What Neuroimaging Can Tell Us? From Correlation to Causation and Cognitive Ontologies

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Neuroimaging techniques allow to measure brain functions and to establish associations with cognitive functions. Yet, associations per se do not inform about the causal mechanisms that govern how brain functions give rise to cognitive functions. To advance our understanding of the human brain, it is essential to move beyond associational studies and identify the causal mechanisms that form the basis of cognition. This symposium presents the current state of research in this endeavour and charts open research directions for the neuroimaging community.

The opening talk by Russell Poldrack will argue that understanding the brain is to know the causal mechanisms of brain and cognitive functions (Poldrack and Farah, Nature, 2015). To achieve this goal a systematic terminology of cognitive functions needs to be developed (Poldrack et al., Frontiers in neuroinformatics, 2011). Thus, advancing neuroimaging is to research ways to establish cause-effect relationships between brain functions and cognitive ontologies. In striving for this goal, Martin Lindquist will discuss both the potential and current limitations for causal inference in neuroimaging, which is crucial for informing the design of subsequent studies (Lindquist, Statistical Science, 2008; Sobel and Lindquist, Journal of the American Statistical Association, 2014). Sebastian Weichwald will move this idea forward and present new ready-to-use methods that allow to derive causal hypotheses from observational data alone (Weichwald et al., NeuroImage, 2015; Grosse-Wentrup et al., NeuroImage, 2015). These hypotheses yield testable predictions on the effects of interventions. However, only interventional studies can validate the hypothesized cause-effect relationships. Validation can be accomplished by stimulation techniques that will be presented by Christoph Herrmann (Helfrich et al., Current Biology, 2014; Herrmann et al., International Journal of Psychophysiology, 2015; Vosskuhl et al., NeuroImage, 2015).

What is it that we are mapping onto the brain?
Russell Poldrack, Stanford University, Stanford, CA, United States

Establishing causal relationships in neuroimaging: Pitfalls and promises
Martin Lindquist, Johns Hopkins University, Baltimore, MD, United States

How to obtain causal hypotheses from neuroimaging studies?
Sebastian Weichwald, Max Planck Institute for Intelligent Systems, Tübingen, Germany

How can we validate causal hypotheses by brain stimulation?
Christoph Herrmann, European Medical School, Oldenburg, Germany