SOAR as a world view, not a theory

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Newell's SOAR proposal is just that, soaring. It attempts to gather almost all of cognitive psychology under a single theoretical tent. Newell distinguishes several levels or, as he sometimes calls them, bands of human behavior and suggests that qualitatively different laws apply to each. In Newell's terms, there are seals between each level. In particular, he distinguishes between biological, cognitive, and rational bands, with their own explanatory laws. (He also discusses a social band, but we shall not.) The thrust of his argument is that the SOAR program is an appropriate vehicle for building theories of thought at the cognitive and rational levels. This argument implicitly assumes that complex programs such as SOAR are appropriate ways of expressing theories of cognition.

We raise two questions. Do these three bands indeed "carve nature at its joints," so that self-contained theories are possible within each? And is SOAR, or anything like it, an acceptable form for a theory?

Newell's biological band is defined, conceptually, by such physical mechanisms as neural transmission. He argues that basic events in this band span from 10 to 100 msec, and the relevant laws are physical and causal. The cognitive band spans from 0.1 to 10 sec and encompasses the phenomenon of information-processing psychology. In particular, symbols are manipulated with little regard to their semantics. An example is the operation of fetching an item from long-term to working memory. Finally, the knowledge level deals with the semantics of symbol manipulation. The congressman who says "When in doubt I always vote against Congressman Y" is operating at this level. Causal relations here reflect the semantics of the world.

The notion of a clear distinction between the biological and cognitive levels is directly challenged by the success of connectionist models designed to derive information-processing functions, such as the Hick-Hyman law (Keele 1986, pp. 30–35) from models of biological organization. To the extent that connectionism is successful, it directly challenges Newell's position.

We are equally skeptical about a seal between the upper-level cognitive and the representational bands. According to Newell, at the upper level of cognition actions take upwards of 10 sec to execute, which is well beyond the time it takes to comprehend a moderately complex sentence and incorporate its meaning into one's representation of the text. Clearly, the semantics of what is being read affects both the strategy used and the ability to incorporate new information into a text. The seal leaks downward from knowledge to cognition. Similarly, the knowledge level is influenced by working memory limitations, especially in situations in which knowledge must be accessed quickly. This is an example of how actions in Newell's knowledge band may be sharply constrained by causal relations at the information-processing level. This is not to deny the existence of purely

knowledge-level representation, but only to argue that the boundary between knowledge manipulation and information processing is fuzzy. Perhaps the seal should be set at 1.5 or 2 sec instead of 10.

Next, how appropriate is a SOAR-like program as a model for thought? As Newell comments on p. 13, normatively "the theory gives answers, not the theorist." More than one grand-sounding psychological theory has failed this criterion. The ideas of Freud and William James were most predictive in the hands of the masters.

Is a theory, stated as a program, independent of its maker? A phenomenon can be interpreted by a program only if it is appropriately represented as input to the machine. Input coding plays the role of the coordinating assumptions that link phenomena to theoretical entities in prosaic mathematically stated theories. The putative user of SOAR is not told how to develop an appropriate representation for the program. One wonders if any "unified theory" is likely to meet this important test, simply because the coding instructions for a unified theory would approach a taxonomy of all psychological observations.

SOAR and theories like it are underspecified in a major way. Newell's description of SOAR is not detailed enough to ensure that any two programmers, having read the book, would produce computationally equivalent programs. Indeed, some important details of SOAR are rather vaguely defined by reference to another computing language, Ops5 (p. 168), without indicating which parts of this language are to be regarded as psychological theory and which parts are to be thought of as programming conveniences. SOAR, as a theory, can be ambiguous even though the specific, but not unique, SOAR programs are unambiguous.

A SOAR aficionado may respond: If one wishes to understand the theory, run the program. This will not do, for two reasons. First, scientific theories are intended to facilitate understanding between humans. Suppose we are told that a SOAR program has simulated phenomenon X. We do not regard this as a satisfactory explanation of X unless we can find out exactly how the results were achieved. In particular, we want to know whether the simulation was achieved by those parts of the program that embody psychological theory or by parts regarded as choices of convenience in programming.

Second, the argument that one can always run the program simply is not true. Scientific theories should communicate over time as well as over place. What are the chances that the compilers and machines required to run SOAR today will even exist twenty years from now? Experience from the last twenty years suggests this is very unlikely.

We contend that SOAR is not a theory, in the sense of being a precisely defined set of statements about a clearly specified domain of observations. The levels of phenomena treated as distinct are probably not sealed off, and the theory itself is not precisely stated. On the other hand, SOAR can be seen as a world view, a way of thinking about psychological phenomena that can lead to the generation of precise, testable models of relations between observables. Such world views are useful and probably necessary. They should be recognized for what they are.