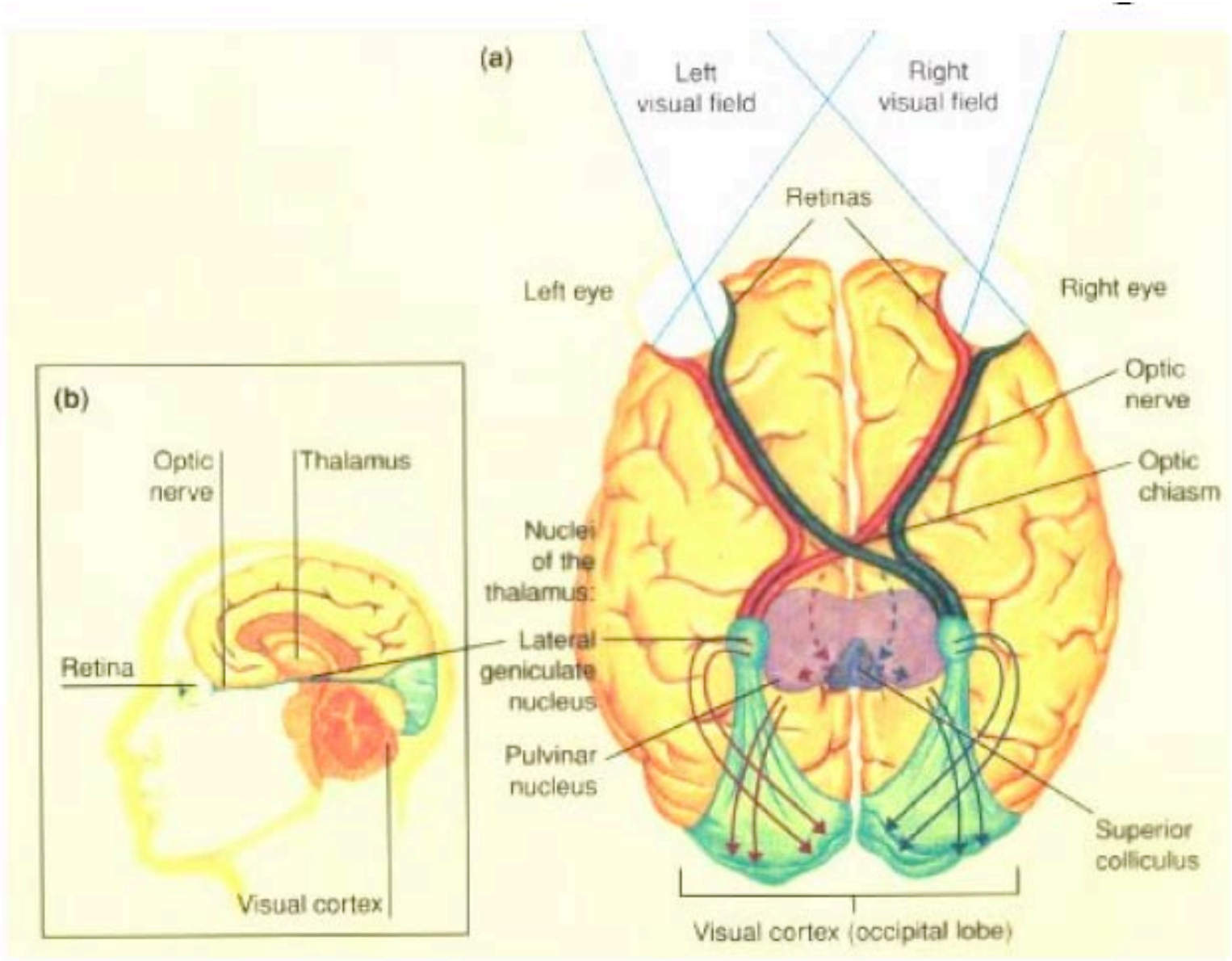
The Reading Brain

Human visual pathway



Human visual pathway

- Does not exhibit the redundancy of the auditory system: signal from one visual field is projected to one hemisphere only.

- Slower than the auditory pathway. Precise timing is controversial -- estimates vary between 50 and 80ms for visual information to reach visual cortex.

Cognitive neuroscience of reading

- Reading is an important part of the cognitive neuroscience of higher level vision in general.

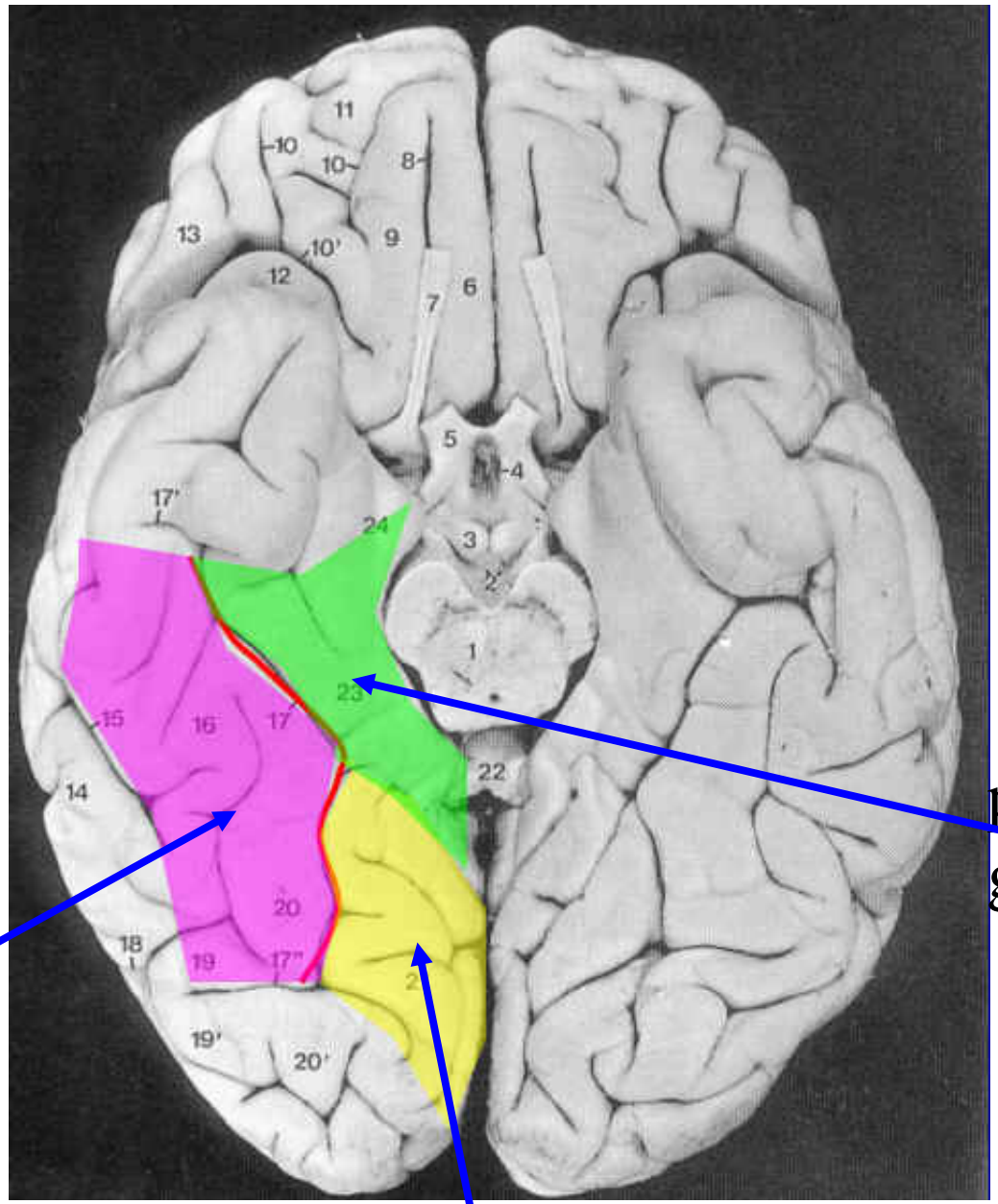
- Are letters and printed words specials kinds of visual objects for our brains?

Famous (and hotly debated) example of category specific specialization in the human visual system: Faces

- Right fusiform gyrus responds selectively to faces as opposed to other categories, such as hands, houses or animals (Kanwisher et al., 1997)

Right

Left



parahippocampal gyrus

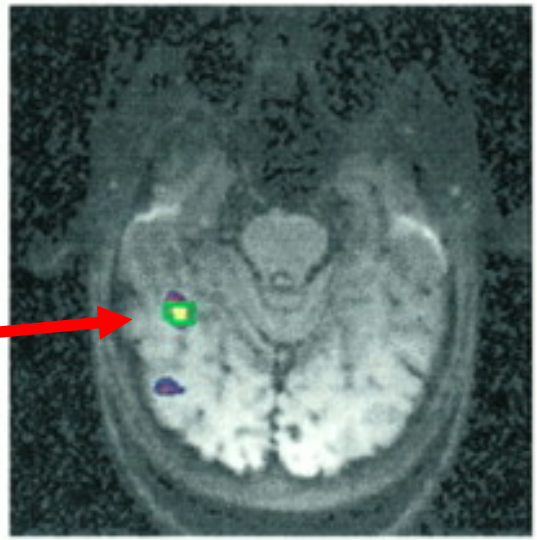
fusiform gyrus

lingual gyrus

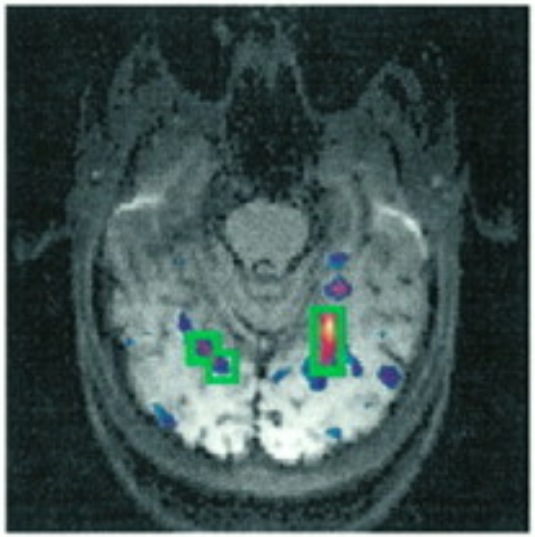
Kanwisher et al., 1997

Fusiform Face Area (FFA)

1a. Faces > Objects



1b. Objects > Faces



4a. Faces > Objects

Other controls: Scrambled faces, houses, hands

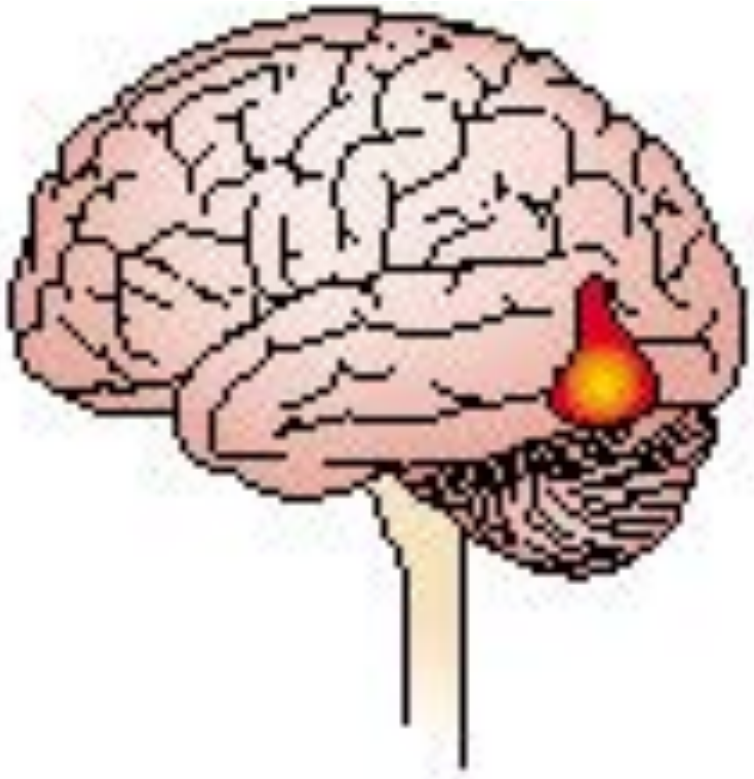
Relevance for reading

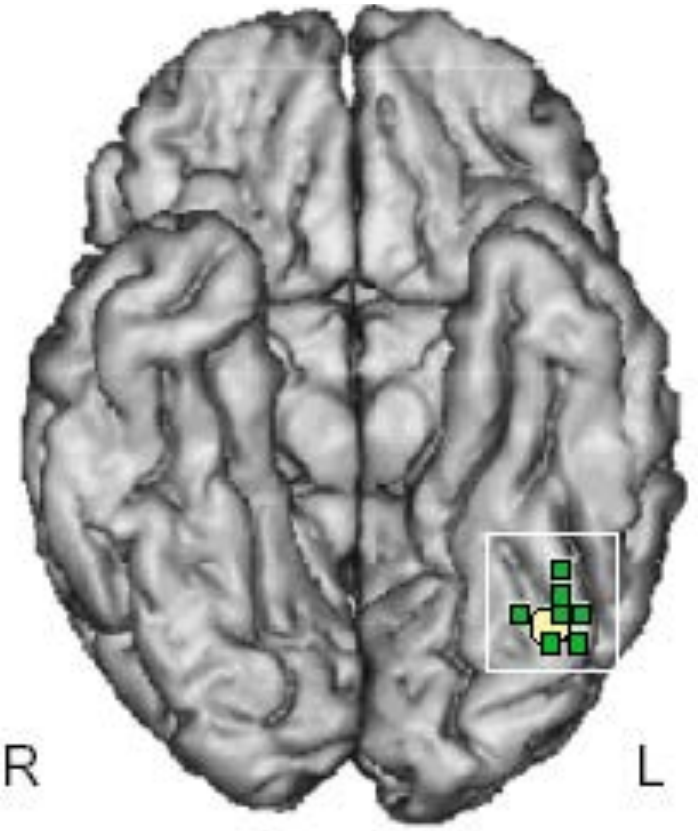
- Faces have been around forever. The idea that an area of the brain would have evolved to specifically perceive them is at least plausible.

- But humans have only been reading for a few thousand years.
  - **First writing system: Sumerian scripts, roughly 3500 BC.**
    - Contemporary to the sailboat and the wheel.

- In evolutionary terms, writing is a very recent innovation. It does not seem like there would have been enough time for an area of the brain to develop to specialize for visual word recognition. Nevertheless, there is some evidence that we do have such an area.

Left fusiform gyrus
The Visual Word Form Area, VWFA





McCandliss, Cohen and Dehaene, The visual word form area: expertise for reading in the fusiform gyrus. *Trends Cogn Sci.* 2003 Jul;7(7):293-299.

Left fusiform gyrus
The Visual Word Form Area, VWFA

- Activated by words and pseudowords

  table blicket

to a greater degree than other similar control stimuli, such as consonant strings

  trwbrts [Cohen et al. 2002]

- Specific to the visual modality
  - **Though potentially adjacent to a more multimodal area [Cohen et al. 2004]**

- Insensitive to variance in case: table – TABLE

[Dehaene et al., 2004]

Aphasia

- Damage to the VWFA can lead to ***pure word alexia***
  - **A deficit in reading while object naming is intact.**
  - **"Letter-by-letter" reading**
    - parallel letter perception seems to be impaired.
    - slow and laborious reading.

VWFA activation in electrophysiology

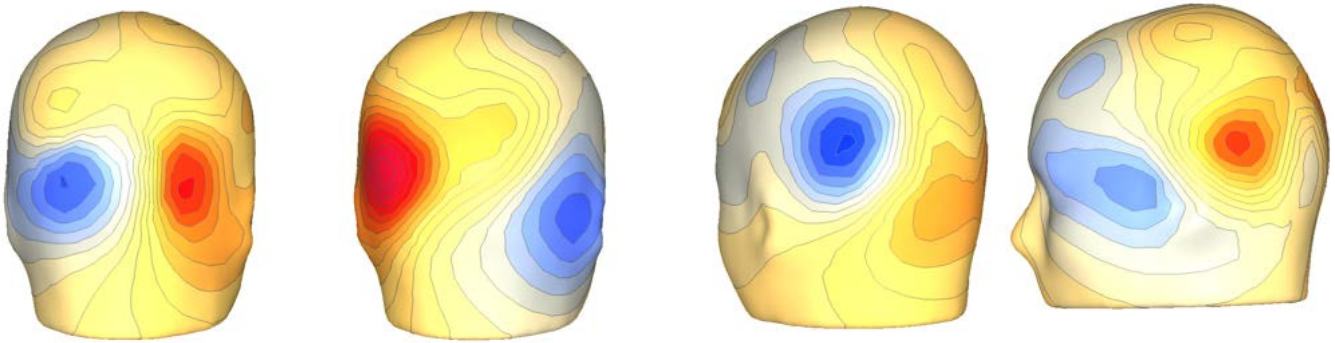
MEG response to visual words
When does sensitivity to letter strings emerge?

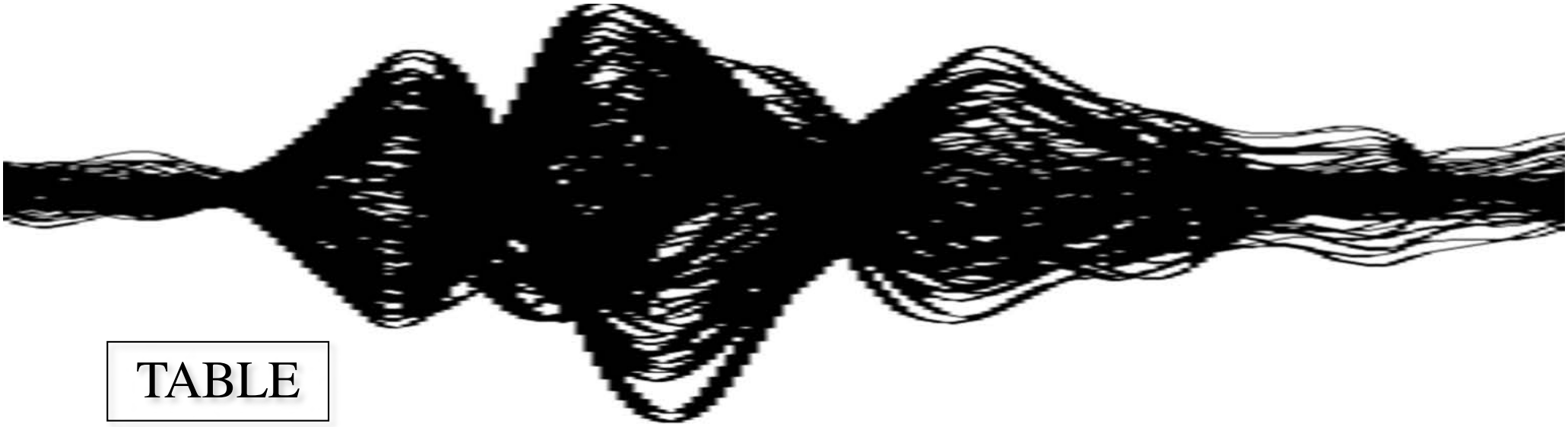
M100
100-150ms

M170
150-200ms

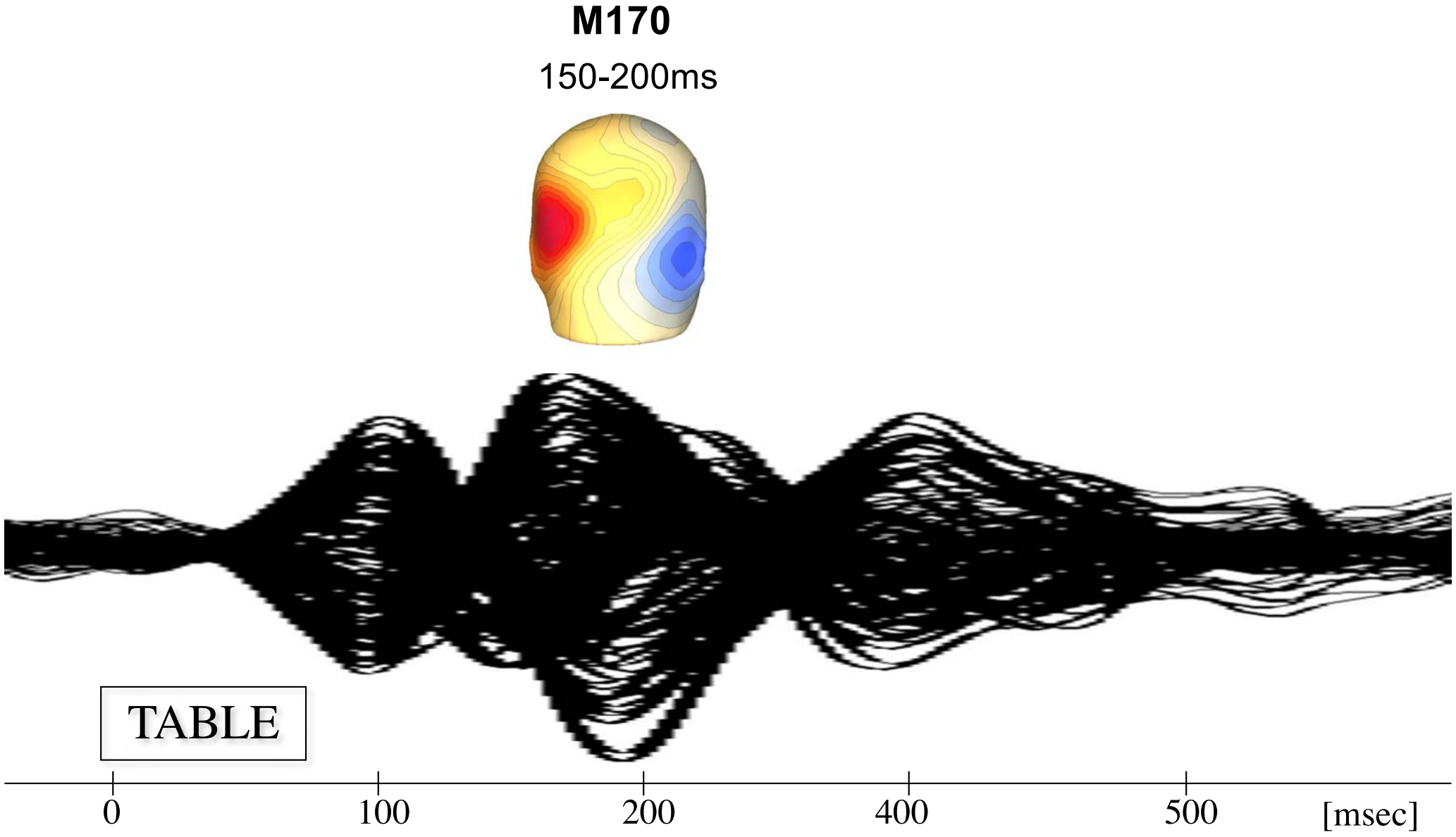
M250
200-300ms

M350
300-400ms

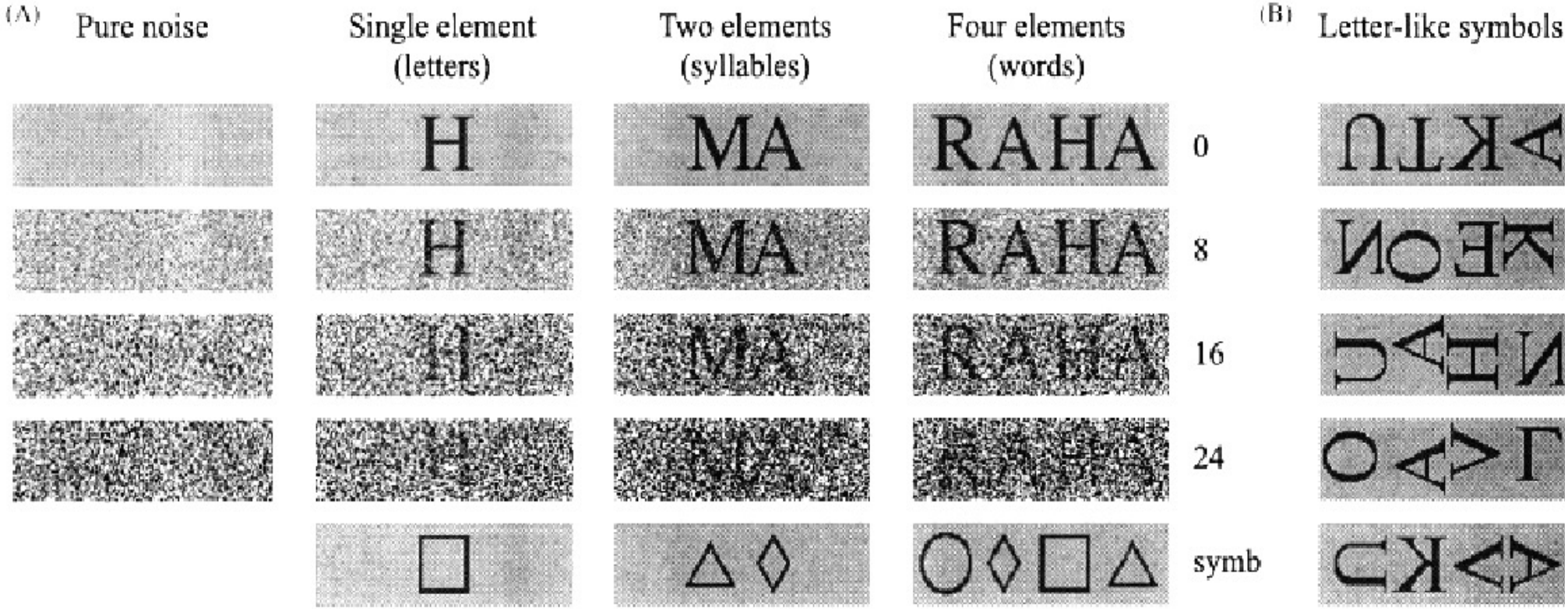




M170 is the clearest MEG correlate to the VWFA



Tarkiainen et al., 1999, *Brain*



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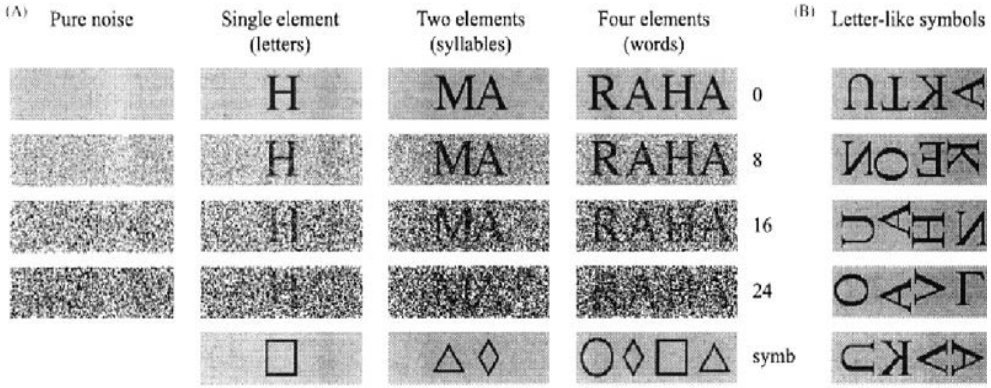
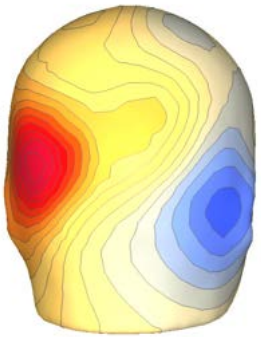


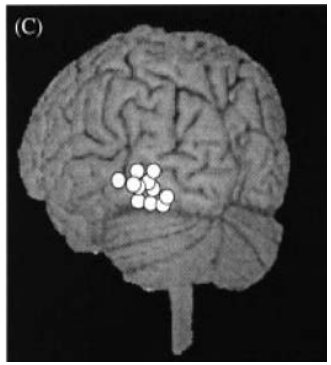
- Activity stronger for letter strings than for symbol strings
- Activity delayed or decreased for less detectable letterstring stimuli

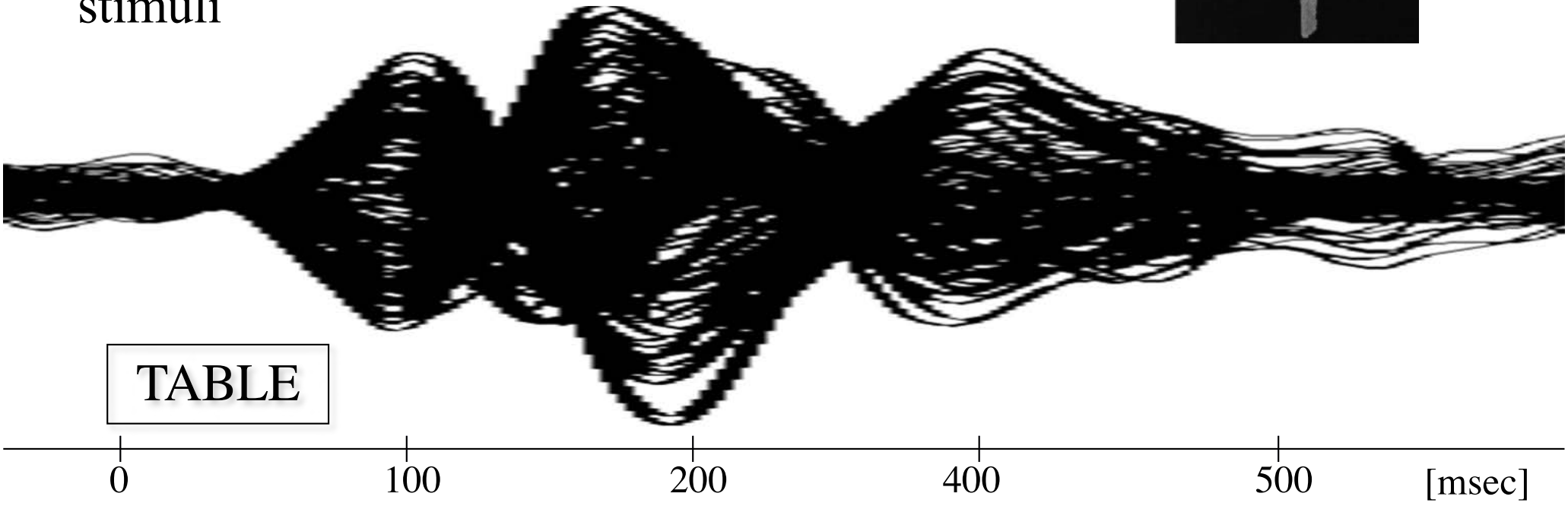
M170

150-200ms



- Activity localizes in the VWFA





Summary across methods

- fMRI
  - **Visual word effects in the left fusiform gyrus.**
- MEG
  - **Visual word effects in the left M170, which localizes in fusiform areas (more or less)**
    - (today we know though that visual word form effects can emerge even earlier, at the M100..)
- Aphasia
  - **Damage in left fusiform gyrus can result in pure alexia, or letter-by-letter reading.**

How do our brains get this way?
(if an evolutionary story is implausible)

- The human visual system seems to have a readiness to specialize particular regions for the perception of specific categories (McCandliss et al., 2003).
- Exactly why all human brains seem to encode visual words in a similar region is a puzzle.
- One proposal hypothesizes that the visual word form area piggybacks on a region more generally involved in object recognition, in particular the perception of line junctions (Szwed et al., 2011)
  - **If true, this would explain the systematic localization of reading in terms of a much older ability, for which a dedicated brain region could plausibly have evolved.**
  - **Hypotheses of this form are called "neuronal recycling" hypotheses**

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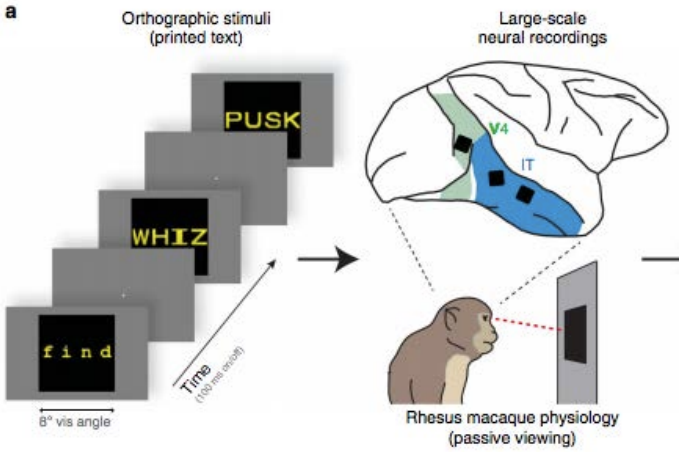

Rajalingham et al. 2020:

"The inferior temporal cortex is a potential cortical precursor of orthographic processing in untrained monkeys"

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