NeuroImage 156 (2017) 29–42

Contents lists available at ScienceDirect

NeuroImage

journal homepage: www.elsevier.com/locate/neuroimage

The impact of MEG source reconstruction method on source-space connectivity estimation: A comparison between minimum-norm solution and beamforming

Ana-Sofía Hincapié[a,b,c,d,*,1,2,3,4], Jan Kujala[b,e,2,5], Jérémie Mattout[b,2], Annalisa Pascarella[f,6], Sebastien Daligault[g,7], Claude Delpuech[b,g,2,7], Domingo Mery[c,3], Diego Cosmelli[d,4], Karim Jerbi[a,b,1,2]

[a] Psychology Department, University of Montreal, Quebec, Canada
[b] Lyon Neuroscience Research Center, CRNL, INSERM, U1028 – CNRS – UMR5292, University Lyon 1, Brain Dynamics and Cognition Team, Lyon, France
[c] Department of Computer Science, Pontificia Universidad Católica de Chile, Santiago de Chile, Chile
[d] Escuela de Psicología, Pontificia Universidad Católica de Chile and Interdisciplinary Center for Neurosciences, Pontificia Universidad Católica de Chile, Santiago de Chile, Chile
[e] Department of Neuroscience and Biomedical Engineering, Aalto University, Espoo, Finland
[f] Consiglio Nazionale delle Ricerche (CNR – National Research Council), Rome, Italy
[g] MEG Center, CERMEP, Lyon, France

ARTICLE INFO

Keywords:
Brain connectivity
Magnetoencephalography (MEG)
Minimum Norm Estimate (MNE)
Linearly Constrained Minimum Variance (LCMV)
Beamforming
Dynamic Imaging of Coherent Sources (DICS)

ABSTRACT

Despite numerous important contributions, the investigation of brain connectivity with magnetoencephalography (MEG) still faces multiple challenges. One critical aspect of source-level connectivity, largely overlooked in the literature, is the putative effect of the choice of the inverse method on the subsequent cortico-cortical coupling analysis. We set out to investigate the impact of three inverse methods on source coherence detection using simulated MEG data. To this end, thousands of randomly located pairs of sources were created. Several parameters were manipulated, including inter- and intra-source correlation strength, source size and spatial configuration. The simulated pairs of sources were then used to generate sensor-level MEG measurements at varying signal-to-noise ratios (SNR). Next, the source level power and coherence maps were calculated using three methods (a) L2-Minimum-Norm Estimate (MNE), (b) Linearly Constrained Minimum Variance (LCMV) beamforming, and (c) Dynamic Imaging of Coherent Sources (DICS) beamforming. The performances of the methods were evaluated using Receiver Operating Characteristic (ROC) curves. The results indicate that beamformers perform better than MNE for coherence reconstructions if the interacting cortical sources consist of point-like sources. On the other hand, MNE provides better connectivity estimation than beamformers, if the interacting sources are simulated as extended cortical patches, where each patch consists of dipoles with identical time series (high intra-patch coherence). However, the performance of the beamformers for interacting patches improves substantially if each patch of active cortex is simulated with only partly coherent time series (partial intra-patch coherence). These results demonstrate that the choice of the inverse method impacts the results of MEG source-space coherence analysis, and that the optimal choice of the inverse solution depends on the spatial and synchronization profile of the interacting cortical sources. The insights revealed here can guide method selection and help improve data interpretation regarding MEG connectivity estimation.

* Corresponding author at: Psychology Department, University of Montreal, Pavillon Marie-Victorin, 90, avenue Vincent d'Indy, Quebec, Canada.
E-mail addresses: ashincap@uc.cl (A.-S. Hincapié), jan.kujala@aalto.fi (J. Kujala), jeremie.mattout@inserm.fr (J. Mattout), a.pascarella@iac.cnr.it (A. Pascarella), daligault@cermep.fr (S. Daligault), claude.delpuech@inserm.fr (C. Delpuech), dmery@ing.puc.cl (D. Mery), dcosmelli@uc.cl (D. Cosmelli), karim.jerbi@umontreal.ca (K. Jerbi).
[1] Postal address: Pavillon Marie-Victorin, 90, avenue Vincent d'Indy, Montreal, Québec, Canada.
[2] Postal address: INSERM U1028, 69675 Bron Cedex, France.
[3] Postal address: Av. Vicuña Mackenna 4860 (143), Macul, Santiago de Chile, Chile.
[4] Postal address: Av. Vicuña Mackenna 4860, Macul, Santiago de Chile, Chile.
[5] Postal address: P.O. Box 15100, FI-00076 Aalto, Finland.
[6] Postal address: Via dei Taurini, 19, 00185 Roma, Italy.
[7] Postal address: INSERM U1028, 69675 Bron Cedex, France.

http://dx.doi.org/10.1016/j.neuroimage.2017.04.038
Received 19 August 2016; Accepted 15 April 2017
Available online 04 May 2017
1053-8119/