NEMO Data Analysis Workflow and MATLAB Tools

An Overview
NEMO Information Processing Pipeline
(Where I Come In)
NEMO Information Processing Pipeline
ERP Pattern Identification and Labeling

• Obtain ERP data sets with compatible functional constraints
  – NEMO consortium data

• Decompose / segment ERP data into discrete spatio-temporal patterns
  – ERP Pattern Decomposition / Segmentation

• Mark-up patterns with their spatial, temporal & functional characteristics
  – ERP Pattern Metric Extraction

• Label patterns

• Cluster patterns within data sets

• Link labeled clusters across data sets

• Label linked clusters

• Publish
ERP Data Transformations

Algorithms

• ERP Pattern Decomposition
  – Latent Source Separation
    • Principal Components Analysis (PCA)
    • Independent Components Analysis (ICA)

• ERP Pattern Segmentation
  – Microstate Analysis
    • 1-D Centroid Dissimilarity
    • 2-D Centroid Dissimilarity
    • Global Map Dissimilarity
    • Global Field Power
ERP Data Transformations
Implementation in MATLAB

• NemoErpPatternDecomposition
  – Spatial or Temporal PCA
  – Spatiotemporal (2-stage) PCA
  – Varimax / Promax / Infomax Rotations
  – Pre / Post Rotation Factor Retention Options

• @NemoErpPatternSegmentation
  – ERP Microstate Segmentation
  – Variable Microstate Durations & Transition Bands
  – Topographic Stability, Centroid Stability, or Global Field Power Minima
PCA / ICA Workflow

ERD Data

PCA

Mode
Temporal
Relationship Matrix + Scaling
Covariance + Kaiser
Factor Retention Pre-Rotation
Full Retention
Rotation
Varimax/Promax
Factor Retention Post-Rotation + Sort Order
FacVar: 25
Projection to Scalp Surface - Reconstruction

ICA

Mode
Spatial
PCA Dimension Reduction Pre-Rotation
10 PCA Comp.
Rotation
Infomax
Factor Retention Post-Rotation + Sort Order
FacVar: 10

FacVar: 10
The topography of the electric field at the scalp does not vary randomly as a function of time, but rather remains in a stable configuration for brief time periods.
Microstate Analysis
Extraction of Representative Topographies
NEMO ERP Metric Extraction
Marking up ERP Components / Microstates

- Mark-up observed patterns (components / microstates) with user-specified information on the experimental procedure and subject group
- Each mark-up element has a unique label that maps to a corresponding element in the NEMO ontology

<table>
<thead>
<tr>
<th>Mark-up Name</th>
<th>Mark-up Definition</th>
<th>Mark-up_ID</th>
<th>NEMOlex_Name</th>
<th>NEMOlex_ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>ExptID</td>
<td>ExptID represents &quot;experiment ID&quot; and specifies the experimental procedure and subject group.</td>
<td>ID:0000003</td>
<td>experiment_id</td>
<td>NM:0000059</td>
</tr>
</tbody>
</table>
NEMO ERP Metric Extraction
Marking up ERP Components / Microstates

- Mark-up temporal characteristics of observed patterns
- @NemoErpMetricExtraction class methods extract temporal metrics for each condition, subject and observed pattern
  - Data driven
  - Harnesses expert-knowledge: Domain experts specify the characteristics of interest

<table>
<thead>
<tr>
<th>Mark-up Name</th>
<th>Mark-up_Definition</th>
<th>Mark-up_ID</th>
<th>NEMOlex_Name</th>
<th>NEMOlex_ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ti_Max</td>
<td>Ti_Max specifies for each temporal component the time point of its peak absolute intensity, in milliseconds.</td>
<td>ID:0000019</td>
<td>ERP_pattern_peak_latency</td>
<td>NM:0000047</td>
</tr>
</tbody>
</table>
NEMO ERP Metric Extraction
Marking up ERP Components / Microstates

- Mark-up spatial characteristics of observed patterns
- @NemoErpMetricExtraction class methods extract spatial metrics for each condition, subject and observed pattern
  - Data driven
  - Harnesses expert-knowledge: Domain experts specify the characteristics of interest

<table>
<thead>
<tr>
<th>COP_X2d</th>
<th>COP_Y2d</th>
<th>CON_X2d</th>
<th>CON_Y2d</th>
<th>COP_X3d</th>
<th>COP_Y3d</th>
<th>COP_Z3d</th>
<th>CON_X3d</th>
<th>CON_Y3d</th>
<th>CON_Z3d</th>
</tr>
</thead>
<tbody>
<tr>
<td>LatIndex_Threshold</td>
<td>Laterality_COP</td>
<td>LatIndex_COP</td>
<td>ROInolat_COP</td>
<td>Laterality_CON</td>
<td>LatIndex_CON</td>
<td>ROInolat_CON</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EGICh_COP</td>
<td>ITTCh_COP</td>
<td>ROI_COP</td>
<td>EGICh_CON</td>
<td>ITTCh_CON</td>
<td>ROI_CON</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mark-up Name</th>
<th>Mark-up Definition</th>
<th>Mark-up ID</th>
<th>NEMOlex_Name</th>
<th>NEMOlex_ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITTCh_COP</td>
<td>International 10-10 electrode location closest to the component pair’s center-of-positivity xy-coordinate pair (COP_X2d, COP_Y2d), in L2-norm, on a montage-specific 2-D flat map of scalp-surface electrode locations.</td>
<td>ID:0000036</td>
<td>TBA</td>
<td>TBA</td>
</tr>
</tbody>
</table>