Humans as Scientists: Scientists as Humans

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Abstract

This article discusses how constructivist psychology might contribute to studies of the history and philosophy of science. It is suggested that this would be a fruitful topic for graduate research, and a brief analysis is provided of what would be required to model the construct systems involved in the Priestley-Lavoisier controversy over the roles of phlogiston and oxygen in calcification. It is also suggested the rich literature and conceptual frameworks of science studies can contribute significant enhancements to constructivist psychology.

1 Introduction

One interesting and unusual feature of Cromwell's stimulating, provocative and entertaining book is his perceptive analyses of various aspects of scientific endeavours and conceptual frameworks from a constructive perspective (Cromwell, 2010, pt.7). This article focuses on these analyses.

Kelly (1955, p.4-5) contrasts his notion of "man-the-scientist" with those of other psychological frameworks and suggests that the processes of prediction and control that we associate with science are precisely those that characterize all human phenomena and provide the foundation for psychological science. He states that the range of convenience of personal construct psychology is restricted to "human personality and, more particularly, to problems of interpersonal relationships" (p.11), but does not hesitate to apply it far more widely, for example, to constructs of *mass*, *weight* and *energy* in physics, as well as to many constructs of the human sciences. Cromwell has followed in his footsteps by providing accounts of aspects of scientific thought processes that raise interesting questions as to how constructivist psychology might contribute to studies of the history and philosophy of science, and also how the rich literature and conceptual frameworks of those disciplines might contribute to constructivist psychology.

Cromwell's project is daunting because of the wealth of material available. We now have ready access to the notes, diaries, correspondence, papers and biographies of many major scientists such as Newton, Boyle, Priestley and Lavoisier, but these comprise many thousands of pages requiring a major effort to assimilate even in part, and the associated interpretive and background literature is substantially larger. We suffer not from lack of data but from a veritable *embarras de richesses*. Similar considerations apply to the massive literature on the history, philosophy, psychology and sociology of the community that we characterize as scientists.

However, the project is timely because Dewey's pragmatic constructivism which provided the foundation for Kelly's psychology has become mainstream (Margolis, 2010) and the extensions and interpretations made by Kelly and others may contribute nuances that are relevant to science studies. The synergy is apparent in Margolis' exposition: "the human being we call a 'self' or 'person' is an artifact of cultural history" (p.xiv); "pragmatism favors a constructivist realism freed from every form of cognitive, rational and practical privilege, opposed to imagined

necessities of thought and reality, committed to the contingencies of the human condition, and open to plural, perspectival, provisional, even non-convergent ways of what may be judged valid in every sort of factual and normative regard" (p.3).

2 Kelly's Contribution

How realistic is Cromwell's suggestion that personal construct psychology may contribute to science studies? What unique and significant contributions did Kelly make that went beyond Dewey's pragmatic constructivism and might be valued by those in other disciplines?

The nature and originality of anyone's contribution to any topic will always be subject to debate. However, I suggest there are major aspects of personal construct psychology that are significant to its application in science studies. First, Kelly took Dewey's notion of the significance of *anticipation* in living systems as a minimal, and yet complete, foundation for psychology from which all other psychological constructs could be derived. This is important in countering tendencies to attribute causal agency to a range of poorly defined notions such as 'drive,' 'motivation' and 'learning.' Second, he derived construction and categorization as mechanisms evolved to facilitate anticipation rather than as independent processes. Third, he emphasized the significance of *constructive alternativism*, that we may construe the same events in different ways possibly with different anticipations. Fourth, he emphasized that when construing the behaviour of others we do so through our construct systems rather than theirs. Fifth, he emphasized the personal aspect of even what are taken to be 'public' constructs, that there is never a perfect consensus on how a distinction should be made. Sixth, he noted that the elements of experience that we construe are themselves personally constructed and we can never be sure that two people, or one person at different times, are construing the 'same' element. Seventh, he noted the construct systems we use on different occasions may differ and be incompatible. Eighth, he noted that, in adjusting our construct system to take into account new experiences, there are 'core' constructs that we are reluctant to change and such preferences are themselves idiosyncratic.

Kelly places no constraints upon the nature of what is anticipated except that it will be in terms of one's construct system. A nuance of this is that anticipations may involve constructs apparently remote from what is being construed and may conflict with one another as guides to action. Schütz (1943, 142-143) provides a phenomenological account of human rationality, again deriving from Dewey, that emphasizes the plurality of anticipations that may be relevant to any decision: an end's relationship with other ends; the consequences and side-effects of achieving an end; the means appropriate to the end; the interaction of such means with other ends and means; the accessibility of those means; the construal that others might place on the actions; its interaction with their own planned actions; and so on. This provides a significant gloss to the fourth point above, that our construct systems used to attempt to understand and explain the behavior of others may need to be extended to attempt to capture a much broader range of anticipations than might be our focus of interest.

These issues arise in science studies but often in a non-systematic way. Personal construct psychology provides a coherent logical framework in which they can all be derived from an extraordinarily simple model of human anticipatory processes.

2 Science Studies

Making a contribution to other disciplines could be satisfying in providing wider validation of Kelly's insights, but might make no direct contribution to the development of personal construct psychology. However, I see Cromwell as suggesting rather more, that construing science studies through the lens of personal construct psychology would by no means be a one-way trade. The extensive historical and philosophical literatures already existing provide significant theoretical frameworks and richly documented data that could enhance psychological theories of the personal scientist. There are major philosophers of science, such as Kuhn and Millikan, in the pragmatic constructivist tradition documented by Margolis whose studies parallel those of Kelly and may be viewed from a personal construct psychology perspective as providing fresh insights into issues that he regarded as fundamental.

For example, Ruth Garrett Millikan's (1984) studies of *language, thought and other biological categories* have pragmatic, constructivist foundations even though her links to Dewey are indirect through later pragmatists such as Davidson and Rorty who were influenced by Dewey. Her analysis of "substance concepts" provides specific examples of notions that are consistent with and extend those of Kelly. The term 'substance' in the philosophical literature derives from Aristotle's ontology where the category of primary substance is the range of convenience for everything, characterized as a concept that has no opposite. It encompasses material substances and also events, ideas, and anything else that we might construe as having existence and persistence; that is, what Kelly terms an *element* of experience.

This definition of 'substance' may appear so general as to be vacuous, but Millikan gives it a more profound and operational meaning by proposing that what we characterize as substances are those aspects of the world about which we might reasonably expect to have anticipations; that is, what Kelly terms "the replicative features of experience" (p.73-74). She notes that "the most immediately useful and accessible subjects of knowledge are things that retain their properties, hence potentials for use, over numerous encounters with them. This makes it possible for the organism to store away knowledge or know-how concerning the thing as observed or experienced on earlier occasions for use on later occasions, the knowledge retaining its validity over time. These accessible subjects for knowledge are the things I am calling 'substances'" (Millikan, 2000, p.2).

She introduces a notion of "substance templates" that exactly parallels Kelly's "transparent patterns or templets which man creates and then attempts to fit over the realities of which the world is composed" (p.8-9): "The primary interest of groupings like persons, species, and chemical elements is not that they themselves correspond to substances, but that they bring with them 'substance templates.' Many of the same sorts of questions can be asked and answered though not, of course, answered in the same way, for all members of each of these groups. They are natural groups, the members of which display a common set of determinables rather than, or in addition to, a common set of determinates" (Millikan, 2000, p.2). *Determinable* is a logical term introduced by Johnson (1921, pt.1, ch.11) for what Kelly terms a *range of convenience* and determinate for what he terms a *pole*, together constituting a *construct*.

Millikan's concept of substance is no longer Aristotelian. Her 'substance' has many opposites, that which cannot be anticipated for some reason, because it never repeats or its repetition is not apparent, or because it is a random or chaotic phenomenon, and so on. She has replaced

substance as the apex of being with anticipation as the basis on which we construe being, a constructive realism close to those of Dewey and Kelly.

Other examples are Kuhn's (1970) well-known studies of the cognitive transitions in scientific revolutions, and later developments in the philosophy of science such as Giere's (2006) 'perspectivism' which are obviously consonant with Kelly's analyses of *constructive alternativism*. Kuhn unknowingly adopted some of Kelly's ideas when he used the notion of *contrast sets* to model Wittgestein's family resemblances (Andersen, 2000); Frake (1969) developed the notion of contrast sets to model primitive cognitive systems in anthropology and attributed it to Kelly (1955).

I have emphasized the common ground between Margolis, Millikan, Kuhn, Giere and Kelly to illustrate that the fundamental ideas of personal construct psychology are to be found in other literatures that are foundational to science studies, and hence that Cromwell's constructivist analyses of issues in scientific research explore an interesting area of cross-disciplinary research. The following sections discuss how one might proceed.

3 Psychological Studies of Science

Cromwell discusses a wide range of scientific topics and scientists, from phlogiston to superstrings, from Priestley to Hawking, all of which are documented and discussed in a wealth of historical, scientific, philosophical, psychological and sociological literature. What might further analysis from a personal construct psychology perspective add to these existing commentaries? An example of what might be valued is Manuel's (1968) psycho-analytic study of Newton and the influences of his personality upon his science which provided new insights into his scientific discoveries. A constructivist analysis that models the anticipatory processes involved in terms of the constructs underlying them, their sources, their roles in the personality and wider life experience of the scientist studied, and their propagation to others, could also be a major contribution to understanding the processes of scientific innovation.

The analyses of Manuel and others portray a very different Newton from the hagiographic portrayal common in textbooks and simplistic accounts of the scientific revolution. Newton was primarily concerned to anticipate the second coming and to date it from biblical prophesies to ensure that temple of Solomon was prepared at the appropriate time. The dating required a knowledge of planetary motion and he developed mathematic techniques and laws to model such motion. He also developed an elaborate set of rules to guide biblical interpretation, of which those of his scientific method are a sub-set (Manuel, 1974). This link between his religion and his science not surprising if one notes that he, Boyle and, later, Priestley, saw understanding the physical world as a puzzle set by God that, through his benevolence, was soluble by man; the phenomena of the world were construed as if they were text in a sacred book and could be studied in the same way.

In many respects, the literature on the scientific revolution has already identified the anticipations of the major scientists and the constructs they developed to facilitate them, but has not done so systematically within a constructivist framework and it could be an interesting and worthwhile exercise to do so.

4 A Framework for Constructivist Studies of Science

Suppose some graduate students in constructivist psychology focus their dissertation research on developing in-depth one of the areas of science that Cromwell discusses. What would be involved?

Cromwell commences (p.313) with the chemical revolution initiated by Lavoisier and the puzzle as to why Priestley resisted Lavoisier's explanation of the calcification of metals as resulting from their combination with oxygen rather than their loss of phlogiston; a puzzle because Priestley is often credited with 'discovering' oxygen (Hudson, 2001) and also with being very ready to change hypotheses as the result of experiments (Barrotta, 2000).

The topic is significant to the philosophy and logic of science because three imponderable substances, *aether*, *phlogiston* and *caloric*, are taken to epitomize substances that have played major roles in scientific progress but are no longer believed to exist. How can concepts with no referents be significant to the advance of science except as impediments, and yet were involved the development of major theories such as Newton's gravitation (Aiton, 1969), Maxwell's theory of electromagnetism (Siegel, 1991), and Lavoisier's theory of oxidation and acids (Siegfried, 1989)?

The twenty five volume set of Priestley's works (Priestley & Rutt, 1817) is readily available in most libraries and freely available in digital form on the web. The minute books of the London coffee houses where Priestley, Kirwan and others discussed phlogiston are also available (Levere & Turner, 2002) as are relevant papers in the Proceedings of the Royal Society. There is a massive secondary literature in books and journals that draws upon these and other historical materials to documental Priestley's life. From this one can develop a model of Priestly as a powerful intellect, fluent in some eleven languages, adopting a critical Newtonian framework for both his theology and science, moving from his childhood Calvinism through Arianism and Socianism to Unitariansim, writing a major history of research on electricity that led to his doctorate and FRS, and like Lavoisier commencing studies of 'airs' based on Hales (1727) book on Vegetable Staticks where he saw the way in which plant life replenished breathable air as evidence of God's benevolent design. He made major contributions to the ongoing industrial revolution in Britain through his nitrous oxide technique for testing air pollution and his links through the Lunar Society with major industrialists such as James Watt and Josiah Wedgewood (Schofield, 1963).

Priestley is situated in the 'chemical revolution' of the eighteenth century, nearly a century after the scientific revolution of the seventeenth century, based, in Britain at least, on Newtonian principles but occurring later because the processes that change the nature of physical substances in chemistry are far more complex than those of unchanging matter in motion in mechanics. His instrumentation (Badash, 1964) was based on Boyle's air pump (Shapin & Schaffer, 1985) which he saw in these terms: "real history resembles the experiments with the airpump, condensing engine and electrical machine, which exhibits the operations of nature, and the nature of God himself" (Priestley & Rutt, 1817, V.24. p.30). Like his contemporary, Joseph Black, the discoverer of "fixed air" (carbon dioxide) he saw Newton's advice of investigating nature without hypotheses as fundamental and his research was empirical with one experiment leading to another. This is the major difference between his construct system and that of Lavoisier who

was a theorist and systematizer providing the conceptual framework for what became modern chemistry, drawing heavily on the experiments of, and controversy with, Priestley to do so.

Our graduate students will need to draw on the secondary literature on Priestley, Lavoisier, Newton, Hales, and so on, which is diverse and conflicting; to make sense of it requires modeling the construct systems of the relevant historians. Fortunately, the historiography is also documented and provides perceptive accounts of the different intellectual stances involved (Chang, 2010; McEvoy, 2010; Schaffer, 1984). They will also need to understand basic constructs of historiography such that of 'Whig history' that construes past theories and experiments in terms of present-day science and 'anti-Whiggism' that construes present-day science as it might be understood by past scientists (Allchin, 1992).

Anti-Whiggism is exemplified in Chang's (2011) study of the *persistence of epistemic objects* (Millikan's 'substances,' Kelly's 'elements') which considers what would have happened if phlogiston theory had continued and concludes that Lewis (1926, p.168) is correct in suggesting that phlogiston would eventually have become construed as constituted by free electrons. In fact phlogiston theory did continue for far longer after oxygenation had been accepted than is generally appreciated (Allchin, 1992). Lavoisier's theory only addressed weight change not the phenomena of colour, heat, and so on, which were core constructs in chemists' construal of the material world (Boantza & Gal, 2011), and his introduction of another imponderable substance, *caloric* (Fox, 1971) seemed just another term for phlogiston.

Chang's (2012) recent book, *Is Water H2O?*, takes the constructive approach to science to new levels that have never before been explored. He analyzes in depth and with careful attention to both historic and scientific accuracy what would be the situation if scientific theories that have been discarded were revived; what contribution might they make to current scientific issues? It is a *tour de force* of constructive alternativism applied rigorously to hard science, and provides detailed material for the application of personal construct psychology to science studies that our graduate students will not find anywhere else.

They will also need to gain some background in chemistry, and constructivist accounts such as those of the Latour school will prove very useful (Bensaude-Vincent & Stengers, 1996), as will those from a Kuhnian perspective (McCann, 1978). There are also role models in the many studies of the cognitive systems of particular scientists and scientific communities such as: Mitroff's (1974) on the changing concepts of moon scientists as Apollo data was received; Nersessian's (1984) and Gooding's (1990) studies of Faradays's mental processes; Atran's (1990) on cognitive foundations of natural history; Rheinberger's (1997) of protein synthesis. The genre is not new, but a personal construct psychology methodology would be innovative.

5 Conclusions

This article has taken one of the themes of Cromwell's book and attempted to indicate how his constructive analyses of scientific activities might be developed as a research program. It would be a daunting but extremely worthwhile exercise, and one that might have major benefits both to the historiography of science and to the extension of personal construct psychology to include insights from other disciplines concerned with human anticipatory processes. I hope that the discussion above encourages researchers to address this area rather than makes the effort involved seem overwhelming—the latter was not my intent!

Priestley remarks that "were it possible to trace the succession of ideas in the mind of Sir Isaac Newton during the time he made his greatest discoveries, I make no doubt but our amazement at the extent of his genius would a little subside." (Priestley, 1755, V.II, p.167). One pleasant outcome of preparing this article is that my appreciation of Priestley's genius has increased immeasurably as I have come to understand him as a person and what he achieved.

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