Gibson's Affordances

James G. Greeno

Gibson developed an interactionist view of perception and action that focused on information that is available in the environment. He thereby rejected the still-prevalent framing assumption of factoring external–physical and internal–mental processes. The interactionist alternative, which focuses on processes of agent-situation interactions, is taken in ecological psychology as well as in recent research on conversational communication, research on complex, socially organized activity, and philosophical situation theory. The concepts of *affordance* and *ability* are key ideas in an interactionist account. In situation theory, abilities in activity depend on *attunements to constraints,* and affordances for an agent can be understood as conditions in the environment for constraints to which the agent is attuned. This broad view of affordances includes affordances that are recognized as well as affordances that are perceived directly.

In his 1954 article on visual perception of motion and movement, Gibson discussed several ways in which perceptions of motion and movement have to be understood relationally. As he remarked, citing Koffka (1935), "Just as a motion for the physicist can be specified only in relation to a chosen coordinate system, so is a phenomenal motion relative to a phenomenal framework" (J. J. Gibson, 1954, p. 310). Most of the psychology of perception that had been constructed was, and is, about phenomena that occur when an observer is stationary. Implicitly in this article, and more explicitly in his later, more comprehensive theorizing (1966), Gibson argued that a psychology of perception that is only about stationary observation neglects some of the crucial characteristics of what it claims to be about.

Another commitment of Gibson's contributions was to a psychology of perception that avoids subsuming perceptual phenomena inappropriately to an apparently more comprehensive theory. I recall a meeting in which an animal psychologist was reporting on observations of the development of sex differences in young dogs, and he said that one function of urinating by male dogs was to leave messages. Gibson said, "They leave messages? What do they say?" Although there surely is some intercanine function of urination involving territory, Gibson resisted the casual characterization of that process in terms of symbolic communication.

On another issue, J. J. Gibson and E. J. Gibson, in articles also published in *Psychological Review* (J. J. Gibson & Gibson, 1955a, 1955b), argued that perceptual learning should not be subsumed by the general stimulus–response theory that was then at the center of scientific research and thinking about action and learning. They proposed that the psychology of perceptual learning should be about learning to perceive more of the differentiating qualities of stimuli in the environment rather than acquiring associated responses that cause greater differentiation by enrichment of stimuli as a result of past experience. Postman (1955) criticized Gibson and Gibson's (1955a) discussion, arguing that "descriptively, perceptual learning *is* the attachment of new responses, or a change in the frequency of responses, to particular configurations or sequences of stimuli" (Postman, 1955, p. 441) and that "the need to account for changes in response inevitably endows the problem of perceptual learning with an associative component" (Postman, 1955, p. 442). The Gibsons were not convinced by Postman. In their view, "the main difficulty in the way of the traditional enrichment theory is its implication that learning involves a decreasing psychophysical correspondence between perception and stimulation" (Gibson & Gibson, 1955b, p. 448). They reiterated their previous contention that "perceptual learning . . . consists of responding to variables of physical stimulation not previously responded to. The notable point about this theory is that learning is always supposed to be a matter of improvement—of getting in closer touch with the environment" (Gibson & Gibson, 1955a, p. 34).

In their discussions of perception and perceptual learning in the 1950s, J. J. Gibson and E. J. Gibson did not present a broad theoretical framework in which their views were encompassed. In their continued work over the years, however, strong, systematic theorizing was an important part of their contributions. In the 1960s, E. J. Gibson (1969) proceeded to develop a general theory of perceptual learning and development, and J. J. Gibson developed a general theoretical framework for perception and sensation, which he presented in *The Senses Considered as Perceptual Systems* (J. J. Gibson, 1966). Cognitive science was in the early stage of its development around the core idea of information, and the main stream of cognitive science developed a theory of information processing. Gibson differed, and he focused on the question of what information is available. In his view, many questions about how information is constructed by people and animals could be considered better as questions about what sources of information there are in the environment that people and animals use in their activities. This framework is an alternative to the mainstream view, in which people and

James G. Greeno, School of Education, Stanford University, and the Institute for Research on Learning, Palo Alto, California.

Correspondence concerning this article should be addressed to James G. Greeno, School of Education, Stanford University, Stanford, California 92305.

animals are thought to construct the world that they live in and understand. In Gibson's view, people and animals are attuned to variables and invariants of information in their activities as they interact as participants with other systems in the world that we inhabit.

Gibson's view of perception has been difficult for many cognitive scientists (e.g., Fodor & Pylyshyn, 1981; Ullman, 1980; Vera & Simon, 1993) to understand. I believe this is because Gibson's reasoning involves some quite general framing assumptions about activity and cognition that differ from those of mainstream cognitive science. He expressed some of these more general ideas in the 1970s in discussion of the concept of *affordances* (J. J. Gibson, 1977, 1979/1986), and the task of developing a systematic general ecological psychology is being carried on by a growing group of investigators (e.g., Shaw, Turvey, & Mace, 1982; Turvey, 1990, 1992).

Situativity and the Concepts of Affordance and Ability

Bickhard and Richie (1983) argued that Gibson's thinking evolved from a view of perception as encoding features of the environment toward a more general view of perception as an aspect of a person's or animal's interaction with the environment. The encoding view, which is still prevalent in information-processing psychology, involves analyzing cognition in terms of a factoring assumption that supports analyses of different stages of cognitive processing in relative isolation from each other.

A claim of ecological psychology, as I understand it, is that the interactions among aspects of cognition and behavior are sufficiently subtle and complex that our prevalent factoring strategy is scientifically unproductive. As Turvey has put it, "The types of phenomena that should lead the way must be drawn from perception in the service of action and from action in the service of perception" (Turvey, 1992, p. 86). When perception, motor movement, memory, reasoning, or whatever, is studied as a separate factor, one hopes that the conclusions one takes from those studies apply in situations where other factors have significant roles. Although there have been occasional objections to the factoring assumption (e.g., by Dewey, 1896; Lashley, 1951), factoring of processes—especially into events occurring outside and inside the mental system—has been a persistent methodological commitment of psychological research. Gibson was already suspicious that perception and the observer's movement did not factor neatly in the perception of motion when he wrote "The visual perception of objective motion and subjective movement" (J. J. Gibson, 1954). That lack of factoring became a major point of his more general theory of perception (J. J. Gibson, 1966) and has been a key issue in the development of ecological psychology, for example, in the analysis of information that is available to a person or animal moving through a spatial environment (Cutting, Springer, Braren, & Johnson, 1992; Lee, 1980). An important feature of the ecological view involves a shift in situations that are taken as paradigmatic cases of cognition. Rather than building a theory of perception on analyses of situations with stationary observers, and building a theory of action on analyses of situations where an agent tries to reproduce a movement of an object in space, ecological psychologists are working to build a theory of activity,

including perception and movement, by analyzing situations involving continuous interactions, such as cascade juggling (Beek & Turvey, 1992) and pursuit of a batted fly ball by a baseball outfielder (Michaels & Oudejans, 1992).

The framing assumptions of ecological psychology are one form of a general theoretical stance, which can be called *situativity theory* (Greeno & Moore, 1993), in which cognitive processes are analyzed as relations between agents and other systems. This theoretical shift does not imply a denial of individual cognition as a theoretically important process. It does, however, involve a shift of the level of primary focus of cognitive analyses from processes that can be attributed to individual agents to interactive processes in which agents participate, cooperatively, with other agents and with the physical systems that they interact with. If, in analyzing those interactive processes, one concludes that some of them factor conveniently into aspects that can be attributed to the environment and aspects that can be attributed to individual minds, that will be a useful and productive result. Those of us who are developing situativity theory, however, believe that the factoring assumption should not be taken as a general methodological and theoretical commitment.

Research in ecological psychology has focused mainly on relations of agents with physical systems and environments. In other research, processes of communication and reasoning are also being approached in ways that are inconsistent with factoring assumptions that have typically been made. Clark and Schaefer (1989), Schegloff (1972), and others have analyzed conversations as interactive collaborations in which contributions, such as references to a place, are considered as successful joint actions rather than as events that occur when one person uses a referring term. Many studies of socially organized problem solving and reasoning in complex environments have been conducted, including a study by Suchman and her associates (Brun-Cottan et al., 1991) of the ground operations of an airline, and studies by Hutchins (1991, in press) of processes of calculating a military ship's position as it enters a harbor and of remembering to adjust the wing flaps of a commercial aircraft as its speed decreases during a landing. Symbolic representations of information in these situations are very tangible, and the theoretical analyses that turn out to be productive are at the level of functions that are accomplished by groups of people interacting with each other rather than of hypothetical mental representations constructed by and operated on by individuals.

The view of problem solving that assumes a process of search in a symbolic problem space consisting of representations of an initial state, a goal, and a set of operators combined with a problem solver's domain-specific knowledge and strategy for planning, has been challenged in studies of reasoning and decision making in activities of trying to get malfunctioning photocopying machines to work (Suchman, 1987), of grocery shopping and food preparation by American adults (Lave, 1988); of selling produce, candy, and other commodities by young Brazilian street merchants (Carraher, Schliemann, & Carraher, 1988; Saxe, 1991); of making inferences about quantitative properties of a physical system that behaves according to linear functions by middle-school and high-school students (Greeno, Moore, & Mather, 1993); and of solving or constructing explanations of algebra word problems (Hall, 1990). These studies have taken an interactivist view of reasoning, considering it as

an interaction of the problem solver with material systems that include meaningful symbols and considering the interpretation of the symbols' meanings as an important process to be understood. An aspect of this approach was anticipated by J. J. Gibson and E. J. Gibson (1955b), who argued, against Postman (1955), that study of learning to perceive symbols should focus on processes of differentiation. "Symbols, like natural objects, must be differentiated or identified in order to be carriers of meaning. They come in sets, not singly. And it is quite possible that the meaning of a symbol, in the mathematico-logical sense, is given by its univocality within the set" (Gibson & Gibson, 1955b, pp. 449–450).

A proposal by Neisser (1992) is particularly relevant to the perception of symbols. Neisser has argued that one needs to distinguish two kinds of perceptual processes, which he calls direct perception and recognition. Direct perception, which provides information for orientation and locomotion in space, occurs in dynamic interaction with the environment. Recognition, which provides information for identifying and classifying objects and events, is more effective when the observer can accumulate information about the features of an object or arrangement.

If we choose not to factor behavior into the process categories of perception, memory, movement, reasoning, decision making, and so on, one then needs theoretical terms for referring to aspects of the phenomena and systems at the level of agent–situation interactions. Gibson's concept of *affordance* is a key proposal. The idea is quite straightforward. In any interaction involving an agent with some other system, conditions that enable that interaction include some properties of the agent along with some properties of the other system. Consistent with his emphasis on understanding how the environment supports cognitive activity, Gibson focused on contributions of the physical system. The term *affordance* refers to whatever it is about the environment that contributes to the kind of interaction that occurs. One also needs a term that refers to whatever it is about the agent that contributes to the kind of interaction that occurs. I prefer the term *ability*, although Shaw et al. (1982) preferred to coin the term *effectivity* for that concept. I believe my use of the term *ability* is also synonymous with Snow's (1992) use of the term *aptitude.*

Affordances and abilities (or effectivities or aptitudes) are, in this view, inherently relational. An affordance relates attributes of something in the environment to an interactive activity by an agent who has some ability, and an ability relates attributes of an agent to an interactive activity with something in the environment that has some affordance. The relativity of affordances and abilities is fundamental. Neither an affordance nor an ability is specifiable in the absence of specifying the other. It does not go far enough to say that an ability depends on the context of environmental characteristics, or that an affordance depends on the context of an agent's characteristics. The concepts are codefining, and neither of them is coherent, absent the other, any more than the physical concept of motion or frame of reference makes sense without both of them.

As Gibson's idea of affordances has been developed in research, it seems most productive when it is treated as a graded property rather than as a property that is or is not present. A beautifully simple example by Warren and Whang (1987) involves the affordance of an aperture for a person to walk from one side of a partition to the other. The affordance provided by an aperture is a function of its width, and the ability of a person to move through the aperture depends on the person's width. Warren and Whang's analysis of this affordance focused on an interesting feature of behavior in the range of aperture- and person-widths in which the affordance varies. They measured whether participants walked straight through apertures, which varied in width, or turned their shoulders. The frequency of shoulder-turning decreased as the width of the aperture increased. There were two groups of participants: one group of greater-than-average size and the other group of smaller-than-average size. The psychometric functions of shoulder-turning frequency versus aperture size differed between the two groups when aperture size was plotted in ordinary physical units. When aperture size was plotted as a ratio of the physical width of the aperture to the width of the participant's shoulders, the two psychophysical functions were nearly identical.

Affordances and Abilities in Situation Theory

A significant shift in theoretical perspective can be aided by—and sometimes requires—use of a different formal system. Turvey (1992) and his associates have used the theoretical formalisms of dynamical systems theory productively in analyzing systems such as juggling and the gaits of animals.

Another system that provides theoretical and formal support for an interactivist psychology is situation theory (Barwise & Perry, 1983; Devlin, 1991), which includes a significant reformulation of logic. One example of the kind of shift that situation theory proposes is its characterization of the meaning of symbolic expressions, such as sentences. In standard logic and linguistics, the meaning of a sentence is a relation between the sentence and conditions in the world that the sentence asserts, generally focusing on conditions in which the sentence is true. In situation theory, the meaning of a sentence is a relation between situations. The meaning of a spoken sentence is a relation between the situation in which the sentence is uttered and the situation about which uttering the sentence conveys information. Analysis of a sentence's meaning includes specifying the epistemic connection that the speaker has with the situation that the sentence refers to. Relativizing the meanings of sentences this way has very salutary effects, including resolution of the classical philosophical puzzles about reference known as the liar paradox (Barwise & Etchemendy, 1987).

In situation theory, the concept of *constraint* plays a key role. A constraint is a regularity involving *situation types.* A situation type is a class of situations with objects that have a specified property of relation. For example, $\langle\langle reading, \acute{a}, \acute{b}; 1\rangle\rangle$ designates a type of situation where there is something (indicated by $\acute{a}$) that is reading something else (indicated by $\acute{b}$). For example, you are in a situation that is of this type, where $\acute{a}$'s anchor is you and $\acute{b}$'s anchor is this article. A constraint is a dependency relation between situation types. For example,

$$\langle\langle reading, \acute{a}, \acute{b}; 1\rangle\rangle \,\&\, \langle\langle printed, \acute{b}; 1\rangle\rangle \Rightarrow \langle\langle seeing, \acute{a}, \acute{b}; 1\rangle\rangle,$$

is a constraint that says that if one thing is reading another thing, and the thing being read is printed, then the thing that is reading it is also seeing it.

Situation theory provides a way of thinking about knowing how to do things, in its concept of *attunement to constraints.* Barwise (1989) attributed the idea of attunement to J. J. Gibson, and Gibson (1966/1982) attributed it to Lashley (1951). Several analyses (e.g., Barwise & Perry, 1983; Israel & Perry, 1991) have considered attunement to constraints as a basis for making inferences. For example, attunement to the constraint that *smoke means fire* (i.e., a situation of the type that has smoke is also a situation of the type that has fire) will support an inference by someone who perceives smoke that there is a fire there.

Attunement to constraints also can play an important role in analyses of skilled activity. For example, in steering a car, the driver is attuned to subtle and complex constraints that relate changes in the direction of the car's forward motion with amounts of turning the steering wheel. The driver's actions of exerting force on the wheel have effects of making the wheel turn more or less depending on the force that is applied, and of making the direction of the car change more or less depending on the amount the wheel is turned.

Many constraints only hold conditionally, and *conditional constraints* are often used in analyses. For example, the constraints that relate turning a steering wheel to changing the direction of a car's motion are conditional on, among other things, the car's steering mechanism being intact.

The idea of conditional constraints provides a way to characterize affordances and abilities quite clearly. A skilled practitioner's actions have effects that are functional in the activity. In other words, there are constraints of the following form:

$$\langle\langle \text{action by agent} \rangle\rangle \Rightarrow \langle\langle \text{good effects in situation} \rangle\rangle$$

where "good effects" are outcomes that are needed or desirable for a broader activity to be successful. Affordances and abilities can be thought of as conditions in which the constraints of successful performance hold.

As a simple example, consider moving from a hallway into a room in a building. An action that accomplishes that is walking into the room, which has the desired effect that the person is in the room because of the action. The relevant constraint is as follows:

$$\langle\langle \text{walk into the room} \rangle\rangle \Rightarrow \langle\langle \text{be in the room} \rangle\rangle.$$

Affordance conditions for this constraint include the presence of a doorway that is wide enough to walk through as well as a path along a supporting surface. If there is no doorway, or if the floor is too weak to support the person's weight at some point along the path, or if there is a large obstacle somewhere along the pathway, the constraint does not apply. Ability conditions for the constraint to include the ability to walk along the path, including the perceptual ability to see the doorway and the coordination of vision with motor activity needed to move toward and through the doorway.

In the more complicated situation of driving, action–outcome constraints for the driver include moving her or his arms some amount while holding the wheel, with the outcome that the car's direction changes by some amount:

$$\langle\langle \text{movement of arms} \rangle\rangle \Rightarrow \langle\langle \text{car changes direction} \rangle\rangle.$$

Affordance conditions for this constraint include the shape and other mechanical features of the steering wheel, which is designed to afford rotary movement, and the mechanical arrangement of the steering system that translates rotary motion of the steering wheel into turning the wheels of the car. Ability conditions for this constraint include the driver's ability to grasp the wheel and to move her or his arms in the plane of the steering wheel. If we were to focus an analysis on a more general functional action, such as having the car stay in a traffic lane as the road turns, ability conditions would include perceptual abilities to see the lane markers or the edge of the road in relation to the car's movement in the space and perceptual–motor coordination of that dynamic visual information with the action of turning the steering wheel.

Viewed in this general way, the concepts of affordance and ability can be used in any analysis of activity, and some interesting implications are suggested. For example, participants in conversations utter words and phrases that they expect will result in reference to objects, places, properties, events, and so on. People who share a linguistic practice are attuned to a great many constraints that include conventions of reference. Such constraints have the following form:

$$\langle\langle \text{use of a term} \rangle\rangle \Rightarrow \langle\langle \text{refer to something} \rangle\rangle.$$

Constraints of this kind are obviously conditional. They only hold when participants in the conversation are attuned to a shared set of constraints. Many constraints also depend on the conversational setting.

Affordance conditions for reference constraints include properties of the language that the participants use. For example, just as a car's steering wheel, shaped so the driver can grasp and turn it, affords changing the car's direction, a term in a language, composed of phonemes that a speaker can pronounce, affords referring to an object or property that the term is used to designate. Abilities to speak and perceive the terms of the language are among the ability conditions required for constraints of reference to apply in conversational activity.

Affordances for reference constraints also are present in situations where conversations take place. Most obviously, when the objects we want to refer to are in the situation, their presence is an affordance for ostensive reference, for example, by pointing and saying, "That one." In Clark and Wilkes-Gibbs's (1986) study of collaborative reference, two participants were given identical sets of cards with tangram pictures. One of the participants had the cards arranged in a sequence, and the task of the pair was to communicate so the other participant's cards were in the same sequence. The task was made challenging by preventing the participants from seeing each others' cards because a screen blocked their views.

The participants could accomplish the task because their shared language had terms to designate properties of shapes and locations, such as "triangle next to the square," and familiar forms that could be recognized as similar to some of the tangram forms. Over a few trials, the pairs developed conventions that enabled them to refer to the various cards more economically. In the terms of my theoretical proposal here, they developed elements of a communicative practice, including constraints of reference that had not been available to them initially.

Analyses of reasoning also can be framed in these terms. Along with several students and other colleagues, I have been working toward a situativity-theoretic analysis of reasoning about quantitative properties of a physical system that we designed for research purposes a few years ago. The system, which we call "winches," has two tracks in which small metal blocks are pulled by strings that wind around spools when a handle is turned. Distances along the tracks are shown by 1-in. unit rulers, and different sizes of spools are varied to provide different distances per turn of the handle. We have set up situations with the blocks in some starting positions, connected to spools of some sizes, and asked questions. For example, the red block may be at 9, connected to a 3-in. (circumference) spool, with the blue block at 0, attached to a 6-in. spool. An example of the questions we asked students is, "Will the blue block ever be ahead of the red block? If so, after how many turns?" Student participants were quite successful in answering such questions, and they used an interesting variety of methods. Some answers were obtained in ways that involved direct interaction with the physical device, by pointing to successive positions along the rulers where the blocks would be after different numbers of turns. Some answers used another physical medium, paper and a pencil, to record symbols for the positions the blocks would be in after successive turns. Some answers were obtained using arithmetic relations and operations, either spoken aloud as a student worked them out or reported retrospectively after an answer was given. To analyze these processes, we have developed hypotheses about ways in which inferences are made about both ordinal and numerical properties of the blocks' motions, in which the physical presence of the winches provide significant affordances, as do physical symbols for numbers that are on the rulers or are constructed by the participants by writing (Greeno et al., 1993). In answering the questions, students provided evidence that they were attuned to constraints of the winches' operation, such as the constant distance that each block moved on each turn, and the correspondence between the physical distances moved in a sequence of turns and arithmetic relations of adding or multiplying numbers.

Affordances for the activities of reasoning were provided by the physical presence of the winches, so students could point to positions along the track and, we hypothesize, mentally simulate events of moving the blocks. Affordances were provided as well by the physical resources for writing symbolic representations in the form of tables. Affordances also were provided by the conceptual entities and operations of arithmetic, which were available to the student by virtue of their participation in the social practices of school and other settings where numerical symbols and inferences occur.

In a subsequent study, Moore (1993) observed performance on these reasoning tasks in different situations: one with the physical winches present, one with a computer-graphic simulation of the winches along with numerical symbols of the positions of the blocks after each simulated turn, and one in which tables of numerals are constructed without reference to a system to provide a physical (or simulated physical) semantic interpretation. Students' performance provided evidence that the differences among the reasoning environments affected their reasoning activity. Apparently the physical or simulated winches afforded reasoning, to a greater degree, about ordinal

dependencies between variables (e.g., if the spool is larger, the block moves farther on each turn) and relations between the blocks' positions (such as how much one block gains on the other).

As I understand it, situativity theory does not imply that human activity does not use symbols, and its domain is not limited to processes in which symbols play no role. It does treat symbols as a special kind of resource for cognition, however, and attempts to analyze the ways in which symbols function as components of the situations that people are in when they reason and communicate. Hall's (1990) study of algebra students and teachers solving word problems provided particularly instructive examples of ways that problem solvers construct symbolic representations that facilitate their reasoning, locating symbols that relate to each other in convenient spatial arrangements.

Perception of Affordances

Discussions of Gibson's concept of affordance have been plagued by confusion about where to locate the reference of the term. For example, is the affordance that a chair provides for sitting a property of the chair, a property of the person who sits on it or perceives that he or she could sit on it, or something else? It seems clear to me that Gibson's intention was that the affordance is a property of whatever the person interacts with, but to be in the category of properties we call affordances, it has to be a property that interacts with a property of an agent in such a way that an activity can be supported.

Affordances are, in this view, preconditions for activity, as I believe is made clearer when they are treated as conditions for constraints. The presence in a situation of a system that provides an affordance for some activity does not imply that the activity will occur, although it contributes to the possibility of that activity. Additional conditions include aspects of the activity of an agent in the situation, having to do with motivation and perception. Motivation to engage in some action is related to what the agent is doing at a more general level. For example, if a person is engaged in an activity of going to attend a class, then the action of moving into the classroom is a functional part of that activity. That will make the person attentive to aspects of the environment that could provide an affordance for moving into the classroom, such as the doorway from the hall into the classroom.

Consistently with his view of perception as a process of picking up information directly, Gibson characterized affordances as properties of objects and layouts that are specified by information in the array of energy that is available to an agent's perceptual systems. This characterization works well for many affordances, such as the affordance of a doorway for moving to the other side of a partition. The question of how the affordance is perceived is a straightforward research problem, and experiments conducted by Warren and his associates provide elegant examples of analyses that identify the information that human perceptual systems pick up to detect affordances. In the case of perceiving the affordance of a doorway, Warren and Whang's (1987) analysis indicated that the effective stimulus is the visual information that specifies the physical width of the doorway, scaled to the eye height of the observer.

In addition to affordances for orientation and locomotion in

space, it is likely that many affordances for individual actions in conversations and other interpersonal interactions are perceived directly, that is, without need for mediating symbolic representations. In conversations, pauses, facial expressions, and other gestures provide information that influences the opportunities for each participant's actions. Analyses of the auditory and visual energy characteristics that specify these affordances have not been done, to my knowledge. Even so, there is strong evidence that mediating symbolic representations are not required for their perception because infants are responsive to important features of these social stimuli well before they have developed the capability of forming symbolic representations that denote them (e.g., Tomasello, Kruger, & Ratner, in press).

In the broad meaning that I am proposing for the concept of affordance, it would be inappropriate to consider direct perception of affordances as a defining characteristic. J. J. Gibson (1979/1986) used mailboxes as an example. He proposed that a mailbox provides an affordance for posting letters, and it surely does that. It seems likely that for most people, in most if not all circumstances, the process of cognizing that affordance includes classifying the physical object as a mailbox. The information required for that classification has to be visually available, of course, but the process of classification includes, I should think, a mental state that has the epistemic status of a symbol that designates the property of being a mailbox. A theoretical possibility that seems reasonable is that mental symbols of that kind are products of the perceptual processes that Neisser (1992) regarded as recognition, rather than direct perception.

What of symbols that are recognized and used in processes of making inferences? As J. J. Gibson and E. J. Gibson (1955b) recognized, symbols need to be identified to be used meaningfully. In Neisser's (1992) distinction, then, perception of symbols is a process of recognition, rather than a process of direct perception, and if my conjecture about mental symbols is correct, such recognition creates mental symbols. It follows, then, that those mental symbols could be available for processes of making inferences according to operations that transform symbolic expressions into other symbolic expressions. In our analyses of reasoning (Greeno et al., 1993) we have taken this as an assumption. People represent with mental symbols in different ways, just as one does with spoken or written symbols. We represent with some symbols as propositions, and inferences have the form of generating further representations of propositions. One can represent with other symbols as simulations, and inferences have the form of operating on a model to generate states with properties that correspond to the represented system.

A theoretical understanding of mental symbols, including mental states that function as simulations, could provide a basis for understanding conceptual entities, such as numbers, arithmetic operations, and functions. Some progress has been made toward theoretical understanding of the ability to form anticipatory mental models that simulate outcomes of activity in situations (Jordan & Rumelhart, 1992). We need to understand how that ability includes forming models that satisfy constraints that we express and understand in communication with statements of propositions. This could provide a theory of learning that results in shared mental models that support reasoning about the properties of conceptual entities, with the properties represented implicitly in mental simulations rather than being explicitly stated in propositions.

Conclusions

J. J. Gibson's theorizing in the 1950s, in his own writing (Gibson, 1954) and with E. J. Gibson (J. J. Gibson & E. J. Gibson, 1955a, 1955b), reflected two general commitments. One commitment was that important phenomena should not be left out of the psychology of perception simply because they were difficult to study with available experimental methods. Another commitment was that concepts in the theory of perception should not be subsumed under the apparently broader psychological concept of stimulus–response association because the view of perception and perceptual learning that results from that subsumption is theoretically less adequate than another view involving differential attunement.

Gibson did not, however, treat the psychology of perception as a compartment closed off from the rest of psychology. In his later theorizing, he worked toward a broader view of behavior that would be consistent with a theoretically adequate understanding of perception. This view focuses on interactive relations of behaving agents with systems in their environments. In Gibson's view, perception is a system that picks up information that supports coordination of the agent's actions with the systems that the environment provides. This led him to develop the idea of affordances, the characteristics of objects and arrangements in the environment that support their contributions to interactive activity and, therefore, the characteristics of the environment that agents need to perceive.

Considerable efforts are being made to develop a general theoretical account of activity considered as interactions of agents with systems in their environments, and significant progress is occurring. Some of these efforts, in ecological psychology, have used Gibson's idea of affordances quite explicitly. Other efforts, focused on situations involving social interactions as well as interactions with physical systems, mainly use concepts and methods of ethnographic social science. We should aspire to a theory that merges these perspectives, along with the insights and methods of information-processing cognitive science; these support analyses of information structures that are the contents of human symbolic communication and describe the contents of other interactions of agents in situations. I have suggested, in this commentary, some ways in which an extended version of Gibson's concept of affordance is involved in one version of this general theory of activity. Gibson's theorizing was seminal in the development of ecological psychology and is likely to be seminal in a more general development of a theory of activity viewed as interactive relations of agents with other agents and physical systems. Gibson's affordances, then, have already been of great value and will support further valuable activity in our field.

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