FABBS Federation of Associations in Behavioral & Brain Sciences

Opportunities for the BRAIN Initiative 2.0

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FABBS Federation of Associations in Behavioral & Brain Sciences

On behalf of member societies:

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Behavioral sciences are central to the goals of BRAIN 2.0

- For example, Goal 7 aims to *integrate new technological and conceptual approaches produced in Goals 1-6 to discover how dynamic patterns of neural activity are transformed into* ***cognition, emotion, perception and action*** *in health and disease*. (NIH BRAIN report, 2014; emphasis added)

Two key leverage points

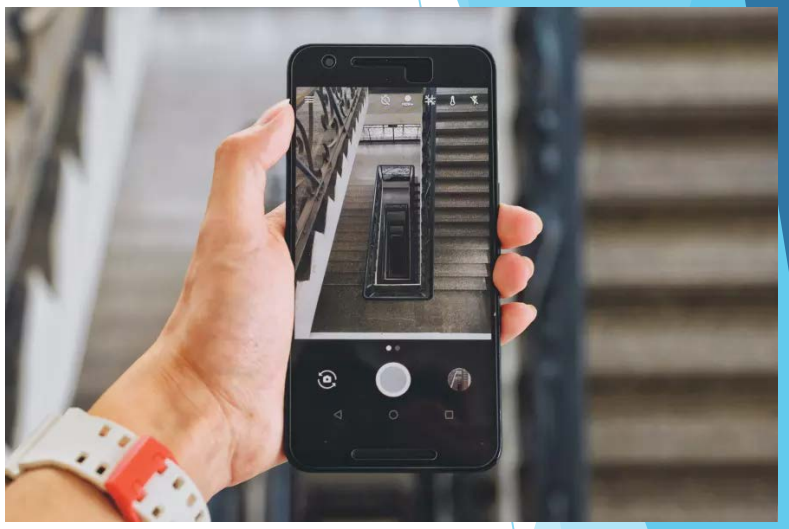
- Revolutionary tool development (Phase I)
- Transforming dynamic neural patterns into understanding cognition, emotion, perception and action (Phase II)

Transformative technologies for ambulatory assessment

- Ubiquitous lightweight technology
  - Eye tracking: New progress in wearable eye-and-head tracking
  - Portable imaging techniques: EEG, fNIRS, and fMRI
  - Body movement tracking: Relate neural control to naturalistic, dynamic behaviors
  - Actigraphy: Unpacks dynamics of activity over longer time-scales, particularly crucial for studies of sleep/wake, circadian rhythm

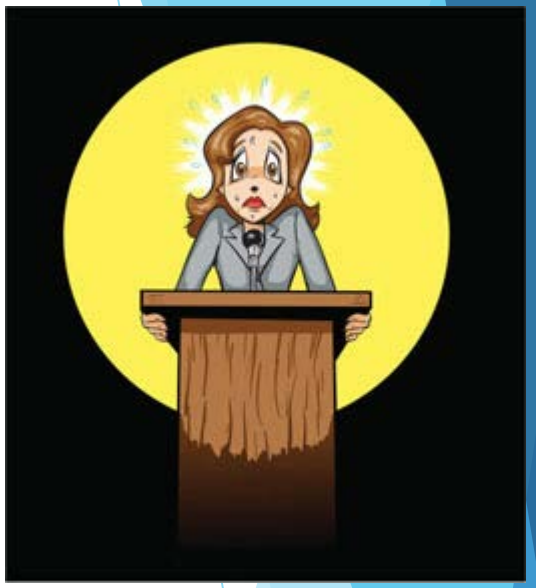
Transformative technologies for ambulatory assessment

- Linking brain data to behavioral data. We can utilize modern technology to gather very large population-representative data sets that can provide powerful analytic leverage on brain-behavior relationships-- where people are, what they hear and say, and what they think and feel:
  - GPS data
  - Real-time experience reports
  - Sound– e.g., Lena recordings

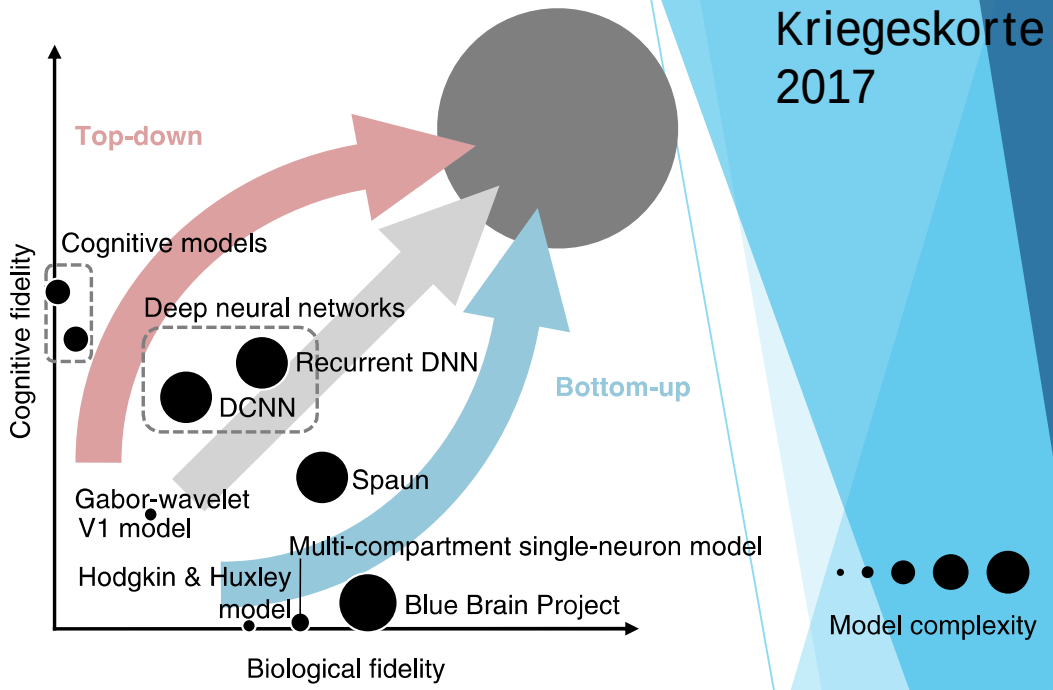


Computational tools

- We need to apply novel computational techniques to modeling behavioral and brain data.
  - Example: New data suggest that reactivated memories can enter a "zone of destruction" in which they are weakened rather than strengthened. With the advent of real-time imaging and mental-state classification, it may now be possible to "titrate" the level of activation to keep the memory in the zone of destruction.
  - Making it real– new virtual reality technology.
  - This intervention builds on a computational model, inspired by neural mechanisms at the *systems* level of analysis, providing a mechanism relevant to treatment of mental disorder.



Computational tools



Kriegeskorte et al., 2017

- Cognitive architectures
  - Large-scale models of whole-organism neural control are essential for integrating smaller-scale data and models
- Neurophysiologically plausible deep learning
  - Close the gap between microscale models that cannot capture phenomena of interest and macroscale models that violate known aspects of the microarchitecture
- Diffusion modeling and linear ballistic accumulator modeling
  - Macro-scale "thermodynamic" models of the computations underlying the computations leading up to an overt behavior
- Bayesian models of latent structure in behavior, including topic models
  - Models of knowledge and belief updating can relate large-scale neural organization to individual and group differences in cognition

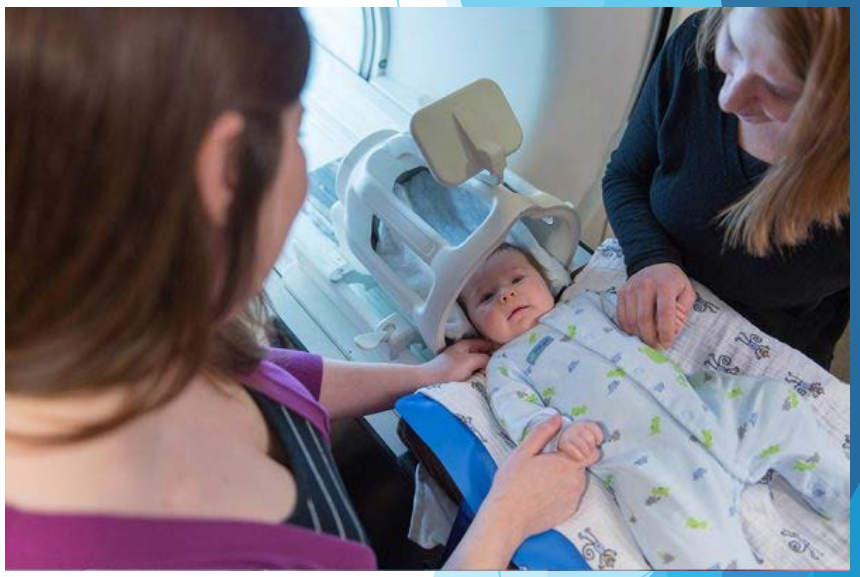
Relating brain activity to behavior on a moment-by-moment basis

- Computational cognitive neuroimaging
  - Models that bridge neural levels and behavioral levels to relate physiological data to mental representation to behavior moment by moment
- Neurostimulation in complex behaviors (human and animal, invasive and noninvasive)
  - There has been rapid growth in tools from invasive (inactivation, electrical stimulation, optogenetics) to noninvasive (TMS, tDCS) and from small to large
  - The next revolution will be deploying these tools in free-ranging behavioral settings in the context of full task models

Polania et al., 2018

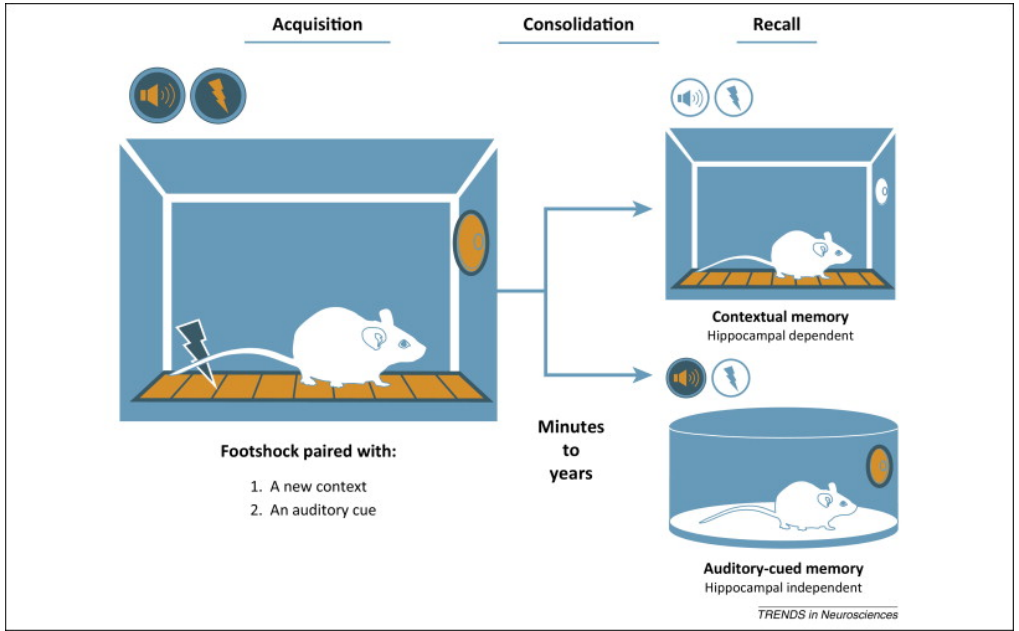
Relating individual and group differences in brains to differences in cognition, perception, action

- Developmental brain-behavior relations require an augmented toolbox and new techniques
  - Large-scale studies have the potential to transform understanding of how mental function relates to the development of brain structure and the expression of genes coding for neurotransmitters
- Computational psychiatry
  - As we move beyond broad diagnostic categories, psychiatry needs fine—grained cognitive models of how alterations in brain function relate to alterations in behavior, characterized taking advantage of new knowledge



Relating paradigms across species

- We need meaningful tasks that work across species (humans, monkeys, and rodents at least) to increase translation
  - As one example, we are never going to study human memory development using conditioned footshock



Strategic priorities for maximizing the contribution of behavioral science to the BRAIN initiative

- Goal should be FOAs targeting behavioral science, and FOA language encouraging teams led by (or incorporating) behavioral and cognitive neuroscientists
- Steps towards this goal
  - Advisory/informational workshops
  - Inclusion of behavioral and cognitive scientists on advisory committees