

Large-Scale Brain Modeling

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The Swartz Foundation

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The mission of the Swartz Foundation is to explore the application of physics, mathematics and computer engineering principles to neuroscience, as a path to better understanding the brain/mind relationship.

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



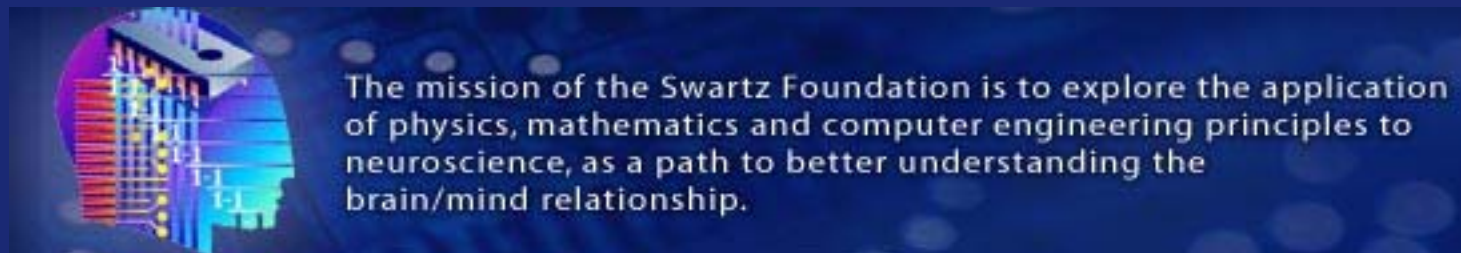
Brains are not computers ...

- 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 \leftrightarrow 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

	Level	Additional Description	Components	Spatial Scale
Behavioral Level	Social Neuroscience (Neuro-anthropology)	— Evolution-driven —	[m:n (many:many) Global/Nation-States] —.....	MMm (MM = million)
	Socio-Political (Geographical/ Cyber)	— Evolution/macro-plasticity —	[1:n (one:many) Regional/cities] —.....	km-MMm
	Human Interaction (Physical/Electronic)	— Evolution-driver —	1:1 (one:one) —.....	dm-m-km-MMm
Information-/System Level Theoretic	Cognitive (Psychological)	- Emotional/Rational/Innerthought —	<div style="display: flex; align-items: center;"> <div style="margin-right: 10px;">[</div> <div style="margin-right: 10px;">Consciousness sublevel (presentation sublevel)</div> <div style="margin-right: 10px;">1:self</div> <div style="margin-right: 10px;">[</div> <div style="margin-right: 10px;">Emotion</div> <div style="margin-right: 10px;">Language</div> <div style="margin-right: 10px;">Decision making ("Thin/thick slices")</div> <div style="margin-right: 10px;">.....</div> <div style="margin-right: 10px;">]</div> <div style="margin-right: 10px;">]</div> <div style="margin-right: 10px;">Unconscious processing</div> </div>	1 m
	Neurophysiological (Anatomical "maps")	— "Network of Networks"/CNS —	<div style="display: flex; align-items: center;"> <div style="margin-right: 10px;">[</div> <div style="margin-right: 10px;">Cerebrum</div> <div style="margin-right: 10px;">Cortical Hemispheres</div> <div style="margin-right: 10px;">Cortical nets (ACC, PFC, etc.)</div> <div style="margin-right: 10px;">5 Senses —</div> <div style="margin-right: 10px;">[</div> <div style="margin-right: 10px;">Visual</div> <div style="margin-right: 10px;">Touch</div> <div style="margin-right: 10px;">Taste</div> <div style="margin-right: 10px;">Olfactory</div> <div style="margin-right: 10px;">Auditory</div> <div style="margin-right: 10px;">]</div> <div style="margin-right: 10px;">Sensorimotor system</div> <div style="margin-right: 10px;">]</div> <div style="margin-right: 10px;">.....</div> </div>	1 cm-dm
	Network	— [Communication /System sublevels Cortical/neuronal Columns] —	Cortical Columns/Neuronal modules —.....	1 cm -decimeter(dm)
	Circuit	— Macrodynamic —	1mm-cm
Physical Coding Level	Neuronal (Soma/Nucleus/Synapse...)	— [Cellular microdynamic level Spike time dependent plasticity/Learning] —	[interneuronal sublevel synaptic/axonal/dendritic myelination/ganglia] —.....	1 μ -100 μ
	Molecular	— [Neurogenetic sublevel Physical/ coding sublevel] —	[Proteins Neuromodulators et al] —.....	1 Å

Closed System Interconnect Model

Banbury Conference, Spring '07

Proposed topic

“UNCONSCIOUS MENTAL PROCESSING”

(Behavioral psychology / comp neuro modeling)



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