

Recent Directions in Cognitive Science, including Cognitive Neuroscience

Identity Crisis of the 1990s: go neural, go ecological, or go cultural?

Computer Science

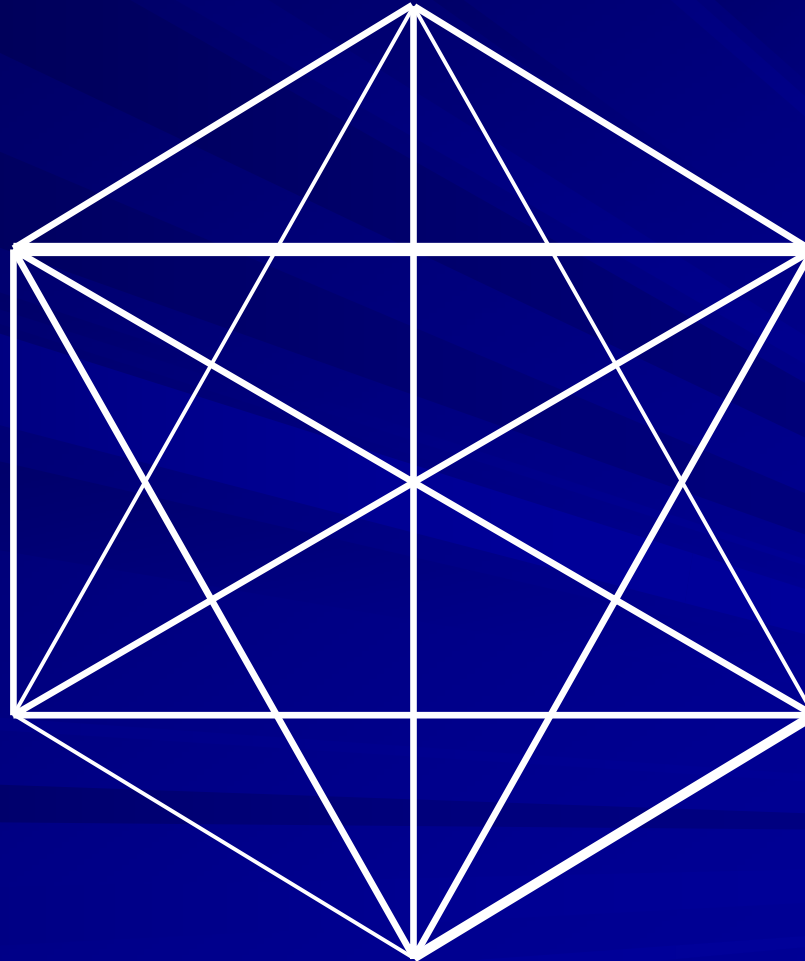
Psychology

Neuroscience

Philosophy

Sociocultural
Studies

Linguistics



Positions on the Mind-Body Problem

- **Eliminative Materialism:** Turning to the brain will show us what is really going on and reveal that folk psychology and cognitive psychology are really false.
- **Philosophical Functionalism:** It is possible to figure out how the mind works without consulting the brain—the mind is a set of operations, and the hardware doesn't matter.
- **Mind-brain identity theory:** There are mental processes, but these are performed in the brain and depend upon the particulars of the brain.

Strategies for Studying the Brain and Cognition

Deficits Resulting from Lesions

Naturally occurring

Experimentally induced
(mostly in animals)

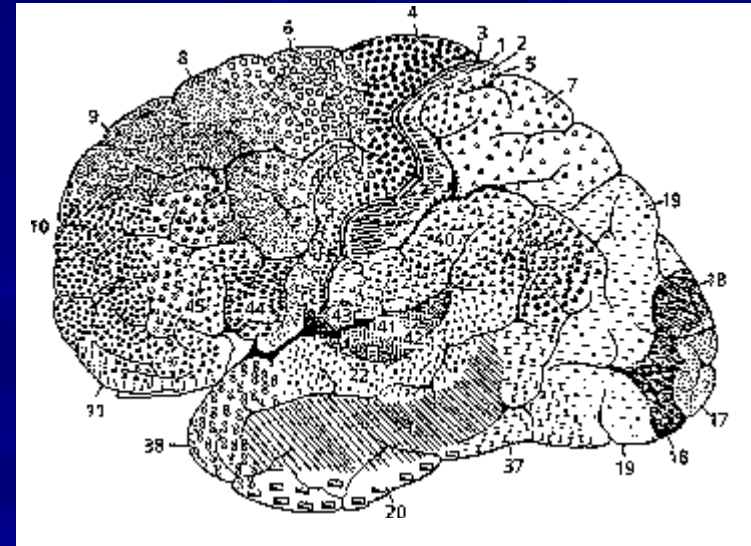
Stimulation of neural tissue

Recording electrical activity

From individual neurons (in animals)

From scalp (evoked response potentials—ERPs)

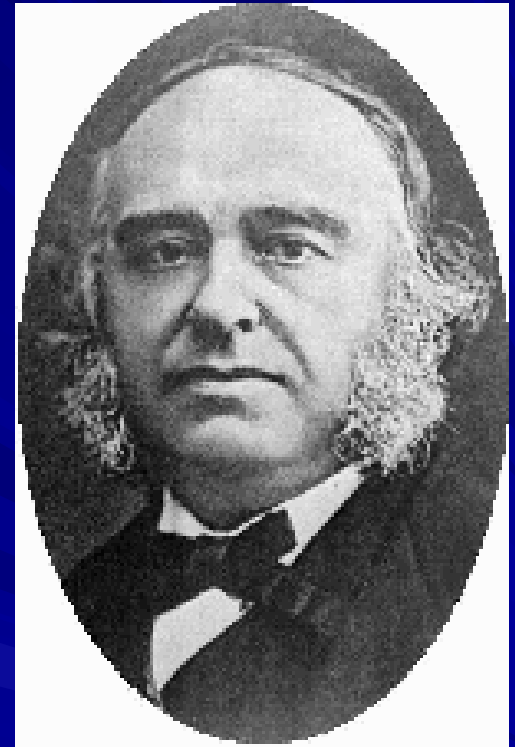
Neuroimaging (measurement of blood flow)



Broca and The Faculty of Articulate Speech

Loss only of speech: α-φήμη: “What is missing in these patients is only the faculty to articulate the words; they hear and understand all that is said to them, they have all their intelligence and they emit easily vocal sounds”

“What is lost is therefore not the faculty of language, is not the memory of the words nor is it the action of nerves and muscles of phonation and articulation, but something else . . . the faculty to coordinate the movements which belong to the articulate language, or simpler, it is the faculty of articulate language.”



Tan

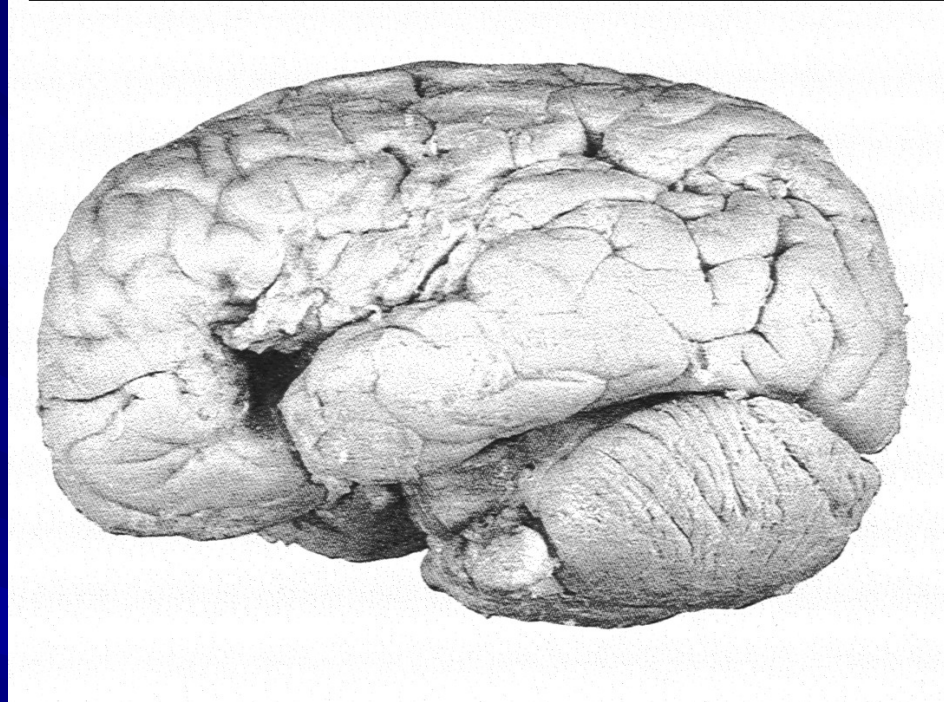
Leborgne

- Epileptic who lost ability to speak at 31
- Main vocal response: “tan, tan”
- Ten years later developed paralysis on right side
- Now had gangrene in his right leg

“From the anamnesis and from the state of the patient it was clear that he had a cerebral lesion which was progressive, which, at the beginning and for the first 10 years of the disease remained limited to a fairly well circumscribed region, and which during this first period, had attacked neither the organs of motility nor of sensitivity; that after 10 years the lesion had spread to one or more organs of motion, still respecting the organs of sensitivity, and that still more recently the sensitivity had suffered together with the vision, particularly the vision of the left eye. A complete paralysis of movement occupied the two extremities of the right side, and the sensitivity of these two extremities was slightly less than normal. The principal cerebral lesion should therefore be in the left hemisphere.”

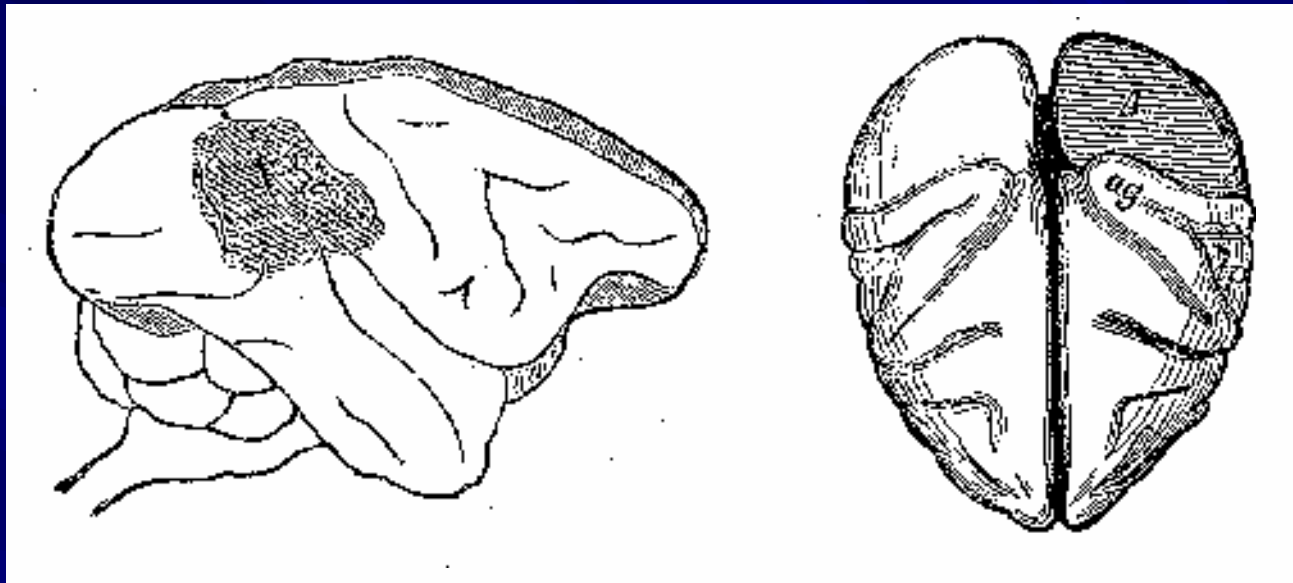
Autopsy of Leborgne

“It is clear therefore, that the first focus of softening occurred where there is today the loss of substance, that the disease then spread gradually by contact, and that the point where it started should not be looked for among the organs actually softened or in the process of softening, but among those which are more or less completely destroyed.”



“If one wanted to be more precise, one could remark that **the third frontal convolution** is the one which shows the greatest loss of substance . . . it alone has undergone a loss of substance, equal to about one-half of the total; that the second or middle frontal convolution, although deeply affected, still preserves its continuity in its innermost parts, and that, consequently, **it is most likely in the third convolution that the disease began. . . .**”

Lesions and Visual Processing

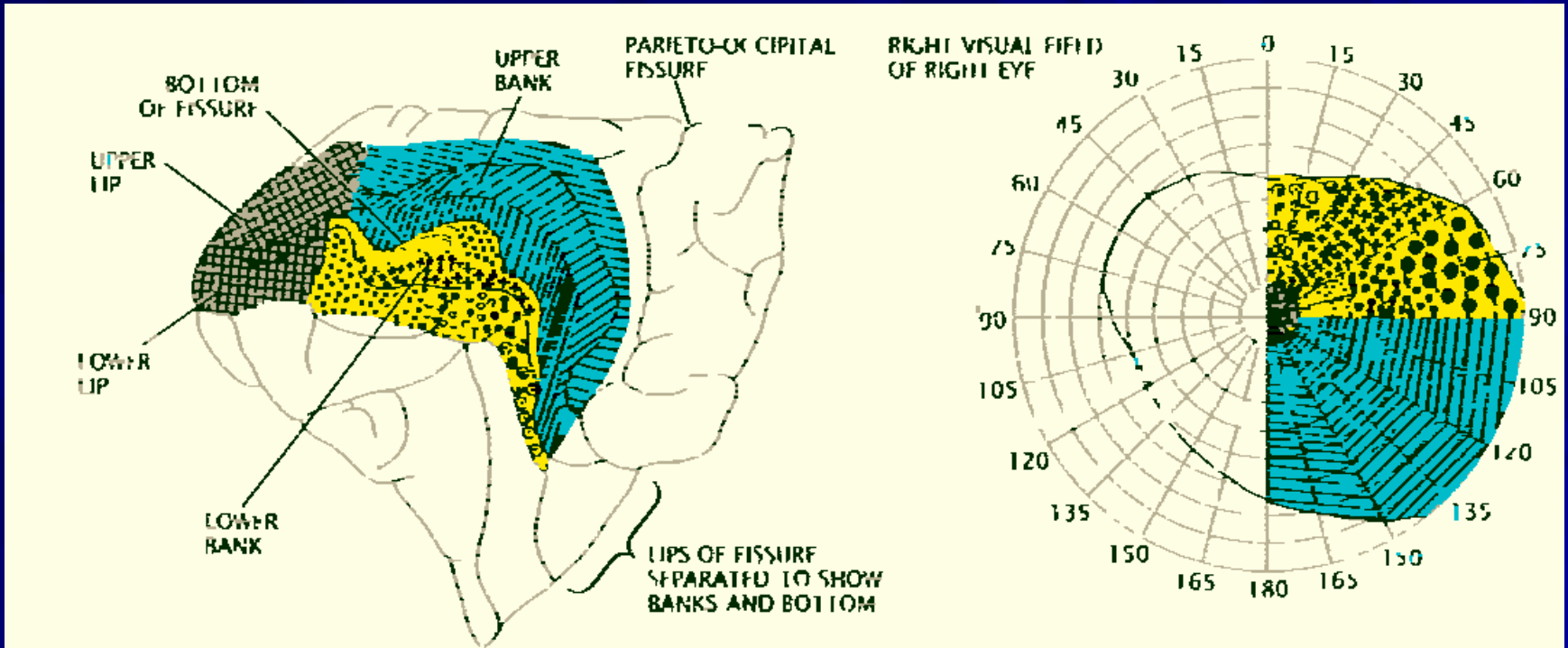


Competing proposals of visual center in late 19th century:

David Ferrier (left)—angular gyrus

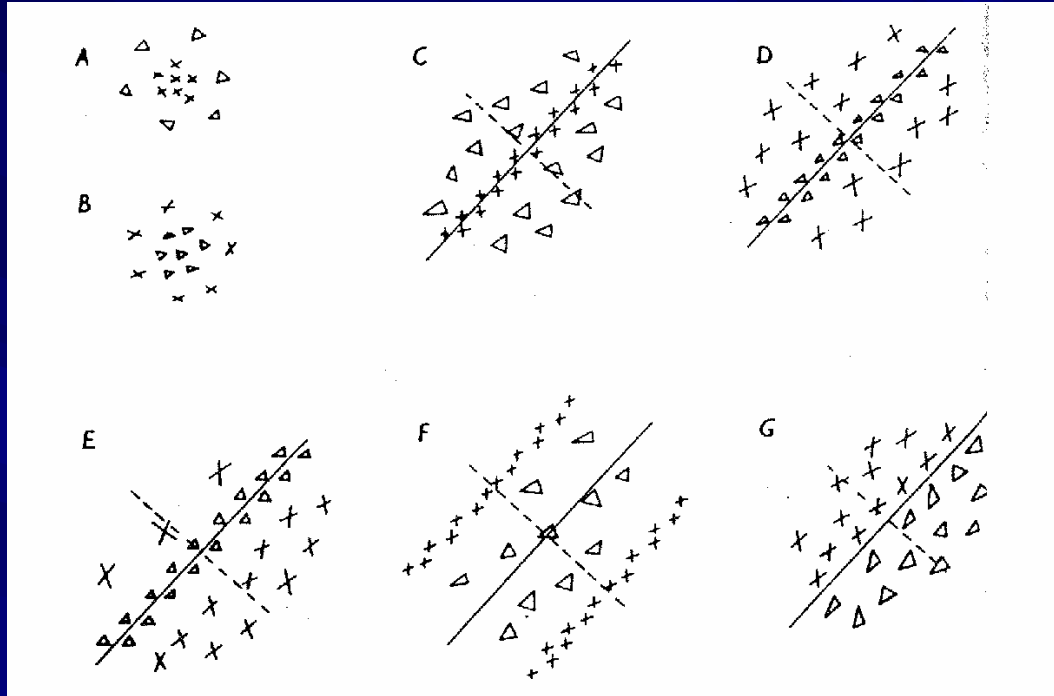
Meynert, Munk, et al. (right)—occipital lobe

Identifying a Visual Map by Lesion



New bullets developed by the Russians produced more localized wounds, including destroying only localized part of the brain. Use wounds to occipital cortex to map visual field

Recording from Visual Cortex: Kuffler, Hubel and Wiesel

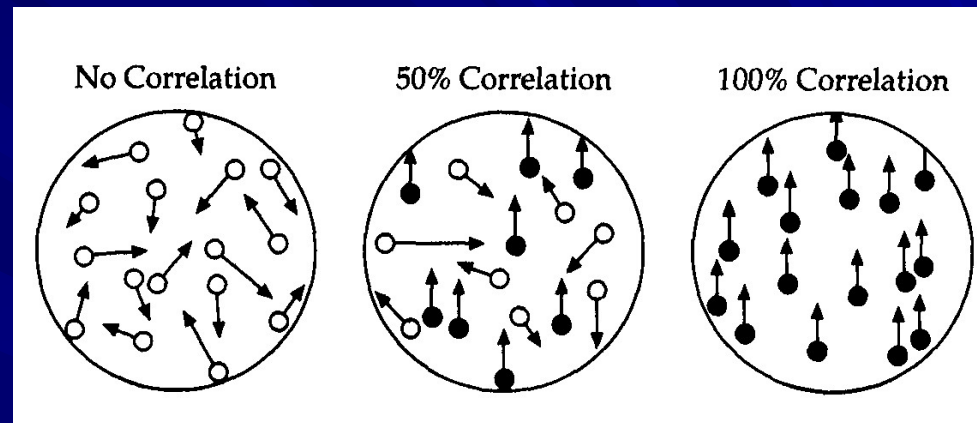


Light or dark circles (A and B) elicit activations in retina
and lateral geniculate nucleus

Light or dark bars of light (C-G) elicit activations in
occipital cortex

Functional Specificity of Prestriate Cortex

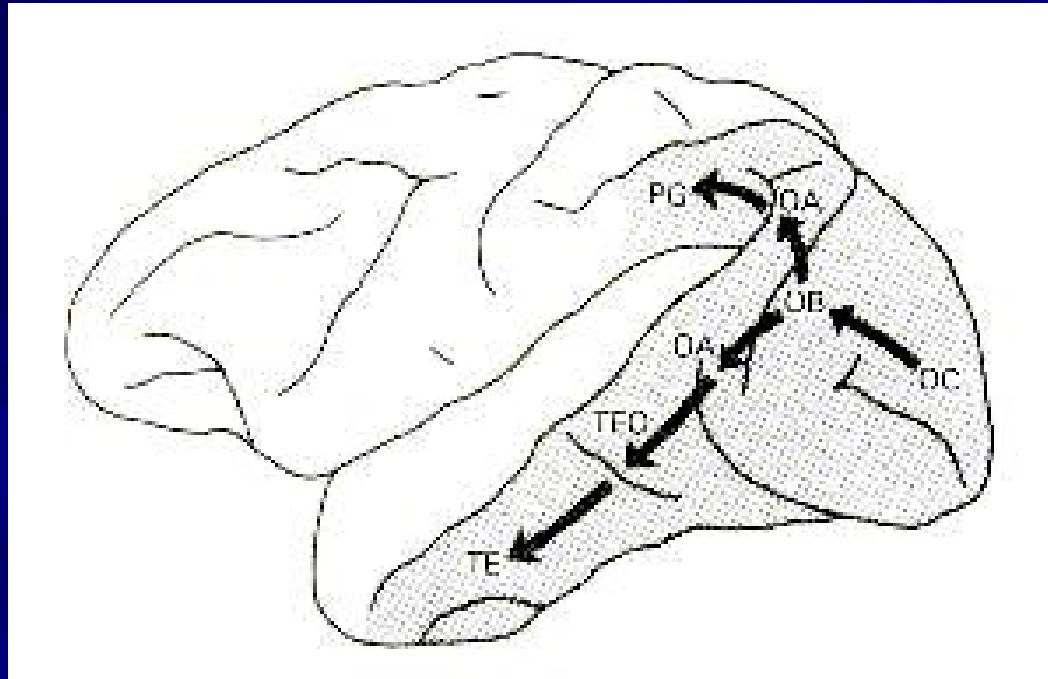
V2: Illusory figures
V4: Color constancy
MT: Motion detection



William Newsome trained monkey's to indicate the direction of perceived correlated motion

- High correlation with recordings from MT cells
- In cases where the degree of correlation of motion was too small for reliable response, MT cells predicted animal's behavior
- Microstimulation of cells could bias behavioral response

Two Visual Systems

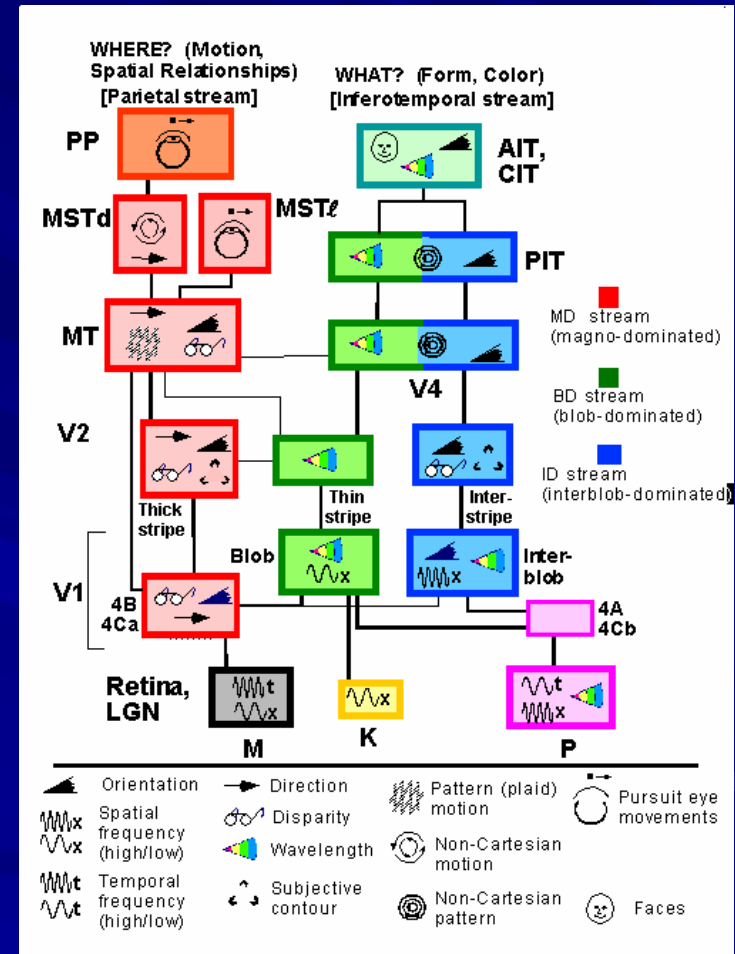
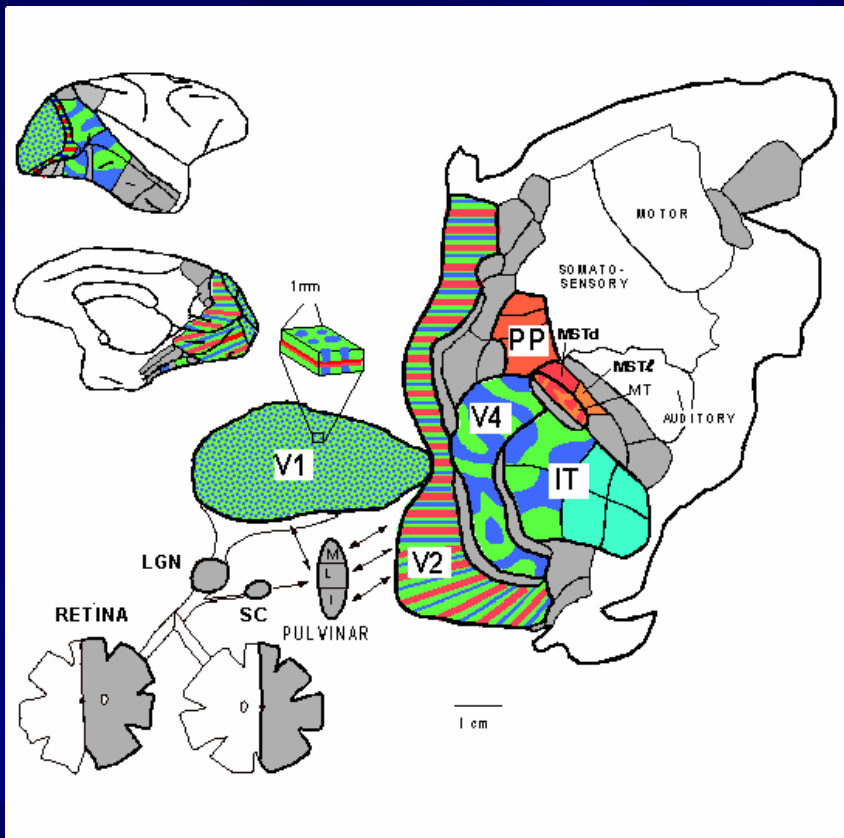


Subsequent research revealed

Areas in temporal cortex that responded to features of objects or their identity

Areas in parietal cortex that respond to location

The State of the Art in Understanding Visual Processing



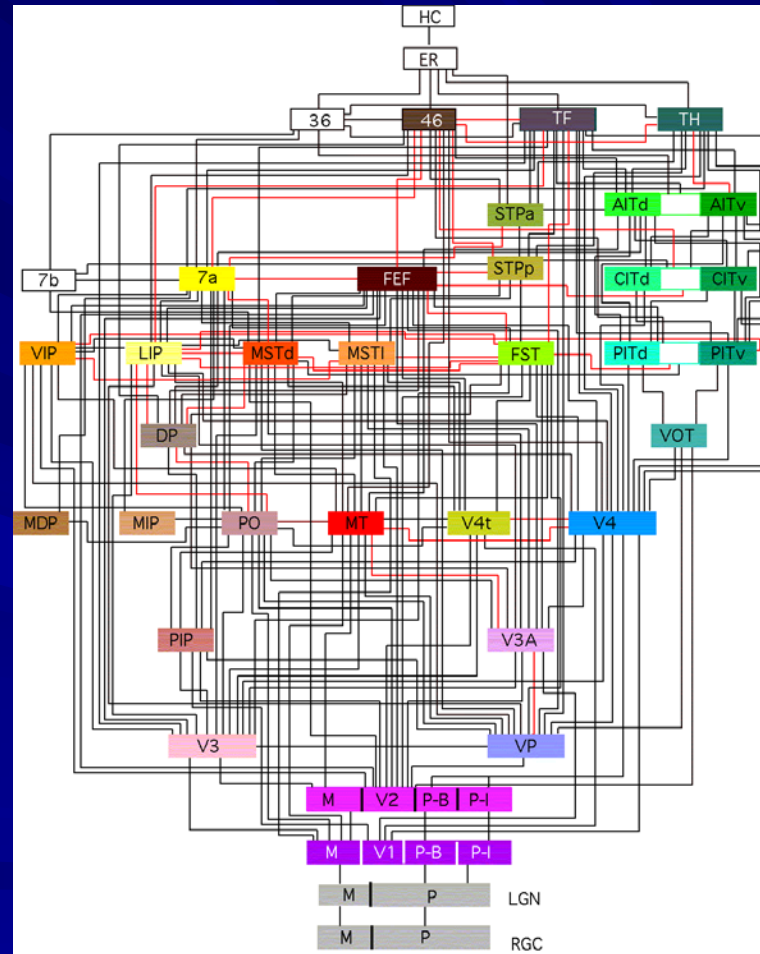
Van Essen and Gallant:
Flat map of monkey cortex and corresponding functions

The Full Visual System

32 areas involved in visual processing

Over half of a monkey's brain

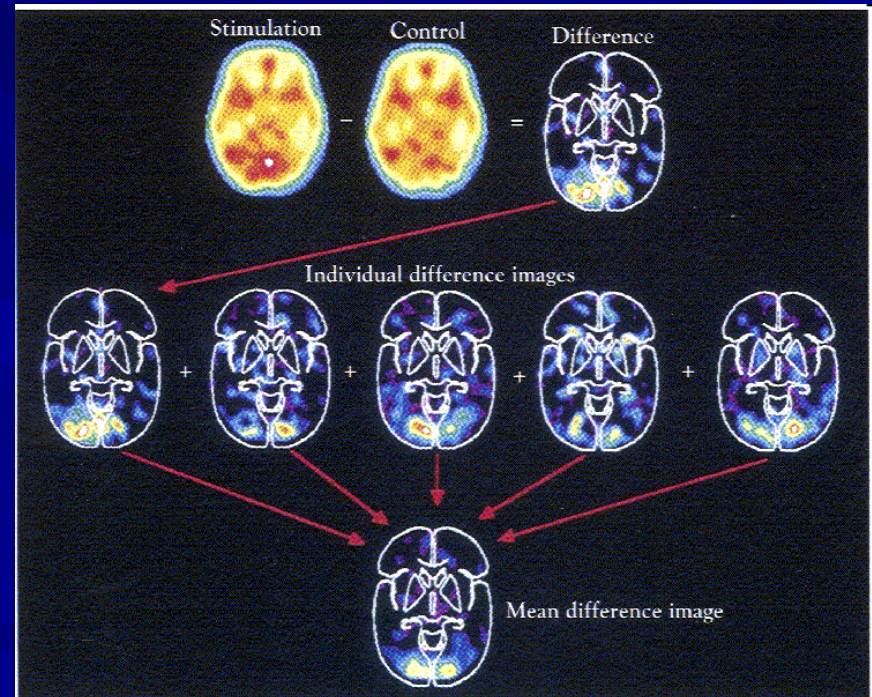
Over 300 connections between these areas



Introduction of new techniques for indirect measure of cognitive activity: PET, fMRI, ERP, MEG

Collaboration of expert in hemodynamics (Marcus Raichle) and psychologist expert in reaction times (Michael Posner)

Adapt the subtractive method to link sub-tasks with active brain regions

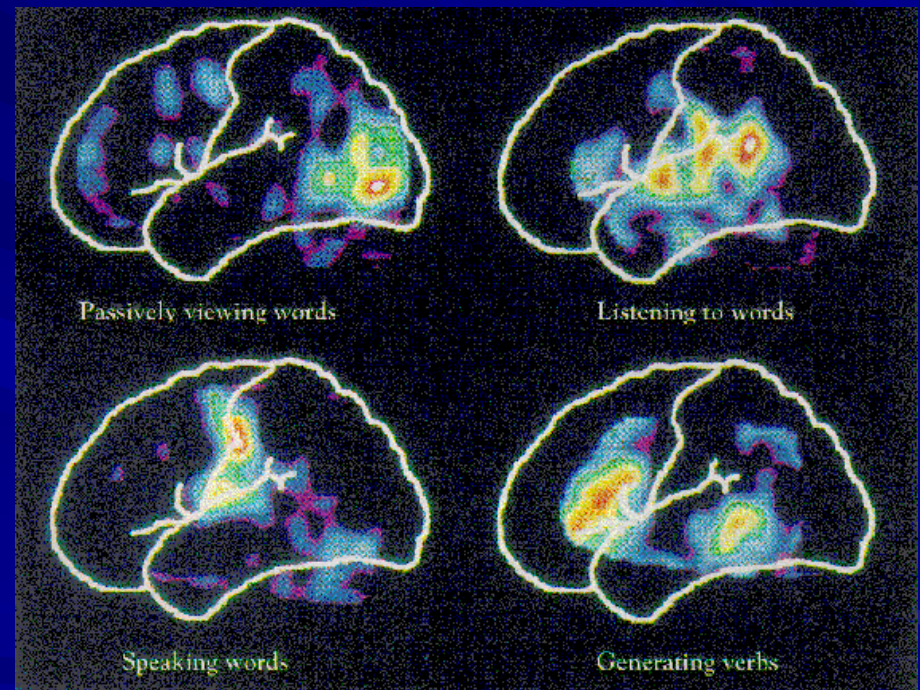


New Results from PET

Subtract activations produced by reading or listening to words from activations produced by reading aloud or repeating them

Subtract activation produced by reading aloud from generating related verb and saying it aloud

Presumably activates center for semantic processing



New interdisciplinary endeavor: Cognitive Neuroscience

Initiative of McDonnell-Pew

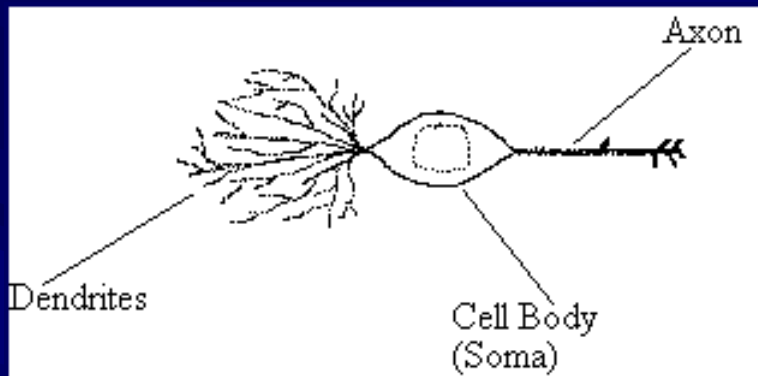
Establishment of centers for cognitive neuroscience:
Oxford, McGill, MIT, Dartmouth, Arizona, UCSD,
Oregon

New journal: *Journal of Cognitive Neuroscience*

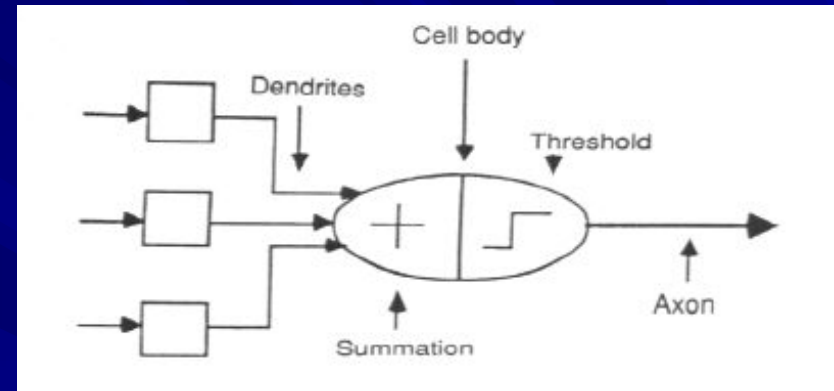
New society: Society for Cognitive Neuroscience

Related development: computational neuroscience

Artificial Neural Networks (Connectionism)



Biological Neurons

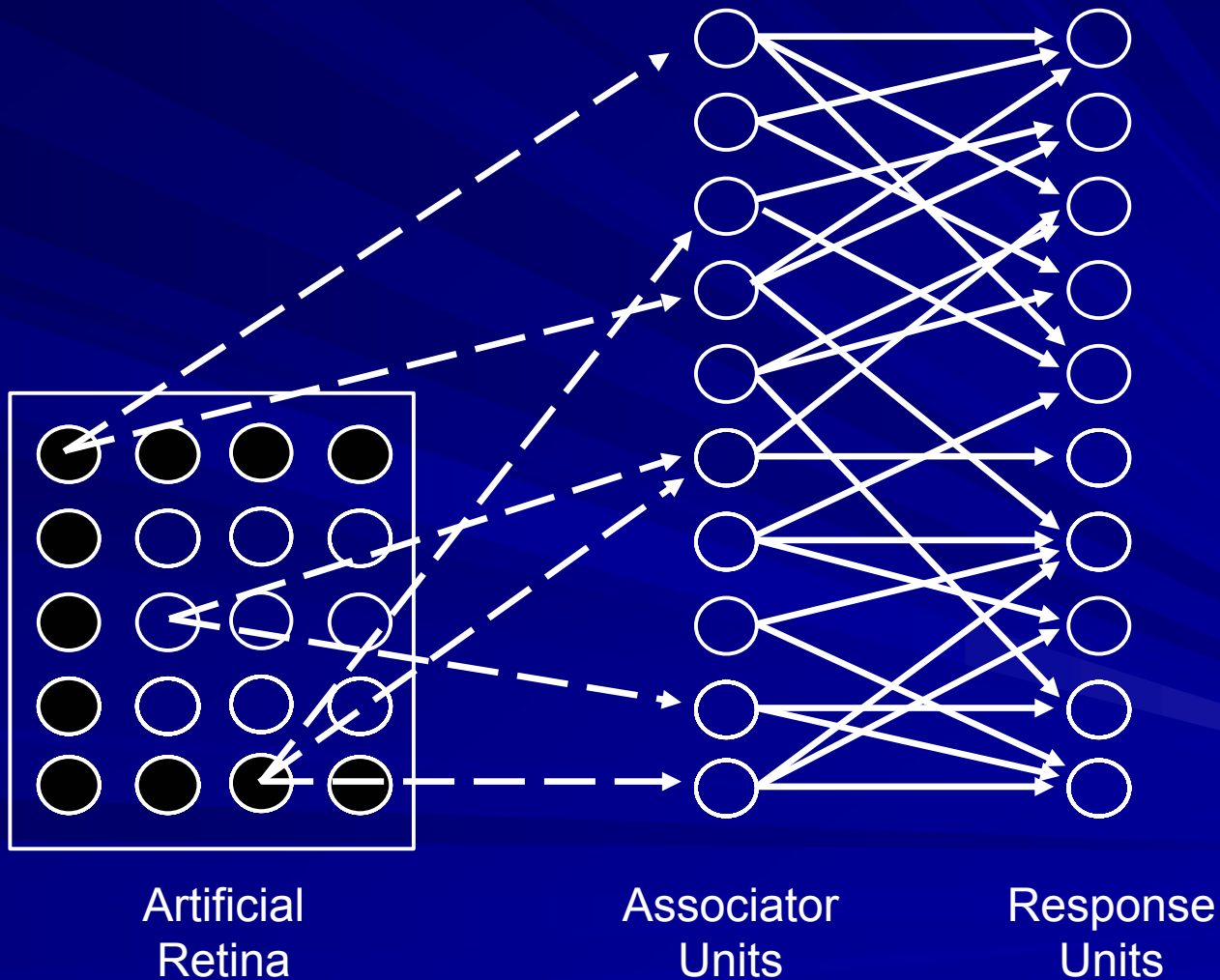


Artificial Neurons

McCulloch and Pitts (1943) saw how to build sentential logic networks out of artificial neurons: negation, and-gates, or-gates

Pitts and McCulloch (1947) saw the potential to model perception, etc. with less structured networks

Rosenblatt's Perceptrons



Minsky and Papert and the Demise of Perceptrons

Exclusive Or

A B A xor B

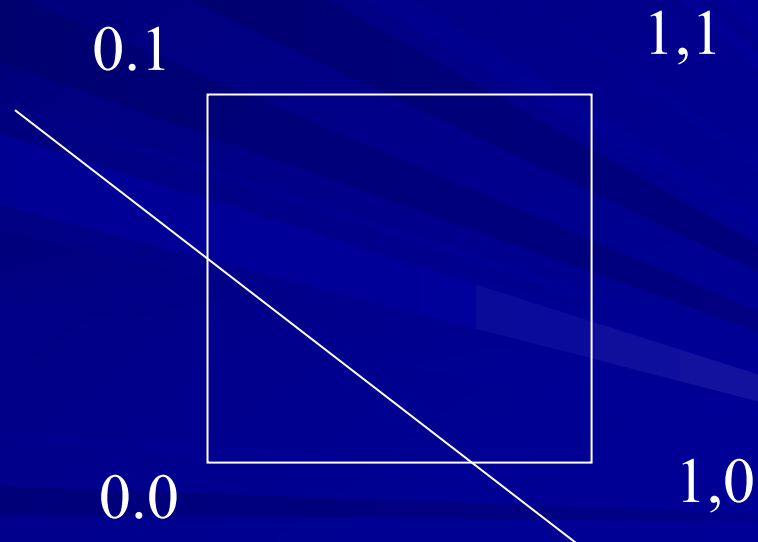
1 1 0

1 0 1

0 1 1

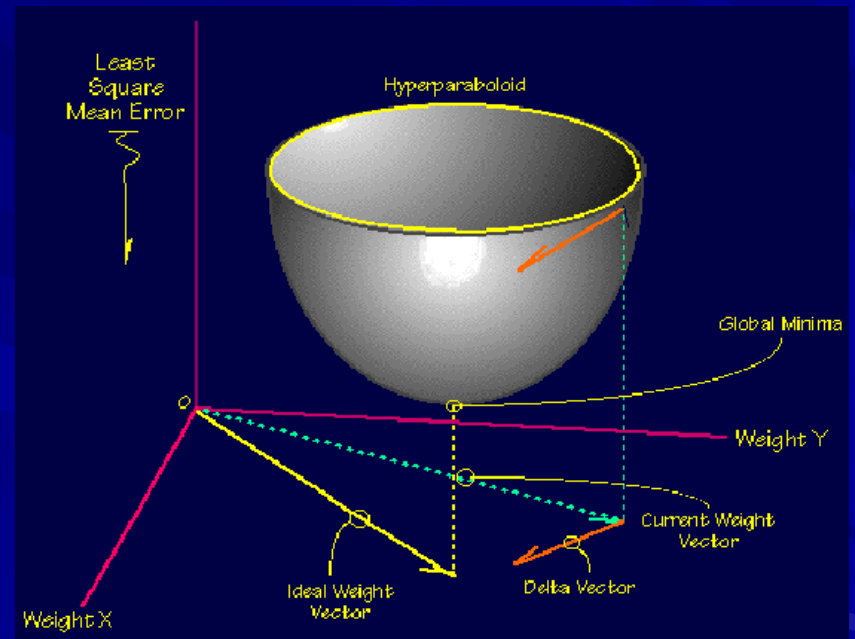
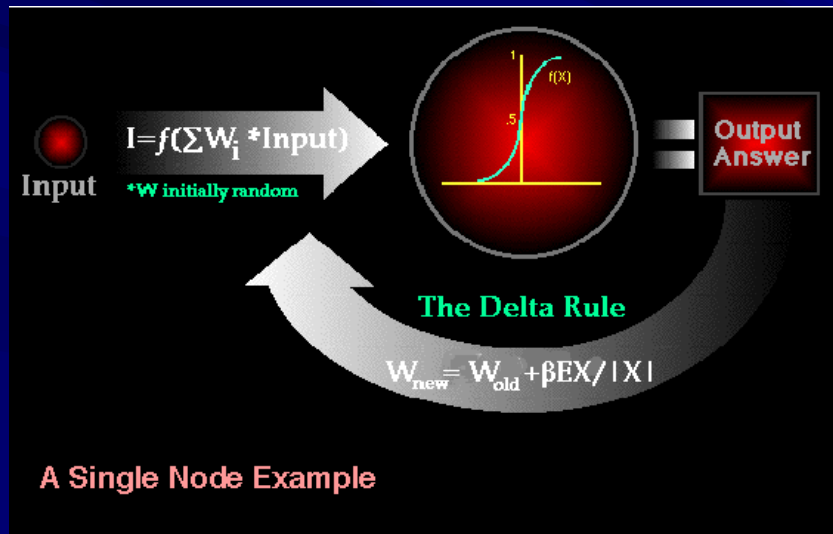
0 0 0

Failure of linear separability

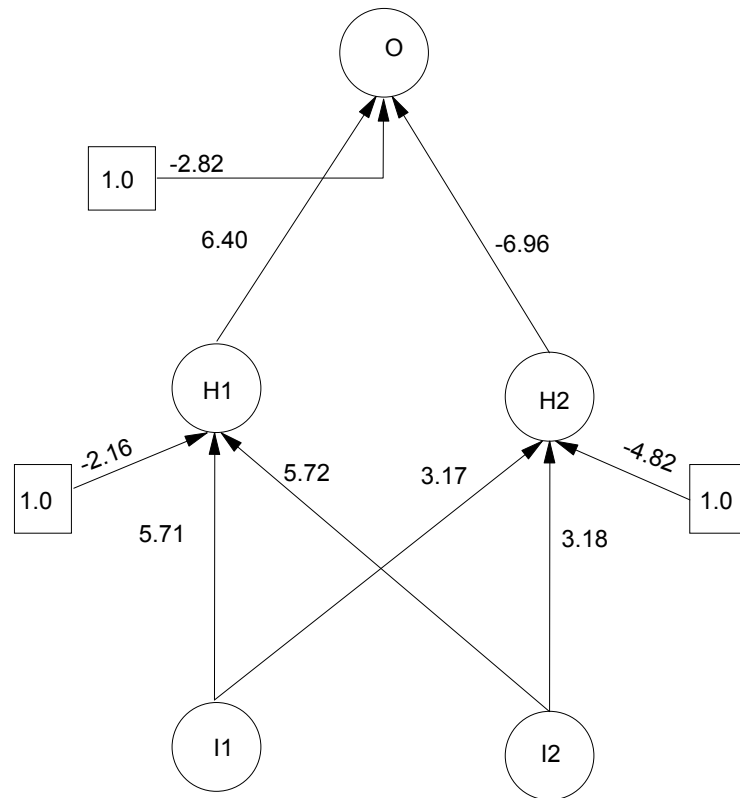


Connectionism Returns

New learning rules: Delta Rule and Backpropogation

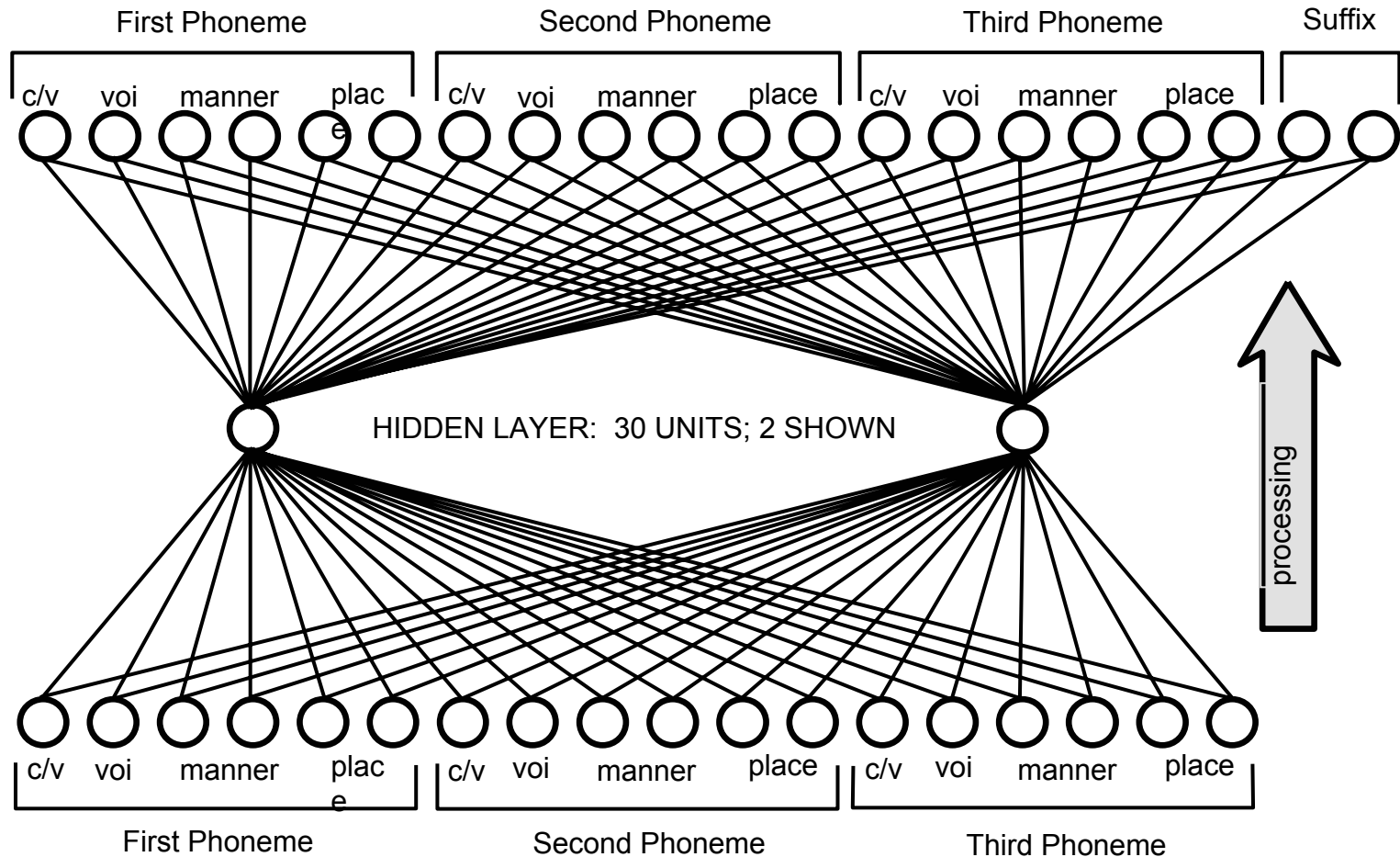


Solving XOR with Backpropogation



The Ubiquity of Feedforward Nets

OUTPUT LAYER: PHONOLOGICAL FEATURE REPRESENTATION OF PAST TENSE FORM



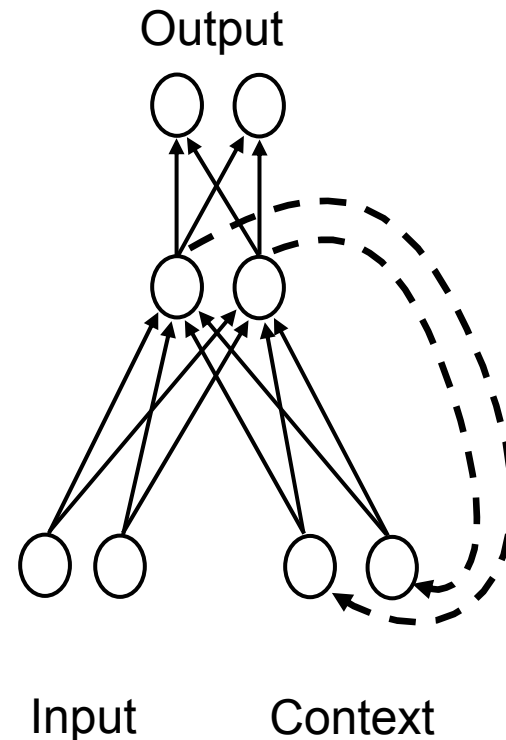
INPUT LAYER: PHONOLOGICAL FEATURE REPRESENTATION OF VERB STEM

Beyond Feedforward Nets

Allows network to process sequential stimuli (such as sentences)

Trained network to predict next grammatical category in sentences constructed from a simplified grammar

Elman's simple recurrent network



Other Directions in Recent Cognitive Science

- Cognitive system situated in environment
- Cognitive system embodied
- Language as grounded in cognition, not autonomous grammar

Turning toward the environment: J. J. Gibson and Ecological Psychology

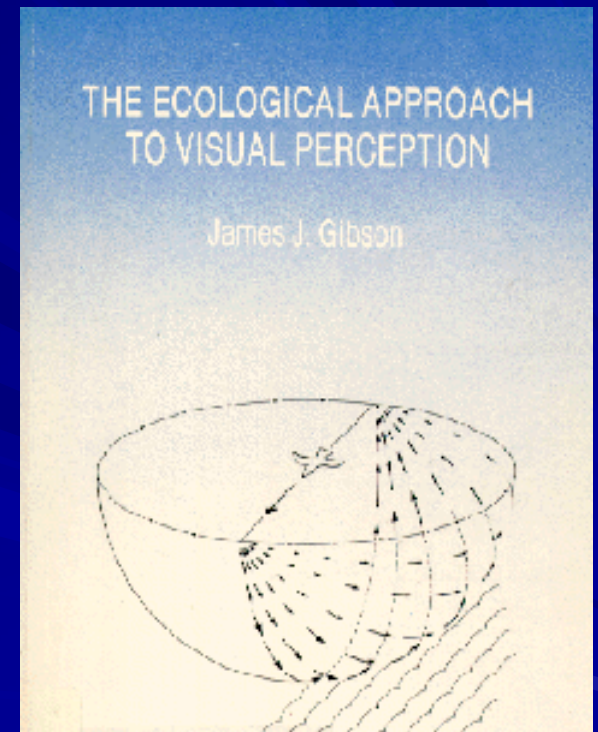
Gibson rejected both behaviorism and information processing psychology

- Information processing psychology, in emphasizing inference, neglected the information present in the environment
- Behaviorism, by focusing on stimuli, impoverished the environment

Direct perception: Gibson emphasized the information “present in the light”

- Especially for active perceivers who sample different parts of the environment

Not just the physical environment but affordances:
“The affordances of the environment are what it offers the animal, what it provides or furnishes...”
(1979, p. 127)



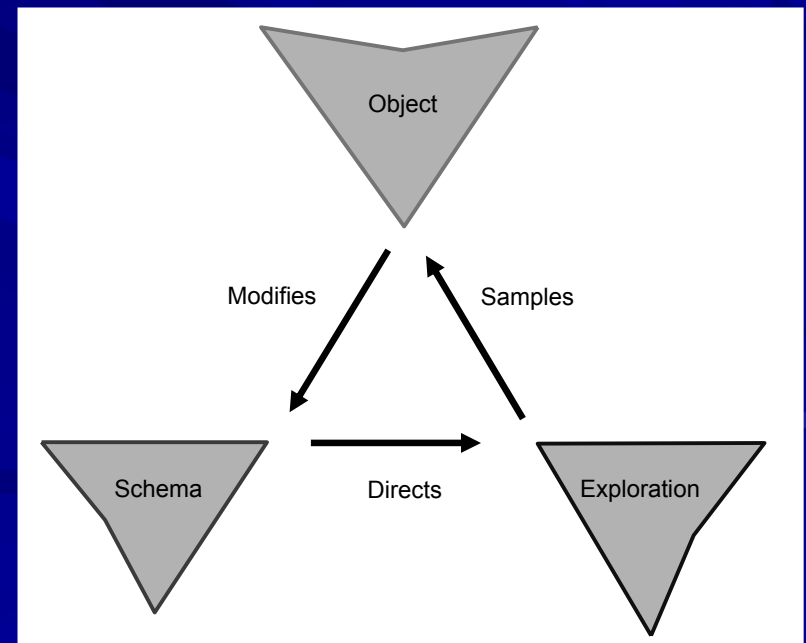
Ulric Neisser's attempt to integrate ecological and information processing approaches

Draws from Gibson the claim that there is more information available than most information processing accounts recognize

But also construes the organism as contributing to its experiences in processing information

Perception-action cycle

Construal of what-where distinction



Embodied cognition and situated action

Emphasis on the body and its engagement with its environment—focus on robots

Emphasis on the social: being situated in human communities is an important determinant of cognition:
Vygotsky

Emphasis on the interactive: cognition arises from ongoing interaction with items in the environment

Emphasis on improvisation rather than detailed planning: creative use of what is available

Denial of representations: Brooks (1997): "the world is its own best model"

Is logic itself perhaps a product of engagement (with external symbols generated by a culture)?



Development of an Alternative Tradition in Linguistics

Generative Semantics, beginning in the 1960s, challenged the autonomy of syntax

John Ross, George Lakoff, Paul Postal, James McCawley
Generate syntactic structures from semantic representations and denying the special, autonomous status of deep structure

Cognitive linguistics, beginning in the late 1980s

George Lakoff and Mark Johnson, *Metaphors we Live By* (and Lakoff's *Women, Fire, and Dangerous Things*) emphasize metaphor as shaping cognition and language, esp. metaphors drawn from the body

Ronald Langacker proposed grounding of syntactic structures in abstract spatial representations

General theme: syntax is a product of other cognitive capacities and not unique