"Social Hypergraph Analysis": Towards an operationalisation of Actor-Network Theory Using hypergraphs

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Despite its wide-ranging influence in social science, the field of actor-network theory (ANT) has proven difficult to operationalise quantitatively. Although social network analysis (SNA) and ANT appear to share certain affinities (e.g., the term ‘network’), attempts to develop an ANT approach to SNA (and vice versa) have stumbled upon fundamental problems or ‘discontinuities’ between them (Venturini, Munk, and Jacomy, 2016). These problems constitute serious obstacles for progressing ANT research using digital data. In this paper, we propose hypergraphs as one way forward to operationalising ANT. Broadly, we term this method ‘social hypergraph analysis’ (SHA). We outline SHA in this paper and apply it to analyse social media data, using a case study of the anti-vaccination debate on Twitter.

Social media data provide us with trace representations of ordered social life. Yet the order we impose on these data has important consequences for how we come to understand, interpret, and model the ‘social’. Nowadays, it is common to reconstruct social media data as networks, using a mathematical formalism (graph theory) that squeezes reality into pairwise relationships (edges) between human and non-human objects (vertices). For example, a friendship network is a type of undirected graph, where the existence of an edge between “John” and “Sally” denotes that they are friends. The World Wide Web provides a well-known example of a directed graph, where a webpage may contain a hyperlink to another webpage, although this relationship is not necessarily reciprocated.

Whilst graphs provide a practical structure and formalism for analysing data as networks, the order that they impose upon the data can be problematic. For social phenomena in particular, interactions between entities are often complex and supra-dyadic, involving more than two actors, and taking place in the context of multi-user groups (Heintz and Chandra, 2015). From a computational perspective, we know that graphs can result in unexpected information loss, which impacts upon algorithm performance and output (Zhou, Huang, and Scholkopf, 2010). A solution to this problem has been to model complex networks as hypergraphs (Estrada and Rodríguez-Velázquez, 2005). Broadly speaking, hypergraphs are generalisations of graphs, whereby an edge, or ‘hyperedge’, can connect more than two vertices. This provides the ability to represent complex relationships between entities unambiguously compared to graphs. In other words, hypergraphs capture higher order relations between entities—not only binary, but also N-ary relations that reflect the supra-dyadic dynamics of many social processes. This more relaxed structure of hypergraphs offers a precious resource for operationalising key social theories, such as ANT, computationally.

Recently, ANT scholars have resurrected Tarde's ancient theory of the 'monad', showing how a 'monadological' approach can provide powerful new insights into digital trace data (Latour et al., 2012). Yet an unsolved problem is how to coherently and practically implement a 'monadological' approach to network analysis and visualisation, given the discontinuities between SNA and ANT (see Venturini et al., 2016). It seems that a key aspect of these problems stems from the ontological constraints inherited from graph theory, that is, the social order it imposes upon data-qua-networks.

We contend that hypergraphs provide surprising affinities and continuities with ANT. All actors in the network (human and non-human) are considered equal; they are granted the same level of importance and ontological status. People, words, objects, buildings, institutions, and so forth, are all assembled as vertices in the network. Proceeding from this, we are able to differentiate and trace associations between entities by assembling them within hyperedges that represent different kinds of relationships and processes. Such an approach implicitly dethrones the privileged status of humans as the only entities capable of 'acting' in the network (read: having agency). It is perfectly reasonable that non-human vertices, such as institutions or hashtags, have a more "stronger, wider and longer lasting associations" in the network (Latour et al., 2012, p. 591). Rather than preconceived notions of 'structure' we are led to consider "differently conceived wholes" (Latour et al., 2012, p. 592) composed of heterogeneous entities who are mutually co-defined through their hyperedge relationships. Thus, we can learn about entities in the network not via a separate stratum of 'node-level attributes', but by tracing associations through the intersecting hyperedges of the network. Indeed, it is this kind of navigational practice that has been recently operationalised within ANT through Tarde's idea of the 'monad': "A monad is not a part of a whole, but a point of view on all the other entities taken severally and not as a totality" (Latour et al., 2012, p. 598). It is the complex, traceable, and quantifiable interrelations of hyperedges that defines the identities and roles of entities in the network.

To position and illustrate these ideas further, we outline an alternative form of SNA using hypergraphs, which we term social hypergraph analysis (SHA). We provide examples and preliminary findings from a project where we apply SHA to study the anti-vaccination debate on Twitter.