim. No one can venture to call themselves a serious critic who ignores it.

This ecological reformulation of old and venerable act psychology rejects its phenomenalism in favor of the realism of a new act psychology defined at the ecological scale of reality. If such a theory remains true to its heritage, a balanced emphasis will be given to process, experience, and act. This is because, in addition to act psychology, an equally important part of that heritage is James's pragmatism, especially, as promoted by a group of his followers called the *New Realists* (Harlow, 1931). That Gibson (1979/1986) was heir to these views and their emphasis on both experience and process is clearly indicated by his own words:

> The act of picking up information … is a continuous act, an activity that is ceaseless and unbroken. The sea of energy in which we live flows and changes without sharp breaks. Even the tiny fraction of this energy that affects the receptors in the eyes, ears, nose, mouth, and skin is a flux, not a sequence. The exploring, orienting, and adjusting of these organs sink to a minimum during sleep but do not stop dead. Hence, perceiving is a stream, and William James's description of the stream of consciousness (1890, Ch. 9) applies to it. Discrete perception, like discrete ideas, are as mythical as the Jack of Spades. (p. 240)

On experience (construed as awareness of something, rather than mere awareness), Gibson (1982c) offered this remarkable insight regarding intentionality of experiences at the ecological scale:

> What about so-called "subjective" reality? Awareness of the persisting and changing environment (perception) is concurrent with the complementary awareness of the persisting and changing self (proprioperception in my extended use of the term). This includes the body and its parts, and all its activities called "mental" and those called "physical." Oneself and one's body exist along with the environment. They are co-perceived. They are inescapably *in* the environment at the place called "here." They exist, but in a radically different fashion from ecological realities. The two kinds of existence should not be confused. One's nose, hands, feet, heart, and stomach are co-perceived, and so are one's pains and itches and the after effects of stimulation (after images and feelings of vertigo); as so are one's ideas, insights, fantasies, dreams, and memories of childhood. But they should not be thought of as a different realm of existence or a different kind of reality than the ecological, nor are they "mental" as against "physical." (p. 418)

Gibson (1979, 1982b) meant to repudiate any notion such as Brentano's (1973) claim that some mental objects, namely, intentional objects, have a different kind of existence than objects in the world to which they might refer. For Brentano, the latter enjoyed full-fledged existence, whereas the former only had a ghostly "intentional inexistence." However, Gibson (1979, 1982b) was careful to distinguish the concurrent objects of coperception in the subject domain from the objects of perception in the environment. The experiences of self do not exist in a different way than experiences of invariant information or affordances of the environment, but they do have a different reality, or significance, for agents. Affordances, defined as opportunities for action, are specified by higher order, or compound, invariants; they are more likely to be perceived than those subjective "realities" specified by lower order invariant information (sensations) such as itches, pains, sensations, or after-images (Gibson, 1979/1986, chap. 8). The ecological realities have social significance in that they are available for animals of the same kind, whereas the nonecological realities, like sensations, are private and have no shared experience. For this reason, affordances are more relevant to the promotion of adaptive acts than sensations.

The intentionality of perception and coperception are bound up with the nature of physical process and biological process, respectively. This is also true of cognition. Cognition is no less an intentional act than perception. In the case of cognition, deliberating and planning a course of action or drawing inferences from perceptions clearly goes beyond the neural circuitry in which the electrochemical signals are carried. In the case of emotions, being in an emotional state, such as feeling fear or anger, prepares the animal for action, such as fleeing or fighting. Here the preparedness to act is achieved by the secretion of certain chemicals (e.g., adrenaline or serotonin) that putatively modulate transmission of neural signals that control the associated behaviors.

The very fact that neural or chemical states must be referred beyond themselves to explain the support of biological or psychological phenomena is to assert prima facie that intentionality is intrinsic to their nature. No reduction to their local causes can properly express the content of the deeper principles required to explain life and experience. For example, the chemical molecules (e.g., neurotransmitters) that prepare the actor to act toward a goal (of escape or attack) serve the same function as perceptual information that alerts the animal to danger, but they do so at the level of biological process rather than physical process. They each have their role to play in keeping the perceiving–acting cycle intact and the associated flow of experience unbroken—the perceptual information does so by signaling the approach of an enemy through physical processes (e.g., the photic field) and the molecules by continuing the signal through neural processes (e.g., synaptic potentials). The organism–environmental system, as an ecosystem, is made up of the processes, the acts, and the experiences functionally organized to exhibit intentionality, that is, to be about something—the preservation of the organism through adaptive acts.

In all these cases, intentional functions are characterized by three factors that they coordinate: physical processes, biological acts, and psychological experiences. Physical processes dynamically convey the relevant energy distributions to the sensory detectors that transduce their structure into neural signals, which then act to control the effectors that produce the intended behavior. The relative success or failure of these control processes must be experienced both as prior estimates and as final results or perceiving would be useless, actions would be aimless, and learning would be groundless. Awareness of the promise of results is as necessary as awareness of the results themselves if actions are to be adaptive.

The following two quotes from Gibson (1979/1986) show that in spite of rejecting Wundt (1912/1973) and Titchener's (1924) mentalism and declaring himself an act psychologist free of its mentalism, he still placed great stock in experience as awareness of something: "Visual kinesthesis 'is the awareness of movement or stasis, of starting or stopping, of approaching or retreating, of going in one direction or another, and of the imminence of an encounter. Such awareness are necessary for control'" (p. 237). And, "Also necessary is an awareness of the affordance of the encounter that will terminate the locomotive act " (p. 236). Which scheme in Figure 4 best fits this approach? Being both a new act psychology and a new functionalism, the proper choice is again Figure 4f. Of course, as pointed out before, this agreement in scheme does not mean identity in all aspects of theory or practice. Although ecological psychology shares much with the functionalism of James (1890) and Dewey (1896), especially its aims and breadth, important differences are due to several new ideas that Gibson (1979/1986) and his followers have introduced into ecological psychology in its current state of development: the important notion of invariant information that specifies affordances, the idea that senses act as perceptual systems, that neuromuscular effectors define action systems, the perceiving–acting cycle that brings these systems together to perform adaptive acts, and mutual and reciprocal nature of affordances and the associated effectivities that realize them. All of these ideas are needed for a scientific theory of intentionality at the ecological scale. Table 1 summarizes many of the most basic concepts of physics, biology, and psychology at the ecological scale. A careful study of it now will make the rest of the story easier to digest.

In the remaining sections, I suggest some still newer ideas that may help consolidate the ecology of psychology of intentional process, acts, and experiences.

AN ECOLOGICAL THEORY OF INTENTIONALITY

A Copernican Revolution in Psychology?

When Copernicus revolutionized astronomy by exchanging the roles of earth and the sun, he rejected the geocentric theory that had been accepted for a millennium and a half in favor of the heliocentric theory. This amounted to an overthrow of naive realism in the following sense: It repudiated our everyday experience of the sun passing over the earth from dawn to dusk, as witnessed by each of us each day. This fact of experience was replaced by the notion of the earth revolving around the sun, even though such a journey could not be seen from the everyday perspective. Hence, an act of replacing origins took precedence over experience, and theory held hegemony over observation. Of course today, with the unrestricted perspec-

TABLE 1
Ecological Physics

I. Physics		
Perspective-free classical physics general relativity		Perspective-dependent quantum physics (?) ecological physics
	Ecological Physics (Perspective-dependent Physics)	
habitat (where one lives)		niche (how one lives)
environment (affordances as opportunities for action)	<intentional dynamics> (intending to realize affordance goal by applying effective means)	organism (effectivities as means to realize affordance goals)
II. Perception (informing control)		
	Invariance Structure	
exterospecific information (information about Other independent of Self)		propriospecific information (information about Self independent of Other)
	Perspective Structure	
expropriospecific control (information about Other's relation to Self)		proexterospecific control (information about Self's relation to Other)
III. Action (controlling information)		
	Invariance Structure	
exterospecific (Other's action *not* directed toward Self)		propriospecific (Self action *not* directed toward Other)
	Perspective Structure	
expropriospecific (Other's action directed toward Self)		proexterospecific (Self action directed toward Other)

tive sampling from outer space, astronauts or satellite cameras can verify that Copernicus was indeed correct.

This suggests an interesting comparison. Gibson (1966, 1979/1986), in his ecological approach to perception, likewise repudiated restricted perspectives in our limited everyday experience in favor of the act of extracting invariant information that exists over such limited perspectives. For example, the stick in the water may look bent but under extended samples, such as paying attention to what you see in pulling the stick from the water and putting it back again, we encounter a less superficial and less ephemeral fact of experience: The water is seen as refracting the light rather than the stick as bending under unaccounted for forces. Although the shape of the stick appears to change when placed half in and half out of the water, the felt shape of the stick does not change but conforms to what is seen when the stick is either fully submerged or fully out of the water. It so happens that the process of light bending and the process of stick bending are clearly adjudicated by the act of changing from an arbitrary, limited perspective on the stick to an unrestricted perceptual sampling of it.

Here we see the importance of the notion of invariant information and what it means to say the senses (vision and tactile sense) act as perceptual systems detecting the same information. The issue is whether water affords bending sticks or whether it alters the information in one mode but not the other.

It is so commonplace that we hardly think about what must be true if this familiar effect is to hold. The stick in the water must be perceived as the stick out of water, so that putting it in and taking it out, each distinct but reciprocal events, must be nested components of a larger event in which the identity of the stick is maintained. Consequently, it is not enough to have a perspective of a stick in water and a stick out of water; instead the two individual perspectives must be seen as belonging to a continuous perspective transformation over space–time. A still more inclusive perspective transformation must hold if the observer is moving relative to the stick and water. Observer movement defines a more extensive event that covers more area in space, which may be extended in time if you move more slowly or if you choose to repeat the experiment over and over again.

Of course, what holds true for you as an individual holds true equally for others, for instance a few spectators. How about a stadium of spectators equipped with binoculars? Through television, the stick-in-and-out-of-the-water experiment might be seen in Calcutta, on the moon, or Mars. In general, any perceptible event can be conceived as being nested under ever more global events as the number and locations of viewing participants become distributed far afield. The astounding conclusion is that even the most insignificant events—so long as information is made available, for example, through tools of information amplification or recording devices—can, in principle, be viewed from anywhere in the universe, even in its most remote recesses. Hence, we come to appreciate that intentionality conveyed by information can be viewed separately from the source event from which the information originates.

There is no way that information could be disembodied; it must always have structured energy distributions as a vehicle. It is tempting, for the sake of generality, to try and take the argument to the limit and conclude that information for any event could be experienced over arbitrary distances and thus even made coextensive with the universe—being, as it were, "experience-able" everywhere that energy processes may be structured by acts. The possibility that events interpenetrate and globally distribute throughout the universe (or at least vast regions of it) strongly suggests that psychology should adopt a field theory for information distributions just as physics has adopted one for energy distributions—otherwise the vastness of the problem of event perception cannot be theoretically contained (Kadar & Shaw, 2000).

We might consider the information and the associated energy fields to be, mathematically speaking, conjugate field descriptions of the same underlying reality—the universe of events that is a home for both inanimate particles and life forms. The nature of the conjugate relation between the two fields is refined by how life forms are able to detect and use the information to perform acts that have energetic and informational consequences—namely, engage in informational controlled behaviors. Biology must be concerned with the mechanisms responsible for information detection and movement control because these are prime requisites for life. The forces exerted for movement both require a certain functional morphogenetic architecture and help to shape it through evolutionary design and exercise. How could the biologists not be interested in the conjugate field description of the milieu of development?

Thus, a concern for conjugate information-control field descriptions is another quarry that we have bagged on our hunt for a theoretical language common to physics, psychology, and biology.

Information as Intrinsically Intentional

As the previous example indicates, information can be just another name for intentionality in the generalized perceptual sense that something detected in the here and now specifies to some agent something else happening in the there and then. The reasonable assumption that information is carried by structured energy distributions that are ubiquitous strongly suggests that information fields are just as ubiquitous as the energy fields that support them. Intentionality, therefore, must likewise be as ubiquitous a property of the universe, being as it were coextensive with perspectives that agents might in principle take to detect and use the information.

The field description proposed tells us that intentionality might be considered a conjugate field property in the following sense: Where Einstein moved clocks and meter sticks around the universe to measure the curvature of space–time, so ecological field theory assumes portable agents who might also be hypothetically transported to detect and use information. If such a thought experiment is valid, then physical reality may be no more causal than it is intentional. Where ordinary physicists have to figure out how energy works causally, ecological physicists have to figure out how information is used intentionally. Both are part and parcel of the cosmology in which organisms exist as particles in an energetic medium at the same time that they live as agents in an information medium.

Intentional Dynamics: An Unavoidable Problem

Intentional dynamics refers to the means by which a particle or other object is lawfully propelled along a path to a goal. Such means need not involve teleological attraction to the goal (time-backward "causation") if the particle is self-motivating and furnished with information it can use which specifies where it should go to find the goal.

Surprising, perhaps, is to discover that intentional dynamics as a concept need not apply only to animate objects, that is, organisms, robots, or other machines designed to carry out human intentions. On the contrary, in this section, I want to provide further argument that dynamical processes traditionally assumed to be free of intentionality may not be. A corollary issue is that information specifying intentional (i.e., goal) constraints may or may not be perspective-free. Consider the following arguments.

Traditional physics has always had as its goal the creation of a perspective-free explanation of nature. In other words, they wanted to give a God's eye view of causality that transcended the need for any human perspective to explain phenomena. This is the heart of mechanistic science: Get rid of subjectivism so that explanations may be truly objective. A great boost to this program was given by the beautiful theorem of Emmy Noether in which she related the symmetries over space and time to the conservations. Essentially, she proved that no matter what perspective one took on a system, say from different places, at different times, oriented in different directions, certain quantities like momentum (symmetric over position), energy (symmetric over time), and angular momentum (symmetric over direction) remain invariant. Thus, it follows that conservations are path-free, and because particles must follow paths, they must be perspective-free as well.

Nineteenth century mechanics formulated particle paths in two ways: in differential equations that expressed Newton's laws of motion and gravitational attraction and in integral equations that expressed Hamilton's principle of stationary (e.g., least) action. Newton's laws explained motion by means of forces applied to the particle, step-by-step (i.e., *dx/dt*-by-*dx/dt)*, from an agency located in the environment (and assumed in the initial conditions). In contrast to Newton, Lagrange explained a particle's motion by integrating the difference between its kinetic and potential energy (a quantity called *the Lagrangian density*). Hamilton's principle of stationary action asserts that particles prefer those paths that are at equilibrium along the path of average Lagrangian density. This will be the so-called "least" (or better) stationary action path as compared to all other paths along which action (energy × time or momentum × distance) never changes (hence, the term *stationary* action path).

Lagrange's action integral method always yields a path that satisfies a condition known as the Euler-Lagrange equation and that coincides with Newton's solution. The two methods are formally equivalent, in the sense that they always give the same particle trajectory as their solution, and they both entail the involvement of intentionality in dynamical explanations. Let us see what this means.

If a particle is pushed by Newtonian forces applied to it from the outside, agency is externalized such that the particle has no choice but to move as made to. By contrast, if a particle must find which path out of all possible paths is the least action path to follow, then it seems to require that a particle makes choices. It seems that it has intentions. For this reason, Poincare called Hamilton's principle an offence to reason because it apparently anthropomorphizes particles by requiring that they choose so as to satisfy a criterion (i.e., exhibit an intention). Furthermore no mechanistic explanation has ever been given for how a particle is able to do this intentional task. Physicists have typically expressed their chagrin at the apparent need for a particle to consider its choices, especially when only the Newtonian path is considered real—the other paths being mere possibilities and thus not to be numbered among physical entities populating the universe. Not being actually allowed by the laws of nature, how could they have any real status even if particles could choose. Such choices would be nonphysical and to consider them would be to consider violating natural law. No particle or agent has such freedom! In spite of this absurdity, let us push the issue still further.

Even if the particle were an agent, we would still need to explain how it could make such choices. It would seem to imply some kind of information field that informs the particle qua agent and then require the particle to have an on-board action potential that would allow it to be guided by that information along its goalpath. As stated earlier, how animate particles with complex interiors (i.e., action potentials) pursue goals is the topic explored by the method that we have called *intentional dynamics*. I mention it again in this context to show that even traditional physics has trouble keeping intention out of their mechanistic accounts—as confused as that account may be. Likewise, given the need for the particle to be informed about what it should do to follow the least action goalpath, its perspective must be taken into the account.

Why then do physicists not simply stay with the Newtonian account to avoid such particle chicanery? One reason is that this account has its own problems. If the particle only goes where external forces make it go, how do the external forces themselves get directed? A regress to the most prior initial conditions seems unavoidable. Could initial conditions not be explained as the product of prior application of the laws? It seems not, for initial conditions are complementary to dynamical laws in the sense that not only can they not be explained by such laws, but are needed if the laws as stated in their general form (differential equations) are to be made specific to a given situation. Without the initial conditions, the laws have no power of prediction or explanatory relevance.

To make something specific, in Gibsonian terms, is to provide information. Hence, the Newtonian approach is no more free of information and the intentionality it entails than the Hamiltonian approach; the issue of how the particle becomes informed is just raised at the beginning rather than at the end of the process of generating a least action path. In the Hamiltonian approach, however, the particle itself must be the recipient of the information rather than the initial conditions that set the external forces.

Perhaps, the Newtonian account is the more objective view because the initial conditions lie outside the particle and the particle remains both inanimate and insensate, but not so for the Hamiltonian particle. In its case, the information must be defined for the particle, which then somehow uses it to seek its way. Thus, such paths are not perspective-free, and this poses a serious problem for traditional physicists.

The question of intentionality is no less problematic when one advances to quantum physics. Some quantum theorists attribute a necessary role to observation or measurement in what is called the "collapse of the wave function." In the uncollapsed world of quantum physics, all possible paths a particle may travel from a source to a detector are assumed real—even those that are nonphysical (i.e., acausal or nonstationary action paths). This liberal view of what is allowed follows from the notion that anything is allowed that is not explicitly forbidden by the conservation laws (the so-called Plenitude Hypothesis). Each possible path interacts with every other possible path; the result is that those paths most in phase contribute the most to an uncertainty corridor within which the classical stationary action path may be found. Those that are most out of phase contribute the least. This approach was developed by Richard Feynman as a path integral approach that attempts to provide a mechanism for Hamilton's principle (Feynman & Hibbs, 1965). Moreover, this approach has been shown to be formally equivalent to the other quantum theories (e.g., Schrödinger's wave mechanics and Heisenberg's matrix mechanics). Regardless of which approach one assumes in quantum physics, no satisfactory account has been given for how the set of possible path solutions "collapse" onto the classical path. The intentionality issues that surround the classical approaches do not get resolved; they merely get focused into the idea that possible path solutions, no matter how causally improbable, can mathematically specify the classical path solution. Here many paths intend a single path through the yet to be explained mechanism of collapse.

It is important to note that Feynman's "mechanism" of phase correlation postulated to explain Hamilton's principle is not a causal principle. It operates through a kind of wave interference process across all possible paths at the same time. In fact, no one knows quite how to interpret the mathematics physically. There is agreement that it works but it remains a mystery by what physical principle it does so. Could it be that this is just another case of intentionality in physics and that this is the root of the mystery?

Intentional dynamics becomes relevant because it offers a method by which the "collapsing" (specification) might be directed by perception informing action of the goalpath to be traversed. Here goal-specific information and goal-relevant control are included in the characterization of the stationary action path to be found and provide the means (effectivity) by which a set of possible paths might intend (realize) a preferred goalpath (affordance goal). Unfortunately, space does not permit us to go into this new method at this time.

Look back at Table 1 for a reminder of the overview of how ecological physics and other physics relate. This table indicates the central role I think intentional dynamics must play in interfacing the ecological psychology of agents to environmental physics. Ecological physics provides the best vehicle for importing intentionality into nature, both in the sense of information intending (specifying) an affordance goal and the self-control of forces intending (determining) a goalpath (i.e., an effectivity).

By making intentionality part of the warp and woof of space-time, intentional dynamics treats it as fundamental to cosmology and physics as causality. It contrasts sharply with Cartesian dualism, which restricts intentionality to mental phenomena alone and avoids the panpsychism of Spinoza and others (e.g., Leibniz and Whitehead), who would endow all objects in nature with some degree of consciousness.

Unresolved Controversies: Intentional Black Holes and Unconscious Intentions

If intentionality is rooted in the fabric of space–time as an ubiquitous physical phenomenon, then it should show up in some ways that are independent of living systems. Perhaps, there is 'prototyping' in nature whose expression in living systems is but a derivative outcome of something far more basic. Consider the following curious case of the "intentional" black hole.

Most of us have a nodding acquaintance with those denizens of deep space known as "black holes." However let us remind ourselves of some of their key properties. A black hole is a celestial object, probably a massive old star, that has collapsed under its own gravitational attraction so that particles trapped inside its boundary, or *event horizon*, cannot escape with a velocity less than that equal to the speed of light. Events occurring within the event horizon, the surface in space at which the gravitational field reaches a critical value, cannot be observed from the outside.

Figure 5 shows the make-up of a black hole to include a singularity, a point in space of essential zero dimensions surrounded by a horizon. The temporal trace of the singularity is depicted in Figure 5 as a dark vertical line with time running upward (note the order of time tags). The event boundary is depicted as the cross-section of two cylindrical sleeves of different radii, ($t_1 - t_2$) and ($t_2 - t_3$). The nonlinear jump in the radius of the cylindrical boundary is what happens when a particle is swallowed by the black hole at time t_2. Although the radial increment must be a discrete jump to accommodate the particle mass instantaneously added to the black hole, the field properties surrounding the black hole require that the transition from the smaller to the larger radius be smooth and continuous. Hence, there is a conflict here between quantum theory and general relativity: On the one hand, causality requires that the radial change be a retarded potential and not take place until after the particle is swallowed (i.e., the effect must follow the cause), whereas on the other hand, the field property requires an advanced potential so that the smooth transition indicated by the arcs connecting ($t_2 - \Delta t$) – t_2 can anticipate the arrival of the particle.

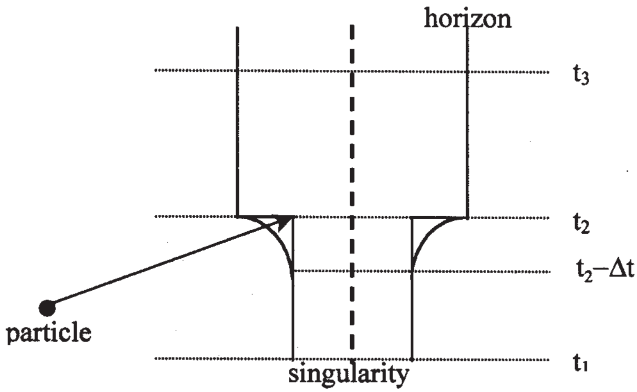

FIGURE 5 Particle colliding with a black hole.

In other words, if the horizon is to undergo the smooth continuous change field theory dictates, then it must begin expanding before the particle arrives—a clear case of the effect preceding the cause! Note especially, that the degree of the expansion must be specific to (i.e., informed by) the mass of the particle and its time of impact. Does the black hole then "know" the intention of the particle? If it were sentient, we would ask three questions: (a) In what form is the information about the impending collision of the particle made available to the black hole? (b) How is that prospective information detected by it? (c) How is the anticipatory response of the horizon's radius controlled by prospective information?

This may all sound quite farfetched, but the alternative explanation is no less so. For if there is no prospective information, then it must instead be a case of action-at-a-distance. If so, then how does the distal particle cause the black hole to begin its early responding? To avoid action-at-a-distance and to preserve both the causality condition and the continuity principle that underwrites relativistic field theory, we have no choice but to postulate an information field that is co-extensive with the relativistic field. (This is consistent with Bell's famous theorem. This theorem states the conditions under which action-at-a-distance, or nonlocality, may be used to retain a semblance of causality even though it acts between locales that lack continuous connection.)

To my knowledge, there is no known energetic field to support such particle time-to-contact and mass-to-contact information, and there are no candidate impulse force sources to control the horizon expansion. It seems that this case could be construed as satisfying all three of the conditions required for intentionality to hold, as discussed earlier. The Reciprocity Condition can be satisfied; namely, *X* (the black hole's horizon expansion) is intentional (anticipatory) if *X* is entailed (informed) by something *Y* (the impending particle collision), which *X* entails (specifies). However, the other two conditions regarding information and control remain a mystery.

If such intentionality prototyping exists, as exemplified by black holes, then living systems may exploit it when they evolve. If so, then one should expect to find evidence for this atavistic mechanism in life forms. It would be especially convincing if intentionality were manifested in a way not dependent on psychological processes, rather, conversely, as something fundamental that psychological processes might, like biology and physics, draw upon. In this regard, consider the curious case of the readiness potential, or intention without apparent awareness.

Libet (1985) presented empirical evidence of the existence of a neuro-physiological readiness potential (RP) that occurs 15 to 25 msec after a stimulus (S) is applied and precedes a voluntary motor act to the stimulus by as much as 550 msec. In addition, he also presented evidence that the onset of awareness of the intention to commit the voluntary motor act came much later, about 200 msec before the voluntary motor act.

$$|S| \text{ 15 to 25 msec} \rightarrow |RP| \text{ 350 msec} \rightarrow |\text{intent}| \text{ 200 msec} \rightarrow |\text{act}|$$

Libet reasoned that the readiness potential amounted to an unconscious neurogenic control that commits the person to the voluntary action before they become aware of such an intention. If this interpretation is accepted, it raises the question of whether our "felt" volition, or urge to act, is the true cause of our acts. One interpretation offered for this data posits two distinct temporal orders—one temporal dimension along which the neuronal events are assigned for the initiation and completion of the action (i.e., a causal order and another along which the psychological events are assigned for which there is awareness, or an intentional order). Furthermore, the causal order is defined for the third person—the scientist making the record of the neurological events, while the intentional order is defined for the first person—the person who reports the urge to act.

Too much discussion and debate has ensued since the target article by Libet was published to review and evaluate here (e.g., Dennett & Kinsbourne, 1992; Libet, 1991; Navon, 1991; Snyder, 1987; Velmans, 1993). Many unsubstantiated accounts have been given, several even invoking the relativity of simultaneity and temporal order in different frames; another assumes a kind of complementarity principle holds between first person and third person physics (as between wave and particle). None of these accounts are very convincing. Consequently, after a decade of debate, no scientific consensus has yet been achieved. Nevertheless allow me to weigh in with still another possible account.

If intentional orders and causal orders exist in the same space–time, might they not be distinguished by the pairing of *retarded* and *advanced* potentials acting along the same time dimension. Retarded processes are those that causal events (acts) may parse in the time-forward direction, whereas advanced processes are those that intentional events (acts) may parse in the time-backward direction. The well-known time-reversibility of classical, quantum, and relativistic physics clearly allows this possibility. (This is known as the CPT invariance theorem. This theorem asserts that the combined operation of changing charge conjugation [C], parity [P], and time reversal [T] is a fundamental symmetry of relativistic quantum field theory. No violation of this theorem has ever been found experimentally, although time reversal symmetry, T, has been found to be broken in certain weak particle interactions.) Just as a black hole is allowed, under the clash of quantum and relativistic accounts, to exhibit an anticipatory response to the impending collision of a particle, so neurogenic processes may be allowed to anticipate the awareness of the intent to respond.

All that is required is that we allow intentionality to hold *soma-psychically* and not just *psycho-somatically*. In addition, we must be democratic about the role of intentionality in nature and allow that it is no more psychological than it is biological or physical so that it may bridge these "phases" of matter. Perhaps, under the proper circumstances, intentionality and causality are allowed to commute temporally, as in the two cases just reviewed. I am not ready to argue that this is indeed true, but only that it is not disallowed by anything we know scientifically.

Intentionality as a Coalition of Reference Modes

Regardless of which psychological process intentionality works through, schematically speaking, it assumes a fixed number of modes of reference. These can be characterized by the two algebraic properties: reflexivity and symmetry. Given that the reference relation minimally requires two objects—the referring object and the referred to object—intentionality can act reflexively on either of the two objects or symmetrically between them (see Figure 6).

Intentionality has four modes of reference: propriospecific, exterospecific (Gibson's, 1979/1986, two terms), expropriospecific (Lee's, 1978, term), and proexterospecific (Shaw's, 2000, term). These terms can apply to objects of percep-

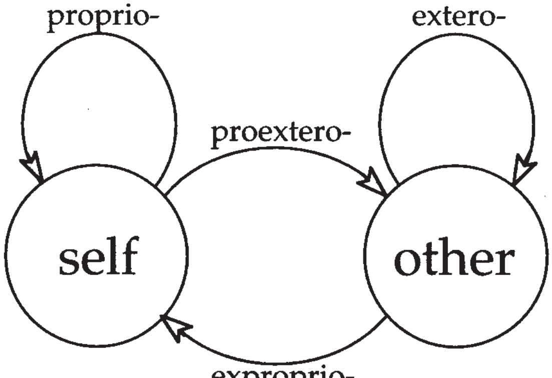

FIGURE 6 Intentionality as a coalition of four modes of reference.

tion, action, cognition, and emotion. Intentionality denotes four types of reference depicted by the arrows in the figure: An object or situation can refer to itself without at the same time referring to anything else, that is, it can exhibit propriospecific intentionality (first person perspective = Self), or conversely, from the viewpoint of the first object, another object can refer to the itself without at the same time referring to any other object, that is, it can exhibit exterospecific intentionality (third person perspective = Other). These are both purely reflexive properties of reference. Two other modes of reference are obtained from the fact that reference can be also be symmetrical: An object or situation may refer beyond itself to another object or situation (i.e., exhibit proexterospecific intentionality when the Self refers to the Other and exhibit expropriospecific intentionality when the Other refers to the Self).

The group of intentional relations (Figure 6) that emerge from this characterization suggest an alternative way to look at anticipatory control in physical situations (e.g., black holes) and biological situations (e.g., readiness potentials). A bold hypothesis might assume that the strongly connected digraph (depicted in figure 6) is a minimal specification for the connection possibilities in space–time locales everywhere in the universe. In other words, such a group tells us what the topology of space–time allows, just as in an ideal Euclidean space the property of rigidity (or fixed distance metric) that is everywhere available tells us that shapes will not change under translation to new locales, or just as in Einstein's relativistic space, gravitation is likewise everywhere defined and provides the crucible for force generation from geometry.

This dual pair of duals (i.e., coalition) would define the universal bases on which intentional systems might be erected—whether living or nonliving. By building this coalition of connections into every nook and cranny of space–time (what is known as a compactification), the seed for intentional systems is planted and the cosmic soil made fertile. Living intentional systems, of course, require that additional properties be present in some locations if the intentional systems are to be viable and relatively self-sustaining. Evolution of life requires much more than "inner entailments" being built into the structure of space–time connection.

The main point, however, is that such a move toward an ecologically valid cosmology that can in principle support intentional systems, allows for life to progress on the rather rapid time scale that it has been observed to follow. Without this intentional seeding, life and consciousness are left as mysterious accidents—even miracles. If we accept this added richness to our cosmic matrix, the spontaneous germination of intentional systems, whether they be as grand as black-holes or as modest as viruses, are made more explicable. It also provides a reason for the apparent validity of the anthropic principle. (This principle asserts that the observable universe must have the properties required to support observers or we would not be here to observe it. What keeps this from being trivial is that it explicitly connects the conditions for the evolution of the early universe, such as certain values of the physical constants and the conservations, with the start-up of life. Here I am suggesting that those primordial conditions must include conservation of intentionality as connection possibilities.)

Let us return to the historical development of ecological psychology to see how these speculative ideas are rooted. Gibson (1979/1986) recognized these four modes of intentionality in the four types of information—although he did not explicitly name them all. Pay attention to the intentionality relations incorporated into the following observations by Gibson (1982b): "Hence a given observer perceives other perceivers. And he also perceives what others perceive. In this way each observer is aware of a shared environment, one that is common to all observers, and not just his environment" (p. 411). Here reciprocal intentions are implicated between the observer and the observed, between the self and the other. The reality of affordances as the most useful description of the environment offers unique foundations to the ecological theory of intentionality by arguing against all facile attempts to reduce intentions to mental constructs. At the same time, their functional status precludes reducing them to mere causal constructs as well.

> An important fact about affordances of the environment is that they are in a sense objective, real, and physical, unlike values and meanings, which are often supposed to be subjective, phenomenal, and mental. But, actually, an affordance is neither an objective property nor a subjective property; or it is both if you like. An affordance cuts across the dichotomy of subjective–objective and helps us to understand its inadequacy. It is both physical and psychical, yet neither. An affordance points both ways, to the environment and to the observer. (Gibson, 1979/1986, p. 129)

When animals perceive the affordances of the shared environment they do not perceive private possessions that belong only to them. Rather they see something that may be graspable, edible, drinkable, or more generally, what may afford positive or negative encounters for other agents like themselves. Affordances are important theoretical constructs because they specify those functional properties of the shared environment about which the society of creatures have the same invariant information, the same intentions, and hence social agreement. This defines their econiche not their habitat—how they live rather than where they live, respectively. Because the topological scheme for intentionality is ubiquitous, one agent can envision itself in the place of other agents and show sympathy or even empathy for their conspecifics' circumstances and, perhaps, although to a lesser degree, the experiences and intentions of other species. In a sense, the cosmological habitat of all agents is a primitive niche for intentional interactions. The house is a home! We all share in the causal nexus and its conjugate intentional nexus.

Returning to a more mundane level, perhaps, then there is a legitimate basis to our tendency to anthropomorphize animals, especially our pets. If intentionality is as ubiquitous as it seems, then perhaps all living creatures share the same rudiments for its four modes. Could what has been traditionally called *mind* be nothing more than the crude realization that the four intentional modes exist at every place that an agent might occupy in the ubiquitous information field?

Could this field not also provide a common framework on which evolution might erect the biological scaffolding for epistemic functions that the most modest and the most advanced creatures alike need for realizing affordances? If so, then the most rudimentary of all epistemic functions would be ones that effect a reciprocity between biological agent and physical environment, in which the detection of information specifying sustaining affordances at the same time instigate the assemblage of the effectivities needed for realizing such goals. Automatic coordination of such biological functions with the physical resources the environment allows would be achieved if the process that provides the means to an end, at the same time, also recognizes the existence and location of such ends.

A step toward such reciprocal solutions was taken by Gibson (1979/1986) in recognizing that invariant energy distributions may be both informing and controlling. Gibson recognized that the same dynamical information that specifies the environmental layout independent of the perceiver (invariance structure) also specifies the perceiver's relation to that environmental layout (perspective structure). The expropriospecific mode of intention is carried by the same energy distributions as the exterospecific mode of intention. Of course, our movement through the world also has consequences for the propriospecific and the proexterospecific modes of intention; for we not only experience ourselves as acting toward environmental goals but experience how our actions produce reactive forces to be overcome, ignored, or exploited.

It is important to consider how the social dimension of the intentional modes can also be exploited. The leader of a team—a coach, a therapist, an air-traffic controller, a teacher—or any other person who must exercise social leadership is expert to the extent that they show social reciprocity with those they must understand to advise, direct, or lead. Small children, as Piaget (1929) told us, must learn social reciprocity if they are to become socialized into the value system shared by their family and community. Control of one's social behavior calls for taking a perspective that is superordinate to one's own parochial viewpoint. This is not to be merely dispassionate, objective, free of any viewpoint, but to be compassionate because one shares an intersubjective viewpoint that provides a context for one's own. Hence, one becomes an overarching subject whose circumstances and perspectives incorporate other subjects and other viewpoints. It is in a word to be "superjective." Without the superjective perspective, there can be no true humanity, no true ecology of emotions, values, or understanding.

The Ontological Descent of Intentionality

How many different ways can intentionality be expressed? We have seen that reference relations (the relation between the referring and the referred to) belong to a well-defined system of interrelated reference modes. The various ways that intentionality might be exhibited corresponds to the nested "worlds" in which we live, where each so-called world is defined by the degrees of freedom allowed the intentional act. Table 2 summarizes the main points that a lengthier discussion would have to cover. The reader is invited to study the table and to develop his or her own rationalizations to justify the entries. Is anything omitted that should be included for a complete coverage? Can the entries be collapsed or omitted without damaging the integrity of the table?

How to read the table. All of the properties of the higher rows of Table 2 (e.g., 1, 2) are included as constraints on what is listed in the lower rows (e.g., 3, 4): Hence, there is a cascade of constraints from top to bottom so that the lower the entry, the more restricted the intention allowed. When all constraints are satisfied, the convergence is on the actual world in which the conditions under which intentional actions can succeed are most stringent. There are myriad examples that can be entered in the third column. The examples in the lower cells (e.g., column 3, row 5) must exhibit more mutual compatibility than those in the higher cells (e.g., column 3, row 1) because they must satisfy more of the cascading constraints.

To read the table from bottom to top merely substitutes the inverse terms: lower for higher, degrees of freedom for degrees of constraints, less stringent for more stringent, and so forth.

TABLE 2
Ontological Descent From Possible Worlds to Actual Worlds

Levels of Process Constraints[a]	*Intentional Acts*[b]	*Exemplifying Experiences*
1. Logically possible worlds (all possible *dfs*)	*p* intends *q*, where *q* is specific to *p* in context *r*	Mary (*p*) believes a picture accurately depicts a unicorn (*q*) described in a myth (*r*).
2. Physically potential worlds (all physical *dfs*)	*p* intends *q*, where *q* is lawful effect of *p* under initial conditions *r*	Geophysicist (*p*) predicts an earthquake (*q*) will register 6.5 on the Richter scale (*r*).
3. Perspective-specific worlds (*dfs* leave perspectives invariant)	*p* intends *q*, where *q* informs *p* from perspective *r*	Eye-witness (*p*) reports a murder (*q*) seen from his window (*r*).
4. Ecologically scaled worlds (*dfs* leave scale invariant)	*p* intends *q*, where *q* fits *p* at scale *r*	Woman (*p*) believes the doorway(*q*) will allow her wheelchair (*r*) clear passage.
5. The actual world (no *dfs*)	*p* intends *q*, where *q* occurs in *p*'s historical context *r*	Batter (*p*) knew the game (*q*) was won when the ball (*r*) cleared the centerfield fence.

Note. p = subject; q = predicate; r = reference context.
[a]Descent from greater to lesser *dfs*. [b]Intentionality: *p* intends *q* if *p* refers to *q* and *q* refers back to *p* in context *r*.

This table provides a summary of how intentionality is manifested at the various levels of reality (1 through 5) dependent on the mutual influence of process on experience through intentional acts. Level 1 (i.e., row 1 in table) pertains to possible intentions, ones that may be conceived but may be totally unrealistic. Levels 2 to 4 introduce the constraints that make the mere possible intention a potentially realizable intention. The realizing of the potential intention as an accomplished actual occasion is denoted by Level 5.

In ecological psychology, affordances belong to Level 4 because they are dispositional; they can dispose an agent to act, even help inform the control the agent applies, but cannot make it act. The agent must have assembled or recruited an effectivity (a goal-directed function) for that purpose and have actually applied it successfully. Thus, effectivities at Level 5 select affordances at Level 4, which then influence how the effectivity unfolds to produce the final result. In this sense, the affordance and the effectivity merge in the actual occasion and cannot be separated.

Intentions propose, affordances dispose, and effectivities deliver—but only because the intention is subsumed under the process of holding fast to an affordance goal (invariant intention) and becomes assimilated into the proper effectivity. Gibson (1979/1986) illustrated this idea in the case of the manipulation of objects:

> The point to remember is that the visual control of the hands [effectivity] is inseparably connected with the visual perception of objects [affordances]. The act of throwing [Level 5] complements the perception of the throwable object [Level 4]. The transporting of things [Level 5] is part and parcel of seeing them as portable or not [Level 4]. (p. 235)

Table 3 offers some other examples.

Here is a first crude pass on an ontology of intentions. Affordances with the same ontological status may be construed as intentions that live at the same level in the ontological descent. These may or may not be the objects of awareness. For example, an affordance at the logically possible level might be inferred but it could not be perceived; whereas one at the physical level is not necessarily scaled to any living creature unless some artifact device is used to measure or detect it indirectly by means of its observables. For example, before X rays were discovered, they were a theoretical (logical) possibility. We now know X rays can afford harm to life but cannot be perceived even though their presence might be detected by photographic plates.

Hence, there are logically possible affordances that may or may not be physical potentials, physically potential affordances that may or may not be scaled to any species of living creatures, ecologically scaled affordances that may or may not be selected as goals to be realized, and realized or actual affordances that we may or may not be directly experienced. For affordance to be goals, however, we must be aware of the opportunities for action that identify them.

TABLE 3
Affordance-Effectivity "Fit" Under Actual Occasions

Level 4: Potential[a]	*Level 5: Actualizing*[b]	*Level 5: Actualized*[c]
graspable	grasping	grasped
climbable	climbing	climbed
catchable	catching	caught
edible	eating	eaten
sit-upon-able	sitting	sat-upon

[a]Affordance of something that is .... [b]Effectivity as the controlling of .... [c]Goal accomplished as something is ... .

Effectivities, by contrast, are those intentions that cascade constraints downward across levels to squeeze out the degrees of freedom of higher level intentions, with successful intentions climaxing in an actual occasion (e.g., being an effectivity that realizes an affordance goal). Effectivities are processes therefore that transform possible experiences into potential ones and potential experiences into actual ones. Acts are those outcomes that partition processes, such as differentiating out the ambient flux of light from a crowd the friendly face we seek. In this simple and natural act, all of the levels of the ontological descent must be successfully traversed. Therefore, it is for each moment of our lives that we stay in touch with ordinary reality.

CONCLUSIONS

Reasons were given for believing that intention is not a single concept but a complex of concepts that involves a system of four modes that are intimately involved in understanding how we can know our worlds, ourselves, and others who occupy those worlds. We considered the claim that for information to be useful in the ecological sense, rather than being merely a measure in Shannon's (1948) sense, it must be intentional. Psychologists have generally agreed that this is so without agreeing on how it might be so. Philosophical analysis may help persuade us that a particular theory of intentionality is incomplete or inconsistent, but rarely does it help us determine if such a theory has any practical or scientific consequences. Here, I have tried to do this by entertaining the proposition that the basic sciences of physics, biology, and psychology tacitly involve the common notions of process, act, and experience, which are the building blocks of intentional systems.

No single discipline can encompass all the ways in which these three components of intentional phenomena play their roles because they receive different emphases. For this reason a move toward an ecological cosmology is of paramount importance, in which the universe is seen as a home for intentional agents who are in equal parts physical, biological, and psychological. Finally, I argued that intentionality is no less a part of the legitimate study of the physical processes than it is the study of the biological acts motivated and shaped by psychological experiences.

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