

The quest for consciousness

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MIT IAP 2005

http://ramonycajal.mit.edu/academia/classes/ncc/iap_2005.html

Fridays 10-11 am (Jan. 07, 14, 21, 28)

E25-202

Summary of previous class

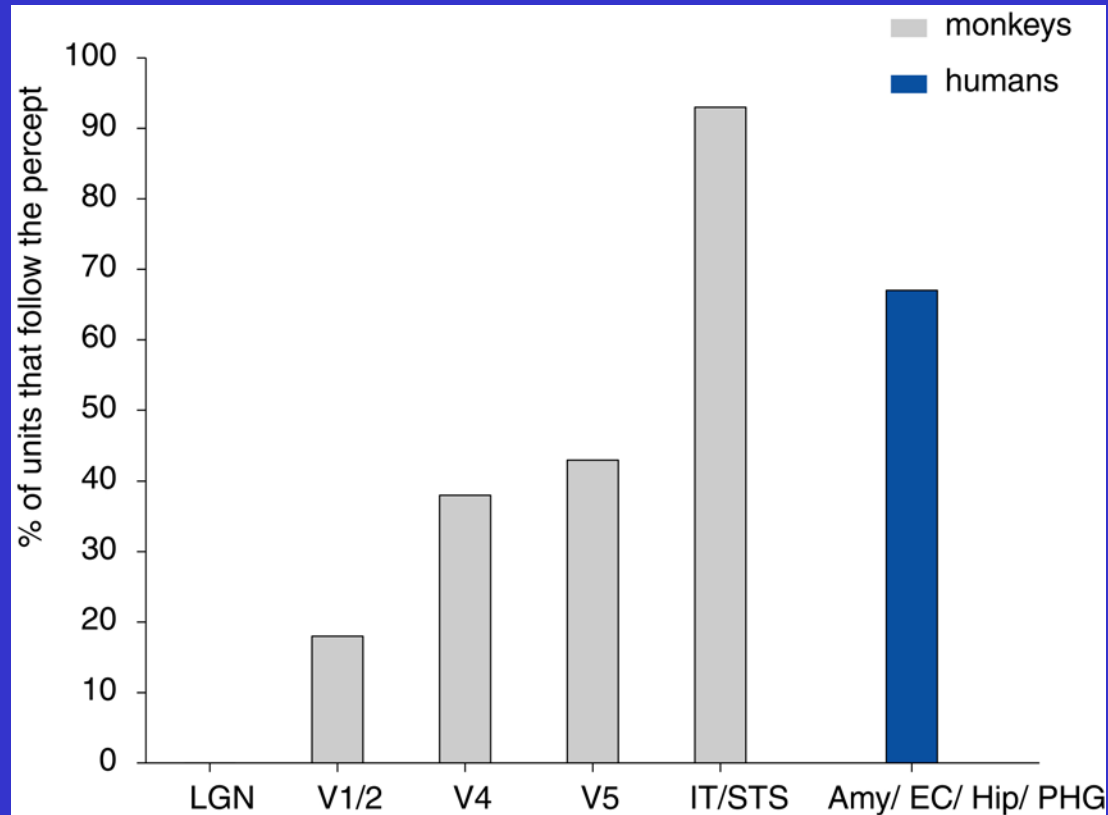
Bistable percepts: constant stimulus, changing perceptions

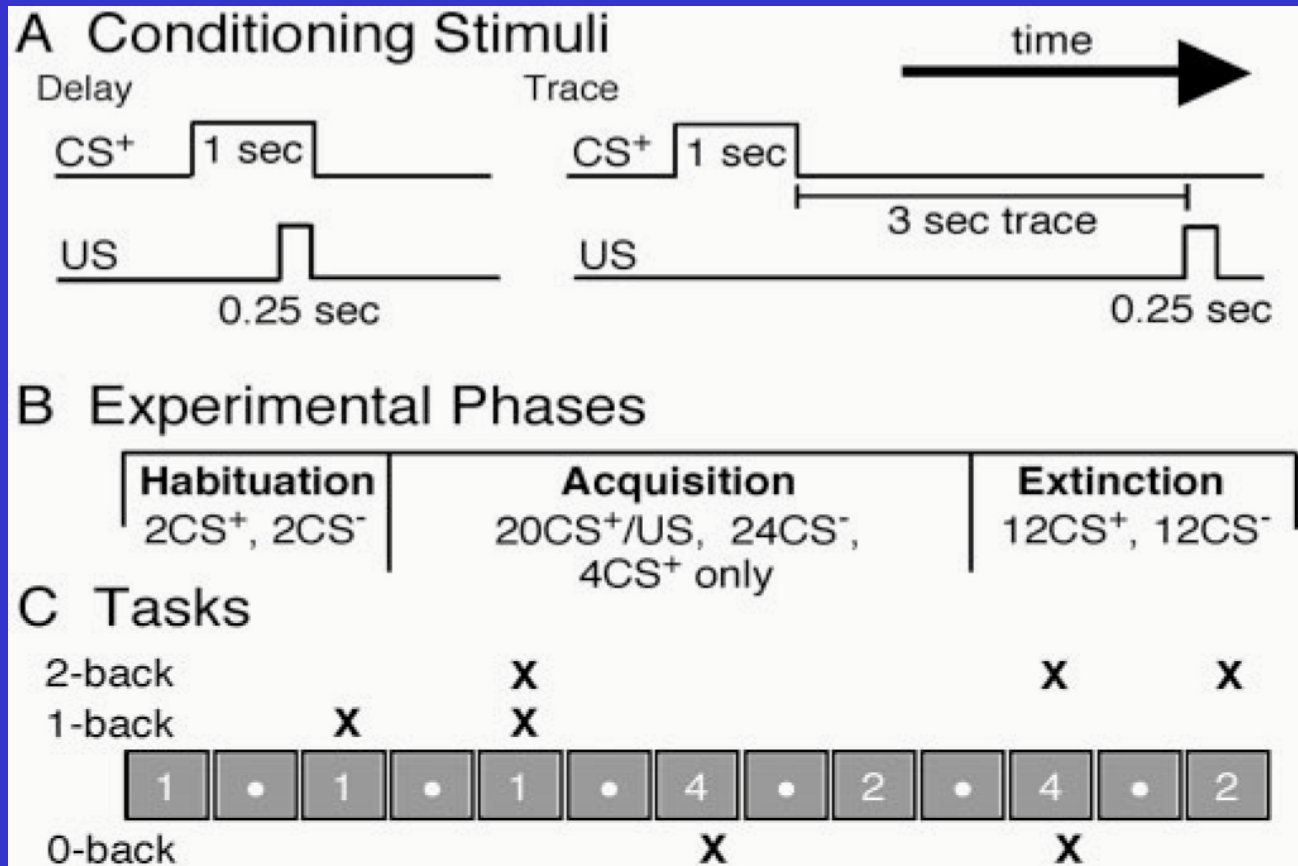
There are neurons that represent the contents of consciousness

These neurons are predominantly located in higher visual areas and not in lower visual areas

The representation is explicit

Neurons in higher areas follow perception





In search of causality

The activation of area X during process Y does not necessarily imply that Y causes X or viceversa

When the TV is on, the top of the TV may be hot. Yet this heat is not a very interesting variable

Perhaps when a subject perceives the stimulus, IT is activated and then the conscious information is sent to the frontal cortex for action, to the MTL for storage, etc.

If area X is involved in process Y then a lesion in X may impair process Y

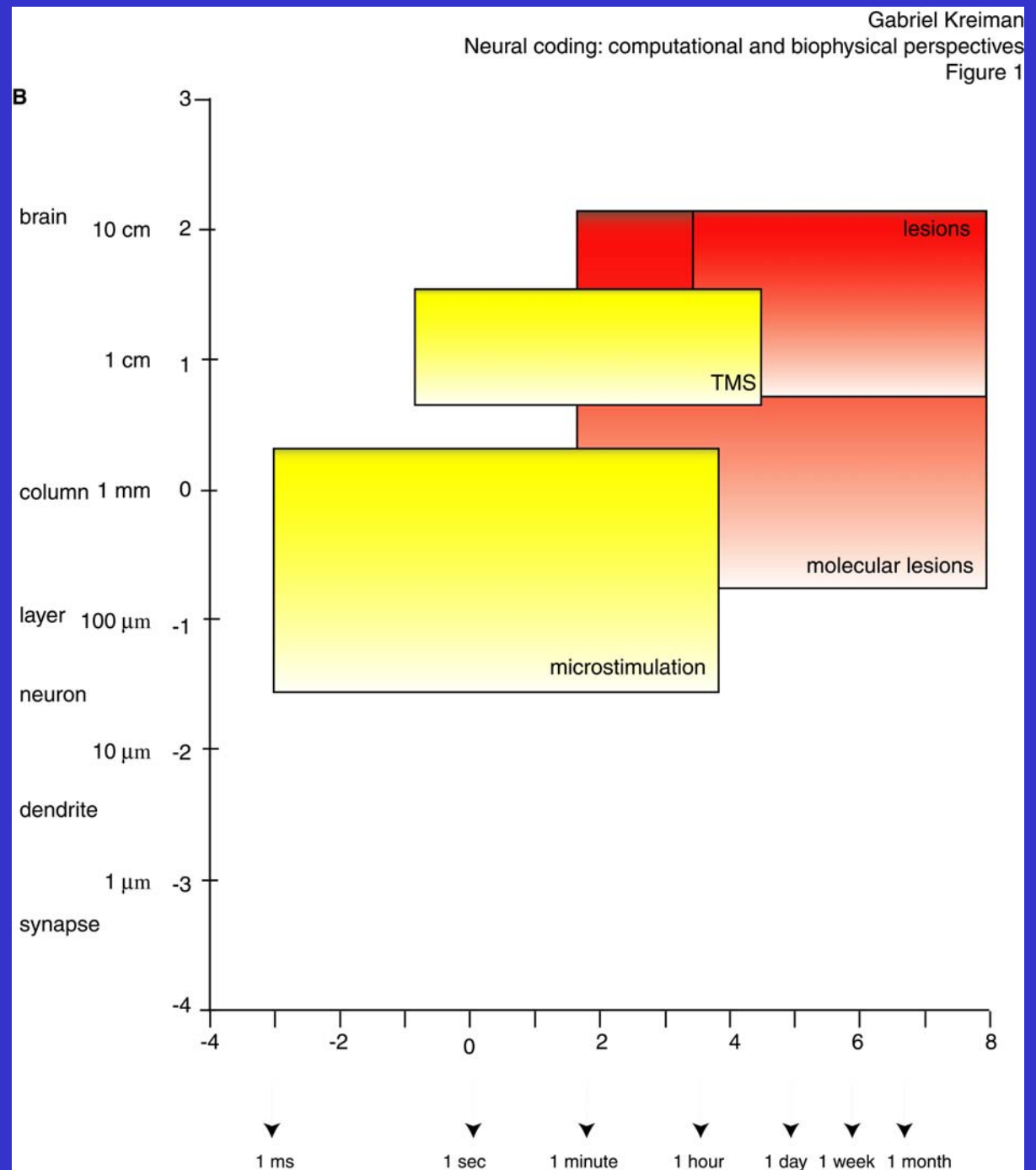
For example, lesions in IT impair the subject's performance in object recognition tasks (this is not the case for the MTL)

However, current lesion techniques are still very crude (--> genomics techniques)

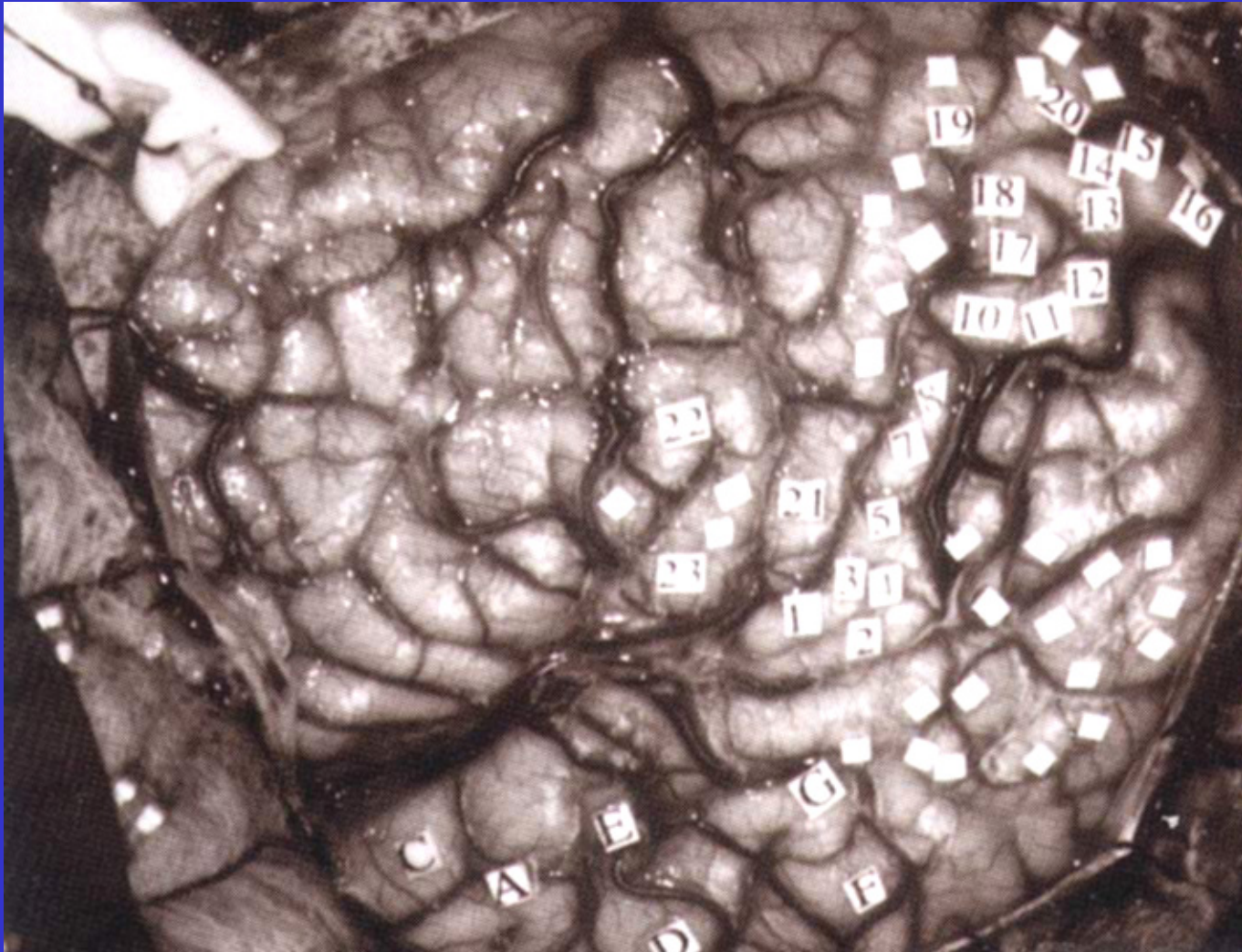
Stimulation of area X may have some effect (interference, facilitation, inhibition) of process Y

Some stimulation and lesion techniques and their resolution

Kreiman, G. (2004).
"Neural coding:
computational and
biophysical perspectives."
Physics of Life Reviews
2:71-102



Electrical stimulation in humans

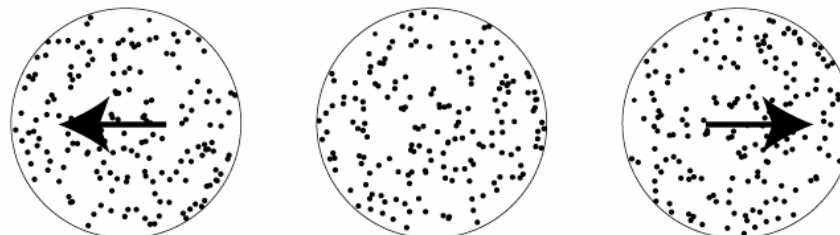
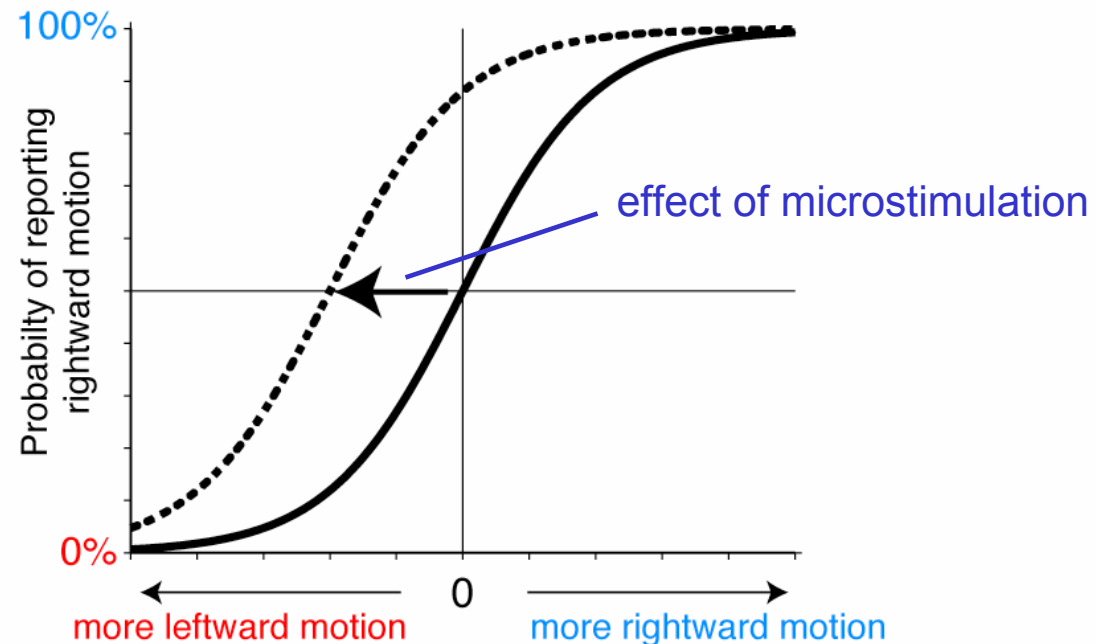


Penfield, W. and P. Perot (1963). "The brain's record of auditory and visual experience. A final summary and discussion." *Brain* **86**(4): 595-696.

Penfield, W. and H. Jasper (1954). Epilepsy and the functional anatomy of the human brain. Boston, Little, Brown and Company.

Perceived motion direction and heading can be predictably biased by electrical microstimulation in the dorsal visual stream

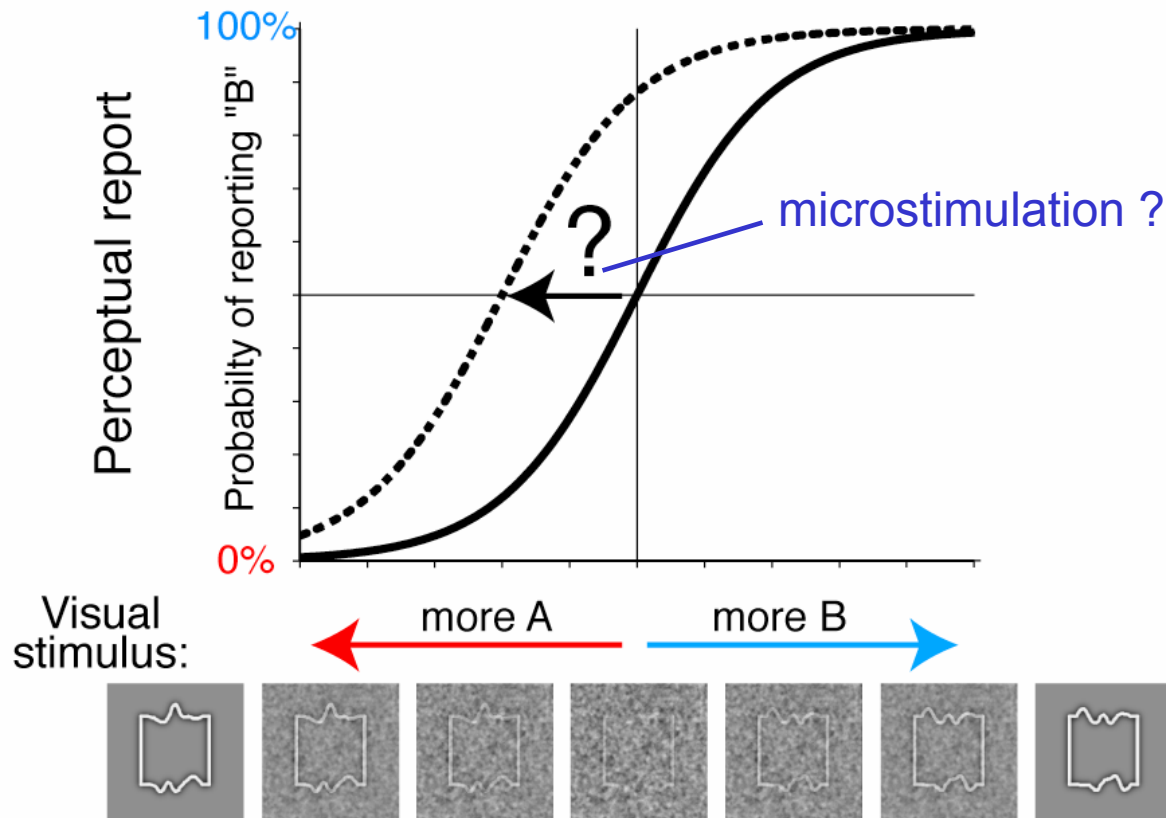
Salzman et al. (1992), Celebrini and Newsome (1995), Britten and van Wezel (1998)



Salzman et al. (1990). "Cortical microstimulation influences perceptual judgments of motion direction." *Nature* **346**:174-177

Microstimulation of AIT neuronal clusters that prefer shape B

(neurons that are likely signaling the presence of "B" to the animal)



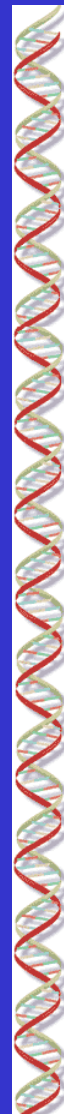
Towards higher resolution

In search of complementary new tools

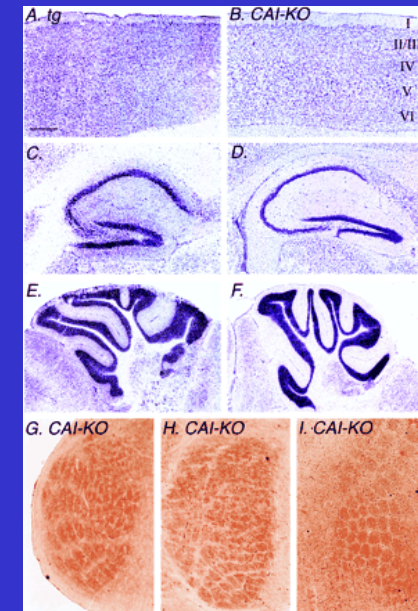
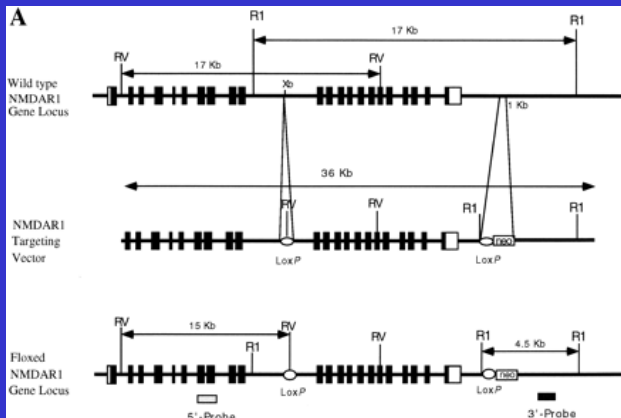
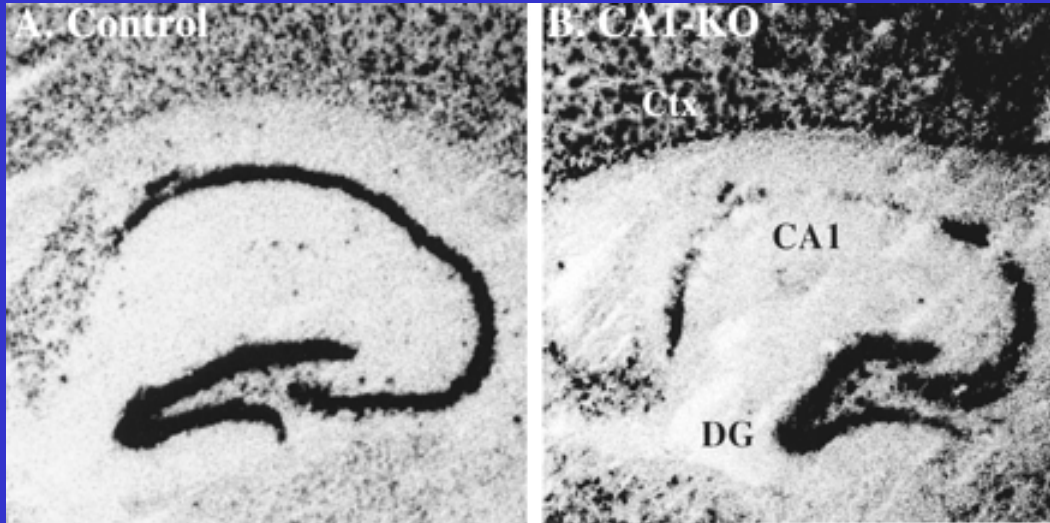
What we need:

- Detailed neuroanatomy
- Inactivation of specific neuronal subtypes
- Spatially and temporally restricted inactivation
- Reversible activation/inactivation

THESE TOOLS WILL MOST LIKELY COME FROM
MOLECULAR BIOLOGY

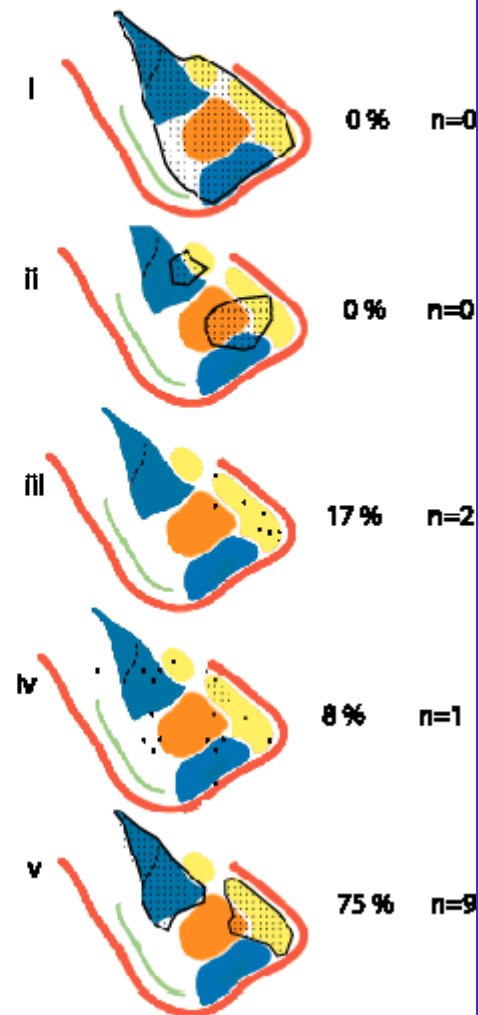


Molecular biology can provide a remarkable degree of specificity



Expression is restricted to specific amygdaloid subnuclei

Ziringer et al
Figure 4



M. Ziringer, G. Kreiman, D. Anderson, *Proc. Natl. Acad. Sci. USA* **98**:5270-5275 (2001).

Some Hilbert questions about neural coding

1. Map from spikes to neurotransmitter release
2. Recording from multiple neurons (~ 100 to 1000)
3. Topography and columnar organization
4. What is noise and what is signal? Why/when/how does the timing of spikes vary?
5. Anatomy! Where do neurons project to? What is the input?
6. Not all neurons are equal. How many types of neurons are there? What are the different properties?
7. Correlation and causation.
8. Detailed and clean lesions using molecular tools.

Recapitulation I

How can a physical system show consciousness?

Several alternative explanations for the origin and mechanisms of consciousness

1. Dualist view
2. Science cannot understand consciousness. New principles are needed
2. Consciousness is an illusion. Consciousness is an epiphenomenon

Consciousness is of the brain, for the brain and by the brain

Recapitulation II

1. The nonconscious *Homunculus*
2. A lot can be done in *zombie mode*
3. The NCC involve *coalitions of neurons*
4. An *explicit* representation is needed
5. Higher levels first
6. The NCC require strong driving projections
7. Consciousness comes in snapshots
8. Attention and binding
9. The NCC may involve specific firing patterns
10. Penumbra, meaning and qualia

Recapitulation III

Bistable percepts: constant stimulus, changing perceptions

There are neurons that represent the contents of consciousness

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Recapitulation IV

Causality:

- lesions

- microstimulation

Research into new techniques

- lesions: selectivity of molecular biology

- stimulation: finer stimulation techniques

Speculations about the future I

Lots of interesting news in Neuroscience in the next two decades

We will get a clearer picture of areas of the brain that are involved in consciousness and other areas which are not

Delimitation of which are appropriate animal models

Extensions to other modalities (e.g. the auditory system)

Speculations about the future II

Dreams

Lucid dreaming

Out of body experiences

Hallucinations

Meditation

Sleep walking

Hypnosis

Self awareness

Qualia

Feelings

What would constitute evidence that we understand the NCC?

The possibility to:

- (a) Model and predict neuronal responses given a perceptual state
- (b) Accurately predict perceptual state given neuronal activity
- (c) Induce a specific perceptual state by selective electrical stimulation
- (d) Inactivate or repress a perceptual state