Biosketch of Christian Habeck, Associate Professor of Neuroimaging, Cognitive Neuroscience Division, Department of Neurology, Columbia University

1. **Methodological research in multivariate analytic techniques** - My main expertise focus is in neuroimaging analysis, particularly multivariate analysis and non-parametric statistical inference for neuroimaging data. I have pioneered the spatial-covariance analytic framework "Ordinal Trend Canonical Variates Analysis" (including a stand-alone Matlab software package http://www.nitrc.org/projects/gcva_pca), which has been applied in clinical and basic neuroscience settings in my own and other researcher's labs. I have also authored several didactic publications dealing with general topics surrounding multivariate techniques, such as non-parametric statistical inference and general best-practices. Ordinal Trend Canonical Variates Analysis has been used widely beyond Columbia Universiy for diagnostic and basic-neuroscience applications in fMRI and PET imaging.

    a. Habeck C, Krakauer JW, Ghez C, Sackeim HA, Eidelberg D, Stern Y, Moeller JR. A new approach to spatial covariance modeling of functional brain imaging data: ordinal trend analysis. Neural Comput. 2005 Jul;17(7):1602-45. PubMed PMID: 15901409.
    b. Habeck C, Stern Y. Neural network approaches and their reproducibility in the study of verbal working memory and Alzheimer's disease. Clin Neurosci Res. 2007 Nov;6(6):381-390. PubMed PMID: 18978933; PubMed Central PMCID: PMC2329589.
    c. Habeck C, Stern Y. Multivariate data analysis for neuroimaging data: overview and application to Alzheimer's disease. Cell Biochem Biophys. 2010 Nov;58(2):53-67. PubMed PMID: 20658269; PubMed Central PMCID: PMC3001346.
    d. Habeck C, Moeller JR. Intrinsic functional-connectivity networks for diagnosis: just beautiful pictures? Brain Connect. 2011;1(2):99-103. PubMed PMID: 22433005; PubMed Central PMCID: PMC3621702.

2. **Diagnostic applications** - Application of multivariate techniques to various neuroimaging modalities form an integral part of my contribution to science. I have used spatial covariance analysis to develop neuroimaging biomarkers of Alzheimer's disease and demonstrated that these are simultaneously more sensitive and more robust than univariate equivalents that are focused on particular brain regions. I have also contributed to the success of various other clinical-neuroscience research groups (Dr. David Eidelberg's lab, North Shore Hospital; Dr. William Jagust's lab, UC Berkeley; Dr. Sean Colloby, University of Newcastle, UK; Dr. Robert Pernezcky, University of Munich, Germany) by providing software and consulting support.

    a. Brickman AM, Habeck C, Zarahn E, Flynn J, Stern Y. Structural MRI covariance patterns associated with normal aging and neuropsychological functioning. Neurobiol Aging. 2007 Feb;28(2):284-95. PubMed PMID: 16469419.
    b. Habeck C, Stern Y. Neural network approaches and their reproducibility in the study of verbal working memory and Alzheimer's disease. Clin Neurosci Res. 2007 Nov;6(6):381-390. PubMed PMID: 18978933; PubMed Central PMCID: PMC2329589.

c. Habeck C, Foster NL, Perneczky R, Kurz A, Alexopoulos P, Koeppe RA, Drzezga A, Stern Y. Multivariate and univariate neuroimaging biomarkers of Alzheimer's disease. Neuroimage. 2008 May 1;40(4):1503-15. PubMed PMID: 18343688; PubMed Central PMCID: PMC2441445.

d. Habeck C, Stern Y. Multivariate data analysis for neuroimaging data: overview and application to Alzheimer's disease. Cell Biochem Biophys. 2010 Nov;58(2):53-67. PubMed PMID: 20658269; PubMed Central PMCID: PMC3001346.

3. **Cognitive-neuroscience applications** - I have successfully applied multivariate analytic techniques --particularly Ordinal Trend Canonical Variates Analysis in parametric task designs-- to functional MRI data. This work has enabled fundamental questions about neural network substrates of visual working memory and perceptual priming to be answered. These contributions were made at a time when univariate analysis was the dominant mode of analysis in the field, and multivariate analysis was still viewed with some skepticism regarding Type-I error computation and robustness. This work demonstrate that multivariate analyses are more sensitive and robust relative to corresponding univariate analyses, and in addition can yield significant mechanistic insight into basic cognition.

   a. Habeck C, Hilton HJ, Zarahn E, Flynn J, Moeller J, Stern Y. Relation of cognitive reserve and task performance to expression of regional covariance networks in an event-related fMRI study of nonverbal memory. Neuroimage. 2003 Nov;20(3):1723-33. PubMed PMID: 14642482.

   b. Habeck C, Rakitin BC, Moeller J, Scarmeas N, Zarahn E, Brown T, Stern Y. An event-related fMRI study of the neurobehavioral impact of sleep deprivation on performance of a delayed-match-to-sample task. Brain Res Cogn Brain Res. 2004 Feb;18(3):306-21. PubMed PMID: 14741317.

   c. Habeck C, Hilton HJ, Zarahn E, Brown T, Stern Y. An event-related fMRI study of the neural networks underlying repetition suppression and reaction time priming in implicit visual memory. Brain Res. 2006 Feb 23;1075(1):133-41. PubMed PMID: 16476414.

   d. Habeck C, Rakitin B, Steffener J, Stern Y. Contrasting visual working memory for verbal and non-verbal material with multivariate analysis of fMRI. Brain Res. 2012 Jul 27;1467:27-41. PubMed PMID: 22652306; PubMed Central PMCID: PMC3398171.

4. **Reference-ability neural networks throughout the life span** - This is an ambitious project to identify the neural-network substrates of 4 fundamental reference abilities (episodic memory, fluid reasoning, perceptual speed, vocabulary) in 12 cognitive tasks that are imaged using fMRI. I have contributed to this project by identifying functional activation patterns that classify the underlying cognitive processes according to the 4 reference abilities across the lifespan. I have also shown using this rich task data a close relationship between the similarity of behavioral performance and the similarity of neural substrates for any pair of the 12 cognitive tasks. This relationship, while perhaps intuitively obvious, has not been demonstrated before.

   a. Stern Y, Habeck C, Steffener J, Barulli D, Gazes Y, Razlighi Q, Shaked D, Salthouse T. The Reference Ability Neural Network Study: motivation, design, and initial feasibility analyses. Neuroimage. 2014 Dec;103:139-51. PubMed PMID: 25245813; PubMed Central PMCID: PMC4312259.

   b. Habeck C, Steffener J, Barulli D, Gazes Y, Razlighi Q, Shaked D, Salthouse T, Stern Y. Making cognitive latent variables manifest: distinct neural networks for fluid reasoning

and processing speed. J Cogn Neurosci. 2015 Jun;27(6):1249-58. PubMed PMID: 25539045; PubMed Central PMCID: PMC4416986.

c. Habeck, C, Gazes Y, Razlighi QR, Steffener J, Brickman A, Barulli D, Salthouse T, Stern Y. "The Reference Ability Neural Network Study: Life-time stability of reference-ability neural networks derived from task maps of young adults." Neuroimage. 2016 125: 693-704. PubMed PMID: 26522424; PubMed Central PMCID: PMC4691438

d. Gazes Y, Bowman FD, Razlighi QR, O'Shea D, Stern Y, Habeck.C. "White matter tract covariance patterns predict age-declining cognitive abilities". Neuroimage. 2016 Jan 15;125:53-60. PubMed PMID: 26477658 PubMed Central PMCID: PMC4691375

e. Habeck C, Eich T, Razlighi QR, Gazes Y, Stern. "Reference ability neural networks and behavioral performance across the adult life span". Neuroimage (in press)