A philosophical analysis of endogenous brain activity in resting state functional connectivity studies

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**Background**: Despite their increasing importance in basic brain and applied clinical research, resting state functional connectivity studies have received comparably little attention in philosophy of science. The present analysis attempts to alleviate this situation by focusing on the role of endogenous brain activity in resting state fMRI research.

**Methods**: Functional analyses in neuroscience can differ according to the containing system investigated, and the causal roles of the system components that contribute to the overall capacity of the system. A survey of the neuroscientific and philosophical literature identified two distinct functional analyses of the role of endogenous brain activity in resting state functional connectivity studies. The direct role view takes the behaving organism as the containing system and investigates how endogenous brain activity directly contributes to cognitively relevant information processing. In contrast, the enabling condition view takes the living brain as the containing system and investigates how endogenous brain activity contributes to the maintenance of functional systems in the brain, which in turn enables cognitive processing. The present analysis assessed empirical and conceptual support for these views, and tentatively suggests ways to experimentally test the differences between them.

**Results**: The direct role view is indirectly supported by electrophysiological experiments on the role of oscillations in cognitively relevant information processing (e.g. theta-oscillations in rat hippocampi tracking the trajectory of the animal during spatial navigation). Direct support from resting state fMRI (e.g. the role of the default mode network in mind-wandering, or the role of endogenous somatomotor activity in motor control) is difficult to interpret, however. Correlations between endogenous BOLD-fluctuations across the brain remain stable during sleep and anesthesia, when online cognition or overt behavior is absent. The enabling condition view can account for these observations because it assumes that functional system pathways need to be constantly maintained, independently of the presence of cognitively relevant information processing. This view is further supported by consistent aerobic glycolysis levels within several resting state networks, suggesting that cellular repair and synaptic remodeling are coordinated at the system level. The spatial covariation of endogenous BOLD-fluctuations and aerobic glycolysis, however, remains currently unknown.

**Conclusions**: While empirical and conceptual support exists for both the direct role and enabling condition view, none of them is favored by current evidence from resting state fMRI research. Further experimental work could draw on the notion of causal specificity to test the differences between these views: whereas the direct role view predicts that a particular information processing aspect (e.g., duration of mind-wandering) is disrupted when endogenous network activity is disturbed, the enabling condition view would not predict such a selective effect.