The relationship between neuroscience and psychology

or

Cognitive Neuroscience (CNS)

Fodor's special sciences (1974)

- Relation between *special sciences* (psychology, neuroscience)
- *Basic* science: Physics
- *Entities/processes from special sciences cannot be defined/described using entities/processes from basic science*
- Psychology **not reduced** to neuroscience
- Each special science: distinctive "**taxonomy**", "distinctive ways of classifying and organizing descriptions and explanations of phenomena"

- One taxonomy cannot be reduced to another taxonomy

- Different particular sciences - Different “levels of reality”: physics - lowest level chemistry, biology, psychology, social sciences

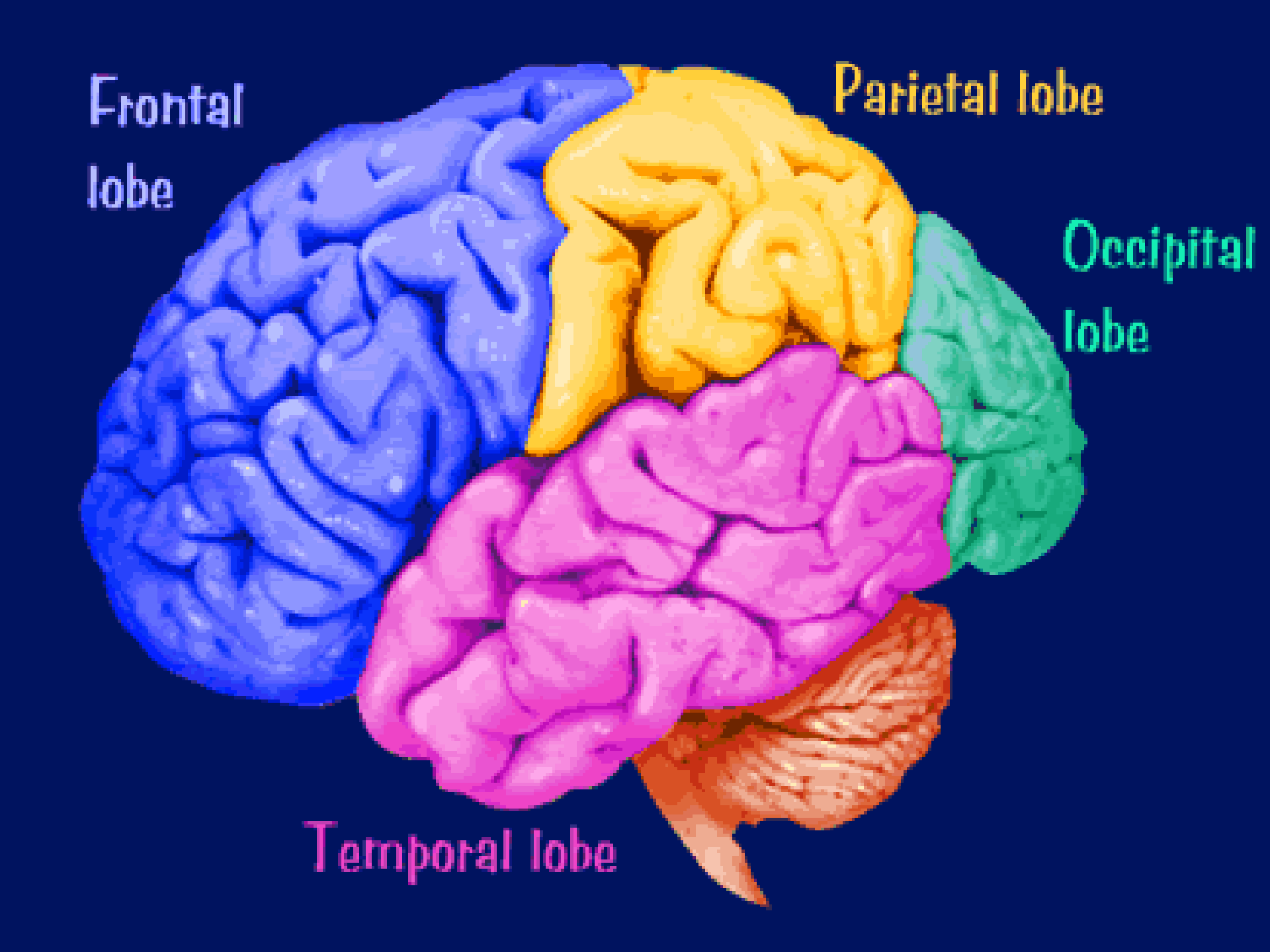
- Fodor rejects reductionism and implicitly the “Unity of Science”

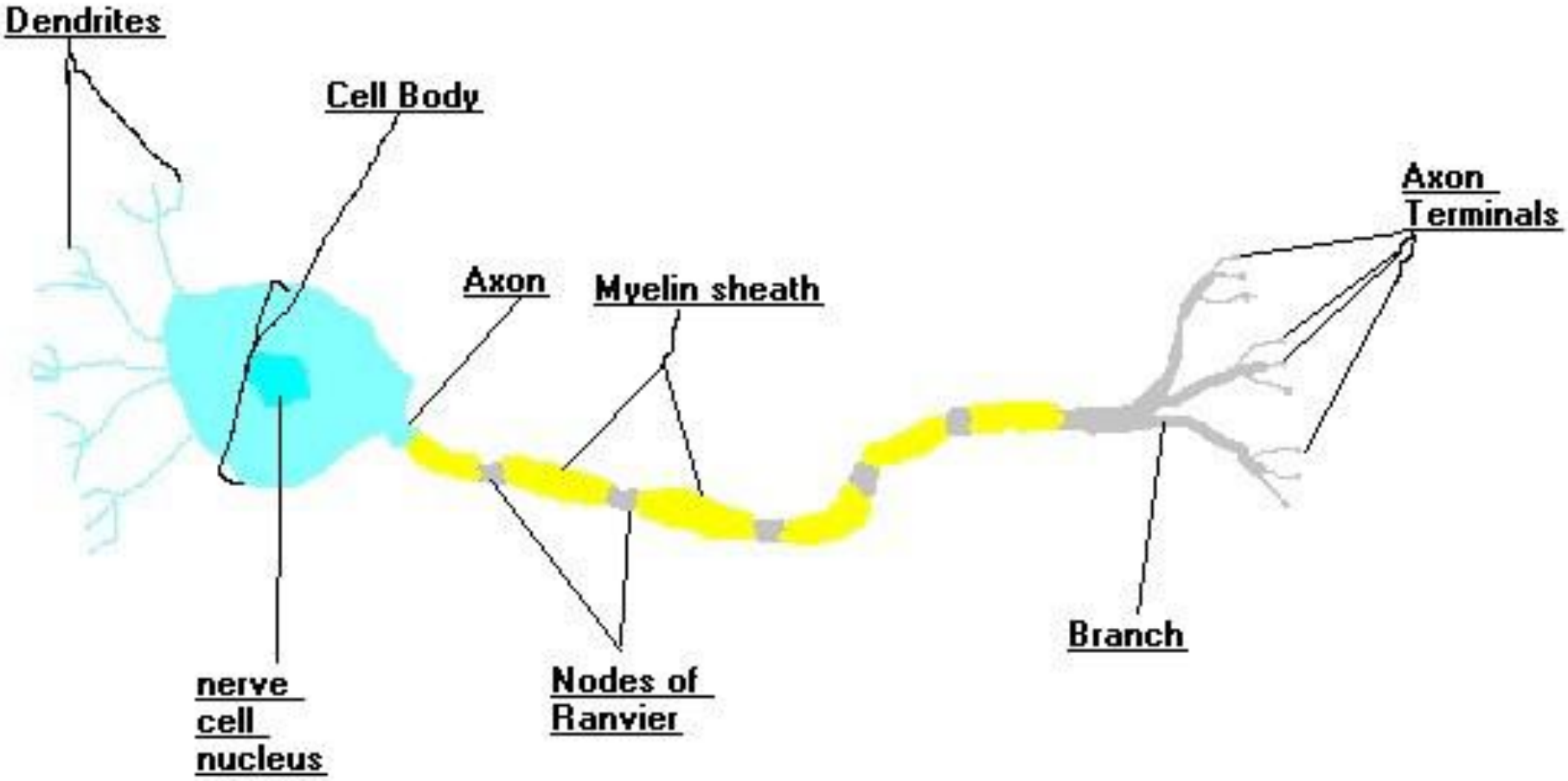
Holyoak “Psychology in CS” (1998)

- “Psychology = Science investigates representation and processing of information by complex organisms”
- Psychology = “Information processing – between sensory inputs and motoric outputs”
- Today: Psychology strong related to neuroscience (CNS)

Anatomy of the Brain

- Brain = ***Cerebral Cortex***
- Has two symmetrical hemispheres
- Each hemisphere consists of large sheets of layered neurons
- Human cortex: Highly folded to pack more cortical surface into the skull
- Surface area of average cerebral cortex is about 2200 to 2400cmxcm


Frontal lobe
Parietal lobe
Occipital lobe
Temporal lobe


Dendrites
Cell Body
Axon
Myelin sheath
Axon Terminals
nerve cell nucleus
Nodes of Ranvier
Branch

CNS: Development of methods and findings from phrenology to present

Gall+Spurzheim(19th Century)**Phrenology:**

2 assumptions:

(1) Different regions of brain perform different functions + associated with different behaviours

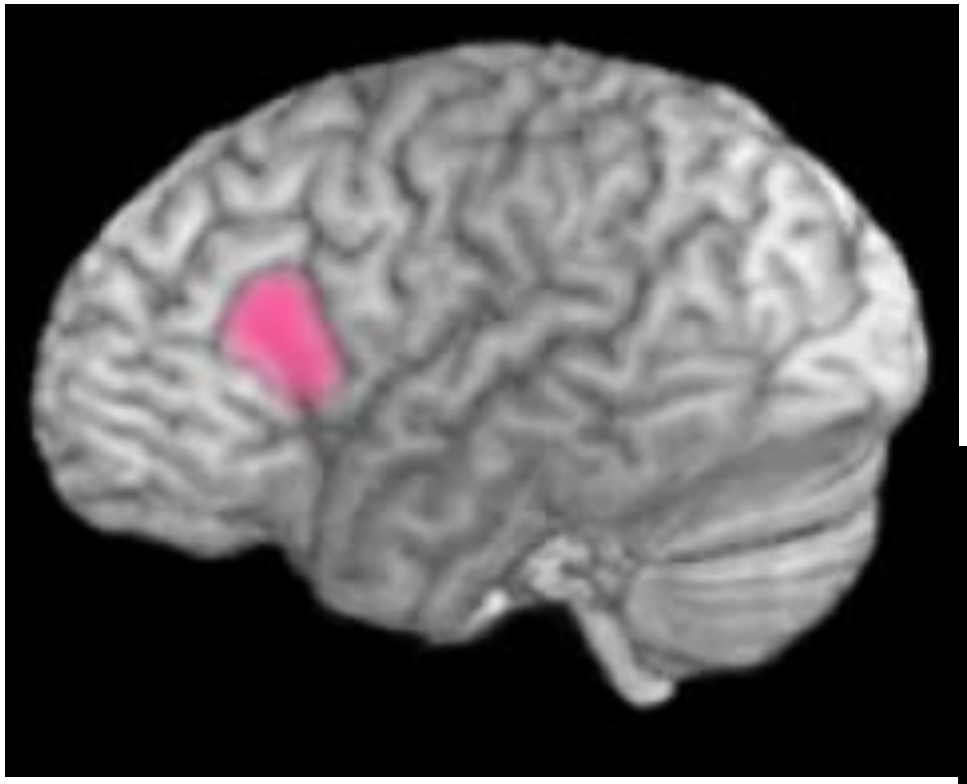
(2) Size of these regions produces distortions of skull + correlates with individual differences in cognition

→ **Functional specialization** within brain

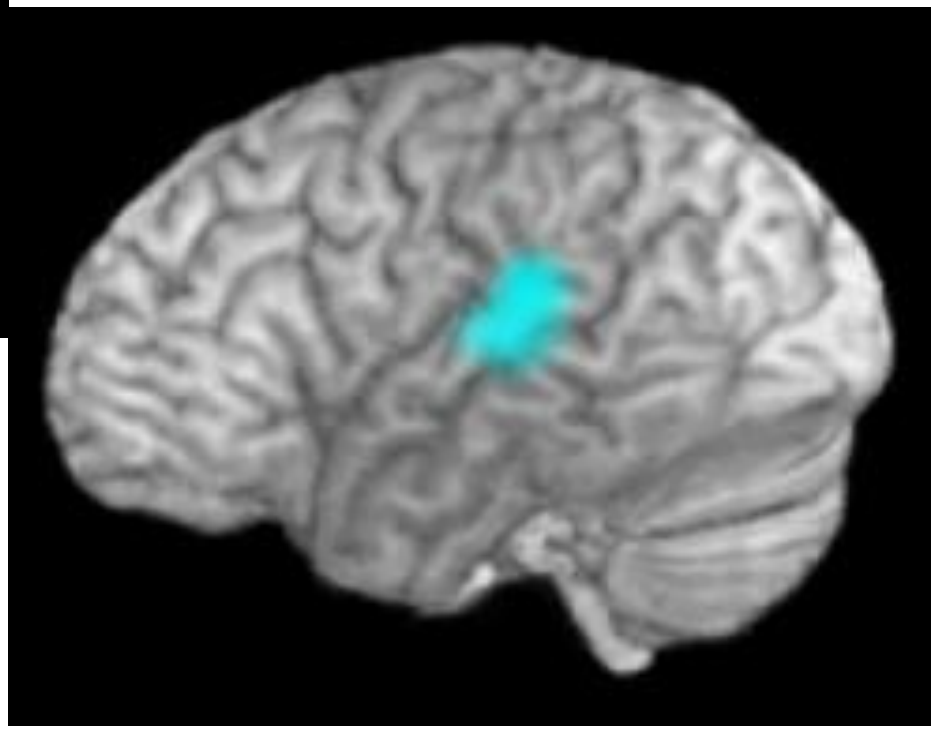
→ Brain: 35 functions (language, color, hope...)

- Broca's area (19th Century): Patient could understand language but not speak
- Patient's left frontal lobe was damaged
- Wernicke: A stroke victim – could talk freely but with little sense
- Could not understand spoken or written language

("Brain story" by Vaia Lestou)

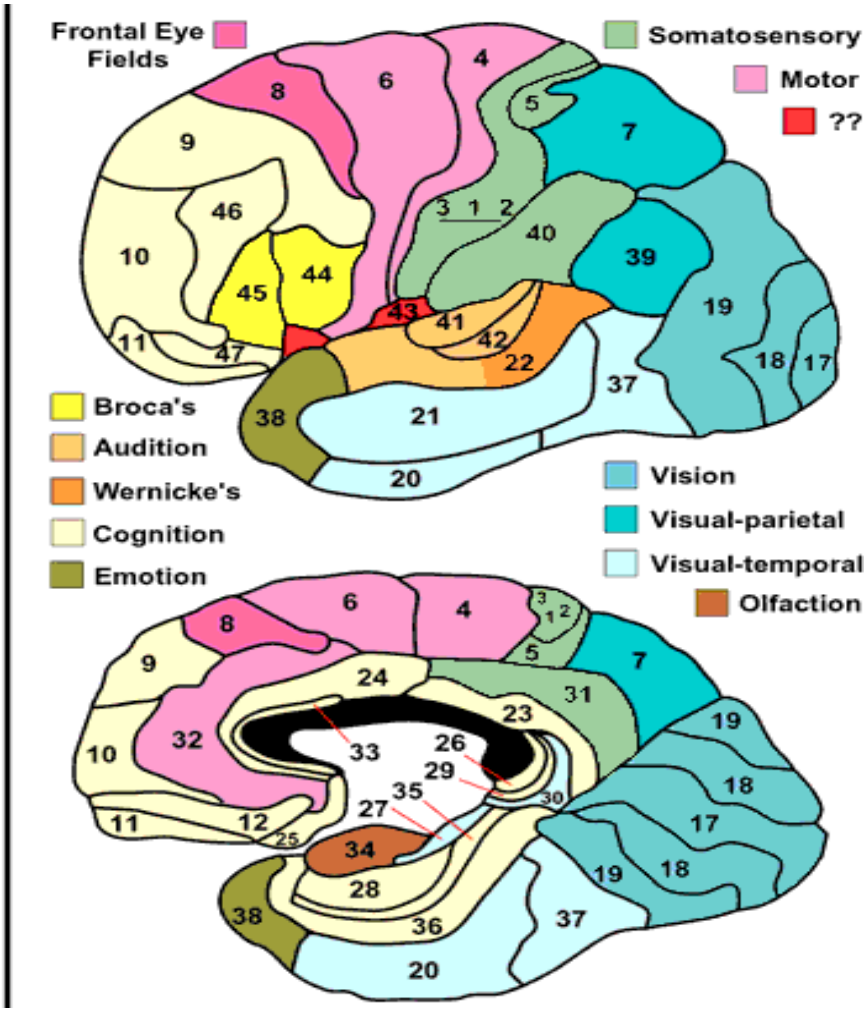


3D MRI of human brain with Broca's area highlighted in red



3D MRI of human brain with Wernicke's area highlighted in blue

- Brodmann: Cellular organization → 52 distinct regions



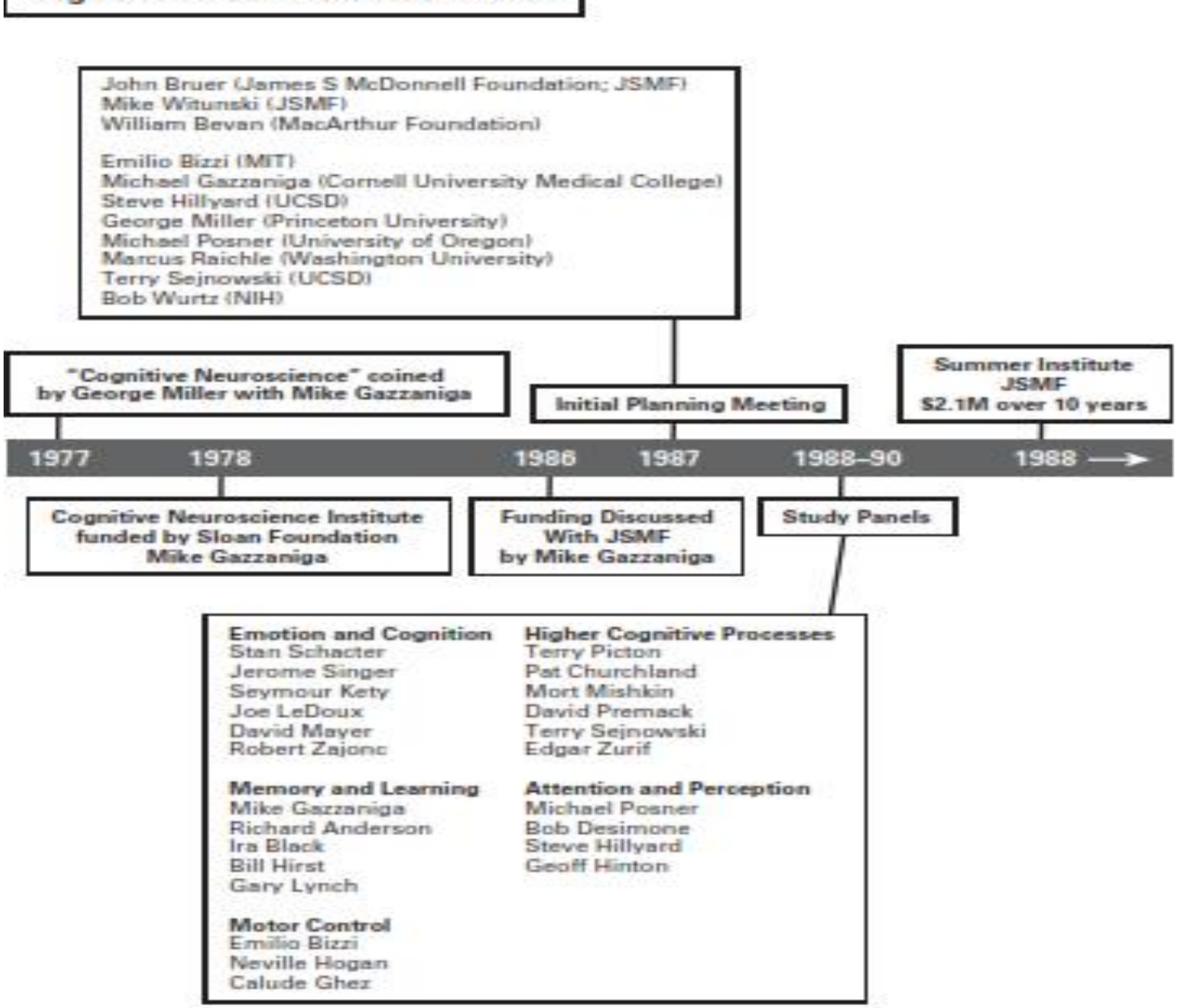
- Revolution in our understanding of the nervous system: Camillo Golgi (Italy) (silver stain - visualization of a neuron, brain a single mass) and Ramon y Cajal (Spain) (neurons = discrete entities, against Golgi!)
- Cajal: Neurons are discrete entities - transmit electrical information in only one directions from dendrites to axonal tip

- ***The Student's Guide to Cognitive Neuroscience* by Jamie Ward (2006)**

(1) Cognitive science + cognitive psychology

(2) Biology + neuroscience

- Michael Gazanniga (with Miller) named "CNS" in a taxi in New York ('70s)
- Squire (memory) + Kosslyn (imagery r)
- Gazzaniga: '89 - *"Journal of CNS"*
- Reuter-Lorenz, Baynes,Mangun, and Phelps (2010):


John Bruer (James S McDonnell Foundation; JSMF)
Mike Wiunski (JSMF)
William Bevan (MacArthur Foundation)
Emilio Bizzi (MIT)
Michael Gazzaniga (Cornell University Medical College)
Steve Hillyard (UCSD)
George Miller (Princeton University)
Michael Posner (University of Oregon)
Marcus Raichle (Washington University)
Terry Sejnowski (UCSD)
Bob Wurtz (NIH)
"Cognitive Neuroscience" coined by George Miller with Mike Gazzaniga
Initial Planning Meeting
Summer Institute JSMF $2.1M over 10 years
1977
1978
1986
1987
1988–90
1988
Cognitive Neuroscience Institute funded by Sloan Foundation Mike Gazzaniga
Funding Discussed With JSMF by Mike Gazzaniga
Study Panels
Emotion and Cognition
Stan Schacter
Jerome Singer
Seymour Kety
Joe LeDoux
David Mayer
Robert Zajonc
Higher Cognitive Processes
Terry Picton
Pat Churchland
Mort Mishkin
David Premack
Terry Sejnowski
Edgar Zurif
Memory and Learning
Mike Gazzaniga
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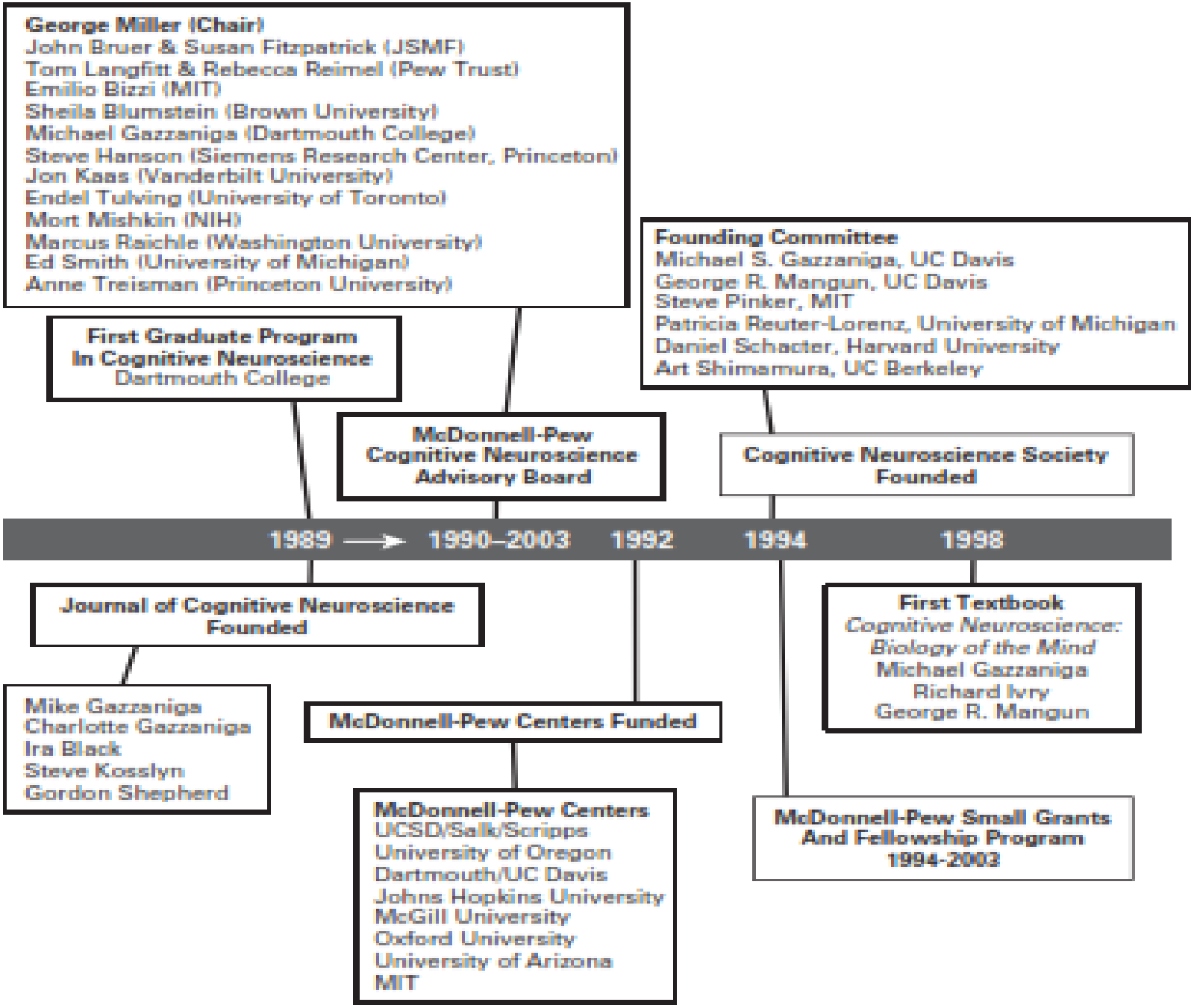
Ira Black
Bill Hirst
Gary Lynch
Attention and Perception
Michael Posner
Bob Desimone
Steve Hillyard
Geoff Hinton
Motor Control
Emilio Bizzi
Neville Hogan
Calude Ghez


George Miller (Chair)
John Bruer & Susan Fitzpatrick (JSMF)
Tom Langfitt & Rebecca Reimel (Pew Trust)
Emilio Bizzi (MIT)
Sheila Blumstein (Brown University)
Michael Gazzaniga (Dartmouth College)
Steve Hanson (Siemens Research Center, Princeton)
Jon Kaas (Vanderbilt University)
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Cognitive Neuroscience Society
Founded
1989
1990–2003
1992
1994
1998
Journal of Cognitive Neuroscience
Founded
Mike Gazzaniga
Charlotte Gazzaniga
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Gordon Shepherd
McDonnell-Pew Centers Funded
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Johns Hopkins University
McGill University
Oxford University
University of Arizona
MIT
McDonnell-Pew Small Grants
And Fellowship Program
1994-2003
First Textbook
Cognitive Neuroscience:
Biology of the Mind
Michael Gazzaniga
Richard Ivry
George R. Mangun

CNS

- Perception
- Memory
- Language
- Reasoning
- Learning
- Attention
- Action (motor)
- Consciousness

The methods of CNS

1. Neuroanatomy
2. Neurophysiology
3. Neurology
4. Functional Neurosurgery
5. Cognitive Psychology
6. Computer Modelling
7. Converging Methods

The brain story by Vaia Lestou

- Imaging the healthy brain
- **See 11bis !!!! (fMRI, PET, EEG)**

- Electrophysiological methods (EEG/ERP and single-cell recordings) + magnetophysiological methods (MEG) record the electrical/magnetic properties of neurons

- Functional imaging methods (PET and fMRI) record physiological changes associated with blood supply to the brain which evolve more slowly over time = Haemodynamic methods

Temporal resolution: Measure *when* an event is occurring

- EEG, MEG, TMS and single-cell recording = millisecond resolution
- PET and fMRI = minutes and seconds

Spatial resolution: Measure *where* an event is occurring

- Lesion and functional imaging = millimetre
- Single-cell recordings = level of the neuron

- “The goal of CNS: To explain how cognitive processes **emerge** from neural activity”
- Two methods: bottom-up and top-down

  Bottom-up: Knowledge from neurons + patterns → Cognitive processing

- 2 steps:

(1) Psychological theory (**computational**) that explain cognition

(2) Looking for neural implementation

Kosslyn - Image representations

- “Lower” brain functions = Early perception + motor control - Small neuronal areas
- Functions: *Reasoning and problem solving* = “High-level” functions - Large neuronal areas

- Kosslyn: “Wet mind” = Explain cognitive processes only by appealing (but not reducing) to neurobiological data-information ↔ Combination between mind-information and brain-information

- Neural level: Difficult to grasp higher functions

- **Johnson**'s book *Developmental Cognitive Neuroscience* (1997) - "Representational Change in Development"
- No method is perfect in CNS (D'Esposito 2010)

(D'Esposito 2010):

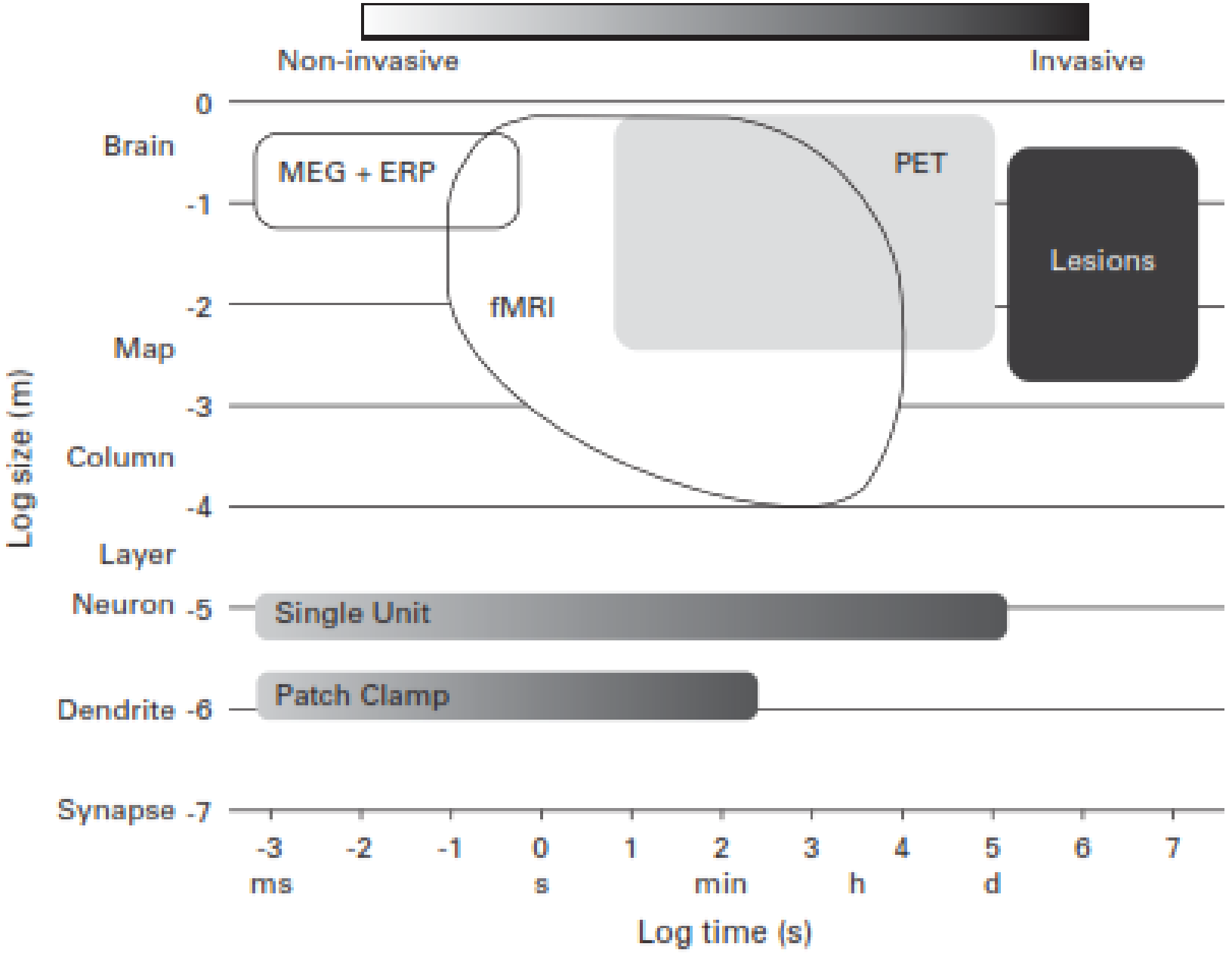
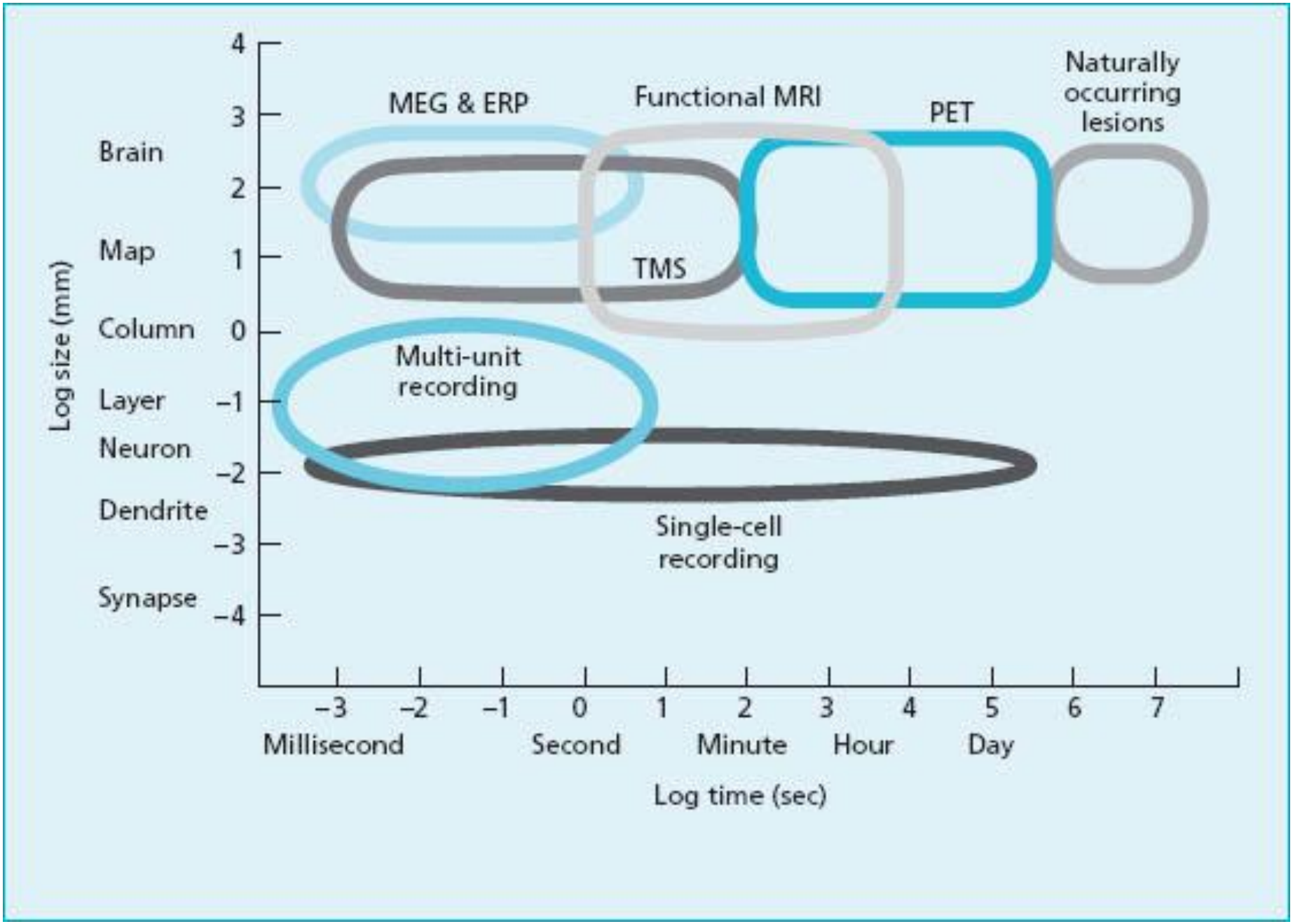


Figure 14.1
Temporal and spatial resolution of various cognitive neuroscience methods.


Log size (mm)
4
3
2
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−2
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−4
Brain
Map
Column
Layer
Neuron
Dendrite
Synapse
MEG & ERP
Functional MRI
PET
Naturally occurring lesions
TMS
Multi-unit recording
Single-cell recording
−3
−2
−1
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2
3
4
5
6
7
Millisecond
Second
Minute
Hour
Day
Log time (sec)

Sporns and Zwi's (2004) "*dual role of cortical connectivity":*

(1) *Functional specificity of certain cortical areas for* specific information

(2) *Integration of this kind of information in a coherent* behavior and cognitive states ("integration into coherent global states through oscillations (Bechtel, in press)

- Task: **Localization** of specific mental functions on neural areas

- Functions: Language, color perception, face recognition, self, etc.

- 2 alternatives: atomistic (localization) or holistic (no localization)

Bechtel (‘02, ‘08, ‘09)

- “A [mental] mechanism is a structure performing a function in virtue of its components parts, component operations, and their organization.

- The orchestrated functioning of the mechanism is responsible for one or more phenomena.” (Bechtel & Abrahamsen; Bechtel)

- “Heuristic identity theory”: over 30 areas in for visual processing (occipital lobe, parietal and temporal cortex) (‘08)
- Localization: Revised during advancing research
- Decomposability and localization
- Reduction and autonomy (“explanatory pluralism” view)

Uttal (2001, 2002)

- Impossibility of explaining mind through brain - **Non-linearity** of neural processes
- Psychological-neural equivalence – necessary at a level much lower than today (resolution of neuroimage tools - too large neuronal areas)
- Uttal: Lesions + neuroimage - we cannot *decompose* a cognitive system in components that can be localized

Hardcastle and Stewart (’02) vs. localization

- They criticize modularity of mind (Fodor + evolutionary psychology)
- Cognitive neuroscientists assume localization of brain function → Discrete, physically constant brain modules
- The main attack: No empirical data, no theoretical framework!

Critics regarding:

(1) Localization and *single cell* recordings

(2) Lesion studies and the assumption of brain constancy

(3) Functional imaging

- None of these methods is sustainable in proving the modularity of the mind

Vul et al (‘09) – analyses 54 articles!

- “The **correlations** between behavioral and self-report measures of personality or emotion and measures of brain activation obtained using fMRI”
- “These correlations often exceed what is statistically possible assuming (evidently rather limited) reliability of both fMRI and personality/emotion measures.”
- Such correlations are “impossible high”