A Framework for Modeling Representational Change in Scientific Communities

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Though representational change has traditionally been a central issue for cognitive studies of science (e.g., Duncan & Tweney, 1997), little research has focused on how these changes occur in scientific communities. A framework is elaborated which may lead to the successful computational modeling of group representational change in science. Of particular interest is how group-level representational dynamics develop from the interaction of individual cognitive processes.

Constraint satisfaction

The framework is connectionist in structure, with sub-elements of cognitive representations encoded as nodes, and their excitatory or inhibitory relationships represented as weights between nodes (à la the schema models of Rumelhart, et al, 1986). Thagard (1989) described a theory of "explanatory coherence" which assessed theories according to the degree that internal and external constraints were satisfied. Using ECHO (a computational model of the theory), Thagard simulated several scientific controversies (e.g., Nowak & Thagard, 1992). However, while ECHO is a useful tool for judging the consistency of a set of subtheoretic propositions with itself and external evidence, it is rarely used in modeling the individual cognitive agent.

Hutchins (1995) used similar architectures for studying the interaction of multiple cognitive agents. He studied a series of linked constraint satisfaction models and showed that differences in organizational structure affected a simple measure of confirmation bias in the networks. The models were relatively abstract, though, and have not yet been expanded into complex domains. The present framework applies an ECHO-like structure to Hutchins' linked networks.

A framework

This framework postulates that the interaction of individual constraint satisfaction processes may be behind complex representational change at the level of groups. Thus, theories are represented as patterns of activation over the set of nodes within several linked networks, each network representing an individual. Like ECHO, component elements of the representation of a given phenomenon are encoded as nodes in each network, with weighted connections between the nodes. As with Hutchins' linked networks, patterns of interconnectedness between networks represents "who talks to whom" while the strength of the connections between networks represents the persuasiveness between individuals.

The networks are interpreted such that the path each takes to a stable goodness-of-fit maximum is analogous to the process of representational change in a real individual. Other modifications include the introduction of external evidence at different times during processing and weight modification during the network runs. It is theorized that these changes will increase the fit between a given set of networks and the data being simulated.

The framework will be applied to the modeling of an important historical case, namely the "Great Devonian Controversy" of early nineteenth-century British geology (Rudwick, 1985). The controversy, which involved several dozen professional and amateur geologists, centered about how to classify a range of rock strata found in Devon, England and was eventually resolved with the development of a new representation of the geologic strata (which has become known as the "Devonian system"). Rudwick's narrative analysis is quite detailed with respect to the representational dynamics at play during the controversy and thus provides a true test of our framework.

References

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