Not everyone will agree with Cheney and Seyfarth's conclusions. However, anyone who now seriously intends to disagree will have to read this book.

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Cognition as Search

Unified Theories of Cognition. ALLEN NEWELL. Harvard University Press, Cambridge, MA 1990. xx, 549 pp., illus. $39.95. The William James Lectures, 1987.

For cognitive scientists, the William James lectures by Allen Newell were the sensation of 1987. The videotapes circulated widely and there were seminars and discussions everywhere. This book version, though intensely personal, provides an unparalleled view of the outlook, accomplishments, and aspirations of information-processing psychology and the articulating aspects of computer science.

Remarkably, after nearly 40 years Newell's sense of wonder and excitement is palpable. The book opens by celebrating the idea of the universal computer that can simulate arbitrary problems coded in symbolic form. But Newell's core concern has always been the prospect of explaining the human mind using the conceptual tools of computer science. The thesis of the book is quite explicit: the best approach to understanding human cognition is the construction of unified theories based on abstract information-processing concepts. The central notion is that all of cognition can be viewed as "search in an appropriate problem space." Particular domain theories are to be expressed as collections of rules written in a uniform notation and interpreted by an "architecture" whose properties constitute the tenets of the general explanatory theory. These ideas are made concrete through the example of Soar, an architecture that Newell and his students have been developing for about a decade.

Soar is an evolving collection of simple but powerful information-processing constructs. All of the knowledge in Soar is represented as situation-action rules of the form: if *this* is in working memory then do *that*. Any computation can be expressed this way, and the notation is used in many applied expert systems. What is unique in the Soar architecture is the way in which the rules are controlled, particularly in the case where two or more of them conflict. In Soar, all applicable rules (even contradictory ones) can operate simultaneously, but all they can do is add new tentative information to the working memory. If this does lead to conflicting data being placed in working memory, Soar treats this impasse as a subproblem to be solved next. The system has strategies for choosing subgoals and completing or abandoning them. One other fundamental feature is a simple learning mechanism called "chunking." Under appropriate conditions, a chain of rule applications is chunked into a single new rule, often in a generalized form. Since most of Soar's strategies are expressed as rules, these also benefit from chunking.

For Newell, Soar helps achieve unified theories in two ways: it provides coherence through the use of a uniform notation and of a fixed architecture. Ideally, all of the rules for different domains would cohere, forming a model of intelligence that would be greater than the sum of its parts. This is an attractive prospect and is essentially the vision that launched the information-processing movement in cognitive science. The program has, however, recently come under attack for its detachment from any underlying physical reality.

Obviously enough, the Soar architecture is too abstract to be mapped directly to brain structure even at a very coarse grain. Newell's move here is brilliant. Instead of trying to ground the theories in brain structure, he focuses on human performance, particularly timing. Taking the millisecond-range computing time of neurons as basic, Newell constructs a hierarchy of timed processing levels, assuming that each level takes about ten steps of the level below. The resulting time estimates are used in constraining particular theories to be consistent with the wealth of chronometric experimental data on some tasks. The hierarchy also provides the argument that human cognition is best modeled at the knowledge level independent of implementation details.

With the framework laid out, the remainder of the book supports the case for unified theories by modeling as many phenomena as possible in the paradigm. A complete task model requires input and output analysis, and this forces Newell to apologetically introduce black-box theories of perception and motor control. He can then exhibit models of well-studied immediate response tasks such as typing and the Sternberg item-recognition task. Moving to a somewhat higher level, he outlines the Soar approach to memory and learning. The most detailed analysis, of nonsense-syllable recall, illustrates how chunking can be specialized for a specific task and how Soar can be used to recreate classical models. There is also a nice discussion of why Soar chunking is consistent with the ubiquitous power law of practice. The next chapter focuses on three complex problem-solving tasks: cryptarithmetic, logical reasoning, and a very simple sentence-verification task. Each is used to illustrate a different general aspect of Newell's theory of cognition as search.

As the author states, these modeling efforts have varying degrees of depth, success, and coverage. But taken as a whole they constitute the most impressive treatment by far of such a wide range of findings. Some readers will find the results unsatisfying because there is still no notion of how the brain actually does all these wonders. But the challenge of unified theories at the knowledge level has been laid down. More biologically oriented theoreticians will have to do better or will need to map Soar to more brain-like architectures. Taking this challenge seriously will lead to significant advances in cognitive science.

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Left Brain, Right Brain

The Decline and Fall of Hemispheric Specialization. ROBERT EFRON. Erlbaum, Hillsdale, NJ, 1990. xvi, 117 pp., illus. $19.95.

The current popular obsession with the "left brain, right brain" duality is not a new phenomenon. There was a similar wave, now largely forgotten, in the latter part of the 19th century following discoveries that the psychological effects of brain injury depended very much on which side of the brain was injured (see A. Harrington, *Medicine, Mind, and the Double Brain*, Princeton University Press, 1987). Then, as now, speculation owed more to enduring myths about left and right than to the empirical evidence.

The new wave began in the 1960s when testing of the so-called "split-brained" patients, who had undergone commissurotomy for the relief of intractable epilépsy, again dramatically revealed the brain's functional asymmetry. As a consequence, notions of hemispheric duality have spread far beyond the scientific journals and into popular culture. If history is to be our guide, this new wave must also soon come to an end, and the volume under review reflects a growing skepticism about the importance and validity of hemispheric specialization.

In spite of its title, however, Efron's slim book will not slay the beast and may strike no more than a glancing blow. It consists of only three chapters, based on a series of invited lectures delivered in 1989 at the University of Alberta. Efron deals with only