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How Science Is Changing

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There is currently a lot of attention being given to reconsidering science. That is, scientists are not only working to advance science within their fields, some are revising their conceptions of science itself (Riegler & Mueller, 2014). This work can be found under several names: science 2.0, science of science, and second order science. There are several causes of these reflections.

1. The availability of the internet and computer technology creates opportunities and behaviors among scientists that did not previously exist (Shneiderman, 2008). In addition to rapid messaging and co-authoring of papers with colleagues anywhere in the world, scientists can easily share data, thereby facilitating replication efforts.
2. Science of science, which was previously based on economics, sociology and political science is now benefitting from bibliographic databases and citation analysis (Feldman, 2016). We have access to data on how scientists operate.
3. The field of cybernetics has created a third way of thinking about how science is done. Previously the two dominant positions within philosophy of science were Karl Popper's (1963) normative approach and Thomas Kuhn's (1962) sociological approach. Work on the biology of cognition was undertaken to test empirically the existing theories of knowledge. That research led to the conclusion that observations independent of the characteristics of the observer are not physically possible (McCulloch, 1965; Maturana & Varela, 1980; von Foerster, 2003). Hence, by studying the brain scientists have come to a new understanding of knowledge and of science. This understanding has ethical implications and implications for research methods, particularly in social

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science (Flyvbjerg, 2006). For a summary of the three views of science, see Table 1 (Umpleby, 2016).

Table 1: Three Philosophical Positions

Popper	Kuhn	von Foerster
A normative view of epistemology: how scientists should operate	A sociological view of epistemology: how groups of scientists operate	A biological view of epistemology: how the brain functions
Non-science versus science	Steady progress versus revolutions	Realism versus constructivism
Solve the problem of induction: conjectures and refutations	Explain turmoil in original records versus smooth progress in textbooks	Include the observer within the domain of science
How science as a picture of reality is tested and grows	How paradigms are developed and then replaced	How an individual constructs a “reality”
Scientific knowledge exists independent of human beings	Even data and experiments are interpreted	Ideas about knowledge should be rooted in neurophysiology
We can know what we know and do not know	Science is a community activity	If people accept this view, they will be more tolerant

4. Interest in “second order science” has led to increased interest in meta-research, where scientists work not with raw data but rather with previous scientific reports (Mueller, 2016). This approach to second order science is a great aid to quality improvement in science and to science policy.
5. There is increased attention to questioning underlying assumptions. Scientists frequently make simplifying assumptions. For example economists for a long time assumed that human beings were rational profit maximizers and all participants in an economy had both complete information and the same information. Lately these assumptions have been questioned. Adding new dimensions to existing scientific theories is the main way that science grows. See Krajewski (1977) *Correspondence Principle and Growth of Science*. Questioning underlying assumptions is now happening in our understanding of science itself (Umpleby, 2014).

6. If we think of social systems as being composed of purposeful systems (individuals, organizations, nations and some machines) the importance of involving people in the design of research in addition to seeing them as subjects of research becomes clearer. Involving subjects of research in the design of research is one feature of “action research” (Umpleby, 2017). More action research would increase the relevance of social research. Citizens are much more likely to support government funding for social science research if they see social scientists working with them to achieve *their* goals, not only the goals of scientists. And scientists will learn more about the purposes their subjects are pursuing.

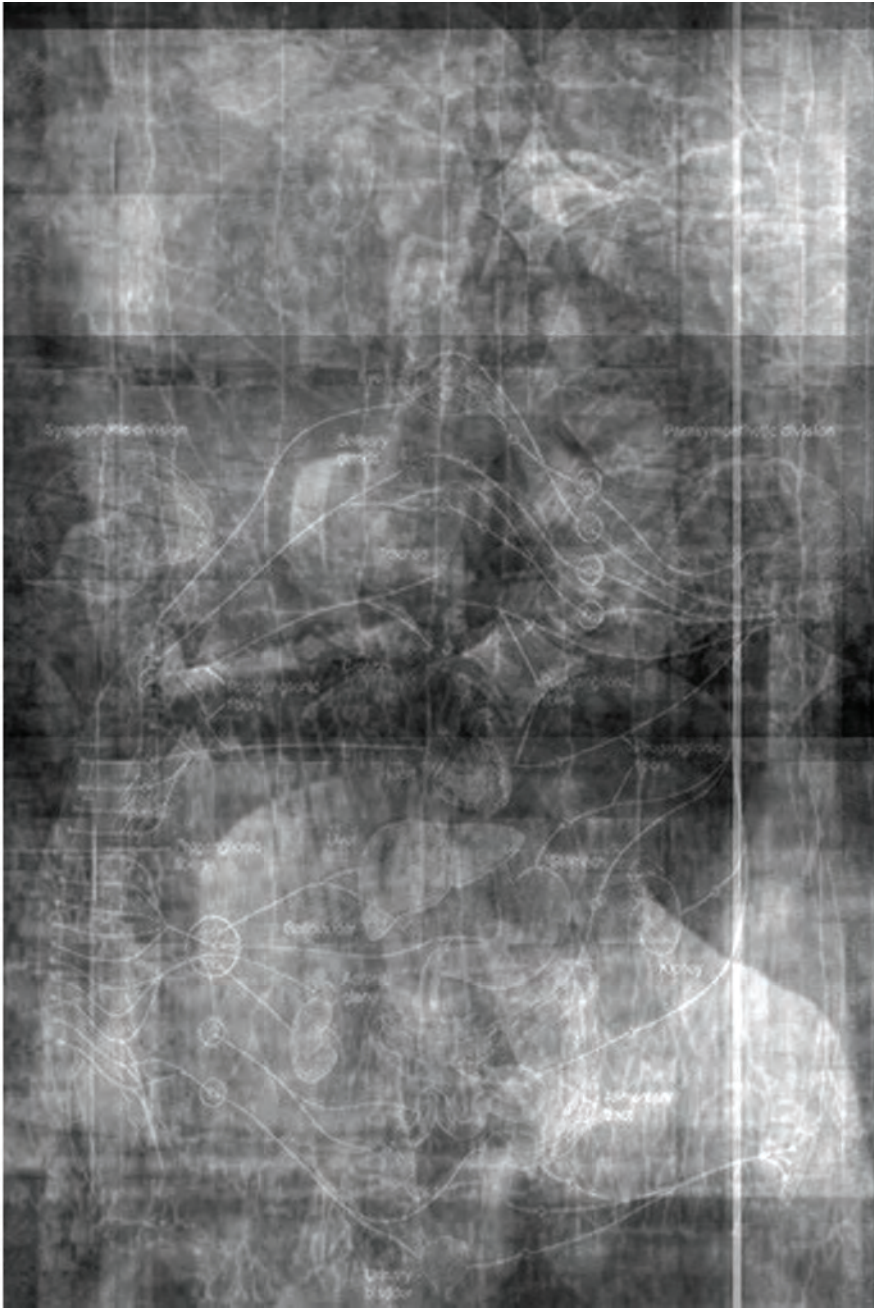
Perhaps these issues will be discussed by the Decadal Survey of the Social Sciences, now being conducted by the U.S. National Academy of Sciences (http://sites.nationalacademies.org/DBASSE/BBCSS/DBASSE_175146).

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