DYSLEXIA

Reading brains vs. poorly reading brains vs. non-reading brains

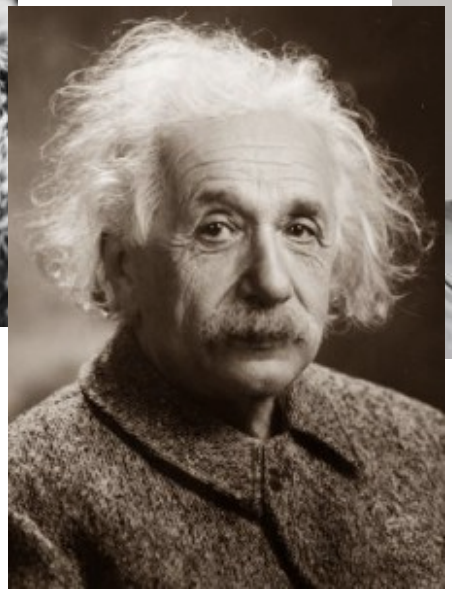
- What distinguishes the brains of individuals who learn to read easily vs. those who struggle?

- What distinguishes reading brains from non-reading brains?

Developmental dyslexia

- Reading development lags behind other academic development. Achieved reading skill is limited: reading is slow and nonword reading is impaired.
- Developmental dyslexia affects about 10-20% of the population, 4% severely.
- Incidence is two to three times higher in males than in females.
- **Being dyslexic has nothing to do with how smart you are.**

Agatha Christie



Albert Einstein

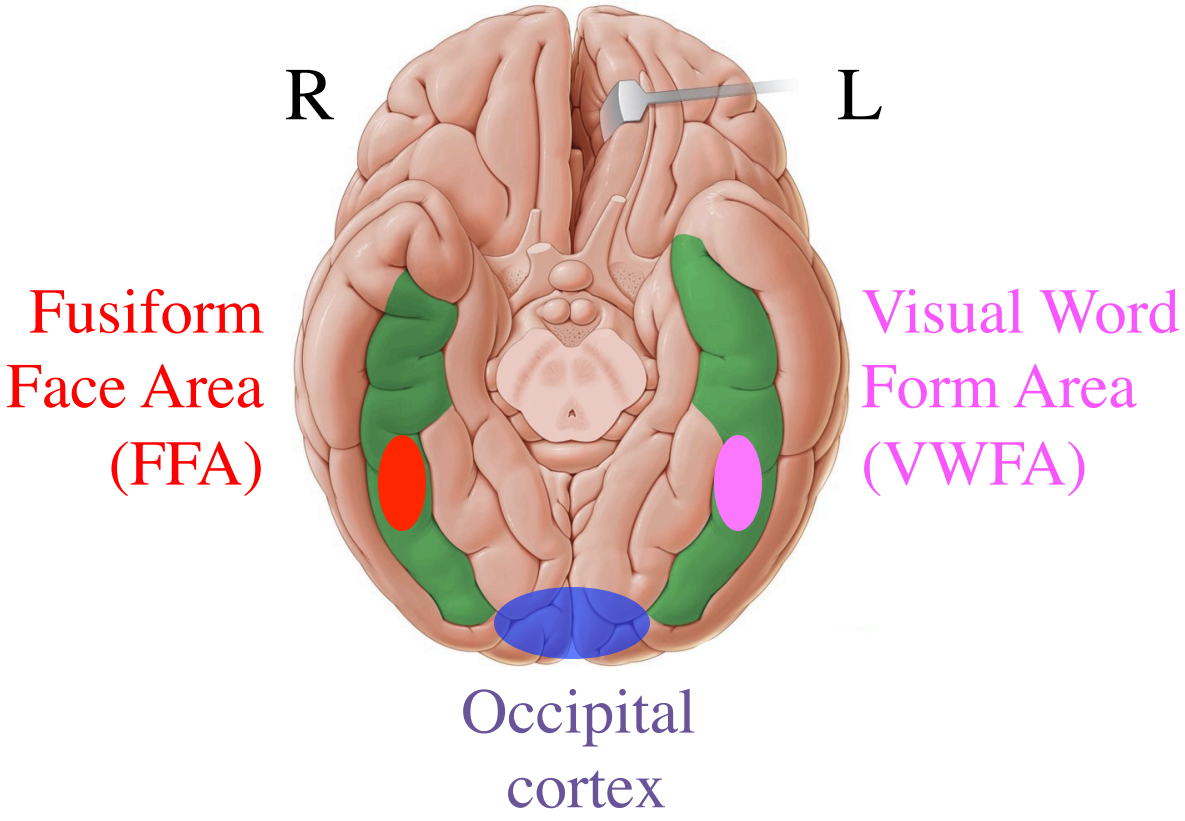
Whoopi Goldberg

William Butler Yeats

George Washington

Leonardo da Vinci

How are dyslexic brains different from non-dyslexic brains?



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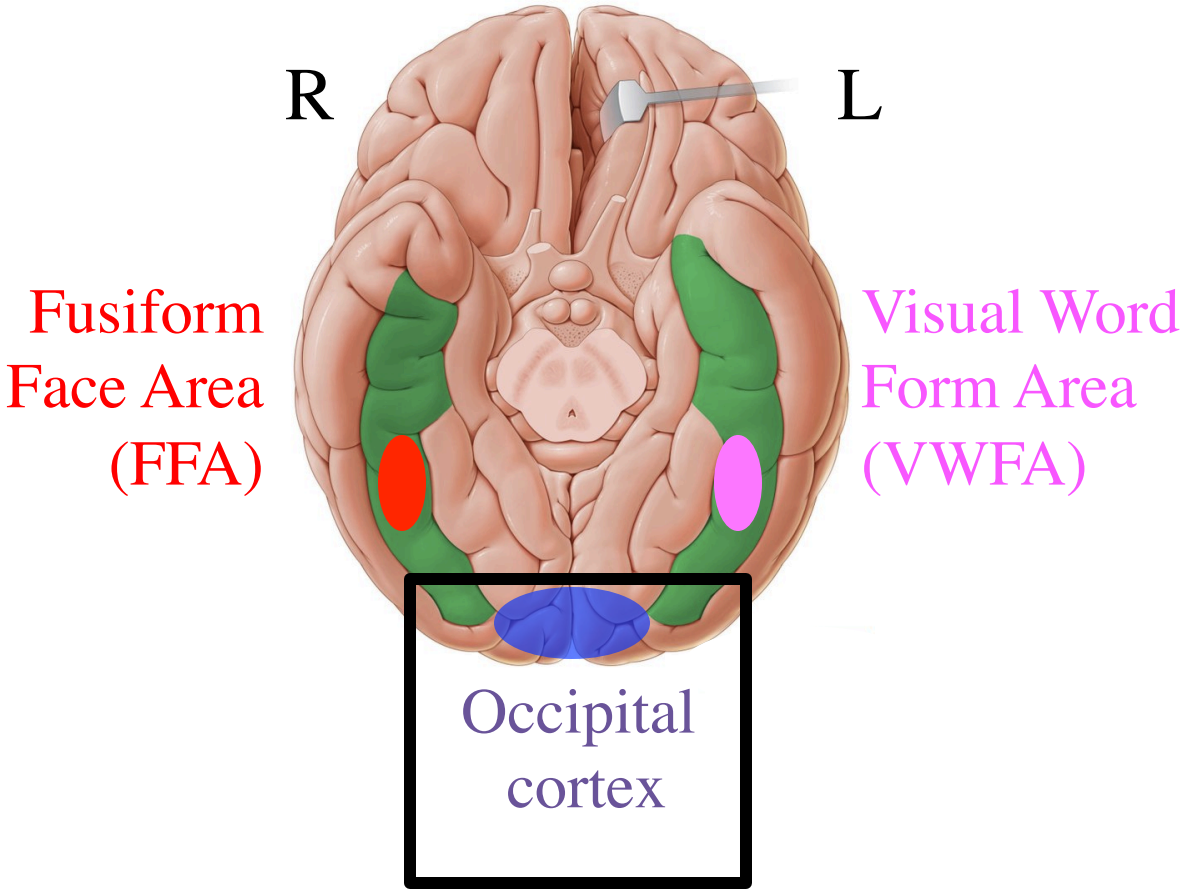
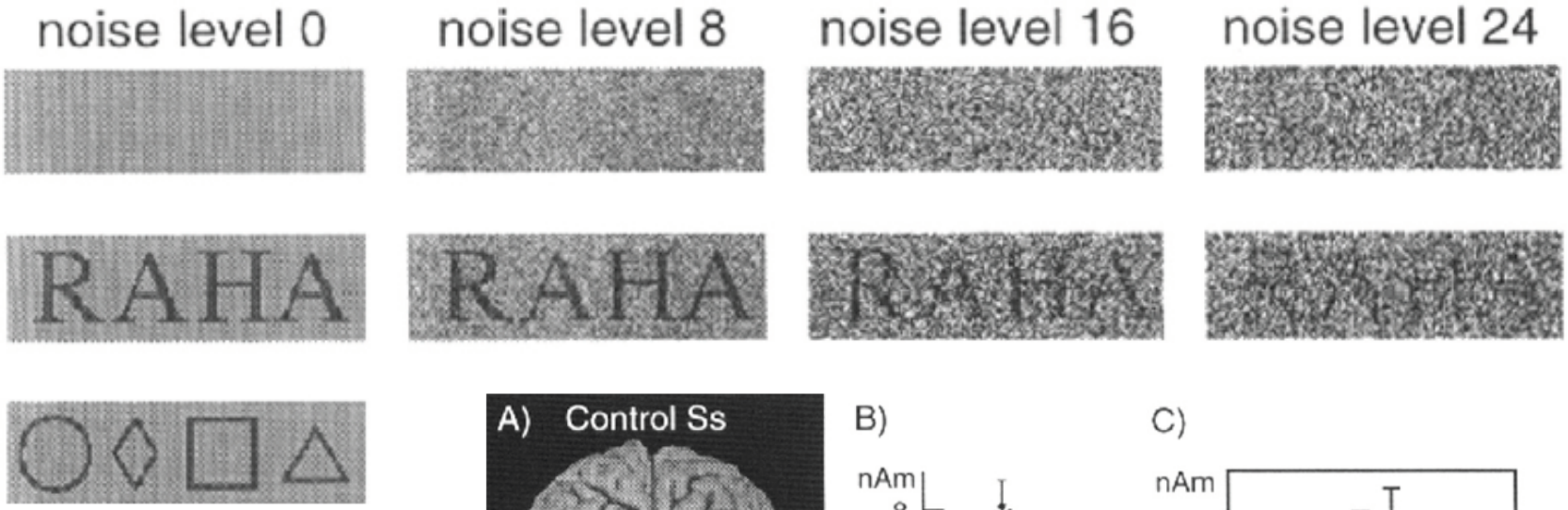
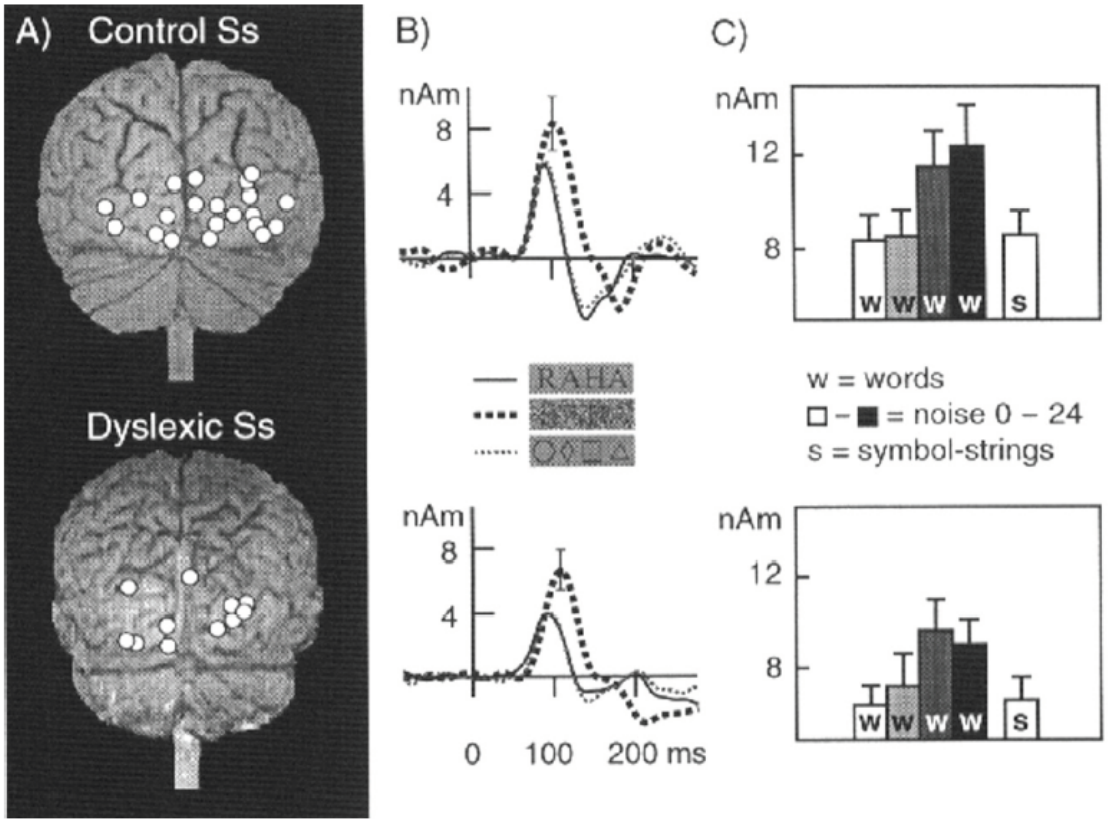




- Visual M100
- Same effect in Controls and Dyslexics
- Early visual perception is not different in dyslexic brains



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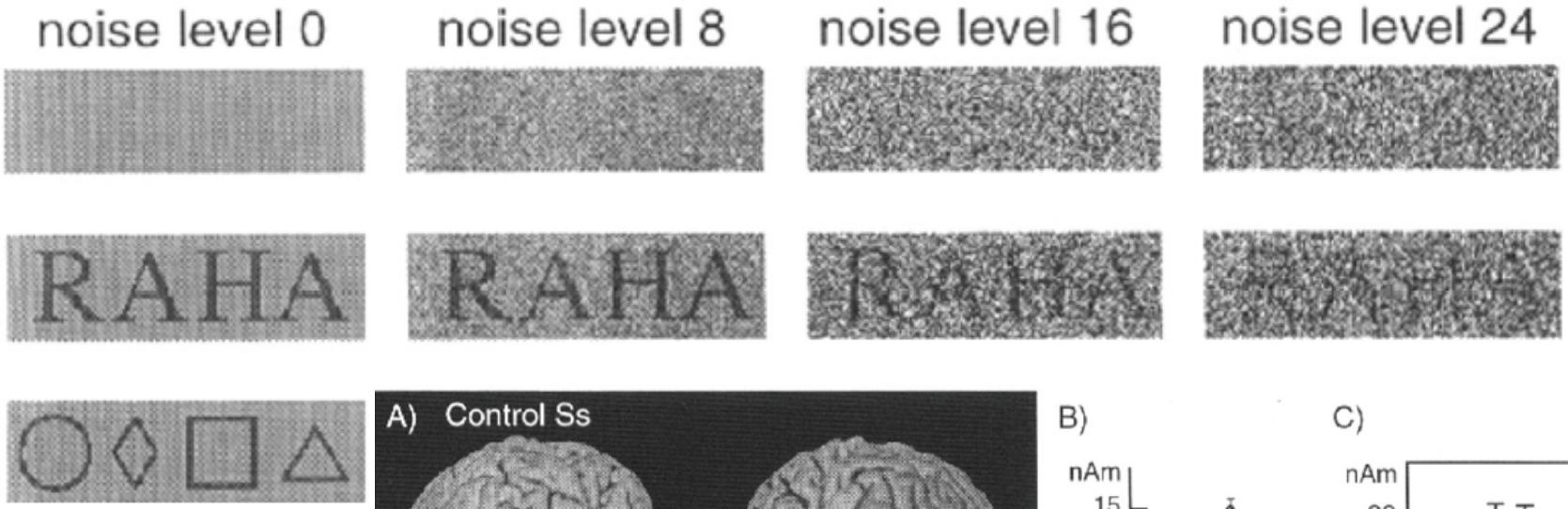
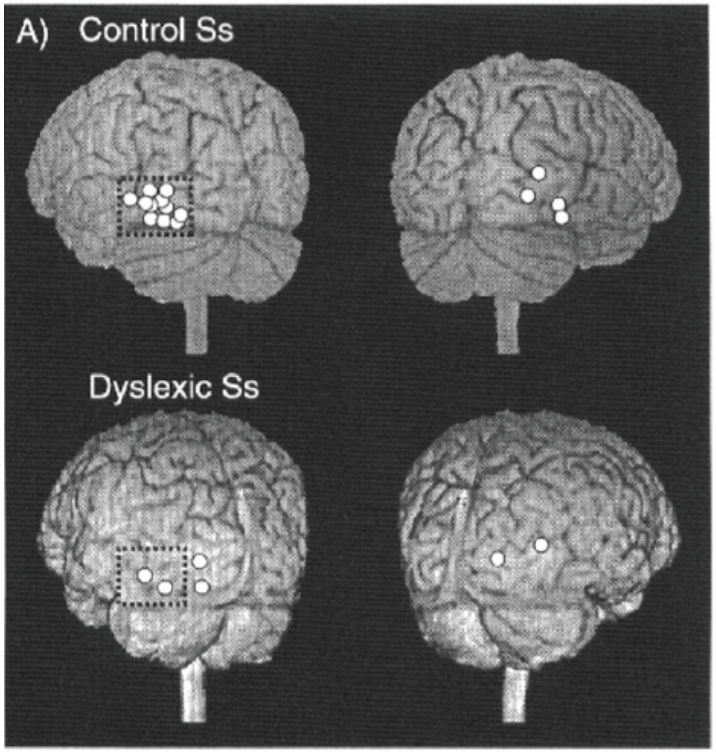
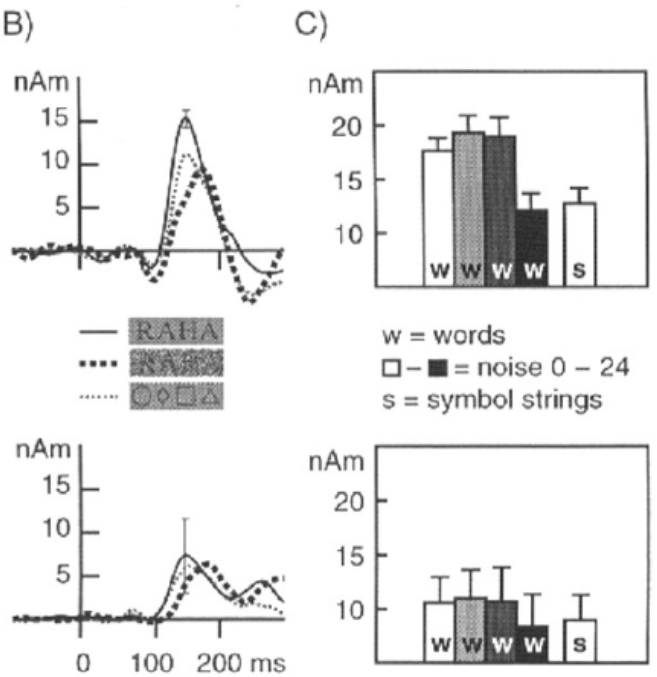


- Visual M170 (VWFA)
- Little activity in dyslexics
- No increase for words over symbols





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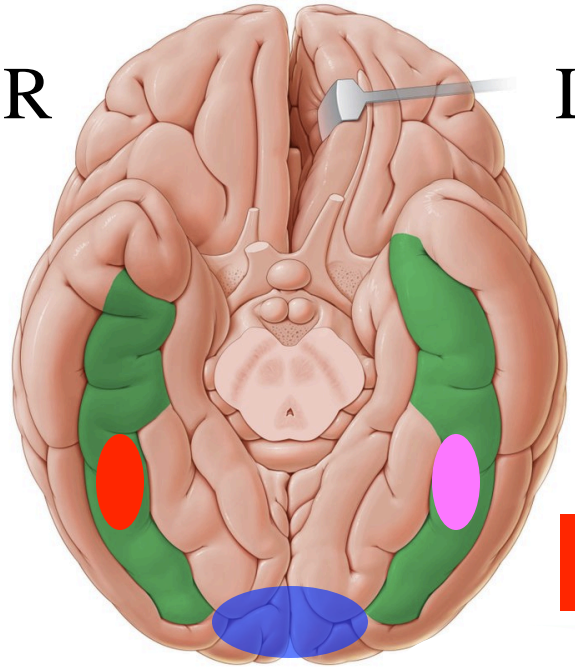


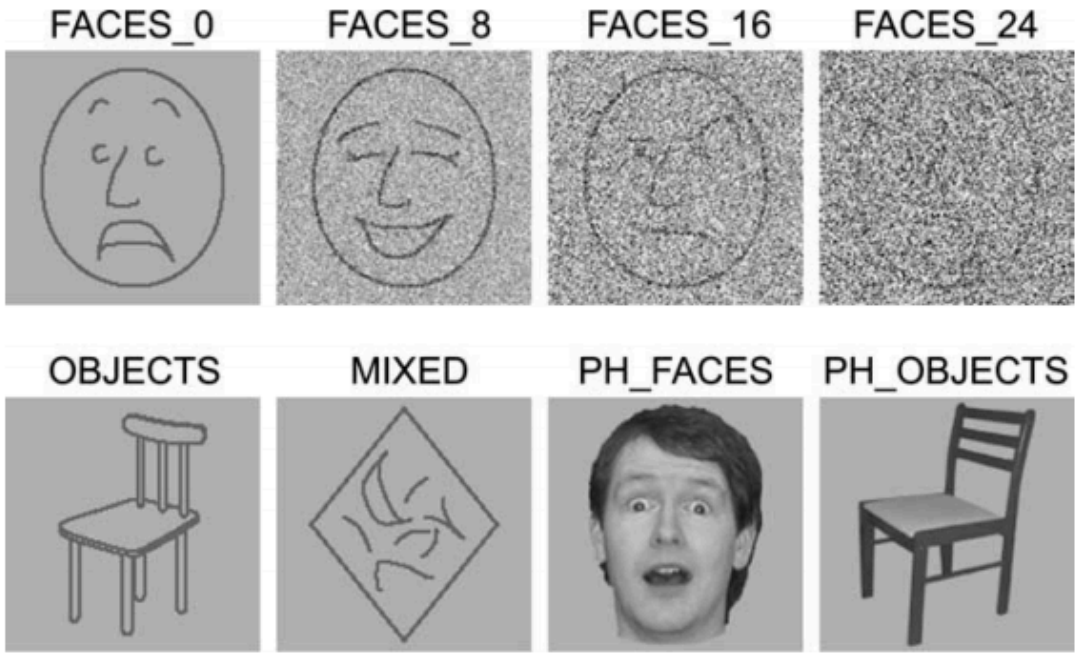
Fusiform Face Area (FFA)

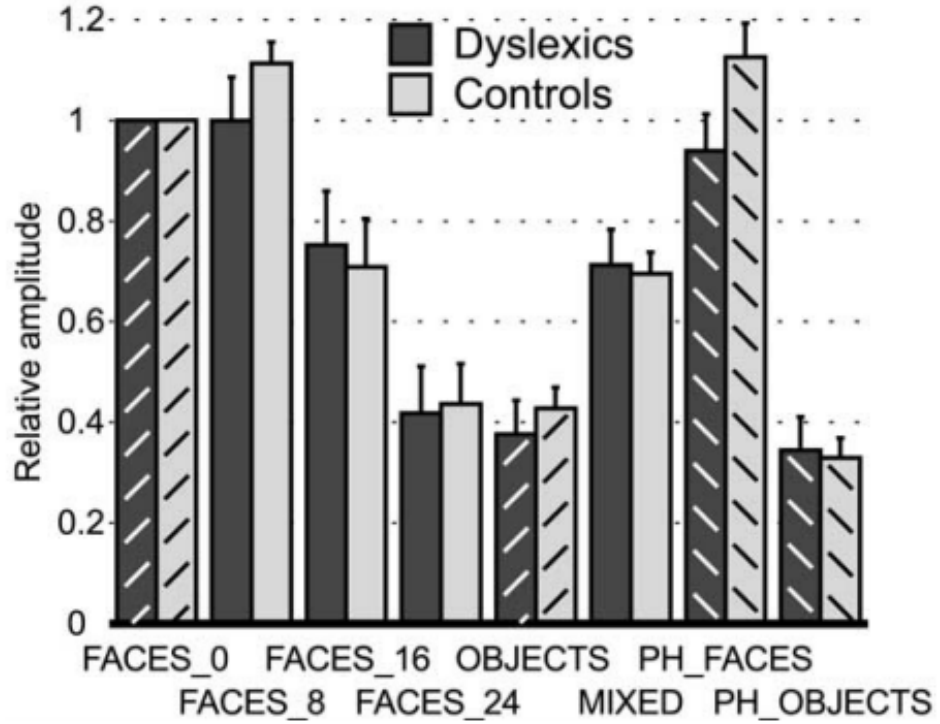
Visual Word Form Area (VWFA)

different!

Occipital cortex

not different

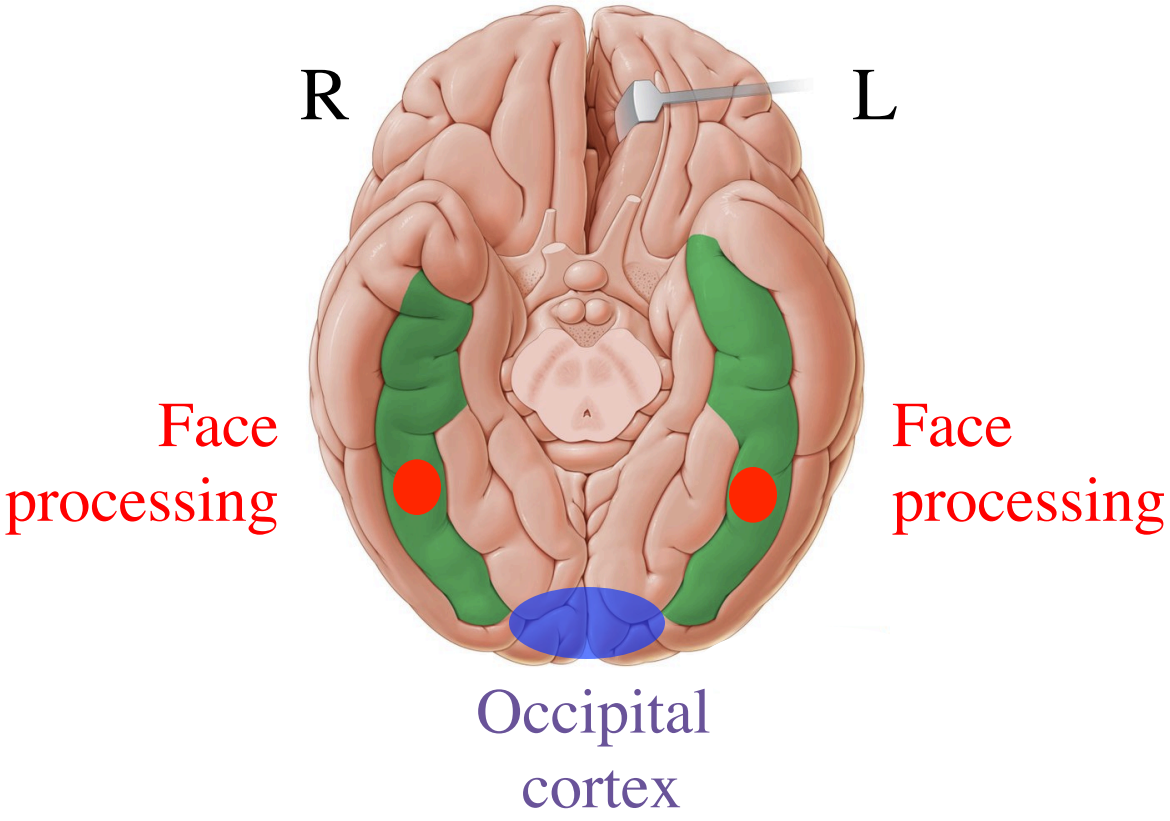




- Same pattern of activation from the FFA at ~170ms in both groups.

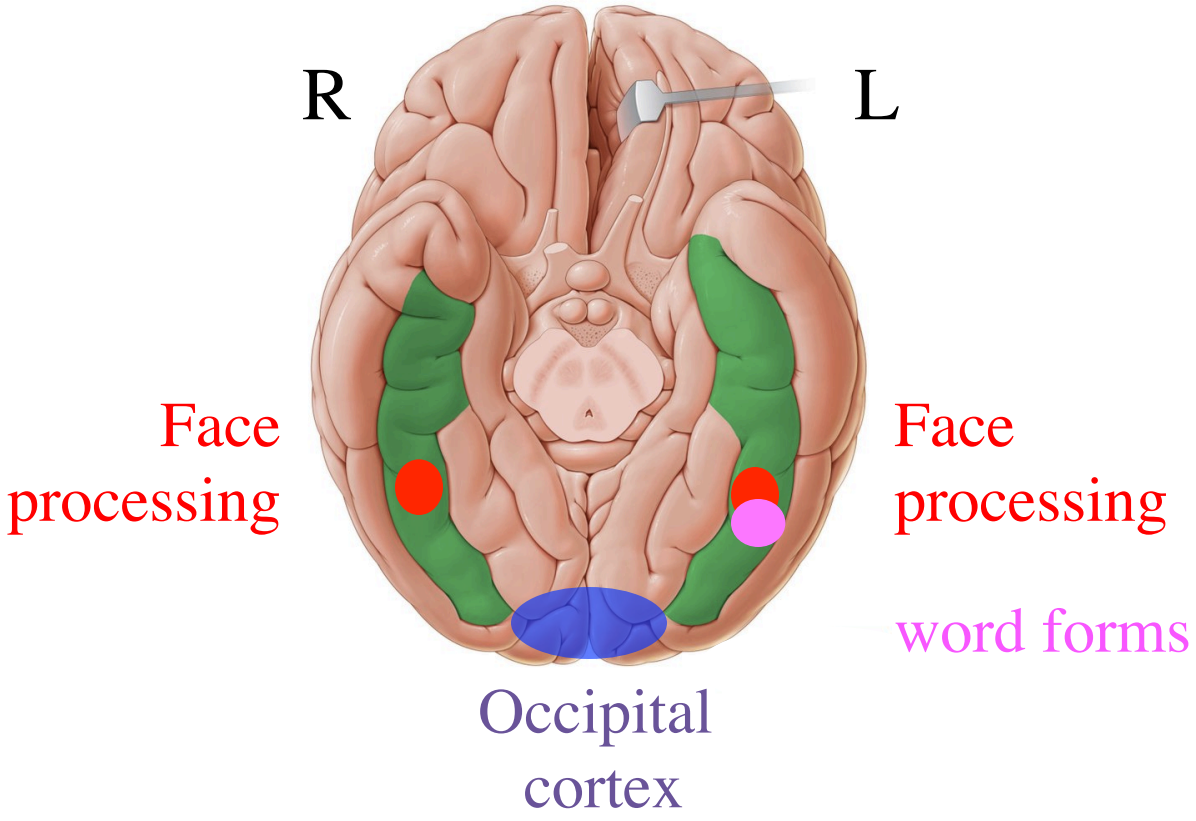
[Tarkiainen et al 2003, *Neuroimage*]

Illiterate brain



Dehaene, S. (2013, May). Inside the letterbox: how literacy transforms the human brain. In Cerebrum: the Dana forum on brain science (Vol. 2013). Dana Foundation.

Brain learning to read: Words push faces to the right hemisphere



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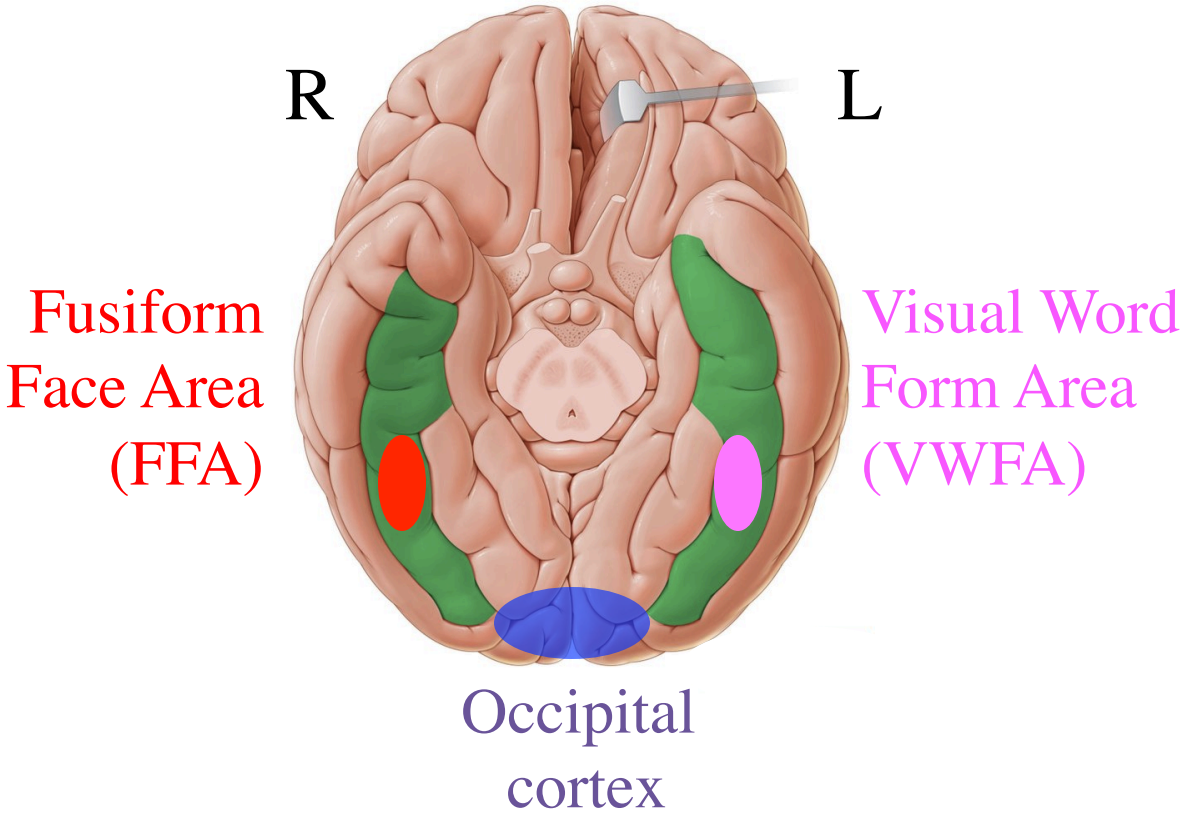
Literate brain



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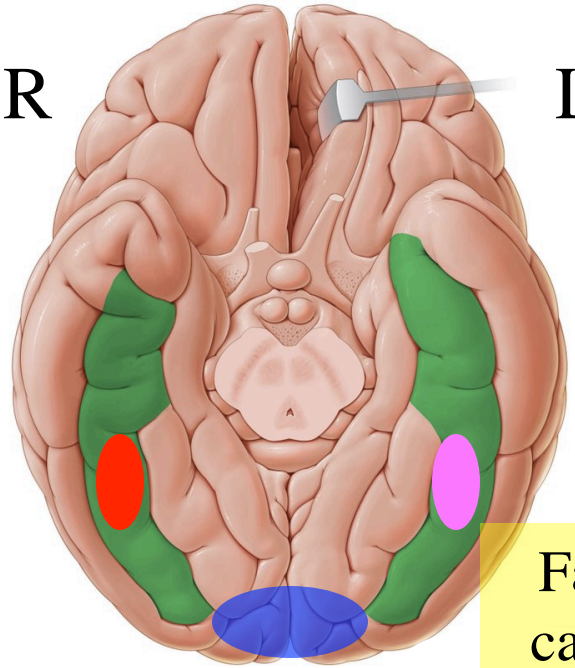


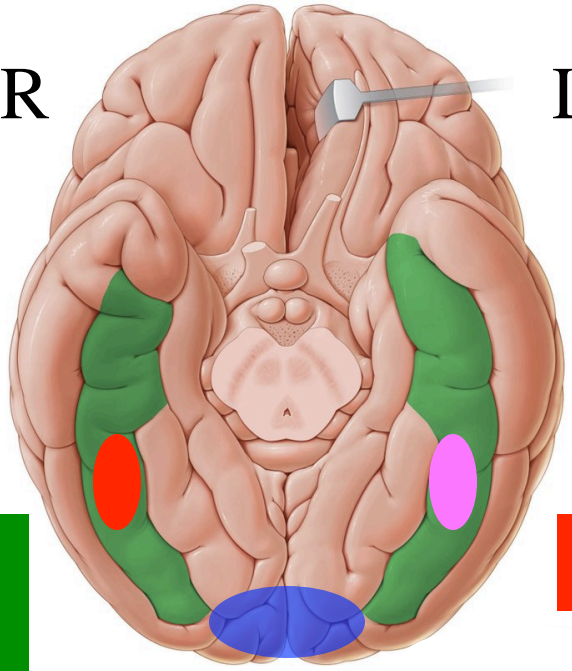
Fusiform Face Area (FFA)

Visual Word Form Area (VWFA)

Occipital cortex

Face processing in dyslexics can look similar to illiterates, because the Visual Word Form Area is not fully developed and has not pushed face processing to the right as much.

How are dyslexic brains different from non-dyslexic brains?



Fusiform Face Area (FFA)

same functional profile (but less activity)

Visual Word Form Area (VWFA)

different!

Occipital cortex

not different

Why is the VWFA of dyslexics underdeveloped?

- The VWFA represents the connections between speech sounds and graphemes.
- If you are taught new "symbol to speech sound" correspondences, the VWFA quickly develops a representation of these correspondences.
- Most likely, the process of developing these correspondences is impaired in dyslexia, leading to lesser development of the VWFA.
- Learning grapheme-to-sound requires the ability to **think about speech sounds**.
  - **PHONOLOGICAL AWARENESS**
  - **Impairment in phonologcal awareness is the most consistent behavioral diagnostic of dyslexia.**

Phonological awareness in dyslexia

- Ability to judge the number, order, and sameness or difference of sounds in words. Ability to replace sounds in words.
  - **Change the first sound of all these words to /k/:**

    pat, sit, door, house

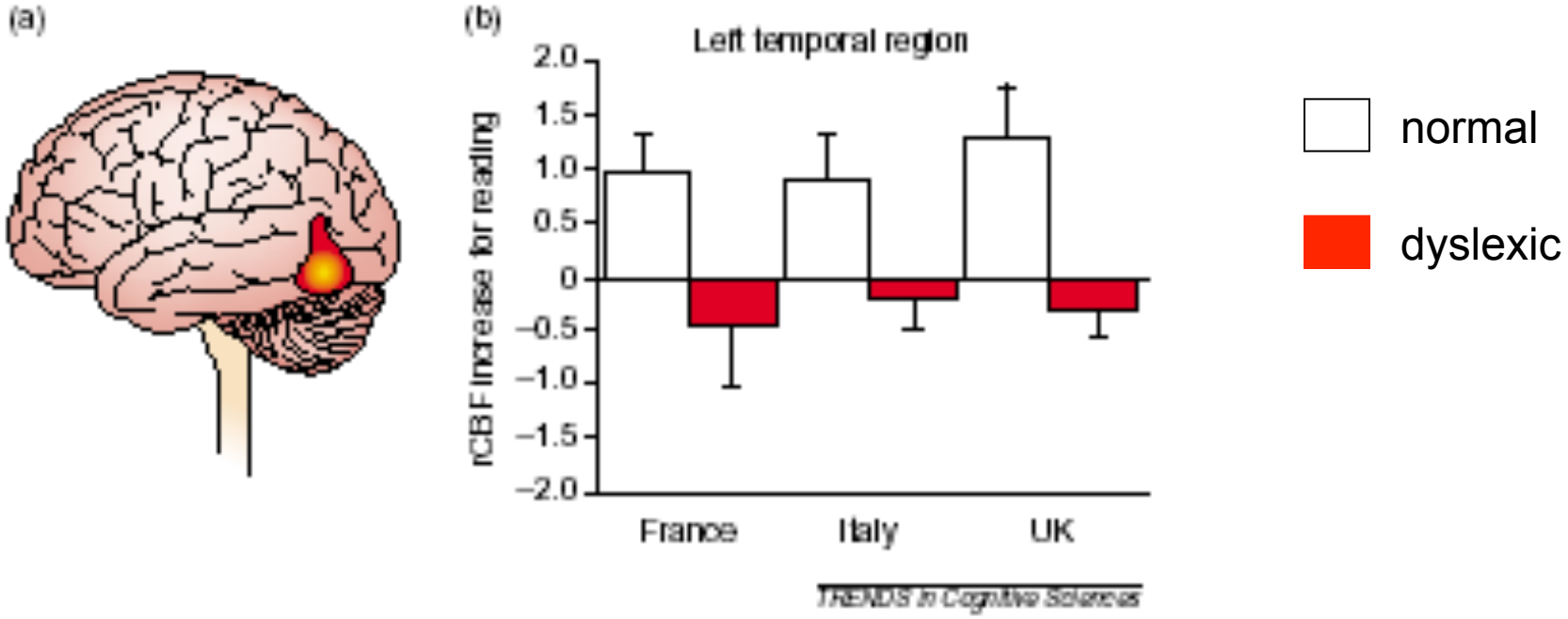
- Lower auditory perception is unimpaired (though there has been much debate about this).
- Phonological representations are normal -- dyslexics don't talk funny!
- But conscious access to sound representations is hard, and therefore manipulating those representations (consciously) is hard.

Ramus & Szenkovits, 2008

Does the rate of dyslexia depend on the language?

- Is dyslexia more common for languages where the orthography-to-phonology correspondence is less transparent, like in English?
  - **Same orthography, different sound:**
    - couch – touch
    - through – tough
  - **Different orthography, same sound:**
    - but – butt
    - hair – hare
- Answer seems to be ‘no’. Dyslexia is just as common say, in speakers of Finnish , where the orthography-phonology relation is completely transparent.
- No matter how “hard” or “easy” the orthography to phonology mapping, dyslexics have trouble with it.

Similar VWFA abnormality in dyslexics across languages



- Equal reduction in VWFA activation in English, French, and Italian dyslexics, despite differing degrees of orthographic transparency (Italian being the most transparent).

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.

In conclusion

- We still don't know why some brains are dyslexics and others are not.
  - **At least to some degree genetic. Complicated. Active area of research.**
- But, we are beginning to understand a lot about
  - **how reading changes your brain**
  - **how the brains of non-readers and poor readers are different from those of good readers**
- The brain of a fluent reader even responds to auditory language more strongly than the brain of an illiterate.
  - **Literacy strengthens the whole system by introducing a new entry point to language.**
- These advances in understanding the neurobiology of dyslexia are allowing us to design better interventions and enable neural tracking of the effects of those interventions.
- Relatively brief training on grapheme-to-phoneme correspondences can enhance VWFA responses in 6-year olds.