The Ability of the Sweeping Model to Explain Human Attention: A Commentary on Christ's Approach

Kevin P. Weinfurt

Georgetown University

The feasibility of Christ's (1991a, 1991b) Sweeping Model as a valid explanation of human attention is explored. As a model of artificial intelligence systems, the Sweeping Model may hold merit, but it certainly cannot explain the phenomenon of human attention. The model's failure in this regard is due to (1) an incomplete conception of the experience of human attention, (2) reliance on an associative neural network that cannot explain human cognition, and (3) the prominence of homunculi that reveal themselves upon closer inspection of the model.

Recognizing the need for attentional capabilities in artificial intelligence (AI) systems, as well as the need for a clearer understanding of human attention and cognition, Christ (1991a, 1992b) has recently proposed the Sweeping Model. The model basically describes a parallel distributed processing (PDP) system with an ability to attend to the environment via frequent "sweeps" of lateral inhibition. That is, the system periodically inhibits some environmental signals from exciting the PDP network while amplifying other signals. Christ characterizes his proposal in the following way: "Although leading toward a computer simulation, this model should be viewed more as a speculative psychological theory of attention and cognition" (1991b, p. 365). I am interpreting "computer simulation" as concerning AI, and "psychological theory" as concerning human cognition. While the Sweeping Model may be an appropriate model for explaining an artificial system, I think it breaks down when one attempts to apply it toward human beings. The Sweeping Model fails to capture human attentional processes for three major reasons: (1) the model seeks to explain data that are already conceptualized in an AI

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framework; (2) the associative neural network which serves as the crux of the model is based on a mediational rather than on a predicational theory of learning; and (3) the model cannot explain attention without invoking a homunculus or black box of the sort it tries to avoid.

Framing the Subject Matter

The Sweeping Model's ability to explain human cognition is limited from the start if what is being explained is conceptualized through a restrictive metatheoretical assumption. One of Christ's underlying assumptions is that human cognition is the same as artificial cognition, at least with respect to attention. One need only read the first paragraph of Christ's article to see that he is explaining at the level of "intelligent systems," be they "natural or artificial" (1991a, p. 247). Such a metatheoretical outlook frames Christ's interpretation of attention from the start. Thus, after a preliminary description of the task of attention for any system, including the attention mechanism, deeper processing of information, etc., Christ states: "The model arising *from the data reviewed here* concerns this internal attention mechanism" (p. 248, emphasis added). Christ maintains that the data could modify or invalidate philosophical ideas concerning the mind (see p. 249), but could data that are already construed in information-processing terminology ever really contradict an information-processing philosophy of the mind?

If Christ's basic notion of attention were true—that meaningful information exists "out there" in the universe and a subset of that already-existing information is selected for deeper processing—then how would it be possible for two different people to see a Gestalt figure in two different ways? In a sense, they are both attending to the same environmental signal or stimuli. Furthermore, how could a person intentionally flip such a figure (e.g., be able to see one edge of a cube facing out as opposed to another)? In both cases, the person *constructs* what exists in the environment. This is not to say that things physically do not exist in the world. It does say that environmental signals do not become information until a person endows them with *meaning*. Regarding Christ's schematization of the attentional process, why does the environment initiate the process? Could we not also imagine the person initiating, attending *to* something, rather than simply sorting and selecting preformed information as it comes in? None of these considerations could be entertained if one chooses to view cognition from an information processing framework. Thus, the Sweeping Model must fall short of explaining attention before it is even conceived of, because the data it seeks to explain do not constitute an accurate picture of the human experience of attention.

PDP Networks and Mediational Learning Theory

The success of the Sweeping Model depends heavily on the veracity of the neural network it invokes to explain cognition. Christ refers to the PDP network as being "where all the magic of attentional processes occurs" (1991b, p. 348), and outlines the basic tasks of such a network:

> The important factors for this model are that the network be able to learn statistical regularities of environmental stimulation, representing these as patterns of activation within the network, and that activation should be able to spread amongst units, in a content-addressable way, to complete these patterns. (1991b, p. 349)

As Rychlak (1991) has pointed out, this type of model is essentially a mechanistic one in that environmental stimuli are taken as *signals* which are processed in a Lockean manner of inputting simple ideas. In such a formulation, the flow and activation of signals are emphasized instead of the logical rendering of meanings. Such a mechanical, signal-chunking machine accurately describes a computer, but not a person.

The mechanistic nature of the Sweeping Model is most evident in the Hebbian learning rule Christ suggests: "at the time of update, simultaneously active units have excitatory connections between them strengthened, and inhibitory connections weakened" (1991b, p. 350). Such a learning theory is in the same vein as the traditional conditioning theories of Pavlov and Hull, where associations are created and strengthened via the frequent presentations of contiguous stimuli. Christ has the same notion in mind when he states that "the system acts like an averager, strengthening *connections between frequently associated units* and not between units rarely paired" (1991b, p. 364, emphasis added). However, the findings on awareness in human learning present strong evidence to the contrary. The plethora of awareness studies done over the course of 35 years underscore the fact that a human cannot be conditioned, in either the operant or classical Pavlovian sense, unless he or she is *aware* of the experimenter's intended association between stimuli (for a review, see Brewer, 1974). Even then, the subject in the conditioning study must *cooperate* with the experimenter's intention. In some cases, subjects recognize the patterned relationship between conditioned and unconditioned stimuli, but they refuse to behave for the sake of that pattern (see Page, 1969, 1972). This line of evidence directly contradicts the idea that people learn by passively receiving environmental information units.

More recently, the PDP models of language acquisition have come under fire from critics who claim that PDP associative networks cannot account for human learning. For example, Pinker and Prince (1988) provide a detailed list of criticisms of Rumelhart and McClelland's (1986) well-known model for

learning English irregular past-tense verbs. One of the most important prob-lems they found is that the PDP model did not correctly simulate or explain the developmental stages in a child's learning of regular and irregular past-tense forms. Pinker and Prince conclude by saying that the problems they detected demonstrate that "there is no basis for the belief that connection-ism will dissolve the difficult puzzles of language, or even provide radically new solutions to them" (p. 183).

Rychlak (1988) distinguishes between a *mediational* model such as tradi-tional learning theories and most information-processing theories, and a *predicational* model of cognition. In a mediational model, the process of thought is directed by factors which were once external to the process, but have now come to play a direct role in the process itself. For most media-tional models, including the PDP networks, it is the frequency and contigui-ty of past inputs that determine the direction of thought. Repeated presentations (*frequency*) of two or more environmental stimuli together (*contiguity*) strengthen the connection between corresponding units in the network. Note that the stimuli come into the system already formed.

In a predicational model, nothing is pre-formed, since everything is con-ceptualized *by the person*. This type of model holds that the person directs cognition via the process of predication, "the act of affirming, denying, or qualifying broader patterns of meaning in relation to narrower or targeted patterns of meaning" (Bugaj and Rychlak, 1989). When people predicate some target, the target is framed by the person oppositionally. In other words, if I say "Bob is friendly," I am affirming (predicating) one pole of a bipolar scale, the other pole being "Bob is *not* friendly." The meanings *friendly* and *not friendly* define one another oppositionally. The PDP network Christ sug-gests could never frame a meaningful judgment about Bob as I have, because the network can only consider "statistical regularities of environmental stim-ulation" (Christ, 1991b, p. 349). Lamiell (1987) has produced empirical research which demonstrates that people do *not* make personality judgments like the one I made above by comparing a person's behavior to some subjec-tive norm (i.e., statistical regularity), but rather by comparing how the per-son acts with how the person *could be* acting—a perfect example of opposition in predication.

Furthermore, Rychlak and his associates have compiled a large body of evi-dence showing that, while frequency and contiguity are considerations in cognitive tasks, it is the person's predications—the extensions of meanings to targeted referents—that determine the direction the person's thought will take (see Rychlak, 1988, for a review). It is interesting to note that most of these findings were obtained in memory studies—an empirical arena where mediational theories should excel.

As an aside, those who would be concerned about admitting a non-mechanistic conception of cognition such as a predicational model presents might accuse such a model of being too abstract or philosophical. I would point out that a mechanistic PDP model is no less abstract in the sense that it is just a set of theoretical constructs. Even Rumelhart and McClelland (1986) have noted that, while the idea of PDP networks was inspired by a neurological metaphor (i.e., nerve cells), there is really no neurological justification for postulating units, connections between them, activation strength, etc. A predicational model stands on just as firm (or weak) grounds as a mediational model does in terms of being a "scientific" explanation.

So, I would argue that the PDP network at the heart of the Sweeping Model will never be able to account for *human* mental processes, no matter how fast the sweep frequency is, because it is based on an outdated theory of learning. If there is any "magic" going on in the attentional processes as defined by the Sweeping Model, it is the illusion that a neural network can serve as an accurate view of human cognition.

Who's Left with the Homunculus?

Christ notes twice that he wants to avoid invoking a homunculus that will ultimately be responsible for the attentional process (1991a, p. 250; 1991b, p. 365). While he may have avoided mentioning a homunculus, he *must* invoke one to explain the more volitional aspects of attention. This becomes clear when the model attempts to explain how the system selects relevant stimuli and how it can shift attention. Regarding the former, Christ maintains that relevant stimuli can be selected over more intense irrelevant stimuli via "top-down influences from the state of activation already in the network adding to the bottom-up sensory activation" (1991b, p. 356). Where does prior activation come from? It comes from environmental inputs. Hence, the system is not choosing anything. It is simply a mediator between past and present inputs. These inputs are contents of a mediational process and not a true top-down predicational process. Christ has not postulated a homunculus here, but how can the model explain the human ability to intentionally attend to certain stimuli? Another subsystem would have to be created.

When Christ discusses shifts in attention, he states that a "positive or negative evaluation of some stimulus" (1991b, p. 360) causes the activation level in the system to uniformly rise, defocusing the attention. These positive or negative evaluations are of some bodily state, and they are accomplished through one or more evaluative "systems." These evaluative systems seem crucial to the model, but they are not explained any further. It appears that the little subsystems act as homunculi, ultimately driving the attentional process. After the defocusing phase, "activity is refocused, possibly in differ-

ent patterns, by the increased sweep rate" (p. 360). This seems to be begging
the question. The sweeps will accent certain environmental stimuli, but we
still do not know how the new target of attention is selected. It certainly is
not determined by the level of prior activation in the system; I already dis-
cussed how this is an unsatisfactory explanation. Here again, a homunculus
has not been mentioned outright, but how else can the Sweeping Model
explain intentional shifts in attention?

In a predicational model, shifts in attention are not controlled by the
spreading activation of past environmental inputs, but rather by the willful
act of predication. Attentional mechanisms considered in this light would be
instrumentalities. In his classic chapter on attention, William James aptly
describes this view:

> The laws of stimulation and of association may well be indispensable actors in all
> attention's performances, and may even be a good enough "stock company" to carry on
> many performances without aid; and yet they *may* at times simply form the background
> for a "star-performer," who is no more their "inert accompaniment" or their "incidental
> product" than Hamlet is Horatio's and Ophelia's. Such a star-performer would be the
> voluntary effort to attend, if it were an original psychic force. Nature *may*, I say,
> indulge in these complications; and the conception that she has done so in this case is,
> I think, just as clear (if not as "parsimonious" logically) as the conception that she has
> not. (James, 1890/1950, p. 453)

Thus, I disagree with Christ when he suggests that we must limit our theories
to "intrinsically ignorant and mechanical devices; anything else might be a
step in the right (or wrong) direction, but only puts off the question" (1991a,
p. 250). As I have shown above, Christ puts off the question more than once
in his formulation of attention. And why would we want to refrain from
something which might be a step in the right direction? If the reason is that
we want to keep working at the level of *artificial* intelligence, then it seems
clear that we should articulate exactly what is the goal of this research. Once
the agenda is made clearer, I think a great deal of confusion in cognitive psy-
chology will be eliminated.

To conclude, the Sweeping Model which Christ has proposed may be a
plausible model for AI systems, but it is an unsatisfactory explanation of
human attention and cognition. The model is lacking because (1) it is based
on an interpretation of human reality that is construed in the mechanistic
framework of information-processing, (2) it employs a PDP network that
does not accurately reflect human learning, and (3) it is left begging the
questions it seeks to answer.

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