Structural Realism: Invariance through Theory Change

Structural realism has various diverse manifestations. One of the things that structural realists of all stripes have in common is their endorsement of what I call 'the structural continuity claim'. Roughly, this is the idea that the structure of successful scientific theories survives theory change because it has latched on to the structure of the world. In this talk I elaborate, elucidate and modify the structural continuity claim and its associated argument. I do so without presupposing a particular conception of structure that favours this or that kind of structural realism but instead by concentrating on neutrally formulated historical facts. The result, I hope, throws light on what a structural realist must do to evidentially benefit from the historical record of science.

The implicit argument underwriting the structural continuity claim can be reconstructed as follows: Premise (1) Only structural elements of predictively and explanatorily successful scientific theories have been (and will be) preserved through theory change. Premise (2): Preservation of an element implies or at least is good evidence for its (approximate) truth. Premise (3): Non-preservation of an element implies or at least is good evidence for its falsity. Conclusion: It is probably the case that only structural elements are (approximately) true.

In this summary I restrict my comments to the first premise. Several points can be raised with respect to it. First, not all structures are created equal. Some play no active role in the predictive and explanatory success of a theory because they do not correspond to any structure in the world. Their non-preservation would therefore not encumber the structural realist. Traditional scientific realists have long employed a distinction between essential and idle posits to weed out those elements of theories that played no substantial role in their predictive and explanatory success. An analogous distinction is required for the structural realists. Those structures that were responsible for a theory's predictive and explanatory success I will henceforth brand *operative*. Those that fail this condition, I will brand *inoperative*.

Second, as many authors have rightly pointed out the neat preservation of structure exhibited by the derivation of a predecessor theory's set of equations from its successor is atypical in the history of science. More typically, an equation belonging to a superseded theory can be recovered only as a limiting case of a successor theory's equation. Aware of this, Worrall (1989) reasoned that structural realism benefits from 'limiting case' survival when appeal is made to the correspondence principle. Redhead (2001) goes on to identify two ways in which limiting case structures are related: via continuous and via discontinuous transformations. According to him, while the former are legitimate cases of correspondence the latter involve too much change in the structure to be of help to the structural realist. Contra Redhead, I argue that quite a few cases of discontinuous transformations still exhibit a preservation of essential features between structures and can therefore be thought of as genuine, i.e. non-trivial, cases of correspondence that can lend credence to the structural realist. To express this difference, I refine the notion of discontinuous transformation by dividing it into three new notions: $\text{discontinuous}_{min}$, $\text{discontinuous}_{mid}$ and $\text{discontinuous}_{max}$. Only the last is undesirable for the task of supporting structural realism.

Third, not all successor equations have limiting case analogues in the predecessor theory. Hans Radder (1996) cites the relativistic equation $E = m_0c^2$ for a particle's energy with rest mass m_0. No analogue of it exists in classical mechanics so any talk of structure transformation from new to old theory would be pointless. Radder and various other philosophers tout this fact as detrimental to the correspondence principle. Against these philosophers I argue that the objection confounds the scope of the principle. The principle does not require that all (successful) successor structures correspond to (successful) predecessor structures. Rather, it requires that all (successful) predecessor structures correspond to (successful) successor structures. The latter simply reflects the fact that successor theories venture beyond their predecessors, describing and predicting new classes of phenomena.

Fourth, if some Kuhn losses – NB: a Kuhn loss is a successor theory's loss of an ability possessed by its predecessor to explain certain phenomena – were operative structural elements, it would no longer be true that all operative structural elements survive theory change. For Kuhn losses to have any bite they need to be explanations that enjoyed genuine empirical success. Radder (ibid., 63) offers the only example that seems to have any bite, namely Poiseuille's law. What's crucial about this law is that it is a classical law that cannot be reproduced within quantum mechanics. It thus seems to be a bona fide case of Kuhn loss in the stronger sense. Yet, even this need not trouble us since Poiseuille's law is still in use today, i.e. it has not been lost. Having said this, Poiseuille's law presents a special problem for structural realism. Up till now we have required that old structures be preserved in some suitable form in new structures. Poiseuille's law is preserved but independently of any new structure. Is this fatal to the structural continuity claim? No. New paradigms, theories or structures need not replace old ones *in toto*. That is, they need not range over all the old domains of phenomena. Those structures that get left out are unsurprisingly still in use.

Modified in accordance with the four aforementioned points, the first premise now reads as follows: 1′. All and only operative structural elements of scientific theories have been (and will be) preserved through theory change either (a) intact by derivation, or (b) via a transformation from new to old structure that is either (i) continuous or (ii) $\text{discontinuous}_{min}$ or (iii) $\text{discontinuous}_{mid}$ or (c) intact but independent of any currently accepted structures.

References:

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Worrall, John (1989), 'Structural Realism: The Best of Both Worlds?', repr. in D. Papineau (ed.) *The Philosophy of Science*, Oxford: Oxford University Press, 1996.