The Psychology of Science has Arrived

Handbook of the Psychology of Science

By Gregory J. Feist and Michael E. Gorman (Eds.). New York: Springer, 2013, 526 pp. Cloth, $00.00

This review of the recent *Handbook of the psychology of science* is a cross review for the *American Journal of Psychology,* as in the current issue of *the Journal*, the editors of the handbook, Gregory Feist and Michael Gorman, review my own book, *Investigating the psychological world: Scientific method in the behavioral sciences.* The editors of this important handbook are leaders in the emerging science studies discipline of the psychology of science. Among other publications, Gregory Feist is well known for his book, *The psychology of science and the origins of the scientific mind* (2006), a synoptic and integrative survey of the field. This book won the American Psychological Association's William James Book Award in 2007. Michael Gorman's extensive interdisciplinary interests boast important publications on topics that include the simulation of science, cognition and invention, as well as ethical studies in science. He is currently exploring the kind of interdisciplinary trading zones needed for the development of new technologies.

The *Handbook of the psychology of science* follows closely on the heels of another major collection of articles on the psychology of science edited by Robert Proctor and E. J. Capaldi, *Psychology of science: Implicit and explicit processes* (2012). Together, these two sizable collections bear witness to the emergence and continued growth of the psychology of science as science studies discipline in its own right. It joins the three longer established science studies disciplines of philosophy of science, history of science, and sociology of science as our primary sources of knowledge about the nature of science. It is fair to say that the nascent psychology of science has arrived, and is now making its own distinctive contributions to our understanding of science. Gregory Webster's contribution to the handbook, which identifies quantitative trends in establishing a psychology of science, suggests that the discipline promises to be as successful as its more established science studies cousins.

The present handbook contains 21 essays on a considerable variety of topics in the psychology of science, distributed across six sections: Introduction and history, foundational psychologies of science, development and theory change, special topics, applied psychologies of science, and past and future of psychology of science. Something of this variety is captured by the different chapter titles, which include the following: 'History of the psychology of science', 'The scientific personality', 'Children as scientific thinkers', 'Creative genius in science', 'The psychology of technological invention', and 'Quantitative trends in establishing a psychology of science'. Because of space limitations, I will largely confine my comments to one chapter in each of the book's four main sections.

Cognitive-Historical Approaches

In his chapter, 'Cognitive-historical approaches to the understanding of science', Ryan Tweney argues for a cognitive-historical approach to the understanding of science, and illustrates the approach by appealing to a number of accounts of important scientific discoveries in the history of science. These include shifts in scientific representations (e.g., Kepler's shift in focus from the concept of an orb to that of an orbit) and step-by-step accounts of scientific problem problem-solving (e.g., Kulkarni and Simon's computational simulation of Krebs's discovery of the ornithine cycle that now bears his name). Herbert Simon's important account of problem solving is itself worthy of comment here. As Tweeny notes, with Simon's approach to problem solving, thought itself follows relatively simple heuristic principles, whereas the complexity of problem solving is located in the symbolic environment of thought. Importantly, for Simon, problem solving depends crucially on structuring problems in order to solve them. With respect to scientific discoveries, scientific problems present initially as ill-structured problems, and the challenge is to better specify a problem's constraints such that they guide the problem solver to solutions of the problems. With respect to genuinely creative scientific discoveries, problems are poorly structured, and the constraints, including the relevant heuristics, are not well known, are difficult to come by, and require the use of weak methods.

Most research in psychology is demographic, for it seeks aggregate measures of populations (the "individual differences" paradigm). Despite its historical importance, idiographic psychological science, understood as the intensive study of individuals, is a minority practice. In his chapter, Tweney rightly asserts that cognitive-historical studies help to promote the legitimacy and importance of idiographic science by placing the person at the center of study the nature of scientific thinking. As he remarks, "[Y]ou cannot "average" Faraday and Maxwell to find out what is generally true of their approaches". There is a very important methodological point that underlies this remark. It is widely assumed that the findings from the study of *inter*individual differences apply to individuals (*intra*individual differences). However, this assumption is generally false in psychology because the processes of habituation, perception, conditioning, learning, cognition, emotion, development, and adaptive processes generally are nonergodic (Molenaar, 2004). That is to say, the structure (e.g., means, variances, covariances) of interindiviual differences and intraindividaul differences are not equivalent. Thus, one cannot use findings from interindividual differences research to draw conclusions about particular individuals. From the array of person-centered methods, the cognitive-historical approach brings case study methodology to the fore. The various case studies reported in Tweney's chapter provide the psychology of science with a rich informational yield about the complexities of real science.

Scientific Reasoning

In the longest chapter in the handbook, Barbara Koslowski's 'Scientific reasoning: Explanation, confirmation bias, and scientific practice', constitutes an insightful broad-ranging examination of explanatory reasoning as it is practiced by children, college students, and scientists. For the most part, her focus is on explanations that are provided by appeal to causal mechanisms.

An important feature of some explanations in science and everyday life is that they are seriously incomplete but useful nonetheless. Koslowski discusses cases where an agent's explicit knowledge of the causal mechanism that produces an effect is absent but an explanation is nonetheless offered by drawing from background knowledge, which suggests that an effect is present. Explanations of this sort are dispositional in nature, and are as varied as appeals to the solubility of sugar, the existence of new astronomical entities, and psychology's appeal to latent variables in structural equation models. Dispositional theories may mark the current limit of our explanatory understanding of some empirical phenomenon, or they might represent an agent's rudimentary understanding where a causal mechanism explanation is available. Koslowski reports studies where children, and even adults on occasion, rest content with something like a dispositional explanation when deeper knowledge cannot be obtained. Interestingly, despite a common belief to the contrary (recall Molière's scoff at explaining the soporific effects of opium by appeal to its dormitive power) dispositional explanations can have genuine, although, low explanatory power. For, they extend our referential reach to new entities, and they provide a stimulus for their own further development. Psychology is replete with theories of this sort, as for example, the postulational theories given to us by the use of exploratory factor analysis. Future research in the psychology of science should be able to tell us what it is about dispositional explanations that agents often find cognitively satisfying.

Koslowski's chapter on explanatory reasoning is well informed by what philosophers of science call "inference to the best explanation". Inference to the best explanation is based on the idea that much of what we know about the world in science, professional contexts, and everyday life is based on considerations of the explanatory worth of our beliefs. Scientists often accept theories about hidden causes of observed events because they are thought to be the best explanations of those events. This was the reasoning Charles Darwin used in judging his theory of natural selection to be superior to the rival creationist explanation of his time (Thagard, 1988). Koslowski remarks that inference to the best explanation is the most comprehensive description of actual scientific practice. In my view, this should not be taken to imply that all non-demonstrative scientific inference takes this form (as, for example, Gilbert Harman and Peter Lipton do), or that all depictions of inference to the best explanation genuinely inform us about scientific practice (being accounts that focus on the logical form of abductive reasoning do not). Koslowski's chapter adds an important sense of psychological realism to this important form of inference. As such, it provides methodologists with a sense of how methods of inference to the best explanation are apt for inquirers, while at the same time providing science educators with useful information to assist in furthering the explanatory competence of student learners.

Postmodernism

In the conclusion of their handbook, Feist and Gorman identify the "critique of the postmodern denial of scientific epistemology" (p.507) as one of a number of projects needed to facilitate the emergence of the psychology of science as a legitimate science studies discipline. The chapter by Capaldi and Proctor, 'Postmodernism and the development of the psychology of science', explicitly undertakes such a critique in the belief that postmodernism, and the related movements of social constructionism and contextualism, constitute a genuine threat to modern science, including the psychology of science. Postmodernism rejects the idea that there is an independent reality existing apart from ourselves as knowers, which grounds truthful claims about reality. Instead, reality is reinterpreted as what members of a culture or subculture agree on. Relatedly, truth is understood, not as correspondence with reality, but as little more than group consensus about beliefs.

Appropriately enough, Capaldi and Proctor's stalking horse is Kenneth Gergen, perhaps psychology's most prominent postmodern thinker (e.g., Gergen, 2001). They convincingly show that Gergen's claims on behalf of postmodernism do not stand up to critical scrutiny. Gergen supports his position by making implausible claims about both philosophy and psychology. For example, he misrepresents Thomas Kuhn as a relativist who is highly sceptical of the modernist outlook on science with its commitment to objective methods of knowledge assessment. Thomas Kuhn's strong rejection of such a depiction of his own views, along with Paul Hoyningen-Heune's (1993) detailed assessment of Kuhn's philosophy of science, give the lie to such misappropriations of Kuhn's views about science. Far from being a relativist, Kuhn was in fact a realist of sorts (a point made by both Capaldi and Proctor and the editors), and he explicitly endorsed the view that objectivity and value judgments underwrite scientific knowledge claims (Kuhn, 1977). Capaldi and Proctor also correct a number of oversimplifications and falsehoods that Gergen makes about science and psychology. These include the claims that psychology pursues '*the* truth' (first and foremost, psychology pursues predictive and explanatory success); that psychology's theories only change, they do not improve (in fact, its theories may increase their explanatory power); and that psychological scholarship virtually ignores historically important studies (the claim is clearly wrong, and many counter examples are given).

Importantly, Capaldi and Proctor warn us that postmodernism's prima facie strong endorsement of qualitative research methods is not a recommendation to use qualitative methods as complements to quantitative methods, but is really an endorsement of a perspective or world view in which an entirely different approach to inquiry is sought. The authors sensibly conclude by suggesting that people interested in the psychology of science should familiarize themselves with the unscientific views of postmodern thinking in order to better counter its threat to the prosecution of psychological studies of science in the manner of modern science.

Heuristic and Biases

In their chapter, 'Heuristics and biases that help and hinder scientists: Toward a psychology of scientific judgment and decision making', Joanne Kane and Gregory Webster examine a variety of biases that can result from using heuristics in the prosecution of social psychological research. Although heuristics play an indispensable role in the conduct of scientific research, bias is one of their defining features. Thus, the faulty reasoning that they often lead to has to be controlled for. The authors offer a number of recommendations for controlling or overcoming the deleterious effects of biases in heuristics. The biases they consider include the familiar confirmation, recency, and availability biases, but also null hypothesis testing and HARKing (hypothesizing after the results are in). Significance testing is not normally included on a list of common biases, and therefore deserves comment. It is well known that null hypothesis significance testing is the most commonly used approach to data analysis and hypothesis testing in psychology. It is also well known that the form in which it is adopted in psychology is subject to widespread criticism, though these criticisms are typically ignored by researchers, textbooks, and instructors. Kane and Gregory endorse the popular belief that the regular reporting of effect sizes may reduce the bias involved in dichotomous hypothesis testing. However, I believe that psychology is insufficiently aware of the fact that standard null hypothesis testing comprises an incoherent amalgam of the Fisherian and Neyman-Pearson schools of statistical thought, and that a neo-Fisherian perspective on significance testing is a viable alternative (Hurlbert and Lombardi, 2009). Among other things this perspective does not specify Type I error rate, *p* values are not misleadingly described as 'significant' or 'non-significant', judgment is suspended about accepting the null hypothesis on the basis of high *p* values, the' three-valued logic' that gives information about the direction of the effect being tested is adopted, and a clear distinction is made between statistical and substantive significance. Importantly, information about effect sizes and confidence intervals is provided as adjunct information where appropriate; it does not replace tests of significance. The neo-Fisherian paradigm contains a package of sensible reforms that improve Fisher's original perspective, and represents a reasoned case for retaining *p*-valued significance testing without the focus on null hypothesis significance testing.

Conclusion

In conclusion, I want to offer a few remarks about the interaction of the psychology of science and the philosophy of science, which is probably the most prominent science studies discipline. It is now clear that the psychology of science can influence the philosophy of science. Capaldi and Proctor (2012) recently traced the historical influence of the psychology of science on the philosophy of science and concluded that the gains in understanding thinking provided by the psychology of science will improve our understanding of the philosophy of science. Modern cognitive psychology and cognitive science, more generally, are prominent in this regard.

Conversely, the philosophy of science can influence the psychology of science. Understandably, this influence is not greatly evident in the present handbook, although there are places where characterizations of scientific reasoning benefit from a philosophy of science input (e.g., Barbara Koslowski's discussion of abductive reasoning and the nature and use of causal mechanism explanations). Clearly, there are numerous opportunities for new studies in the psychology of science to be informed by understandings of science that come from contemporary philosophy of science. These include questions such as the following: Do scientists act as Bayesian agents? Do scientists properly und understand the statistical methods they use? How do scientists construct different types of models? Are scientists scientific realists in their philosophical outlook, and if so, are there realist commitments governed by local considerations? The phrase, "the knowing subject", is due to Karl Popper (1972), who advocated an objective theory of scientific knowledge that made no reference to cognitive agents and their mental states. Happily, the anti-psychologism of earlier prominent philosophers of science such as Popper has given way to a plausible moderate psychologism in which psychology, and cognitive science more generally, play an important role in helping us understand how methods are apt for human inquiry. Herbert Simon and Paul Thagard's computational approaches to the philosophy of science are just two examples of psychologically oriented philosophies of science that will advance our understanding of the structure and growth of scientific knowledge from a psychological point of view.

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