

Cognitive Science versus Cognitive Ergonomics: A dynamic tension or an inevitable schism?

Jean-Michel Hoc, Pietro C. Cacciabue, and Erik Hollnagel (Eds.)

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Review by  
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In their foreword, the editors give a nod toward the “internationally based human-computer interaction (HCI) community, at the level of research as well as at the level of application” (p. xi). This is the community to which the reviewers belong and as such we eagerly awaited this volume of chapters reporting on the work of the mainly European “large-system” cognitive ergonomics community. After witnessing first-hand the excitement and challenge of applying cognitive theory to HCI, we were more than a little curious as to the successes of and challenges to cognitive theory when it is applied to larger scale applications. Alas, for the most part, we were disappointed. While this book contains several excellent chapters, on the whole we came away with the impression of a community that has isolated itself from mainstream cognitive theory and has little interest in testing or contributing to that theory. Indeed, it is not clear for whom, other than the large-systems community, this book is intended. It is heavily laden with jargon and makes little attempt to establish contact with any other tradition. In addition, the book is somewhat “user-unfriendly” containing a meager 2.5 page subject index and no author index (references are listed only at the end of the chapter in which they are cited).

Although our review of the book is primarily negative, several of the chapters are quite good and would justify having your library buy it.

The book is organized into three sections, the first pertains to cognition in dynamic environments, the second addresses expertise, and the third deals with human-computer cooperation. These sections are preceded by an overview chapter and are followed by a conclusion chapter.

Chapter 1 by Hollnagel, Cacciabue, and Hoc organizes and summarizes the large-system perspective and provides pointers into the literature. Of particular note is the importance given to the role of models and simulations in understanding the complex interactions among humans, systems, and tasks.

Section 1 includes four chapters and seems intended to be the theoretical foundations section. Chapter 2, by Hoc, Amalberti, and Boreham, provides a very high level discussion of diagnosis that could benefit from a lessor scope and concrete examples. Chapter 3, by Kjaer-Hansen, is a largely out of date review of “Unitary Theories of Cognitive Architectures.”

The two chapters by Caccibue & Hollnagel (ch. 4) and Woods & Roth (ch 5) would like to distinguish between their use of computational cognitive modeling and everyone else’s. The nub of the distinction seems to be between models of “toy tasks” that the authors claim are based in cognitive theory and models of important, real-world tasks that the authors claim must eschew cognitive theory.

It is interesting that computational cognitive modeling has flourished in the HCI community by taking an approach opposite to that advocated here. In a tradition going back at least to Card, Moran, & Newell (1983), the HCI community has paid close attention to theories of what Caccibue and Hollnagel refer to as “micro-”cognition with the successful goal of applying such

theories to real-world HCI tasks. In recent years the HCI community has embraced cognitive architectures such as Soar, ACT-R, and construction/integration with emerging success (Kirschenbaum, Gray, & Young, in press).

Although we do not like the distinctions made in these two chapters, we understand the authors' motivations and offer some distinctions of our own. It is important to distinguish between modeling done for scientific or theoretical purposes versus that done for engineering purposes (the latter has been referred to in the HCI literature as "approximate modeling," Card, et al., 1983). However, we maintain that approximate models can be built upon the foundations established by scientific or theoretical modeling. Modeling not based upon cognitive theory may work well for complex tasks as long as these tasks involve relatively simple cognition (such as much of expert systems where the complexity is in the task not in the head). However, there are dangers to this approach. The entire infrastructure is arbitrary and less constrained than one based upon a cognitive architecture. Also, if more than one cognitive mechanism is required (complex cognition) it is not clear whether the various mechanisms will be able to interact correctly. That degree of coordination would require an architecture. While we do not disagree with their goals, we wish our "large-systems" colleagues were more interested in drawing from and contributing to cognitive theory.

Section 2 looks at the development of competence and expertise. The section begins with a clearly written chapter by Boreham on expert-novice differences in medical diagnosis. The remaining chapters are less successful, tending to share three negative characteristics. First, they seem largely out of touch with the mainstream research on expertise as represented, for

example, by the Ericsson & Smith (1991) collection of chapters. Second, many seem intent on developing domain-specific theories that make little contact with existing cognitive theory. Third, in their attempt to make theory-based, taxonomic distinctions they neglect to include case studies and examples that would make these distinctions concrete.

Section 3 turns to “Cooperation between humans and computers” and contains the best and worst chapters in the book. In chapter 10, Benckroun, Pavard, & Salembier present an interesting use of cognitive modeling to predict the influence of a new software system on the communication efficiency of an emergency center. Chapter 11 by Moray, Hiskes, Lee, & Muir is a lovely chapter that shows the application of the social psychology construct of “trust” to human-machine interaction. We left this chapter inspired to read more of the literature on process control.

Chapter 12, by Rizzo, Ferrante, & Bagnara presents a collection of categories and anecdotes on human error. Chapter 13, by Millot & Mandiau promises to compare the distributed AI (DAI) approach and the “more pragmatic human engineering approach” (p. 215) to “implementing a cooperative organization” (p 215). The experiment presented to this end seems poorly motivated or maybe just poorly explained.

Hollnagel’s chapter 14 sheds much heat and smoke but little light on a number of tangential issues while demonstrating a lack of understanding for much of contemporary cognitive theory. For example, on page 230 he talks about “the useless automaton analogy” and “A particular case is the use of the information processing metaphor (Newell & Simon, 1972) - or even worse,

assuming that a human being is an information processing system (as exemplified by Simon, 1972; Newell, 1990).” Later on the same page he says,

I will not argue that the automaton analogy is ineffectual as a basis for describing human performance per se; I simply take that for granted. (This point of view is certainly not always generally accepted and often not even explicitly stated, for instance, by the mainstream of American Cognitive Science; it is nevertheless a view which is fairly easy to support.)

On page 240 we are subjected to a rather glib and unmotivated, “the lack of proven theories or methods is deplorable. . . . There are many practitioners, and they all have their little flock of faithful followers” and another, in a similar vein, about AI work on adaptive systems.

While we believe that theories exist to be challenged, we also believe that in the scientific community challengers need to substantiate their assertions. Indeed, not only is such substance missing, but in the pages that follow Hollnagel proposes a theoretical explanation that sounds in keeping with the Newell and Simon account.

We had a better time with the next two chapters. Both Boy in chapter 15 and Lind & Larsen in chapter 16 embrace contemporary cognitive theory with interesting results. While clearly discussed, Boy’s theory nevertheless remains vague due to the lack of a worked example. Lind and Larsen work us through a detailed example of one of their multilevel flow models.

The summary chapter is generally well written but, for us, Hollnagel’s smoke (for example, pp. 281-282 and his unmotivated attacks on Simon, page 284) obscures any light the chapter may have been intended to shed.

### Conclusions

If the goal of this book was to communicate large-systems cognitive ergonomics to a larger community then we judge that it has missed its mark. While there are several interesting (e.g., chapters 6, 10, 11, 15, and 16) and intellectually stimulating (e.g., chapters 4 and 5) chapters the majority are neither. Some seem intended as “in-house” communications, while others build domain-specific theories with numerous abstract theoretical distinctions without ever embedding the distinctions in example. Worse still, others confuse unsubstantiated assertions and innuendos for intellectual discourse.

Cognitive theory is far from sacrosanct. Indeed, in recent years the dynamicism of mainstream cognitive theory has been shown by its adaptation and incorporation of the connectionist challenge from below and its recent response to the challenge of situated action from above (e.g., Vera & Simon, 1993). We firmly believe that applied cognition must be based upon cognitive theory. Any other approach runs one of two risks, either the applied endeavour becomes bogged down with constructing task-specific theories or it tends to the vacuous empiricism that is the bane of much human factors work.

### References

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