Large-Scale Brain Modeling

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Why model the brain?

- Science IS modeling
- Models have power
  - To explain
  - To predict
  - To simulate
  - To augment
... the next research frontier

- Brains are active and multi-scale / multi-level
- The dominant multi-level / multi-layer model…

Computers

- Physical and logical level hierarchy – “brain stack”
  - Physical / implementation levels
  - Logical / instruction levels
Brains are not computers …

• But they are supported by the same physics
  ✓ Energy conservation
  ✓ Entropy increase
  ✓ Time direction

• And by the same logic…implemented differently
  – Low speed, parallel processing hardware model (not software)
The research must be multi-level… both scientific and mathematical

• To understand both theoretically and practically how brains support
  – Behavior
  – Experience

• To model brain / behavior dynamics as Active, require
  – Better behavioral measures and modeling
  – Better brain dynamic imaging measures
  – Better brain ↔ behavior analysis
The research must be multi-level… both scientific and mathematical

• Collaboration is needed
  – Across spatial scales
  – Across time scales
  – Across measures

• Current field borders should not remain boundaries… *curtail Scale Chauvinism*
## Multi-level ("Brain Stack") Framework

<table>
<thead>
<tr>
<th>Level</th>
<th>Additional Description</th>
<th>Components</th>
<th>Spatial Scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Neuroscience (Neuro-anthropology)</td>
<td>Evolution-driven</td>
<td>m:n (many:many) Global/Nation-States</td>
<td>MMMm (MM² million)</td>
</tr>
<tr>
<td>Socio-Political (Geographical/Cyber)</td>
<td>Evolution/macro-plasticity</td>
<td>1:n (one:many) Regional/cities</td>
<td>km-MMm</td>
</tr>
<tr>
<td>Human Interaction (Physical/Electronic)</td>
<td>Evolution-driver</td>
<td>1:1 (one:one)</td>
<td>dm-m-km-MMm</td>
</tr>
<tr>
<td>Cognitive (Psychological)</td>
<td>Emotional/Rational/Innerthought</td>
<td>Consciousness sublevel (presentation sublevel)</td>
<td>1m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 self</td>
<td>Emotion, Language, Decision making (&quot;Thin/thick slices&quot;)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unconscious processing</td>
<td>Attention/awareness, Sleep/awake</td>
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<tr>
<td>Neurophysiological (Anatomical &quot;maps&quot;)</td>
<td>&quot;Network of Networks&quot;/CNS</td>
<td>Cerebrum, Cortical Hemispheres, Cortical nets (ACC, PFC, etc.)</td>
<td>1cm-dm</td>
</tr>
<tr>
<td></td>
<td></td>
<td>5 Senses</td>
<td>Visual, Taste, Olfactory, Auditory</td>
</tr>
<tr>
<td>Network</td>
<td>Communication/System sublevels</td>
<td>Cortical Columns/Neuronal modules</td>
<td>1 cm - decimeter (dm)</td>
</tr>
<tr>
<td>Circuit</td>
<td>Macrodynamics</td>
<td></td>
<td>1 mm - cm</td>
</tr>
<tr>
<td>Neuronal (Soma/Nucleus/Synapse...)</td>
<td>Cellular microdynamic level</td>
<td>interneuronal sublevel synaptic/axonal/dendritic myelination/ganglia</td>
<td>1 μ - 100 μ</td>
</tr>
<tr>
<td>Molecular</td>
<td>Neurogenic sublevel</td>
<td>Proteins Neuromodulators et al</td>
<td>1 Å</td>
</tr>
</tbody>
</table>

**Closed System Interconnect Model**
Proposed topic

“UNCONSCIOUS MENTAL PROCESSING”

(Behavioral psychology / comp neuro modeling)