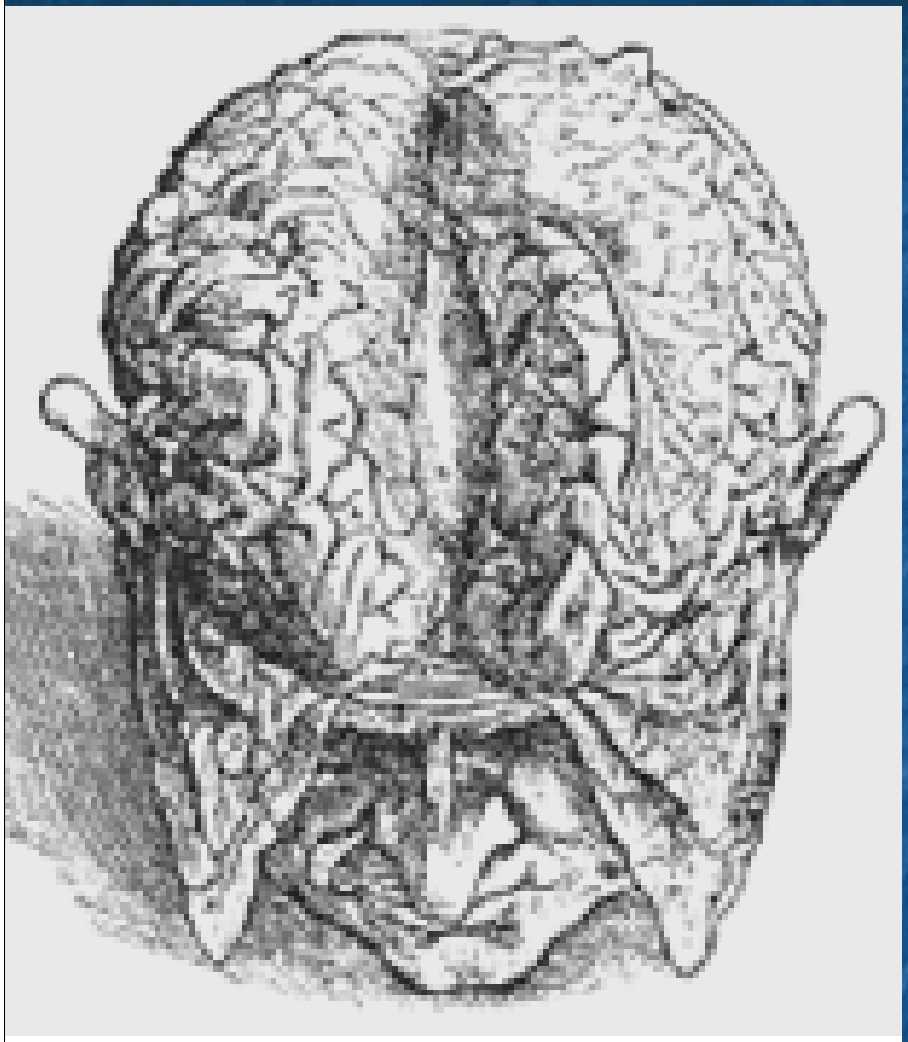
Cognitive Neuroscience of Language: 5: Language, the hemispheres and the corpus callosum

Richard Shillcock

Goals



Vesalius 1542

Understand some of the implications for language processing, of the divided, hemispheric anatomy of the brain

Understand the fine-/coarse-coding difference

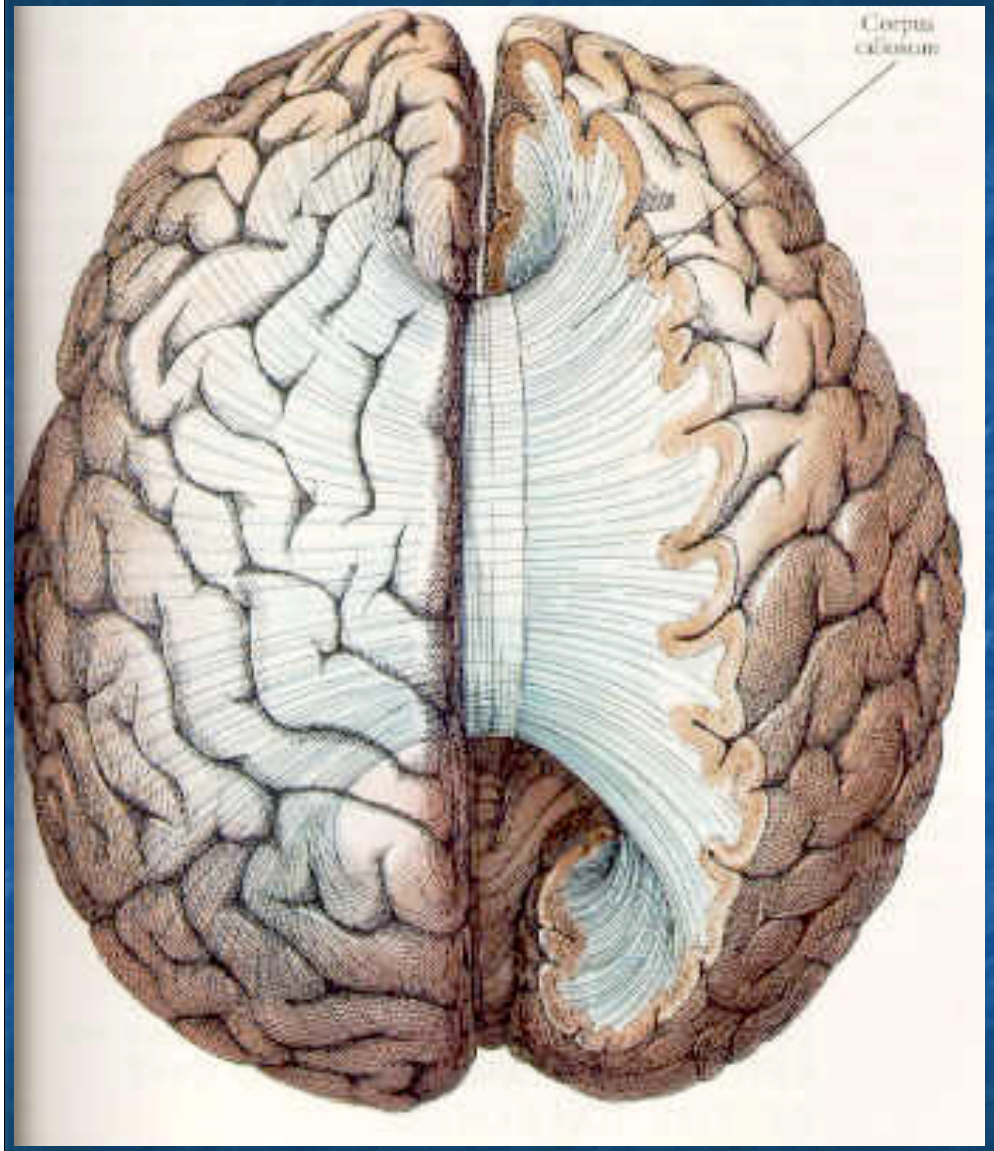
Reading for this lecture

Beeman, M. J., & Bowden, E. M. (2000). The right hemisphere maintains solution-related activation for yet-to-be-solved problems. *Memory & Cognition*, *28*, 1231–1241.

Mevorach, C. , Humphreys, G.W., & Shalev, L. (2005). Attending to local form while ignoring global aspects depends on handedness: evidence from TMS. Nature Neuroscience, *8*, 276–277.

Humphreys

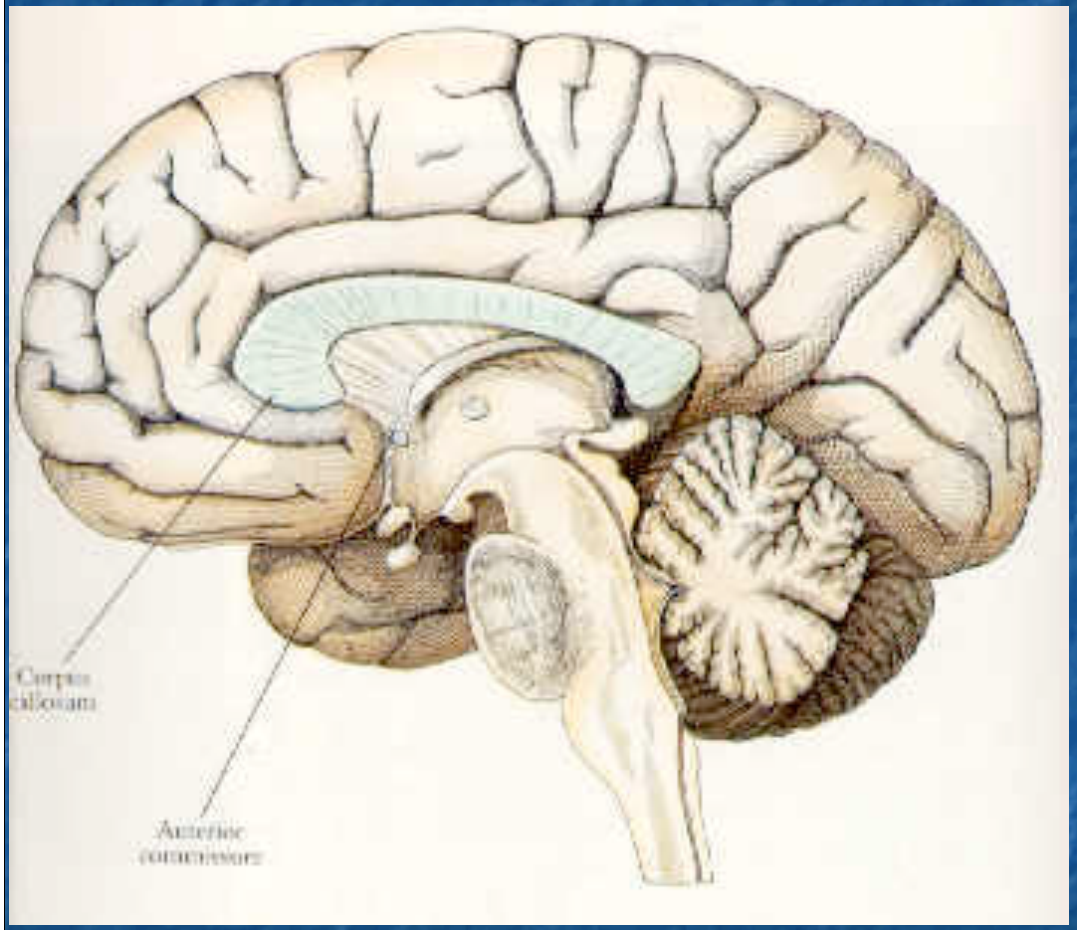
Two hemispheres



The two hemispheres are connected by the 200M fibres of the corpus callosum

There is a broad principle of homotopic connectivity

Two hemispheres



The posterior part of the corpus callosum is concerned with visual information.

The anterior parts connect areas concerned with higher cognitive functions.

Computational considerations

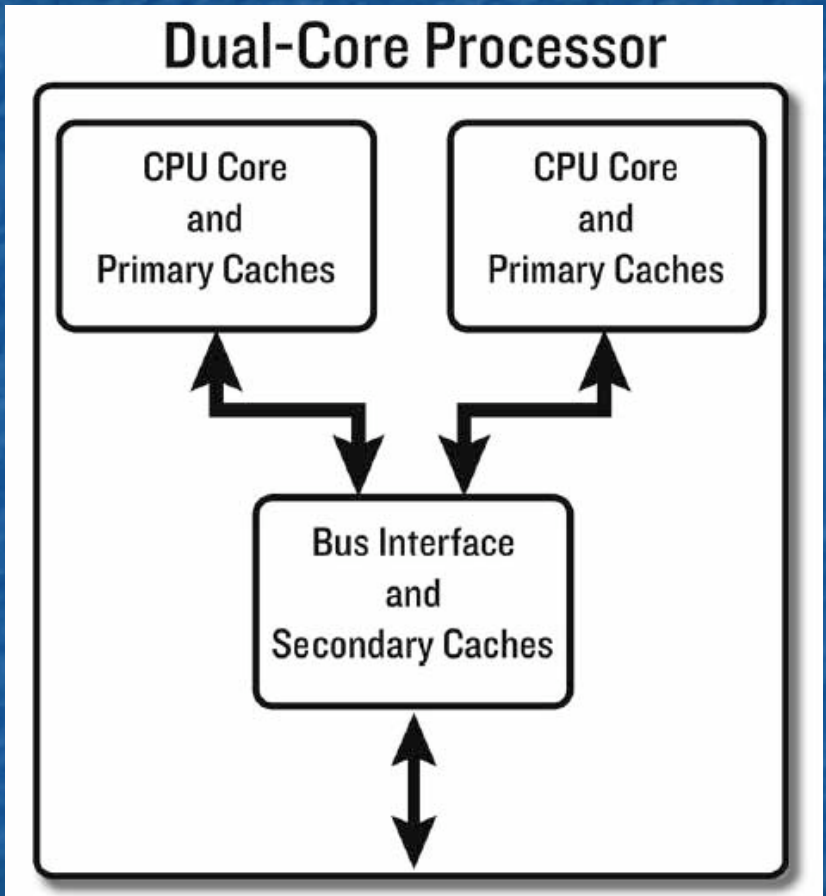
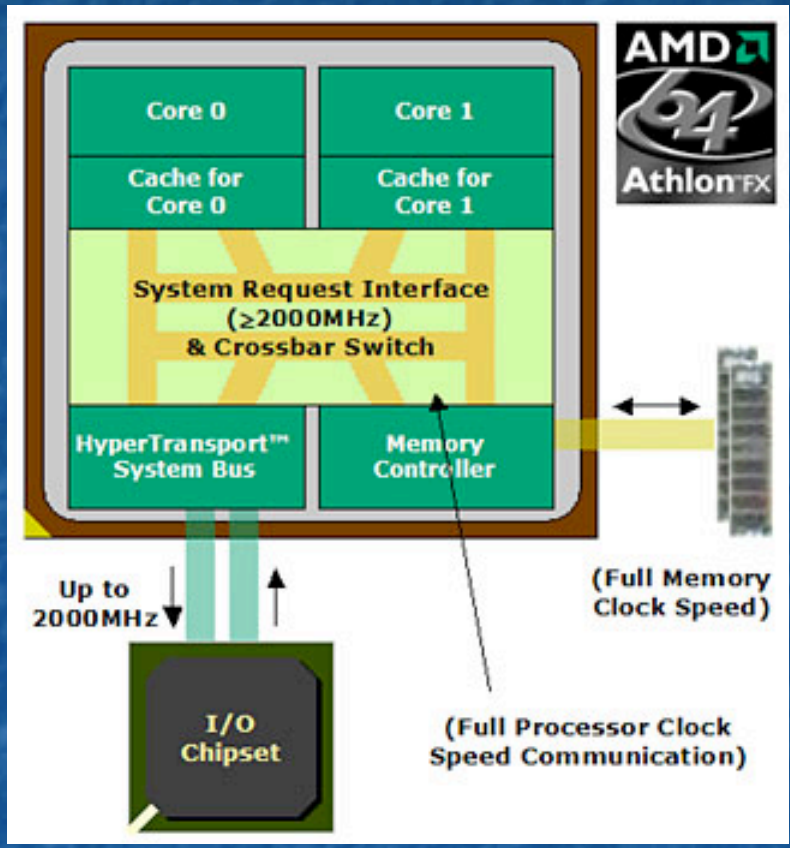


Figure 1: Dual-core processor architecture



A "dual processor advantage"

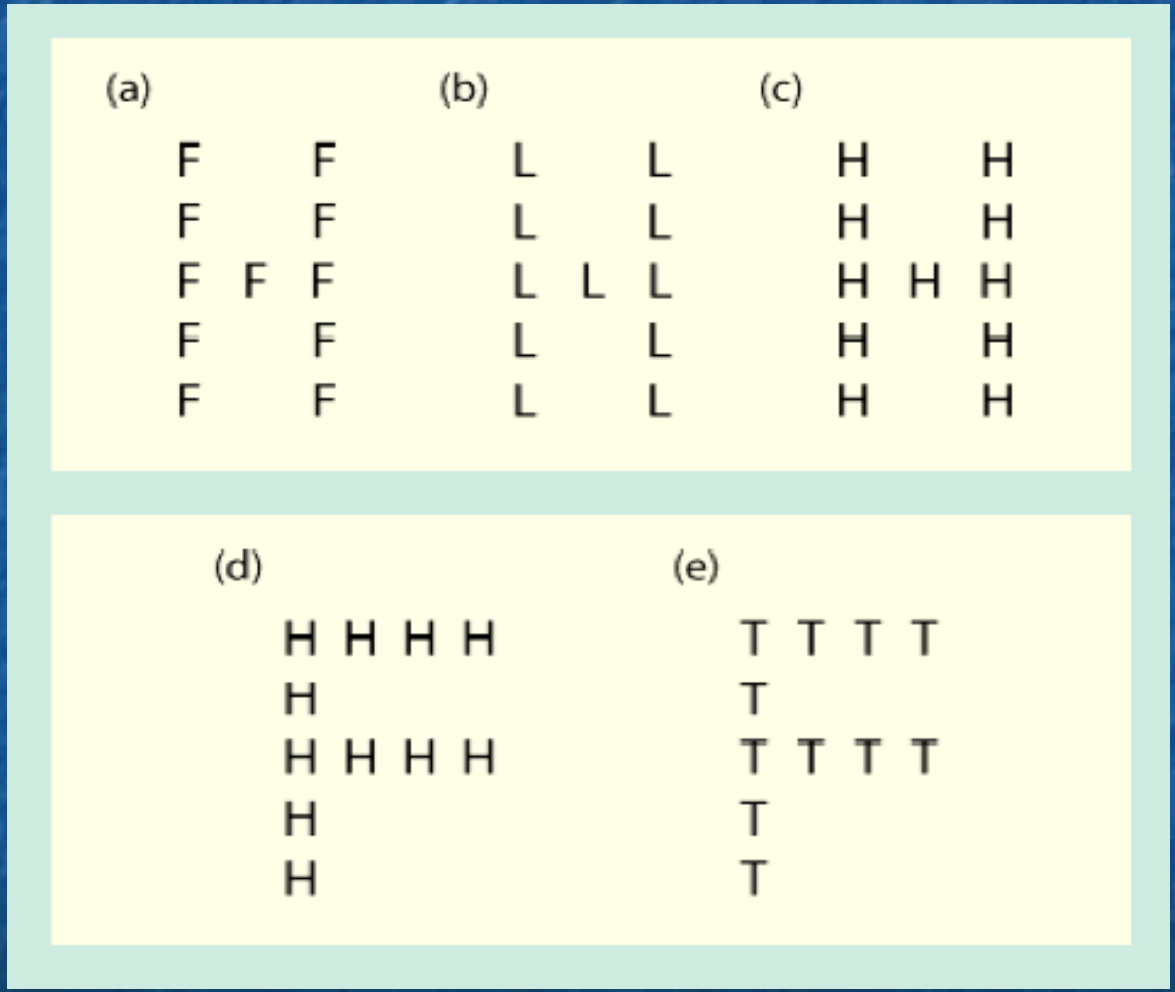
Computational considerations

Superadditivity: Mohr *et al.* (1994) presented a word to the RVF, the LVF or to both fields simultaneously.

There was a word-specific bilateral gain in normals, and no such gain in a split-brain patient.

Transcallosal connections facilitate lexical processing.

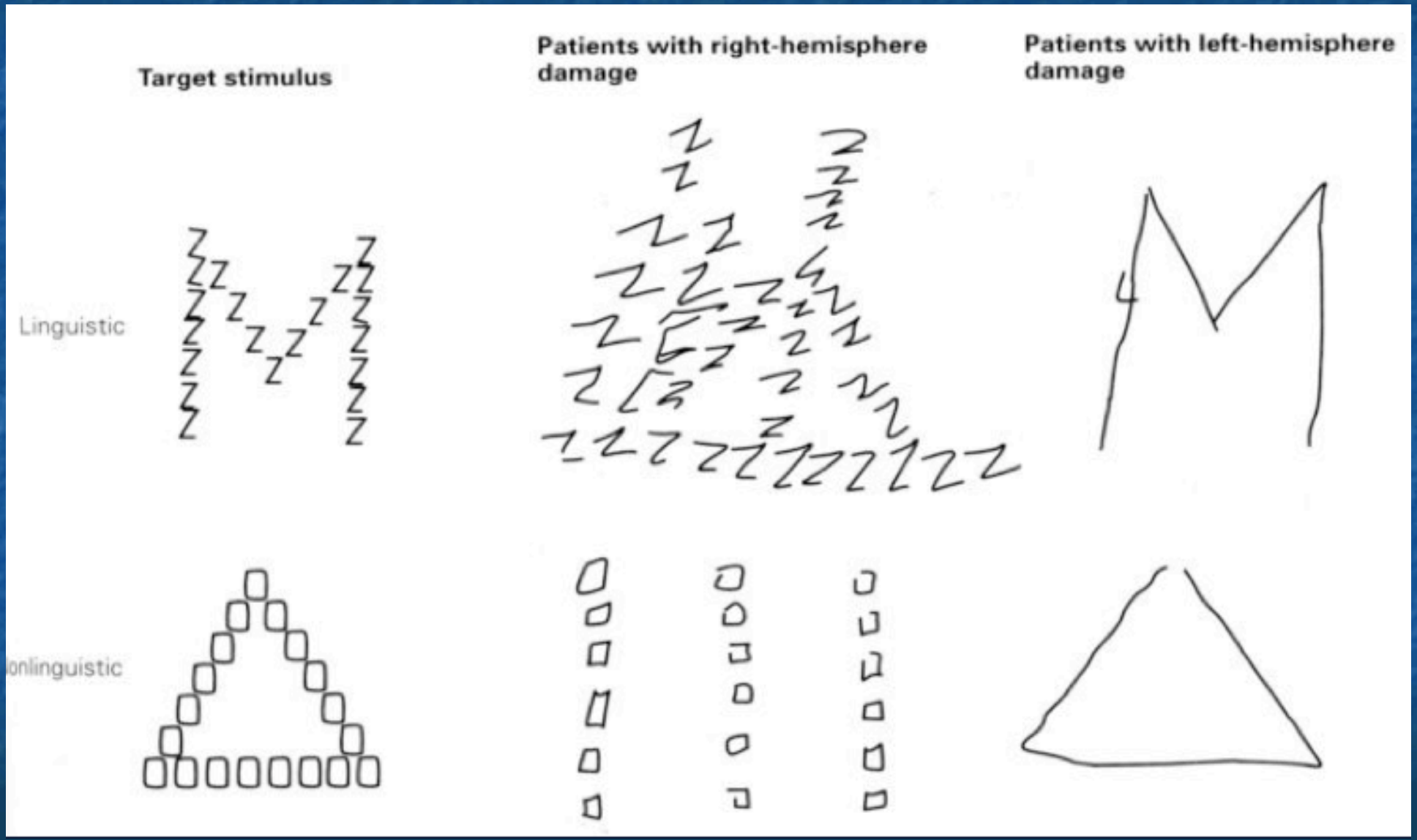
Navon figures



The ease of processing the large figure or its component parts. (Navon, 1977)

LH = fine
RH = coarse

Results of RH and LH damage



Visual field asymmetries in normals

Sergent (1982)

Fast visual hemifield presentations

"Did you see 'L' or 'H'?"

Concluded that the RH was specialized in fast, low frequency processing

Visual field asymmetries in normals

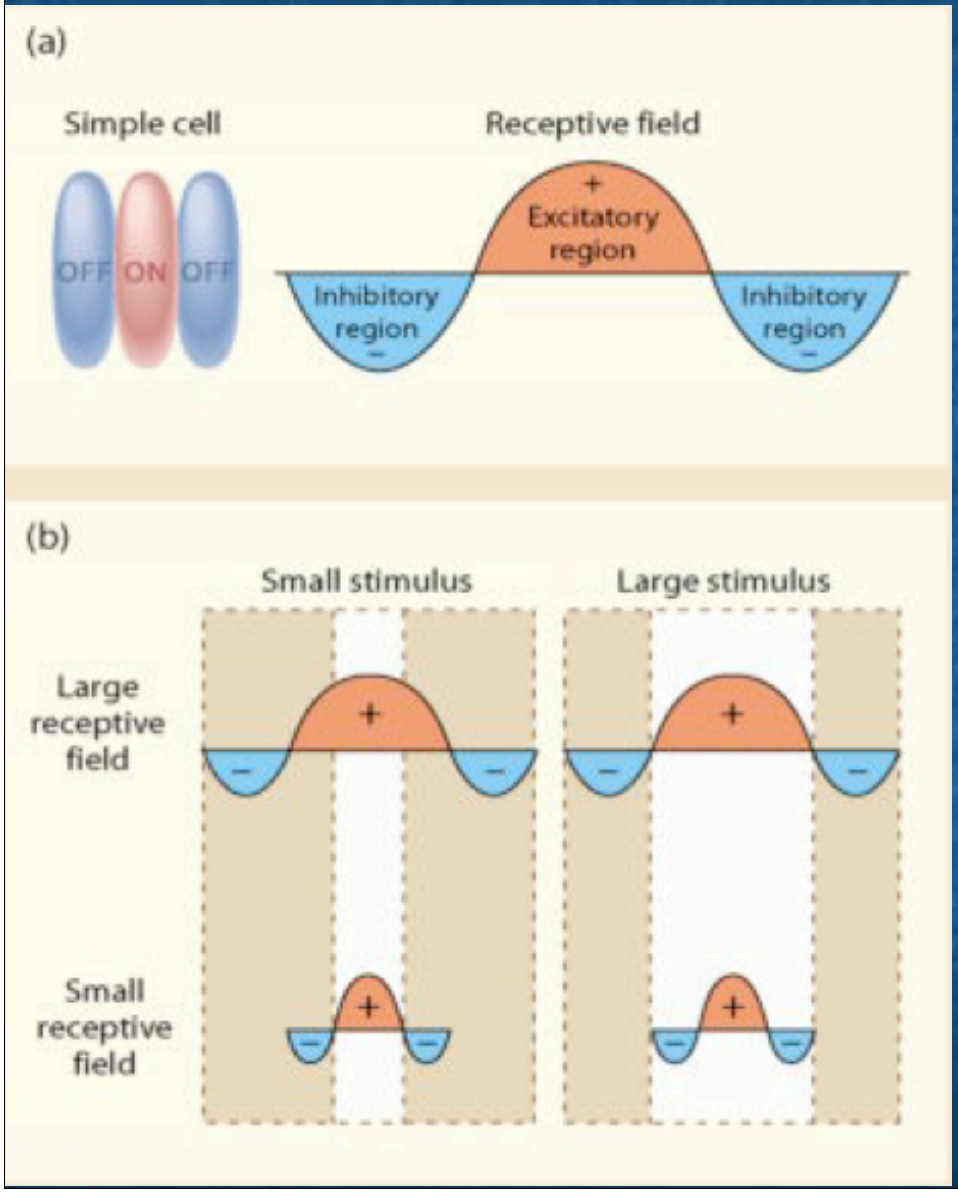
Sergent (1982)

RH specialized for low frequency processing.

LH specialized for high spatial frequency processing.

Sergent (1985) showed different hemispheres to be involved in famous face recognition and in gender decisions.

Receptive field asymmetries

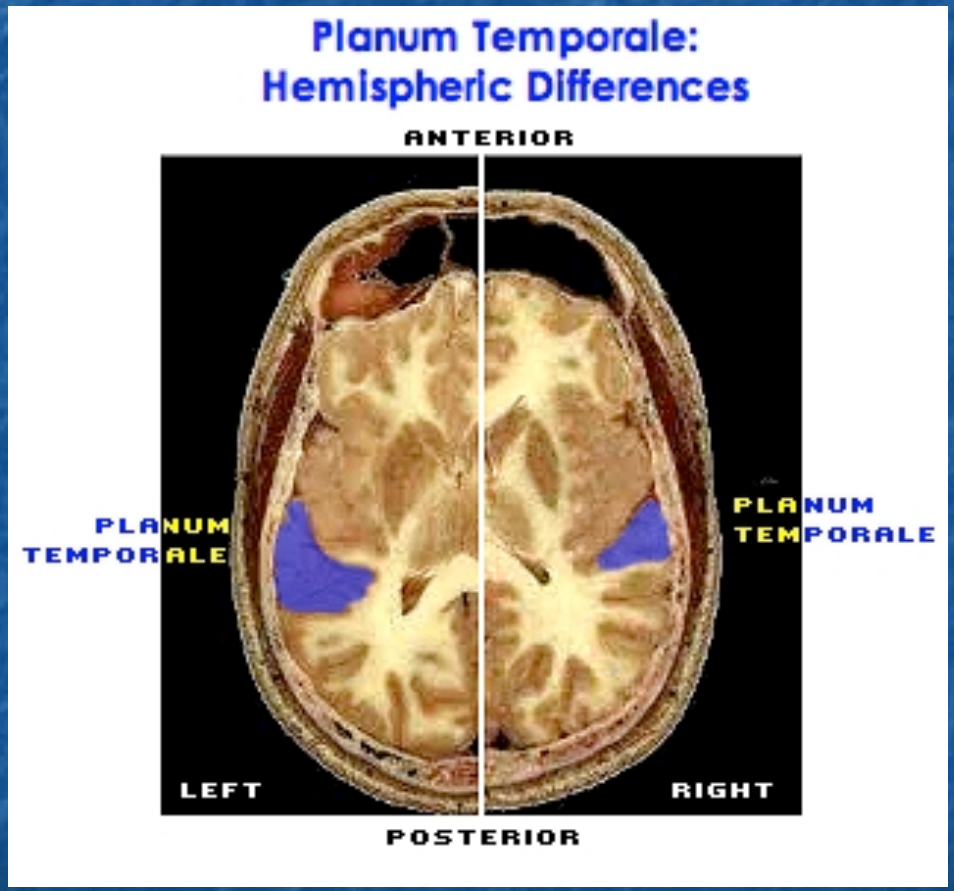


Anatomical differences in the striate cortex

Anatomical hemispheric differences

Left hemisphere	Right hemisphere
Higher grey:white	Lower grey:white
Focal deficits	Diffuse deficits
Larger cell columns, more spaced	Smaller cell columns
Higher density of pyramidal cells in the temporal cortex	Lower density of pyramidal cells in the temporal cortex
Favours close inputs	Favours distant inputs

Anatomical hemispheric differences

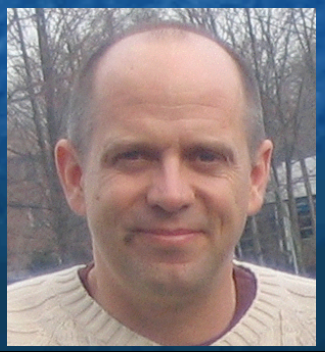


The LH's planum temporale is larger

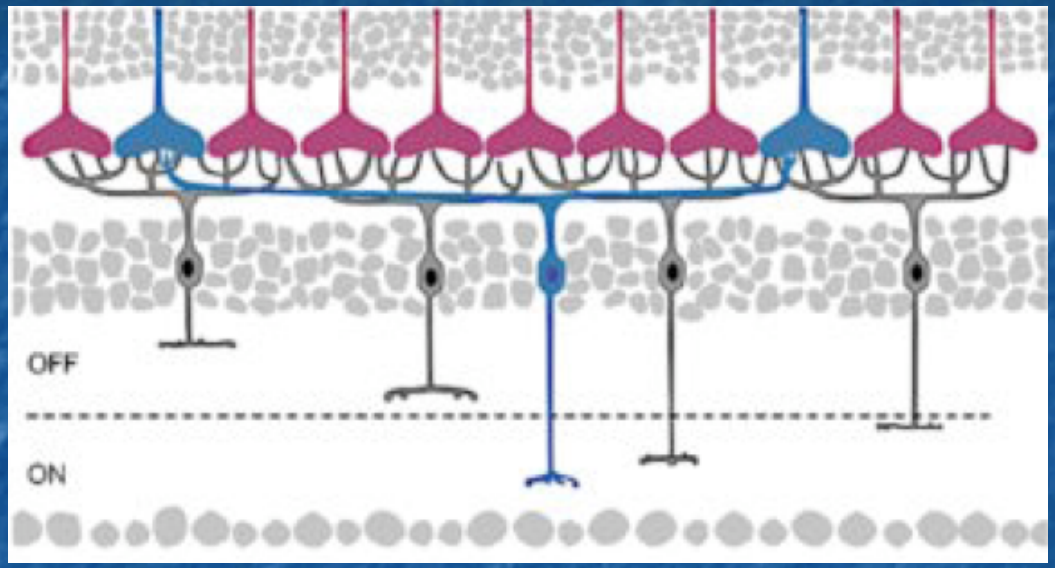
More symmetrical planum temporale is associated with language disorder

Beeman's view of fine-/coarse coding

Left hemisphere	Right hemisphere
Finer semantic coding	Coarser semantic coding
Quicker	Slower
Selects a single, more focused meaning	Activates multiple, more diffuse meanings
("backs the favourite")	("spreads the bet")

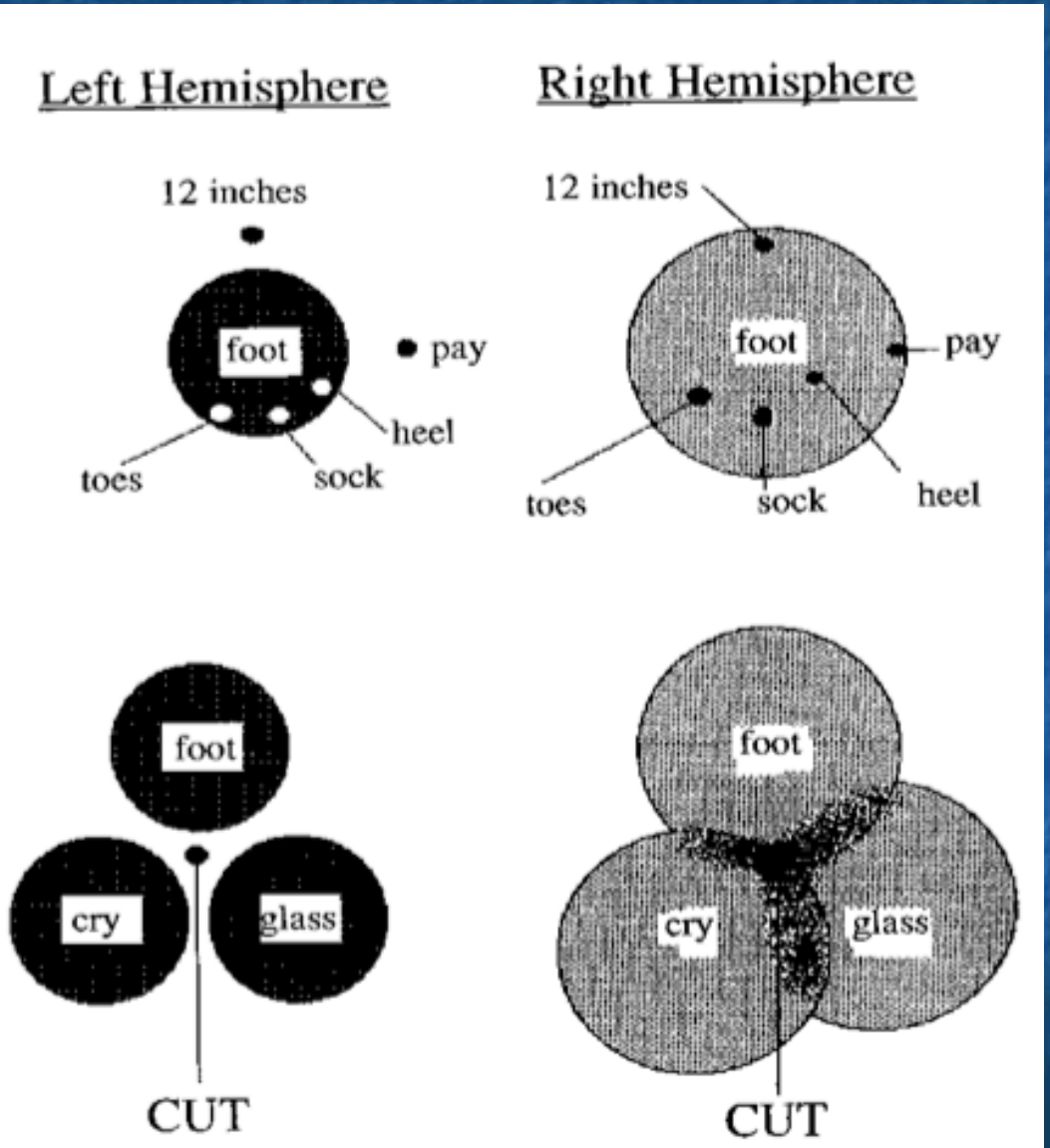


Receptive field differences



LH seems to be biased to receive inputs from visual channels with small, non-overlapping receptive fields, compared with the RH's preference for large, overlapping receptive fields (Kosslyn *et al.*, 1994)

Receptive field differences



Summation priming happens in the RH; diverse activation accumulates (Beeman *et al.*, 1994)

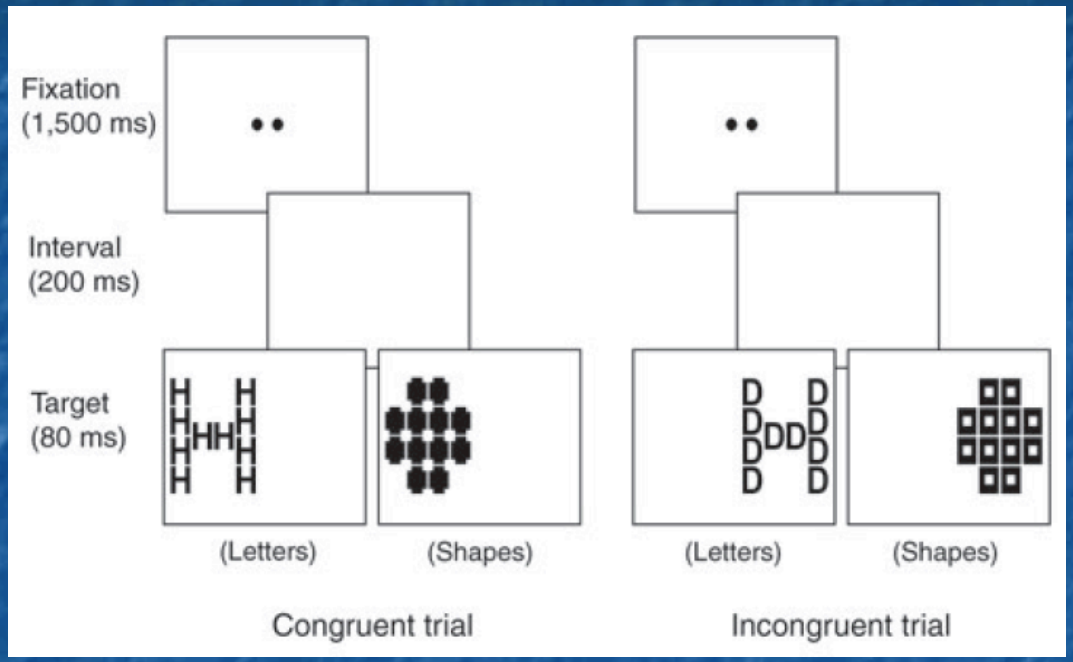
Hemispheric language differences

In RH brain damage, there may be selective insensitivity to *connotative* meaning ("warm" means friendly)

In LH brain damage, there may be selective insensitivity to *denotative* meaning ("warm" means slightly hot) (Brownell *et al.*, 1984)

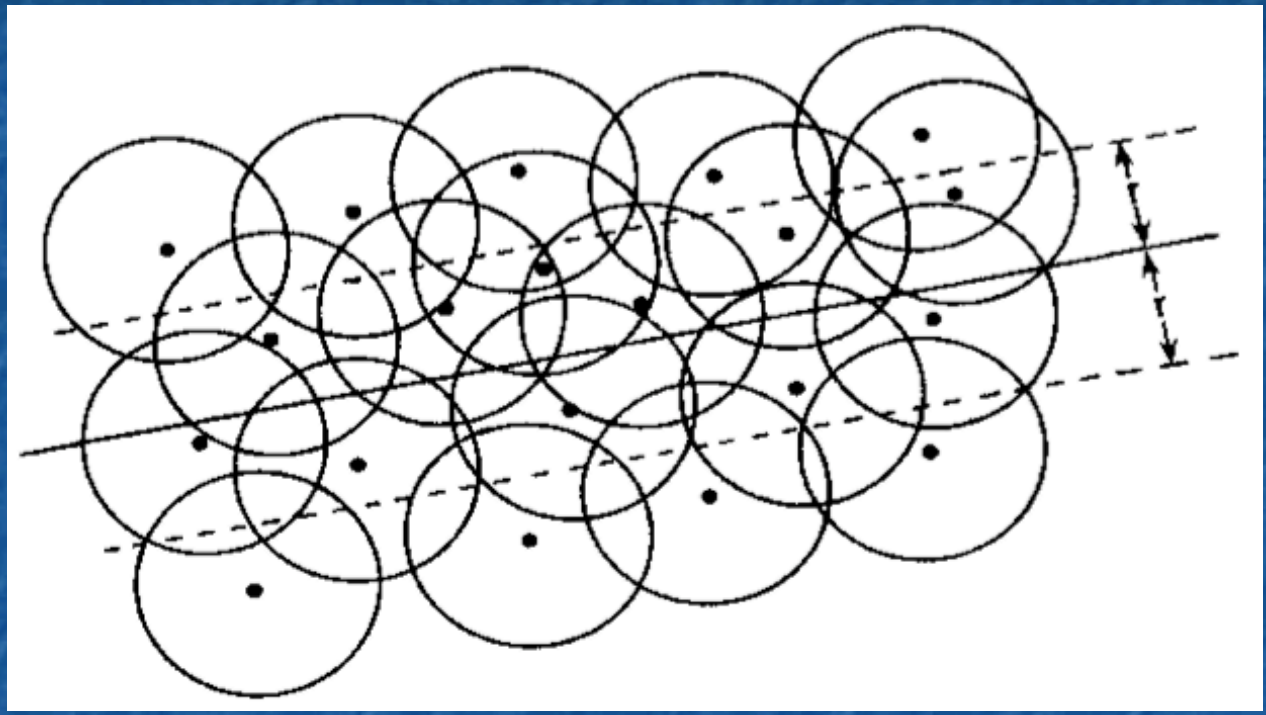
The RH seems to be involved in gists, jokes, metaphors, contexts, ... but the left temporal lobe seems to mediate apophenia ("magical thinking") (Bell *et al.*, 2007)

Fractionation of the differences



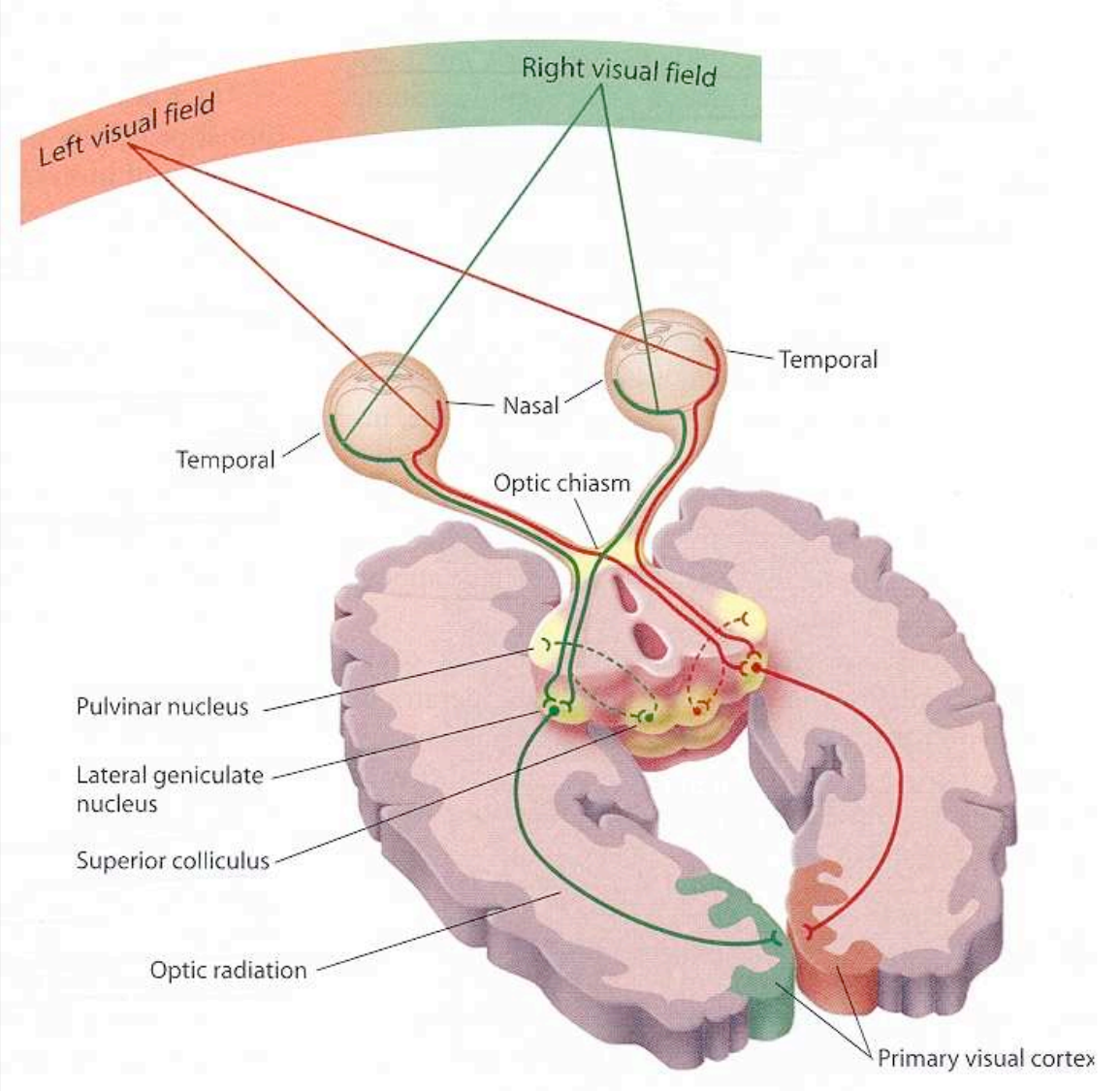
TMS impairs the identification of the local or global aspects of the Navon figure, but shows coarse coding on the *left* for left-handers (Mevorach, Humphreys & Shalev, 2005)

Coarse coding and fine distinctions



The intersection of numerous large receptive fields means that coarse coding can still make fine distinctions (Rumelhart & McClelland, 1986)

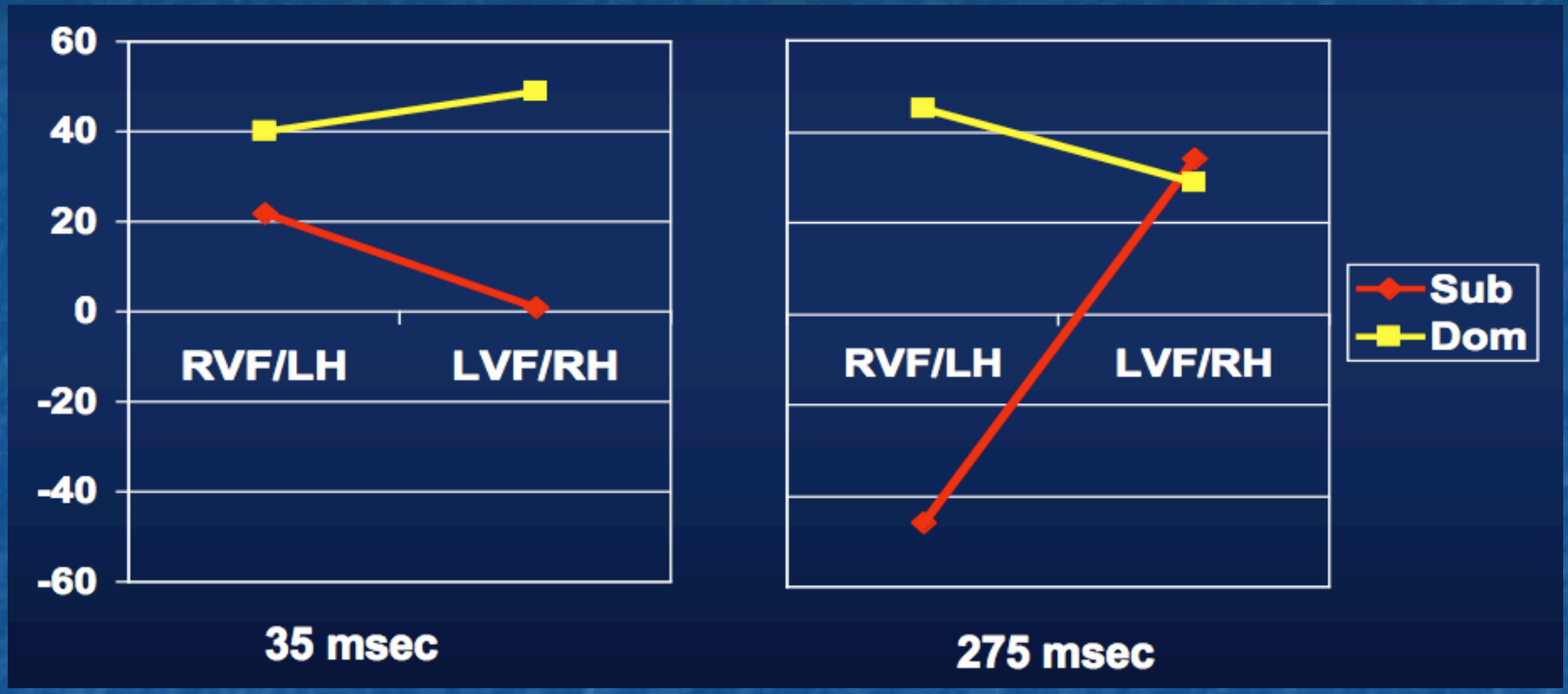
Semantic priming and the RH



Present an ambiguous word ("bank" = "money" or "river") to the LVF/RH or the RVF/LH and test for semantic priming

(Burgess & Simpson, 1988)

Semantic priming and the RH



LH maintains dominant meaning and quickly loses subordinate meaning. RH builds support for the subordinate meaning, and loses support for the dominant meaning (Burgess & Simpson, 1988)

False memories and the RH

The Deese-Roediger-McDermott (DRM) paradigm:

"king ... prince ... palace ... throne ... princess ... royalty ... castle ... crown ..." .....

Did you see "queen"?

Saying "yes" happens more with LVF/RH presentation of the lure (Bellamy & Shillcock, 2007)

The nature of hemispheric interaction

From extreme autonomy to coordination to information transfer

Internal and external cueing to coordinate the two hemispheres.

Sex differences in lateralization, and possibly different strategies regarding the extent and role of fine-/coarse coding

Summary

There are distinct processing advantages in flexible, strategic hemispheric coordination

The two hemispheres have different processing propensities

They can be investigated by visual hemifield studies, by looking at split-brain subjects and impaired subjects, by making inferences from the anatomy