Book Review

A review of *Understanding Understanding: Essays on Cybernetics and Cognition*, Heinz von Foerster, 2003. New York: Springer-Verlag, 362pp. ISBN 0387953922. $64.95 USD.

Reviewed by:

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Heinz von Foerster's book of his collected essays on cybernetics and cognition is a wide-ranging feast of ideas and information. Rather than reading the book as a whole, readers will most likely sample the various articles that range from highly mathematical treatises to polemics on world peace. Educators will find little here that is directly relevant to their profession, but there are "nuggets" throughout the text that are worth considering for their deepening insights into the processes of learning and cognition.

For scholars of complexity theory, especially those working on the history and genealogy of complexity and the related concept of "self-organization," *Understanding Understanding* will be useful in terms of von Foerster's pioneering contributions and the window that they provide into early developments in the field. Although trained as a physicist, von Foerster never seems confined by disciplinary boundaries, thus allowing his agile mind to roam freely across domains that include electronics, cybernetics, mathematics, neurophysiology, psychology, philosophy, politics, and semantic analysis. One of his first papers applies quantum mathematics to an understanding of molecules involved in human memory. Memory is a key theme throughout the book, and in the preface von Foerster shows us one of the many points of departure he takes from his colleagues, stating that memory "cannot be dead storage of isolated data but must be a dynamic process

that involves the whole system in computing what is going on at the moment and what may happen in the future" (p. viii).

Arriving from Austria in 1949, von Foerster found a job in the Electron Tube Research Laboratory at the University of Illinois at Urbana-Champaign. His paper on memory was discovered by Warren McCullough, a leading American neuropsychiatrist, who was part of a working group on "circular causal and feedback mechanisms in biological and social systems" (p. vi). von Foerster was invited into the group, whose other members included Norbert Wiener (founder of "cybernetics"), Claude Shannon (inventor of information theory), Gregory Bateson (philosopher and anthropologist), Margaret Mead (anthropologist), John von Neuman (computer pioneer), and many illustrious others. He also developed a strong relationship with Gordon Pask from England, who "developed some of the first true teaching machines." By 1957, von Foerster had started his own lab at the university, with one of its themes being the emerging concept of self-organization.

It is fitting, then, that self-organizing systems is the topic of the first essay in his book, a talk given in 1959 to The Interdisciplinary Symposium on Self-Organizing Systems in Chicago. Although much of the essay is mathematical, in its introduction von Foerster argues that there are no true self-organizing systems. Rather, he states that for order to arise in a chaotic system, it "must be in contact with an environment that possesses available energy and order," so it can "'live' on the expenses" (p. 3) of this environment.

Much of the essay concerns the concept of noise. To the question, "How can noise contribute to human learning?", he notes that learners are attuned to fluctuations and error, or patterns that arise out of noise. From this insight he confesses that he deliberately introduces errors into his teaching. Students seem to delight in picking up a professor's errors—which, von Foerster believes, keeps them involved and interested.

The next few essays are replete with mathematical notations, but the non-mathematician can generally follow the arguments and understand the conclusions. Given von Foerster's background, it is not surprising that his metaphor for cognition is rooted in electronics and computers. von Foerster conceptualizes humans as extremely complex machines made up of detectors, computers, and effectors. How complex are humans? According to von Foerster, "ten neurons can be interconnected in precisely 1,267,650,500,228,229,401,703,205,376 different ways" (p. 21). There is no explanation as to how he arrived at that number, but we get the point—incredibly complex!

Whilst admitting that he is not an expert in neurophysiology, von Foerster delves into memory again in a 1969 essay entitled "What is memory that it may have hindsight and foresight?"(pp. 101–131) that weaves mathematics

and philosophy into a model of interlinking "cognitive tiles." He also sets out to clarify various "semantic traps" that lead to mistakes in thinking about memory. In particular, he focuses on two pairs of terms that cause difficulties—storage vs. retrieval, and recognition vs. recall. He argues that memory is not a storage and retrieval operation involving pictures or words, but a recognition in context of a particular situation, and the use of hindsight to recall what happened and foresight to predict the likely trajectory of the developing situation. Memory is understood as self-referential in that it is an interpretation based on previous meaningful experiences, and a prediction of the future based on those cumulative experiences. Memory is therefore "the results of these operations" and not "the operations themselves or the mechanisms that implement these operations" (p. 103).

Reflecting on humans' "superior cognitive powers in discriminating and identifying forms and shapes as compared to those powers which allow [them] to discriminate and identify change and movement" (p. 133), von Foerster analyses the different processes reflected in the use of nouns and verbs in a 1970 essay on "molecular ethology." Here we find his strongest statement on his view of learning, "seen as a process of evolving algorithms for solving categories of problems of ever increasing complexity, or of evolving domains of relations between the organism and the outside world [and] of relations between these domains" (p. 137). His views are even stronger in a 1971 essay on "perception of the future," speaking of the "castration" of language (p. 202) and the trivialization of learning that takes place in schools. "Trivial machines" (p. 208) are those in which the input is the same as the output. Essentially, students are given information and supposed to reproduce it. "Non-trivial machines" are different in that their output is influenced by previous output and current circumstances. von Foerster rightly complains that schools too often ask students for the answers to questions to which the answer is already known ("illegitimate questions") rather than for answers to questions to which the answer is unknown ("legitimate questions"). We construct our realities and acquire knowledge through recursive computations and novel input, regulated by our own interests. To quote von Foerster, "Perceiving is doing!" (p. 213).

Von Foerster speaks throughout the book of the importance of circular patterns of the sensory-motor apparatus, but, aside from an essay dedicated to Jean Piaget on his 80th birthday and one reference to "object constancy," there is no discussion of Piaget's much earlier work on circular reactions. Like Piaget, there is constant metaphorical reference to humans as self-regulating machines that learn from experience, a metaphor that goes back to Herbert Spencer and the invention of the thermostat in the nineteenth century. In the end, while he is obviously brilliant, von Foerster is a

product of the metaphors of his time and his experiences as an electronics physicist.

As noted in my introduction, there is little in this book of immediate practical value for teachers. The collection will be of interest to researchers on the history of complexity and to those who study the sociology of science, as it illuminates von Foerster's journey throughout his intellectual life.