Cognition and History: Toward a Cognitive Understanding of Science

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This symposium reports recent research using a cognitive-historical approach to understand scientific thinking. Because of the richness of the historical record in particular cases, it is possible to achieve a depth of analysis that extends beyond laboratory studies of "science-like" thinking or "in vitro" studies of real-world science.

ALEC: A Computational Simulation of the Invention of the Telephone

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This paper investigates the role of historical cases in developing computational simulations of technoscientific thinking by focusing on Alexander Graham Bell's invention of the telephone. Bell's cognitive processes, as described in his notebooks and other materials, have been analyzed using methods similar to those used by Tweney and by Gooding to study Faraday. From these, Gorman derived a series of generalizations about scientific discovery and invention.

Independently, Simina analyzed Bell's invention of the telephone using case-based reasoning as an investigation tool. He then integrated Gorman's work into a program called ALEC that simulates Bell's problem-solving processes. ALEC helped identify the limitations of the traditional case-based reasoning paradigm for addressing scientific thinking and suggested ways of overcoming these limitations at a computational level. ALEC also allowed us to consider whether Gorman's generalizations can be converted into a computationally adequate account of technoscientific thinking. We conclude that historical data can be used to advance cognitive and computational theories of technoscientific thinking.

A Simulation of Multi-Agent Reasoning about Disparate Phenomena

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This paper describes a computer model which originated in cognitive-historical analysis of the diaries of Michael Faraday, and has now been extended to represent belief revision in a community of scientists. The formation and revision of beliefs is modeled as a process mediated both by observation and experimentation and by communication between individuals within groups and between groups. Beliefs are represented with varying degrees of generality, from those which can be fully expressed by logical models to those requiring some interpretation of, and negotiation about, qualitative descriptions. Agents are defined as having a number of attributes, including varying confidence in a range of hypotheses or models and variable sensitivity to the opinions and findings of other observers, and they have the ability to make decisions about whether and how to make new experiments, or consult other actors.

The simulations can be used to explore such factors in scientific discovery as: (i) the consequences of situations in which agents exchange information about logically well defined experiments that produce unambiguous results, versus situations more like that of real science, in which agents exchange information drawn from results of variable precision and ambiguity, and (ii) the consequences of variability of agents' access to information produced or held by others and to particular experiments.

Conceptual Change: Development, Learning, and Science

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The "cognitive-historical" method is reflexive in application: While it attempts to integrate findings from research on cognition and findings from historical research into models of actual scientific practices, assessments of the fit between cognitive findings and historical practices are fed back to aid in developing richer and more realistic models of cognition.

This paper focuses on what cognitive-historical analyses can contribute to a central issue in cognitive science: conceptual change. An extensive literature in cognitive development claims that there are significant parallels between conceptual change in development and in science. Most earlier work focused on similarities of the products of conceptual change. Thus, salient differences between the child's conceptual structure and the adult's are claimed to be like those between the beginning and end points of conceptual change in a "scientific revolution".

Recently, attention in these areas has shifted to the nature of the mechanisms or processes of conceptual change, especially in the debate between the "neo-nativist" notion of conceptual enrichment and the "theory-formation theory" notion of conceptual change. I focus on the "mechanisms" issue and evaluate the cognitive science claims in light of cognitive-historical analyses of scientific practice. My verdict is that there are indeed significant parallels that can be exploited by cognitive scientists. However, current arguments in favor of this position are weakened by inadequate understanding of the practices leading to conceptual change in science.