

Theory Change through a Logical Lens

Ioannis Votsis (New College of the Humanities)

A familiar pattern can be seen in the history of science. Not long after a theory becomes established, the seeds of its demise are sown. In time, those seeds germinate into a full-blown rival theory, which supplants the earlier theory and resets the whole process. How long this pattern continues is unknown as the dynamics of theory change are somewhat opaque. In this talk, I endeavour to throw some light on those dynamics by placing some aspects of the formation, alteration and elimination of theories under a logical lens. Taking the scientific realism debate as a blueprint, I identify some important lessons concerning theory change and offer a number of history of science cases in support. I then put forth two quasi-logical notions, content weakening and content strengthening, which can aid the explication of the dynamics of theory change, particularly in relation to cases of (dis-/)confirmation.

The four lessons that emerge in the context of the debate over scientific realism are chosen primarily because they form common ground between at least some realists and anti-realists. They are:

1. The most empirically successful theories in our possession may be very far away from the whole truth (Kuipers 2000).
2. At least some parts of the most empirically successful theories in our possession must be replaced.
3. Empirically successful successor theories must be such that they either straightforwardly reduce to or degenerate into the well-confirmed parts of their empirically successful predecessors (Radder 1991).
4. Theories ranging over different domains of phenomena sometimes share analogous structures.

Several cases from the history of science are adduced in support of these lessons. For example, with respect to the fourth lesson (Bartha 2010), one can bring up conservation laws as applied to the domains of energy, linear momentum, angular momentum and electric charge.

To explicate the dynamics of theory change, e.g. the replacement of theory parts, we need to conceive of theories as having content that is decomposable into parts. I propose to understand the content of a theory T in terms of a set of sentences that is *closed under the natural consequence relation*. A set of sentences K is closed under the natural consequence relation $D_N(K)$ iff it contains as members all and only sentences that are: (i) members of the deductive closure of K , (ii) non-logical truths, (iii) non-redundant in content and (iv) relevant consequences of one or more sentences in K (Schurz 2014). Two quasi-logical notions can then be constructed to help explain what happens in theory-change:

A theory T is *content-weakened* to a theory T^- if and only if $D_N(T^-) \subset D_N(T)$.

A theory T is *content-strengthened* to a theory T^+ if and only if $D_N(T) \subset D_N(T^+)$.

The application of the two notions fosters our understanding of the dynamics of theory change by painting a more fine-grained picture of the interplay between the content parts of theories in producing testable consequences.

References:

- Bartha, P. (2010) *By Analogical Reasoning*, Oxford: Oxford University Press.
Kuipers, T. (2000). *From Instrumentalism to Constructive Realism*, Dordrecht: D. Reidel.
Radder, H. (1991) 'Heuristics and The Generalized Correspondence Principle', *British Journal for the Philosophy of Science*, 42: 195–226.
Schurz, G. (2014). Bayesian pseudo-confirmation, use-novelty, and genuine confirmation. *Studies in History and Philosophy of Science* Part A, 45, 87-96.