Comparative Models of Neural Connectomics and their Relevance for Social Network Theories

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Experience driven behaviors depend on the spatio-temporal variation in the activity pattern of cortical neurons in the brain. This variation builds on those cellular properties that specify single nerve cells within the enormous complexity of their connections, their synaptic plasticities (i.e. experience dependent changes of synaptic contacts) and the electro-chemical signal variability behind these connections. In this paper we apply some of the most recent findings in synaptic functionality to various relational aspects behind social network theories (Barnes, 1954). We raise one particularly challenging question that accompanies the recent progress in the understanding of cognitive modeling: how can the emerging models of a functional cortical architecture be mapped into 'social space'? Can the lectures learned from structure -function relations in the brain contribute to organizational theories in particular to the interpretation of e.g. communication structures in self-organizing, emergent and complex social networks?

We start by assessing evidence from cognitive neurobiology that provides strong indications for a possible mapping of neuronal properties to social network structures. For example, there is evidence that ranking and hierarchical orders within social communities are associated with synaptic strength in late stage processing areas of prefrontal cortices in animal models (Wang et al., 2011). This sheds light on the possibility to relate the cognitive infrastructure of the brain to the relational strength and topology of social ties between individual agents, companies or artificial processing units possibly in accordance with Actor Network Analysis (Latour, 2005), which by itself cannot explain why a certain network emerged. In particular, we investigate connectoms, sub-sets of hierarchically organized synaptic connectivity patterns, from diverse brain models. We show that particular non-random, skeleton features (Song, Sjöström, Reigl, Nelson, & Chklovskii, 2005) behind these connectoms may serve as the determinants for the importance of perceptual information in the brain. Connectoms are characterized by the product space of pairwise synaptic connections. By analyzing synaptic 'strings' extracted from these relations we can test and compare models of perception and cognition with available social networks, e.g. from affiliation networks on the web or in organizations. We demonstrate an important aspect organized along the hierarchy of synaptic strings, the gradually changing level of abstraction in the coding of perceptual information. This 'bottom-up' maturation of perceptual contents can be mapped into a network description of economically defined communities.

We argue that the found resonation between neuronal principles underlying cognition with social structures and networks can help to disclose a number of frequently hidden aspects of traditional social network models. For example, the combination of ascending and recurrent processes along synaptic strings characterizes the nature of information held by individual actors as the residual discrepancy between lower and higher level codes (the 'predictive coding hypothesis' (Rao & Ballard, 1999)). Further, the 'cognitive network' builds on properties that go beyond simple 'reward' and 'punishment' learning. The emerging functional skeleton combines layers at different levels of organization and evolutionary progression. It combines affective processes with associative learning processes as discussed previously (Bernroider & Panksepp, 2011), pointing into reward independent principles operative at the social level. Finally, we propose that functional neural connectomics can possibly help to reconcile the differences between relational and individual properties in social network concepts. The understanding of such social network characteristics has a number of important practical implications. For example, this would allow organizations to design social engineering mechanisms in the context of IT changes more effectively in accordance with the afore-mentioned properties of social networks for improved organizational learning and business/IT alignment.

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