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Cause and constitution in complex physical systems

Explaining the behaviour of a complex system (or mechanism) characteristically requires a description of the relationships between the whole system and its parts. Therefore, it is critical for the development of such explanations to understand the compatibility of the kinds of relationship exemplied within those systems. This paper argues that two types of relation regularly exhibited in complex systems, causal and constitutive, are not incompatible.

It seems agreed among many philosophers that there could be no constitutive relationships that are also causal relationships (Lewis 2000, Kim 2000, Bechtel and Craver 2007, Fazekas and Kertesz 2011, Ylikoski 2013). Causal relationships are treated as relating logically independent relata (see Steward 2010 for a discussion), as asymmetric (e.g. Lewis 1973, Bechtel and Craver 2007) and non-synchronous. Constitutive relationships, such as the relationship between wholes and their parts, are contrastively treated as relating logically dependent relata (Craver 2007), as being symmetric (in a certain sense) and synchronous (Kim 2000, Leuridan 2012). These distinct treatments are in serious tension with standard characterizations of constitutive mechanisms in the mechanisms literature, as those entities (parts or component parts), and activities (interactions or component operations) which are `productive of' (Machamer et al. 2000), `produce' (Glennan 1996) or `are responsible for' (Bechtel and Abrahamsen 2005) phenomena. If one takes `produce' and `are responsible for' to be synonyms for `cause', then one would be excused for thinking that these are characterizations of constitutive relationships. In causal terms. Craver's use of mutual manipulability as a criterion for mechanism components has most clearly raised this spectre (Leuridan 2012). More generally, explanations which draw on constitutive relationships exhibit many of the features and diculties associated with causal explanations (Ylikoski 2013), again, suggesting a compatibility of the two relations. However, most seem to reject these interpretations and some actively explain how this interpretation can be avoided (Ylikoski 2013, Bechtel and Craver 2007).

This paper first considers arguments that constitutive relationships are incompatible with causal relationships. We show that despite objections (Leuridan 2012, McManus 2012), the mutual manipulation of parts and their wholes can satisfy the preclusion that interventions directly cause the value taken by the effect-variable. We deny that constitutive relationships are identity relations (cf. Ylikoski 2013, pace Fazekas and Kertesz 2011), that they exhibit logical dependency, and we deflate concerns that their synchronicity and symmetry inevitably yield causal loops (Kim 2000). Next the paper examines two contrasting cases of explanation of complex system. In the first, a girder buckles giving rise to the bridge, of which it is a part, collapsing. We argue, via investigation of the structural modelling techniques of finite element analysis, that a girder's buckling, whilst clearly constitutive of the collapse of the bridge, should also be viewed as causing it. In the second, a neutron star is formed when a dying star's core mass surpasses the Chandrasekhar limit. Typically, this increase in mass is treated as a triggering cause of core collapse to neutron star density. However, as the system is simulated, the core must remain above the Chandrasekhar limit, and hence, we argue it is also a constitutive feature of the mechanism of core collapse. In both cases dynamical modelling of the parts of the system over time is crucial, and this is what renders constraints on the compatibility of causal and constitutive relations artificial.

We end by showing how a removal of these constraints is reected in explanation of complex systems. For example, it may no longer be necessary to render complex systems as comprising a strict hierarchy of parthood relationships within wholes; nor need we understand causal relationships within systems as precluding overdetermination (in a qualified sense). We also note why a conceptual distinction between causal and constitutive relationships is worth maintaining, in spite of the argument that metaphysically the two relationships can be coextensive.

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