Computer Modeling of Verbal Behavior

The Cambridge Center for Behavioral Studies has had a long interest in language simulation, as the original sponsor of an annual competition characterized as the “first instantiation of the Turing Test.” Each year, computer systems (sometimes called “chatterbots”) try to fool human judges into believing they are carrying on a conversation with an unseen human. So far, no system has achieved complete success in the Turing Test and won the grand prize by convincing the majority of the judges. Ken Stephens provides a review of conversant systems, including those that won that competition, and discusses how the power of the techniques used to win has steadily increased. This is put in perspective of a paradigm shift within computational linguistics that has brought powerful empirical techniques to bear.

The Cambridge Center believes that a behavioral account of language or verbal behavior has much to offer. In contrast to purely structural accounts which dominated linguistics in the 1960s through 1980s, B. F. Skinner's 1957 book Verbal Behavior offered a functional account of how language is shaped in individual speakers by interactions with listeners and the verbal community. This account was intended to complement rather than replace a formal analysis based on grammar. However, in 1959 the book was the subject of a well-known critique by the psycholinguist Noam Chomsky, which is more widely known than Skinner's original book. The Chomsky review was published in a number of places, and gained the reputation among psycholinguists and those psychologists not in sympathy with Skinner as having demolished Skinner's analysis and behaviorism itself. Skinner chose not to reply directly to his critics, who he felt misunderstood his position so badly that a reply would not be constructive. This silence was incorrectly interpreted as confirmation that Chomsky's criticisms were correct, and that behaviorists could not answer them.

In 1970, Kenneth MacCorquodale did answer Chomsky, with a “review of the review” that demonstrated that Chomsky's straw man arguments were often
appropriate to a much simpler and older S-R behaviorism rather than Skinner's radical behavior analysis, and suggesting that if Chomsky had understood Skinner's concepts of the verbal operants and the way simple components of functional language could combine through the mechanisms of “multiple causation” and “supplementary stimulation,” he would not have dismissed so quickly the explanatory power of Skinner's analysis. Unfortunately, MacCorquodale's paper was published in a behavioral journal, *The Journal of Experimental Analysis of Behavior*, not widely read outside of the behavior analytic community, so it did not have the impact it deserved. We have re-posted the MacCorquodale (1970) article, “On Chomsky's Review of Skinner's Verbal Behavior”, on this web site.

In 1972, A. Charles Catania also wrote an important paper titled “Chomsky's Formal Analysis of Natural Languages: A Behavioral Translation.” This paper was the first paper in the first issue of the new journal called *Behaviorism*, published by the Cambridge Center. Catania's paper made the case that “the controversy between cognitive and behavioral accounts is in part simply a matter of speaking of the same things in different ways. But sometimes also, as when we fall to distinguish between structural and functional problems, controversies arise because we mistakenly speak of different things as if they were the same.” That paper is also reposted here.

A 1986 paper (located on the web site of *The Analysis of Verbal Behavior*, and in Adobe® Acrobat® format) by David Palmer, “Chomsky's Nativism: A Critical Review,” examined Chomsky's argument in detail and made three points:

- He transfers the explanatory burden from the individual's environment to the ancestral environment, but the arguments against the adequacy of the former apply equally to the latter.
- His proposed language acquisition device extracts grammars from "linguistic input." However, the "input" to a child is in the form of stimuli, not grammatical abstractions. Chomsky does not tell us how raw stimuli, which of course vary from one language to another, can trigger the operation of the putative device. Any solution necessarily plunges one into the domain of stimulus classes, response classes, and environmental contingencies, the domain of the repudiated B. F. Skinner.
Chomsky confuses his formal models of language with language itself. In his models, languages consist of an infinite number of sentences. But units in the model do not conform to units in the behavior of organisms. There are uncountable "grammatical sentences," formally defined, that are indiscernible to human beings. Chomsky’s deductions are appropriate to a hypothesized world, not the world in which organisms behave.

The above paper was reprinted in *The Analysis of Verbal Behavior* in 2000, along with “Chomsky's Nativism Reconsidered (2000)” (also in Adobe® Acrobat® PDF format on *The Analysis of Verbal Behavior* web site). The latter was a review of the earlier paper in the light of the passage of two decades. Some minor corrections are offered, but the force of the article remains.

In “The Speaker as Listener: The Interpretation of Structural Regularities in Verbal Behavior” (1998), David Palmer offers an extension of Skinner's account of grammar. Several puzzling grammatical regularities in language are interpreted as the interaction of intraverbal frames with other elementary verbal operants. Intraverbal frames are first established in the listener through reinforcement by parity with the practices of the verbal community. When the listener, in turn, becomes a speaker, intraverbal control governs the order of emission of operants.

In “Cognition” (2003, in press), and in the shorter version of it, “Behavioural Interpretations of Cognition,” David Palmer offers a conceptual justification for the behavioral interpretation of cognition. He makes the following points:

- Science serves two functions, controlling nature and making sense of nature, and the latter function is just as important as the former.
- To understand a phenomenon, we identify one path that nature might have taken to produce the phenomenon, invoking only established principles of science. Much of our understanding of evolutionary biology, astronomy, geology, and psychology rests upon such interpretive exercises.
- The observability of behavior depends upon the tools of the observer and is not an intrinsic property of the behavior itself. Therefore unobserved behavior must be assumed to obey the same principles as observed behavior.
Cognitive phenomena can be interpreted as webs of covert and overt behavior.

Our strategy for understanding cognition is to offer such interpretations and to supplement them whenever possible with experimental analyses.

Such exercises offer understanding, because the principles adduced in behavioral interpretations all have an independent empirical foundation.

This is all that science can offer in a domain where control of relevant variables is impossible.

Computer simulations represent an important test of the explanatory power of quantitative models of behavior. Jeremie Jozefowicz presents an investigation into computer models of conditioning, both operant and respondent, that underlie both animal and human behavior. His work is titled "Reinforcement learning and conditioning: an overview" and we have published the beginning chapters on "Computational foundations of reinforcement learning" and "Applications to conditioning."

Finally, Bill Hutchison presents a description of the "Seventh Generation Technologies" ("7GT") paradigm for developing autonomous agents. 7G, developed over two decades, is the basis for verbal robots which acquire language by way of the functional mechanisms outlined in Skinner's analysis of verbal behavior. Hutchison discusses design principles and core technologies of the 7GT system, and how it solves many of the difficult problems of cognitive systems.