Cognition, History and Science: Phenomena for the Cognitive Science of Science

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A mature cognitive science of science must address the complexity of real-world science, past and present, and must therefore be grounded in the results of both field studies (such as Dunbar's *in vivo* analysis of several molecular biology laboratories) and historical studies which focus upon the "microstructure" of scientific practice (such as Holmes's analysis of Krebs's diaries). In both cases, the task for understanding is based on something like a "fossil" record; as in evolutionary biology, one must reconstruct the progression of ideas from earlier forms to later forms. As in biology, the record is nearly always incomplete, necessitating the reconstruction of events that are not observed. Such reconstruction must meet the constraints imposed by known laws and principles of cognitive science.

The record of scientific thought and practice can take the form of diaries, correspondence, publications, and historical replications of particular experiments (as in Gooding's analysis of Faraday's electrical rotation studies). Broad summaries by historians are likely to be less useful than reconstructive accounts based on detailed surviving evidence (e.g., Holmes, Rudwick). Even so, the records are likely to have broad gaps, necessitating careful interpretive work.

Both concurrent and historical records suffer disadvantages in their potential incompleteness (and even occasional mendacity, given the self-interest of scientists!) However, they possess advantages of richness and depth. Further, for investigations of conceptual change (as by Nersessian, or Duncan & Tweney), they can sometimes be regarded as manifesting a "slowing" of time, in which conceptual change is dragged out across long intervals.

Nersessian has noted that scientific communication necessitates translation from practice to rhetoric, frequently into propositional form. Visualization, analogy, diagrammatic reasoning, and the like, are thus likely to be slighted or distorted. Historical and field records (even diaries meant only for self-consumption) thus need to be interpreted with an eye toward "correcting" for such translation; it is essential that the overtly propositional form of much scientific communication not be taken too literally.

All scientific practice is necessarily "cognition in the wild," to use Hutchins's term. Any theory of scientific thinking must therefore accommodate the cultural, historical, and social contextualization of thought, as, for example, in Gruber's studies of Darwin. In particular, such contexts are often essential parts of the representations used by scientists. In fact, the context can serve to elaborate and clarify the interpretation of otherwise "hidden" aspects of representations, as, for example, in the studies of expert calculus problem solving conducted by Kurz, which capitalized on the "historicity" of calculus as an aid to interpretation.

Interesting theoretical accounts of science must reflect the dynamic changes that characterize scientific discovery. This poses challenges for accounts rooted in symbolic interpretations (examples can be found in Shrager & Langley, 1990) which must establish the sufficiency of an interpretation. Many of the dynamic changes seem to involve a shift from non-symbolic practice to symbolic, or even propositional, form. Further, since scientific thinking typically involves multiple problem spaces which change across time, any adequate theory must incorporate an "episodic" control structure which can deploy multiple resources in a time-shared fashion; many of these, of course, will reflect automated or "expert" functions, while others will be distributed across external representations, computing devices, and collaborators.

Scientific representations frequently include an implied agency; "[Someone] takes Dt to 0," or "If [Someone] connects a battery, then effect X occurs." At times, a scientist's own agency becomes the topic of reflexive research, as in Faraday's studies of optical illusions (Ippolito & Tweney), or can become manifest in actual use of "self-presentations" (as in Clement's study of the "spring problem").

Darden argued that computational strategies derived from AI can serve as representations of scientific theories in fruitful ways; as the number and richness of such representations increases (case-based approaches, connectionist systems, qualitative systems, etc.), and more nearly matches the richness of historical and field accounts, the possibilities for greater collaboration among cognitive scientists, social scientists, and those in the history and philosophy of science is likewise enhanced.

References

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