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Situativity and Symbols: Response to Vera and Simon

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Vera and Simon (1993) have provided a helpful and welcome challenge in their articulate questioning of the point of view that emphasizes the situated character of action, including cognition and learning. A full discussion of their arguments and examples requires more space than we are allotted for this response, and we are preparing a longer article that will consider the issues they raised in more detail. We also welcome this opportunity to comment briefly on their provocative arguments.

The Issue of Symbols

Vera and Simon attribute several beliefs to researchers who are developing situativity theory, some of which we disclaim for ourselves and consider dubious regarding other situativity theorists. However, we do accept their characterization that our view "denies that symbolic processing lies at the heart of intelligence" (pp. 7-8). As we understand the current state of the debate, the issue hinges crucially on the meaning and theoretical status of the concept of *symbol.*

In our view, the emerging scientific practices, empirical findings, and theory that we call *Situativity theory;* include the development of ecological psychology (e.g., Kuglef "&~furvey, 1987; Shaw, Turvey, & Mace, 1982; Warren & Whang, 1987), the ethnographic^study_-oLactivity (e.g., Cole, 1990; Hutchins, 1990,1991; Laboratory of Comparative Human Cognition, 1983; Lave, 1988; Lave & Wenger, 1991; Suchman, 1987), and philosophical situation theory (e.g., Barwise, 1989; Barwise & Etchemendy, 1987; Barwise & Perry, 1983; Devlin, 1991). The central claim of situativity theory is that cpgnitive activities should be understood primarily as interactions between agents and physical systems and with other people. Symbols are

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often important parts of the situations that people interact with, and understanding how symbols are used and constructed in activities is one of the major problems of cognitive theory. From this viewpoint, operations on and interpretations of symbols can be important aspects of cognitive activity, but constitute only some of the phenomena that a theory of cognitive activity should endeavor to explain. We expect that accounts of some individual and social cognitive phenomena will include hypotheses about processes that use symbols, but others will not. More generally, we expect that accounts of most—perhaps all—individual and social cognitive phenomena will include hypotheses about processes that are not symbolic, and that a theory of cognition should help us understand how symbolic processes are involved in individual and social cognitive processes.

According to the symbolic processing view that Vera and Simon advocate, symbols are fundamentally involved in all cognitive activity. Every account of cognitive phenomena consists of a set of operations that construct and modify symbolic structures; that is, every cognitive process is a symbolic process. Some cognitive processes are considered as being situated, and others are apparently thought not to be situated, or at least the situativity of some processes is not crucial for their scientific analysis.

The question, then, seems to be something like this: whether (1) to treat ~ cognition that involves symbols as a special case of cognitive activity,jyitji the assumption that situativity is fundamental in all cognitive activity, or (2) to treat situated activity as a special case of cognitive activity, with the assumption that symbolic processing is fundamental in all cognitive activity. We advocate the first option; Vera and Simon advocate the second. We use the term *situativity theory,* rather than the term in more common use, *theory of situated cognition,* because the phrase *situated cognition* often is interpreted, understandably, as meaning a kind of cognition that is different from cognition that is not situated. Because we assume that situativity is *a* general characteristic of cognition, and want to develop scientific practices, knowledge, and a theory in which that assumption plays a central role, we may signal our intentions more clearly with a phrase that more obviously refers to the kind of theory of cognition that we want to develop, rather than seeming to refer to a kind of cognition.

As we use the terms, a symbol or symbolic expression is a structure—physical or mental—that is interpreted as a representation of something. This use of the term *symbol* is consistent with a long tradition in philosophy, psychology, and linguistics. Examples include Dewey's (1938) distinction between *signs* and *symbols,* and Peirce's (1902/1955) distinction between *indices* and *symbols.* In our version of the view, we treat semantic interpretation as something that people do. Interpretation of symbolic expressions, viewed in this way, is an important aspect of agents' interactions with each other and with the world, but it is not the only aspect that we need to investigate. Understanding the ways in which people construct symbols with meanings and attribute meanings to symbols is a critical problem in cognitive and social science, but it is not the whole problem.

As we understand Vera and Simon's view, which seems consistent to us with other symbolic processing theorists, the concept of *symbol* is used to account for all action in which cognition plays a role. They characterize denotation and designation as follows:

> An information system can take a symbol token as input and use it to gain access to a referenced object in order to affect it or be affected by it in some way. Symbols may designate other symbols, but they may also designate patterns of sensory stimuli, and they may designate motor actions, (p. 9)

In the analyses that they discuss, there is a modal shift from what information systems can or may do to what they do. Actions are explained by processes that construct and modify symbolic structures. To paraphrase Vince Lombardi, Vera and Simon, representing the symbolic processing view, assert that symbolic processing isn't the most important thing, it's the only thing. The theoretical problem of meaning, understood as the question of how symbols are interpreted as having reference, becomes the problem of functional relations among mental states. It seems ironic that, as a result of promoting the concept of *symbol* to such a central role in the theory of cognition, the question of how people use symbols to create and communicate meaning seems to have disappeared.

DIFFERENCES ABOUT AFFORDANCES

An illustration of the theoretical differences is Vera and Simon's discussion of the concept of affordance, which Gibson (1979/1986) began to develop. Vera and Simon discuss the activity of a driver changing the direction of a car. They represent part of this event as a production rule: "If the road curves to the left—turn to the left." (p. 19) They then state that "the condition in the production we have written is closely related to what Gibson (1977) called an 'affordance.'.. .Notice that the affordance is not a simple property of the physical environment___ Contrary to Gibson's view, the thing that corresponds to an affordance is a symbol stored in central memory, (pp. 19-20) Regarding the driver's action of turning the wheel, "The action of the production is the symbol that initiates this whole sequence: denotes it and its functional outcome of following the road" (p. 20).

Our view of affordances is much closer to Gibson's (1979/1986) as we understand his idea. Gibson used the term to refer to characteristics, of things in the environment that are related to characteristics of people or animals in ways that are relevant to the support of activities. The term *affordance,* as Gibson used it, refers to properties of the things in the environ-

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ment that are relevant to their contributions to interactions that people have with them. By saying that the affordance is a mental symbol, Vera and Simon convert Gibson's concept from being about objects in the environment to being about someone's perception of the environment. Perception is important, but it is not the same as the thing that is perceived.

The issue of perceiving affordances is crucial in the theoretical view of situativity, and our position, in contrast to Vera and Simon's, depends importantly on Gibson's (e.g., 1966) concept of direct perception, as developed recently by Neisser (1989, 1992). Gibson argued that information that specifies where we are in a spatial environment and the locations of objects in relation to our paths of movement is not perceived by creating cognitive representations and performing mental calculations (presumably unconsciously), but by a more direct process that he called *pick-up* of information, or *direct perception*. Neisser's theory distinguishes between direct perception and *recognition* as two kinds of perceptual interaction. Direct perception provides information that specifies where a person or animal is and where he, she, or it is moving in relation to other objects and surfaces in the environment; recognition provides information that identifies what the objects, surfaces, and other components of the environment are, either as known individual objects (e.g., finding one's automobile in a parking lot) or as members of a category (e.g., that an object near the edge of a road is a person). This distinction is correlated with—perhaps, corresponds to—the familiar distinction in visual perception between a "where" and a "what" system, more specifically between an *ambient* mode and a *focal* mode. Herschel Liebowitz (personal communication) cited, as an example, the simultaneous activities of walking and reading, with information for recognizing words in the text provided mainly in foveal vision and information for orientation, including avoiding collisions, provided mainly in peripheral vision. Liebowitz and Post (1982) remarked that "although visual information is adequate for the focal mode, the ambient mode involves the coordination of motor activity with the visual, vestibular, auditory, and somatosensory systems, particularly, kinesthesis" (p. 344).

Gibson (1979/1986) proposed that affordances are specified by information in the visual field and are perceived directly, and Neisser (1989, 1992) agreed, although Neisser specified the domain of potential activities with directly perceivable affordances more narrowly than Gibson did. Vera and Simon note this hypothesis; however, they conclude that this ecological view is incorrect: "SA cannot get along without an internal representation. In fact, its representation is the result of a complex translation into functional language of a physical situation of which the functional significance is only implicit" (p. 20). In a response to an editorial question by us about direct perception of affordances, Vera and Simon (personal correspondence) said, "If sensation and perception depend on biochemical and physical meoianisms, then there must be a process that produces an internal representation (in memory) from the physical signals (e.g., light rays) received on the retina from 'out there.'... we cannot accept an effect without both a process and an embodiment (some modification of brain structure). If 'af for dances' were not invented to deny this, then they must refer, as we suggest, to these highly encoded internal function-designating symbols that we describe."

We accept the premises of this syllogism, but do not think that its conclusion follows. The difficulty lies in an additional premise that Vera and Simon do not make explicit, namely, that every biochemical and physical mechanism involved in sensation and perception produces an internal representation, and that every process and embodiment must construct or use mental symbols. That premise is, of course, the fundamental framing assumption *of* .symbol-processing theory, and is precisely the assumption that we believe is open to question.

The alternative that we prefer distinguishes mechanisms and processes that construct and operate on symbols from mechanisms and processes that do not. This is not a claim that sensation and perception do not depend on biochemical and physical mechanisms, nor does it deny that perceptual effects depend on processes and embodiments. Of course, as a community of theorists, we could decide to use the term *symbol* to refer generally to all mental states that are causally involved in perception and action; however, that does not seem to us to be a good idea, for reasons that we have already-mentioned.

THE NAVLAB EXAMPLE

The Navlab system (Pomerleau, Gowdy, & Thorpe, 1991), discussed by Vera and Simon, provides a useful example. To illustrate our distinction between symbolic and nonsymbolic information processes, we consider two components of Navlab's robot guidance system that drives a vehicle along roads: an annotated map and a connectionist network for steering.

Navlab's annotated map is a data structure that contains information about locations of roads and landmarks in the area that the vehicle will traverse. When the vehicle is moving, a symbol that corresponds to the vehicle has a location, calculated by dead reckoning, that corresponds to where the vehicle is in the terrain.

The connectionist network of Navlab's steering module has a 30x32 matrix of units onto which a sensor image is projected. These units are connected to a set of 5 hidden units, which are connected to an output array of 30 units. The output units correspond to radial positions of the steering wheel. To train the network, a human driver steers the vehicle as it traverses a roadway like the one it will drive on later, and the weights between pairs of units are adjusted by back propagation, using the ima$_{b}$^ from a video sensor as input and the position where the person has the steering wheel as the desired output. During driving, the pattern of activation in the output units determines the steering direction.

Vera and Simon characterize Navlab, including its network component, as a symbolic system, and indeed it is by their characterization of a symbol as a token that functions to provide access to a condition in the environment "in order to affect it or be affected by it in some way" (p. 9). In our view, some of the processes are symbolic and some are not. The question for us is whether a process includes a semantic interpretation of a symbolic expression, that is, an interpretation that gives the symbolic expression referential meaning. One process that is clearly symbolic according to our criterion is recognizing physical landmarks that correspond to symbols in Navlab's annotated map. This process creates a coupling that includes the symbol and the physical object that functions as a relation of reference. The process of determining the vehicle's location is also symbolic, according to our criterion. The annotated map is a spatial structure (or a description that can generate a spatial structure—Pomerleau et al.'s, 1991, report does not clearly say which) that includes a symbol that corresponds to the vehicle and symbols for various objects in the environment. There are semantic interpretations of some of the spatial relations between symbols. If the photosensory information that specifies the location of a landmark in relation to the vehicle does not agree with the corresponding relation on the map, the location of the vehicle-symbol on the map is changed.

According to our criterion, the activation network that connects the photosensory input with changes in the position of the steering wheel does not qualify as a symbolic process, although it surely functions as a perceptual system. There is a causal relation between properties of the physical environment and the patterns of activation in the network, but there is no process of semantic interpretation by which these patterns are given referential meaning. The computational system that converts video and range finder images to operations on Navlab's steering wheel seem to us to be computational versions of direct perception, in Gibson's (1966) and Neisser's (1989, 1992) sense. The effect of training is to adjust the ways in which the system responds to photosensory information, but that response does not include recognition. We note that Pomerleau et al. (1991) also declined to attribute the phrase *symbolic knowledge and reasoning* to the connectionist driving modules of Navlab, although they used that phrase to characterize the system's use of the annotated map.

We will briefly offer a conjecture about the correspondence between each of the three aspects of Navlab's information processing that we have discussed and human perception. Due to space constraints, we will have to postpone a more detailed discussion of these issues to a later article. First, we believe that Navlab's connectionist driving modules are of the same general type as human and animal perception in spatial locomotion—that is, both are examples of nonsymbolic direct perception—but the information that Navlab uses is fundamentally different than the information that humans and animals use. Second, we believe that the use of information in the annotated map about relative locations of the vehicle and objects in the spatial layout is fundamentally different from that used in most situations by humans and animals, that is, the Navlab system exemplifies symbolic processing, whereas humans and animals exemplify direct perception of these features, except under some unusual circumstances. Third, we believe that Navlab's and humans' recognition of objects are of the same general type: both are symbolic processes. At the same time, Navlab's symbolic processes, like those of all computer-based systems at present, seem to us to be very impoverished compared to the human version, mainly in lacking any significant capability for interacting socially with other agents in the construction and negotiation of referential meaning.

ARGUMENTS FOR SUFFICIENCY OR NECESSITY.OF SYMBOLIC PROCESSES

We hope that our discussion of Navlab shows the prospect of developing coherent analyses of cognitive processes that distinguish between processes that construct and use symbolic representations and those that do not. In our view, cognition includes symbolic processing, but they are not coextensive. Within the domain of cognitive processes, symbolic processes have a distinctive component, semantic interpretation.

If the view that we advocate is accepted, then in many situations a hypothetical account of cognition that includes symbolic representations will be more complex than one that does not. For example, if a driver steers a car around a corner, an account that hypothesizes that the relevant information is picked up by a process of direct perception would be more parsimonious than an account that also hypothesizes a process of recognizing the identity of the corner if, as we expect, the latter hypothesis would have to include the perceptual processes of the former, along with other processes. (This does not mean, of course, that symbolic processes are generally more complicated than nonsymbolic processes. An account of a passenger recognizing the corner might be simpler than an account of the driver steering the car around it.) We have taken the view, then, that the inclusion of hypothesized symbolic processes of recognition and representation of action in a theoretical account should be supported by evidence, or at least a theoretical argument, that the symbolic processes are needed to account for performance.

In the light of this view, we were surprised by what seems to be the main burden of Vera and Simon's argument. They contend that models that hypothesize symbolic processes are sufficient to account for complex phenomena in a dynamically changing environment. In our view, the question should not be whether a system that uses symbolic processes is sufficient, but whether the symbolic processes that are hypothesized are necessary. Of course, the meaning of the term *symbol* is part of the theoretical question. But if our characterization is accepted, it would clearly be possible to add a symbolic representation to Navlab's driving module, for example, by including a numerical estimate of the angle that the steering wheel should be rotated and matching that numerical symbol to the reading of a dial that showed the angle that the wheel was turned. Showing that such a model could successfully steer the vehicle would not establish that its symbolic component was required for the process to work. Similarly, the inclusion of symbolic processes (in our sense) in the process of keeping track of where the vehicle is on the annotated map does not show that symbolic processes (in our sense) are required for a cognitive system to keep track of where it is in an environment that it knows well. That function could be achieved by appropriate processes of direct perception and states of its orienting and locomoting system. One interesting proposal along these lines was made by Gallistel (1990) who hypothesized a neural structure that changes its state in ways that enable foraging animals to maintain information about their locations relative to their homes.

ALTERNATIVE VIEWS OF THE STATUS OF SIMULATIONS

None of this implies, to us, that symbolic computational models should become less important in the practices of cognitive science. In our own research, we have constructed models of reasoning processes that include some symbolic processes but also include direct interactions between agents and physical systems that we simulate (Greeno, Moore, & Mather, 1992). Our models include symbolic descriptions of states of affairs that are implied by our hypotheses, and we test the model's validity by comparing those statements with states of affairs that we recorded in experiments. Although we depend on our programs to provide a formalism that facilitates our theorizing with rigor and specificity, our use of computational simulations involves a different meta-theory from the one commonly used in information-processing psychology. We interpret our models as *descriptive* simulations, whereas computational information-processing models have generally been interpreted as *demonstrative* simulations. We claim that the cognitive systems that we theorize about have the properties that our models say they have, but in most interpretations, the claim is that the cognitive systems have the properties that the models have. (Our models include demonstrative claims about mental representations, but as special cases.)

CONCLUSIONS

Vera and Simon conclude "that there is no need, contrary to what followers of SA seem sometimes to claim, for cognitive psychology to adopt a whole new language and research agenda, breaking completely from traditional (symbolic) cognitive theories" (p. 46). We agree that "breaking completely" from symbolic cognitive theories would be the wrong thing to do, but we believe that something like "departing fundamentally" is required. We believe that fundamental insights about mind and intelligence have been achieved by adopting and developing the symbolic processing view, and these insights must be built upon in whatever we move toward now. At the same time, we believe that the symbolic processing framework should be subsumed by a theory in which symbolic processes are considered as a kind of cognitive activity, with the goal of explaining symbolic activity in terms of more general individual and social cognitive principles.

We also question whether the changes that we and others advocate would be "a whole new language and research agenda." An aspect of current developments that we find particularly promising is the prospect of developing scientific practices, including a language and research agenda, that would unify concepts and methods of ethnography and ethnomethodology, ecological psychology, and philosophical situation theory with those of cognitive and behavioral psychology, linguistics, and artificial intelligence. *If* such a synthesis can be achieved, it will not be wholly new, but it will have significantly new features that will emerge in the syntheses and extensions that will be needed.

Within the historical development of psychology., we see, in the present situation, a prospect of completing a dialectical cycle, in which stimulus-response theory was a thesis, sympolicjnf^r^rnation-processing theory .was its. antithesis, and situativity theory wUl_be their synthesis. In the 1950s and 1960s, when the theory of symbolic information processing was being developed in artificial intelligence, cognitive psychology, and linguistics, the prevailing stimulus-response theory in psychology lacked resources for analyzing and representing the complex structures involved in mental activity. A goal of stimulus-response psychology was to account for behavior as much as possible in terms of externally identifiable factors, and the structures of information and procedures were contained in a theoretical "black box." The theory of symbolic information processing has allowed us to investigate the contents of that black box in detail.

We contend that symbolic processing theory presents another black box that contains the structure of interactive relations between cognitive agents and the physical systems and other people that they interact with. Vera and Simon assert that "The symbolic approach does not focus narrowly on what is in the head without concern for the relation between the intelligent system and its surround" (p. 12). Even so, this concern has not led to analyses of agent-setting interactions in anything like the detail thai has been characteristic of analyses of hypothesized cognitive structures and procedures.

In symbolic processing theory, interactions between cognitive agents and external systems have been limited by an assumption that internal events (the mental) can be factored from external events (the physical and social). As Vera and Simon's sketch of an analysis of driving illustrates, the role of the environment is assumed to correspond to a symbolic structure that results from perception; additional symbolic structures are retrieved from memory; operations are applied to the structures; and a symbolic structure is produced that determines the agent's response.

The factoring assumption also characterized stimulus-response psychology, and historically there have been objections to the factoring assumption, including arguments by Dewey (1896), Mead (1934), and Lashley (1951), so the goal of developing a detailed understanding of the structure of agent-setting interactions is not new. The resources that are available now in ecological psychology, ethnography, and philosophical situation theory seem to us to provide a prospect of progressing substantially toward a rigorous and detailed analysis of cognitive processes considered as participatory interactions between agents and physical and social systems.

Symbolic processing theory opened the black box that contains the structures of information and mental procedures. That development merged resources of artificial intelligence and linguistics with psychological resources. We believe that the black box that contains the structures of interactions between agents and physical and social systems is beginning to be opened in the scientific development that we call situativity theory. If we see the situation correctly, this development will merge resources of ethnography, ecological psychology, and situation theory with the resources of cognitive science. We find the prospect extraordinarily promising.

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