Brain, Connectivity & Behaviour

From anatomy to cognition

Stephanie Forkel
www.stephanieforkel.com

@StephForkel

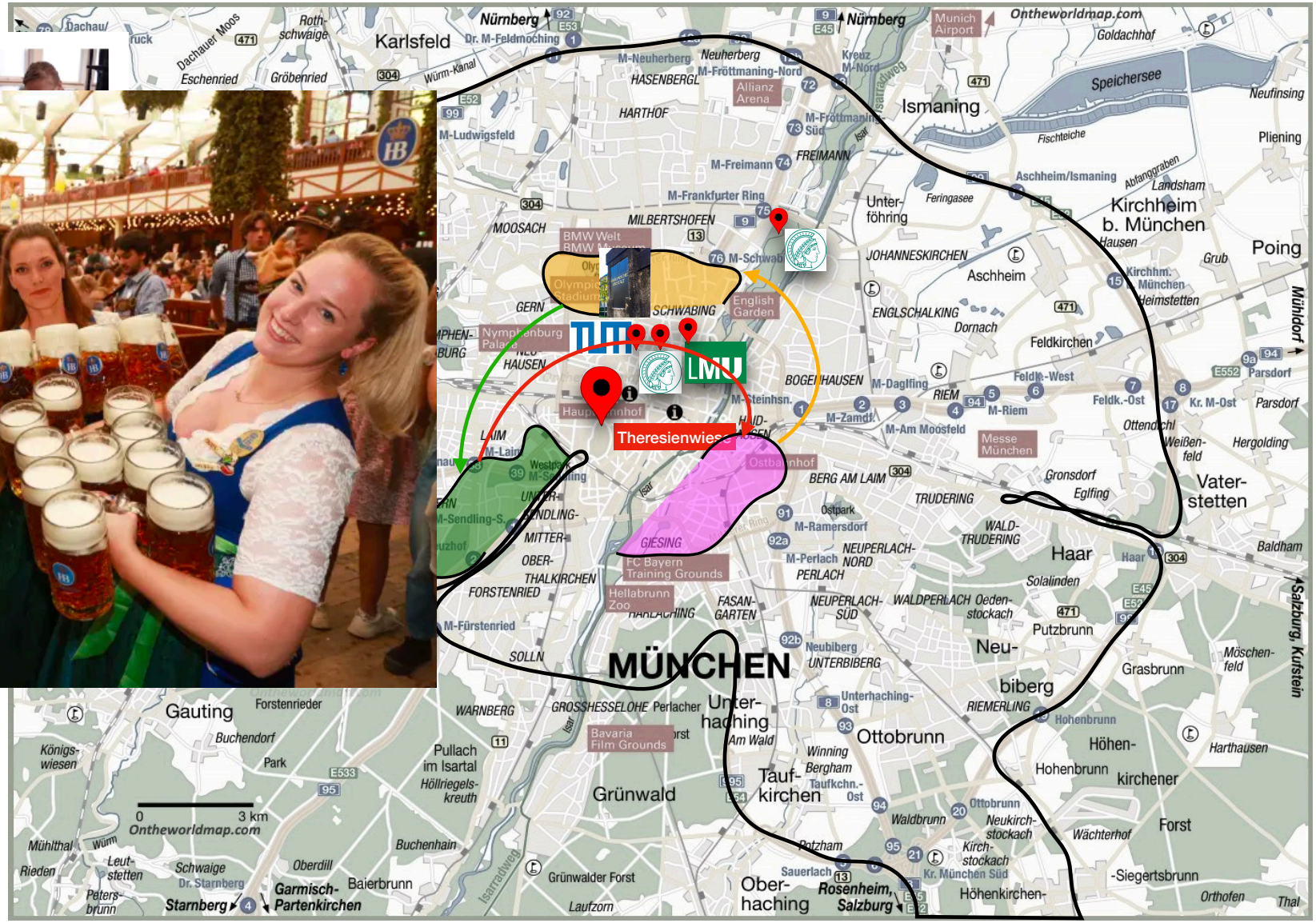
Brain Connectivity Behaviour

DONDERS INSTITUTE

Radboud University
Nijmegen, the Netherlands

Historical detour – ‘A mecca for brain research’

- Alois Alzheimer
  Neurodegenerative disorder
  Pick bodies



17 years of multidisciplinary neuroanatomy

post-mortem dissections

2006

Munich

2017

Zurich

2018

Istanbul

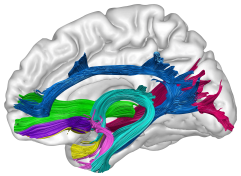
2019

London

2021

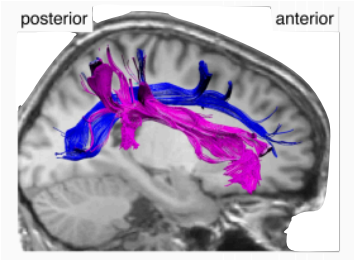
YouTube Brain Anatomy Course
(Clinical Neuroanatomy Seminars)

&



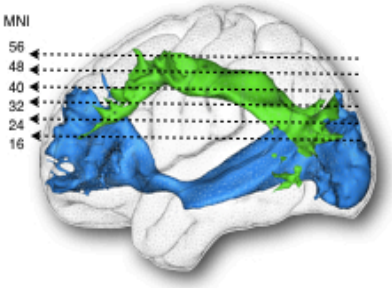
in vivo tractography

Fronto-parietal



Nature Neuroscience, 2011

Fronto-occipital

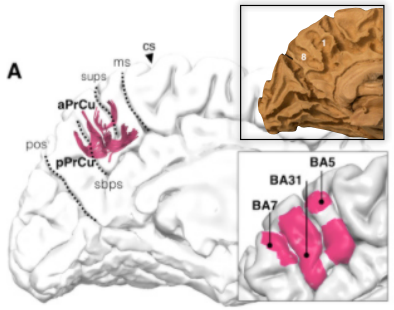


Cortex, 2014

Occipital U-shaped

Cortex, 2014

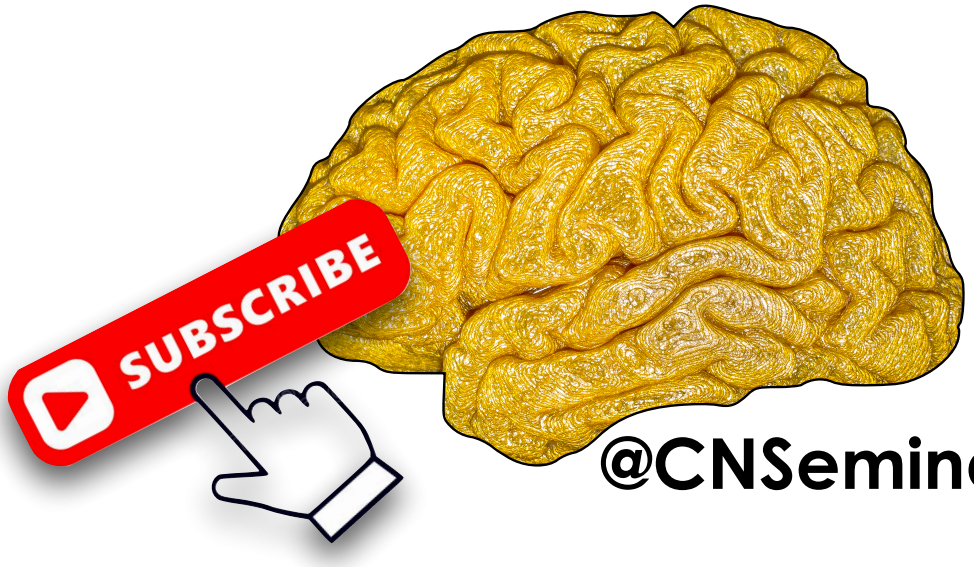
Comparative anatomy



Cortex, 2018

Discover & Discuss Exciting Science

Monday mornings at 9:30am
every last Wednesday of the month at 4pm



@CNSeminars

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zoom

YouTube

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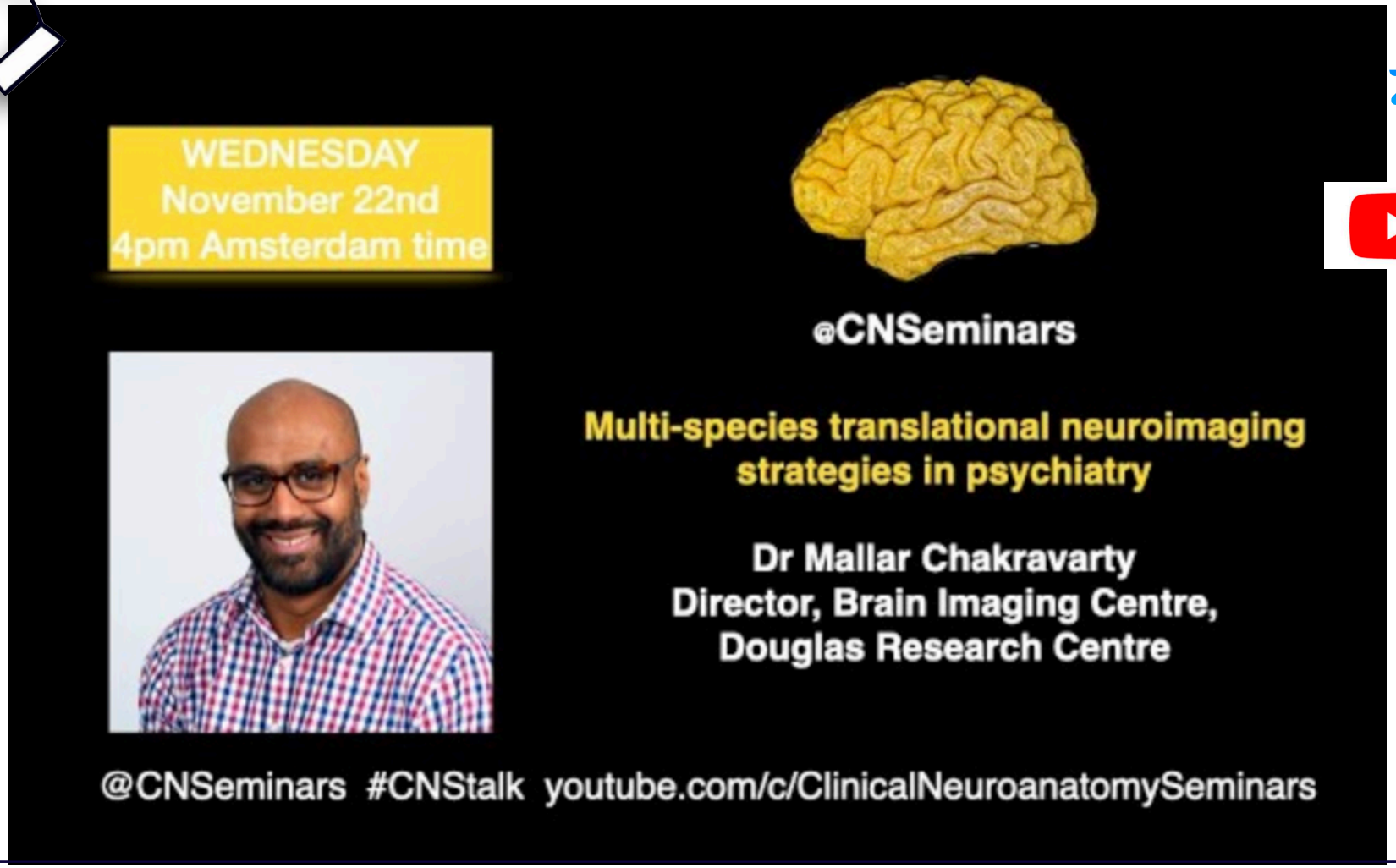
YouTube: ClinicalNeuroanatomySeminars
Website: www.clinicalneuroanatomyseminars.com

THIS WEEK:

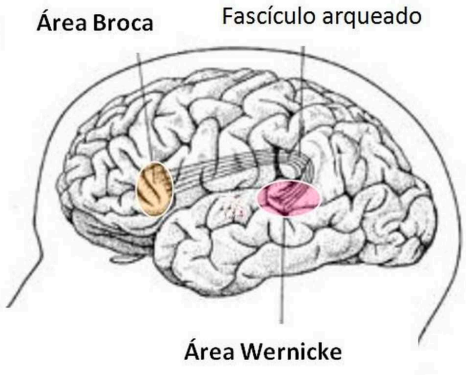
Join us live:

zoom

YouTube



FROM ANATOMY TO COGNITION



Monday:
Brain Models

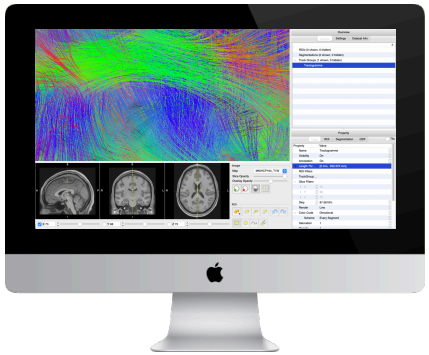
References:
Science 2022,
OUP 2012

Tuesday:
Methods to study connectional anatomy of language

References:
Brain 2014
Neurology 2020

Wednesday:
CNStalks at 4pm on YouTube

References:
n/a



Thursday:
Tractography Practlcal

References:
Book chapter 2023
on my website

WORKSHOP ON THURSDAY

BRING YOUR LAPTOPS

Data

Tutorials

www.stephanieforkel.com/Opendata/ --> workshop

Engage and interact: https://www.stephanieforkel.com/emcl-groningen

Stephanie J Forkel

[ˈstɛ.fə.ni.ˈfoː.kəl]

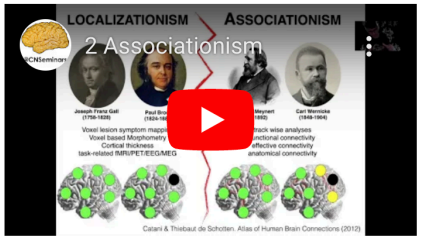
HDR PhD CPsychol SFHEA

Neuroscience Alliance NEURAL

NEWS CV Publications Leadership DONDERS Editorial Work Talks Teaching Awards Outreach Open Data Gallery More

International Research Master in Clinical Linguistics is part of the prestigious international Erasmus Mundus programme in Clinical Linguistics, EMCL++. EMCL++ is an integrated Master's programme offered jointly by a consortium of the Universities of Groningen (NL), Ghent (B) and Eastern Finland (FI) and 26 associated partners from the academic, R&D, and clinical sector, finishing with a joint Msc degree from the three institutions.

On this interactive page, you will find background material on the topics we cover in class. Updates during the week are likely, so please do check back in.



Reading Material:

Atlas Human Brain Connections
https://academic.oup.com/book/24732

The emergent properties of the connected brain. Thiebaut de Schotten M & Forkel SJ., Science (2022) https://doi.org/10.1126/science.abq2591

White matter variability, cognition, and disorders: a systematic review.
Forkel SJ, Friedrich P, Thiebaut de Schotten M & Howells H. Brain Structure and Function, in press.
doi: 10.1007/s00429-021-02382-w

Anatomical predictors of aphasia recovery: a tractography study of bilateral perisylvian language networks.
Forkel SJ, Thiebaut de Schotten M, Dell'Acqua F, Kalra L, Murphy DG, Williams SR & Catani M. Brain 137(Pt7):2027-39, 2014. https://doi.org/10.1093/brain/awu113

Practical:

The data and software are available here under 'Follow a Workshop'. Please download the folder ahead

Brain Models

From anatomy to cognition

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Brain Connectivity Behaviour

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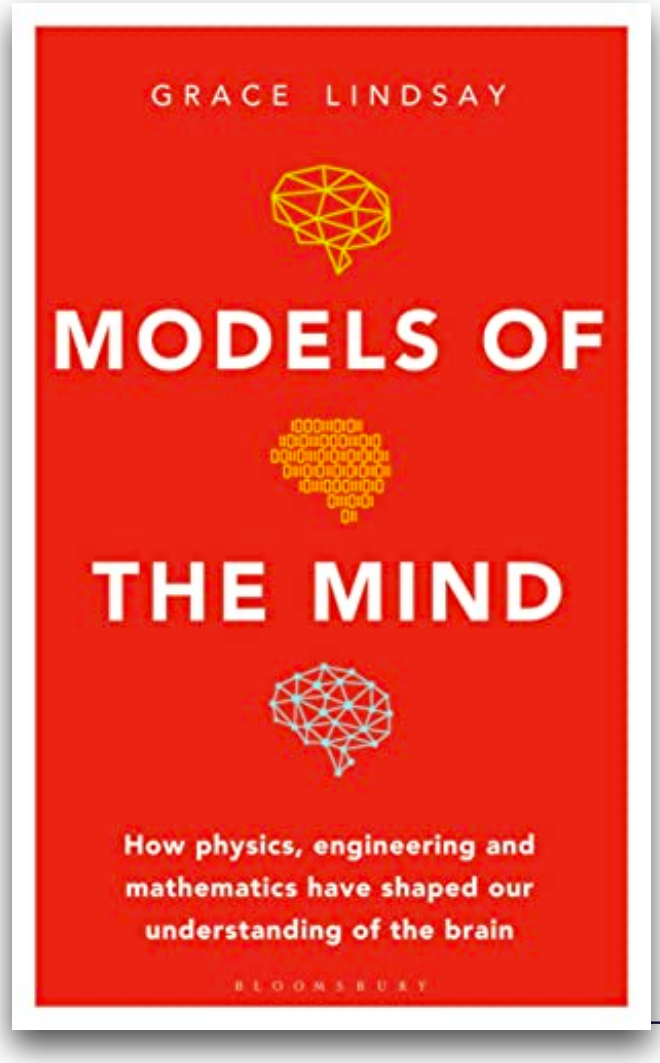
Brain Models



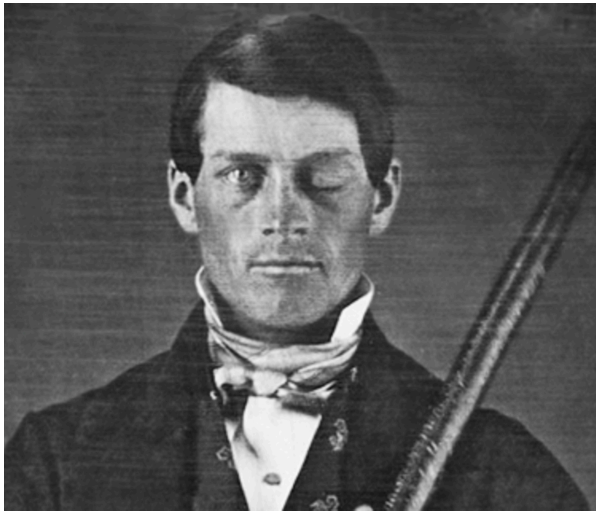
"brain models" can encompass a range of approaches, from computational simulations to conceptual frameworks, all aimed at enhancing our understanding of the brain's complexities and functions. (Source: ChatGPT)

Brain storming

What Brain models do you know already?

Brain Model: Localisationism

Phineas Gage (1823–1860)

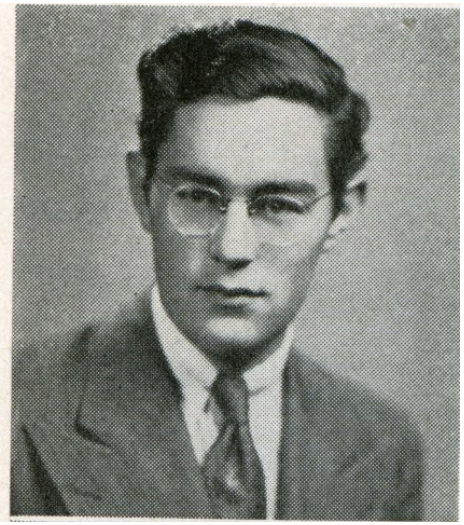


Source: Wikipedia

Louis Victor Leborgne (1809–1861)

Dronkers et al., Brain 2007

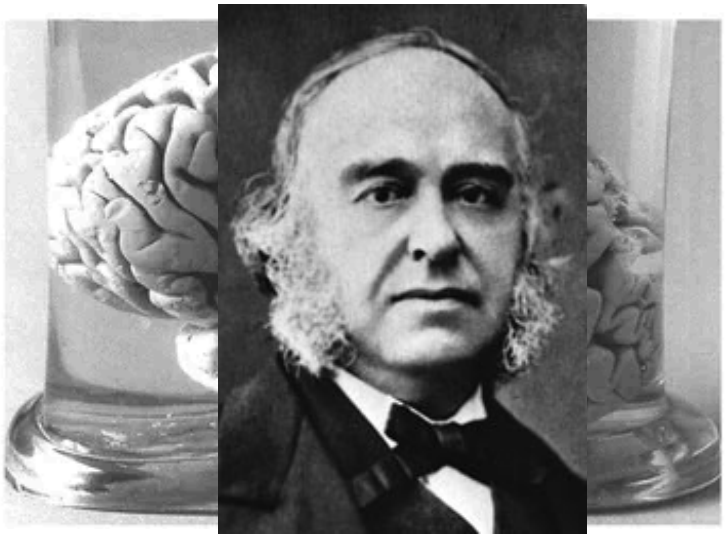
Henry Gustave Molaison (1926–2008)



Source: https://suzannecorkin.com/patient-h-m/

Brain Model: Localisationism

Paul Broca (1824–1880)

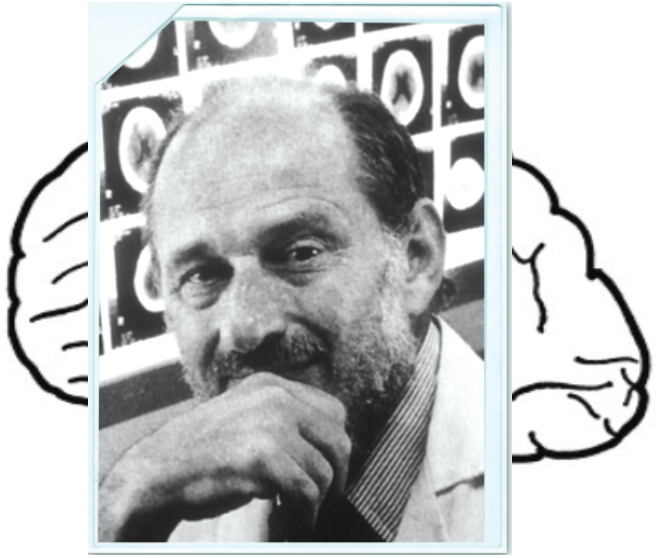


Dronkers et al., Brain 2007

Carl Wernicke (1848–1905)

Wernicke, 1874

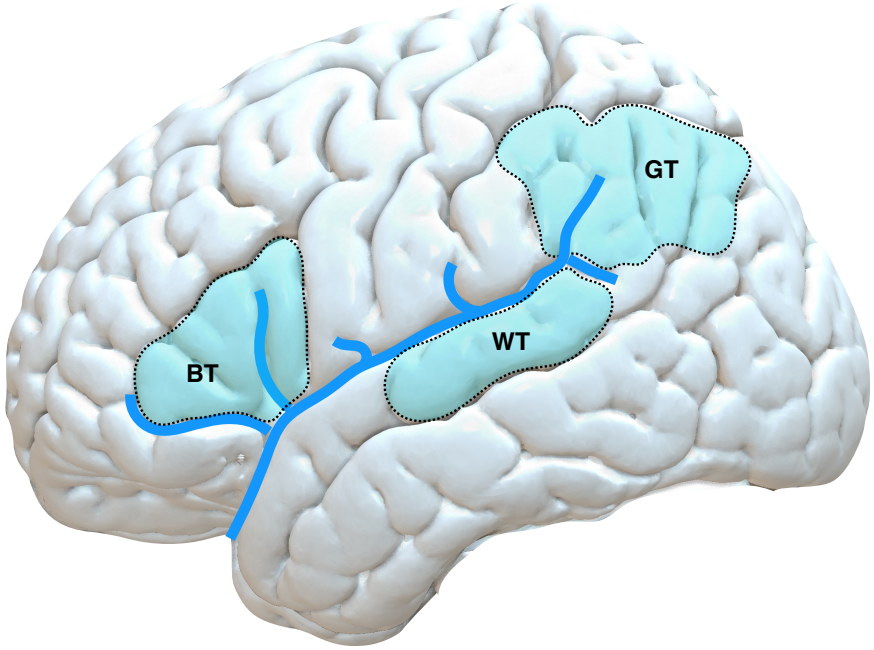
Norman Geschwind (1926–1984)



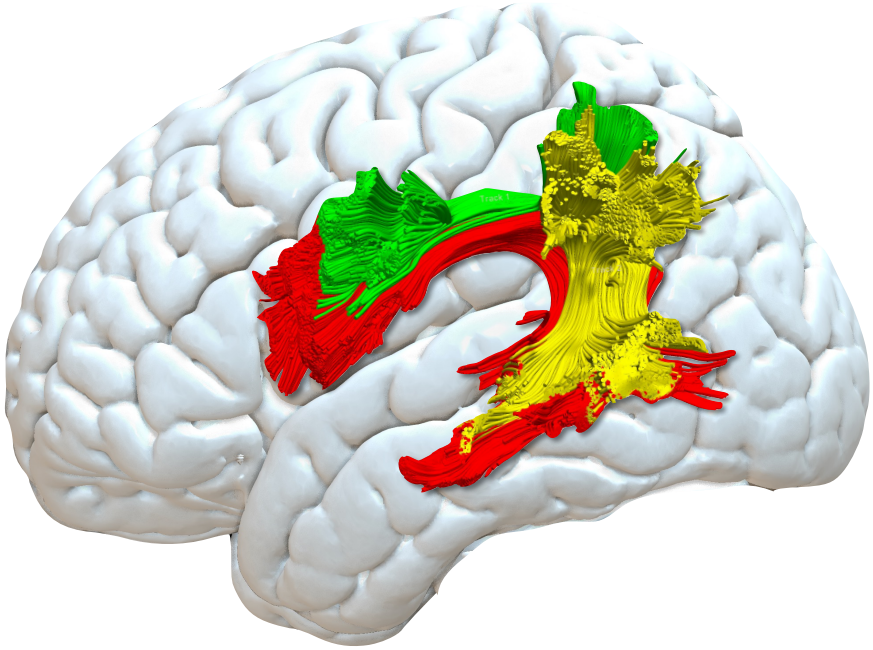
Geschwind, Science 1970

Language Localisationism

Cortical anatomy

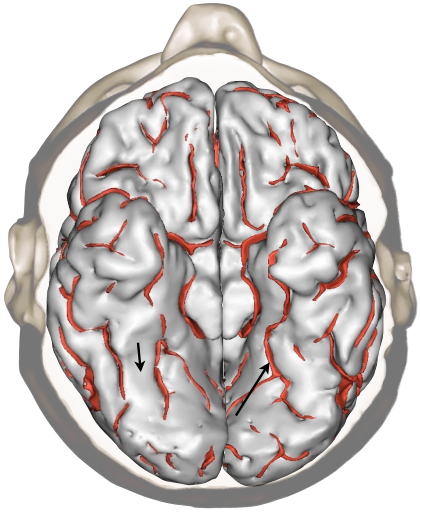
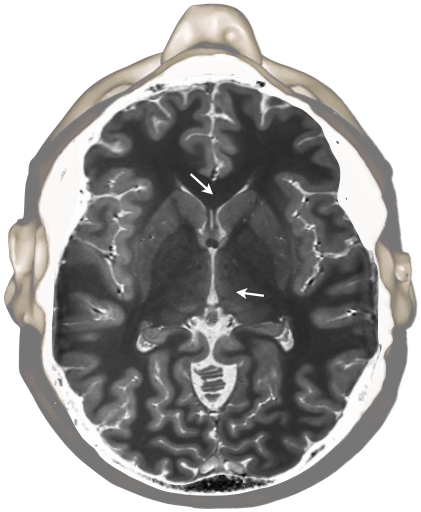
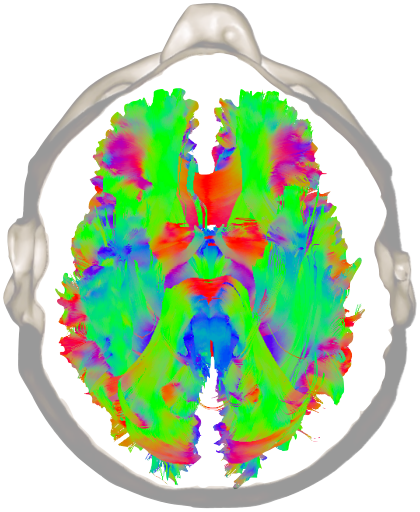
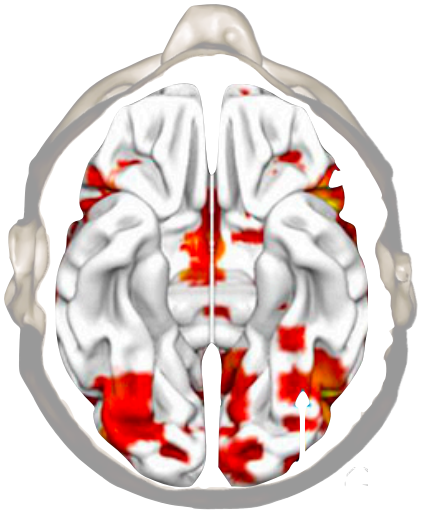


Connectional anatomy



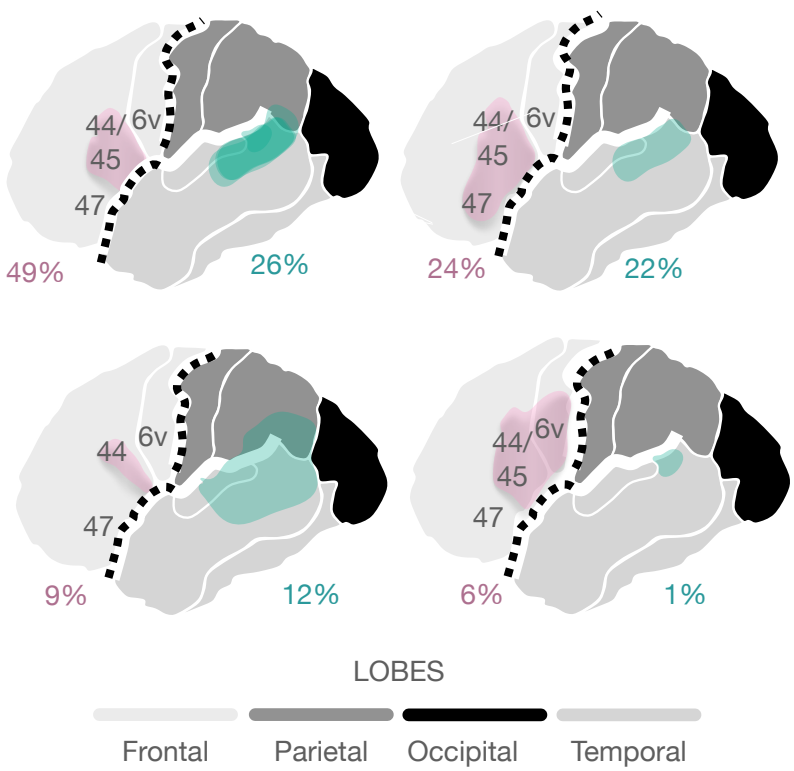
BUT….

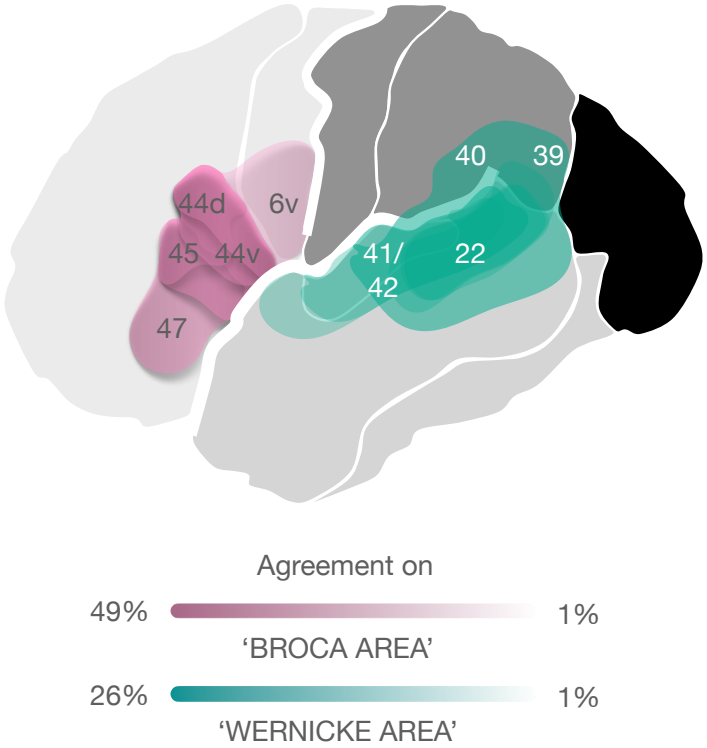
Different Neuroanatomies

SURFACE ANATOMY	SECTIONAL ANATOMY	CONNECTIONAL ANATOMY	FUNCTIONAL ANATOMY
			
Expl. precentral gyrus	**BA6**	**U-shaped fibres**	**M1**

Catani & Thiebaut de Schotten, 2012

Where is language in the brain?



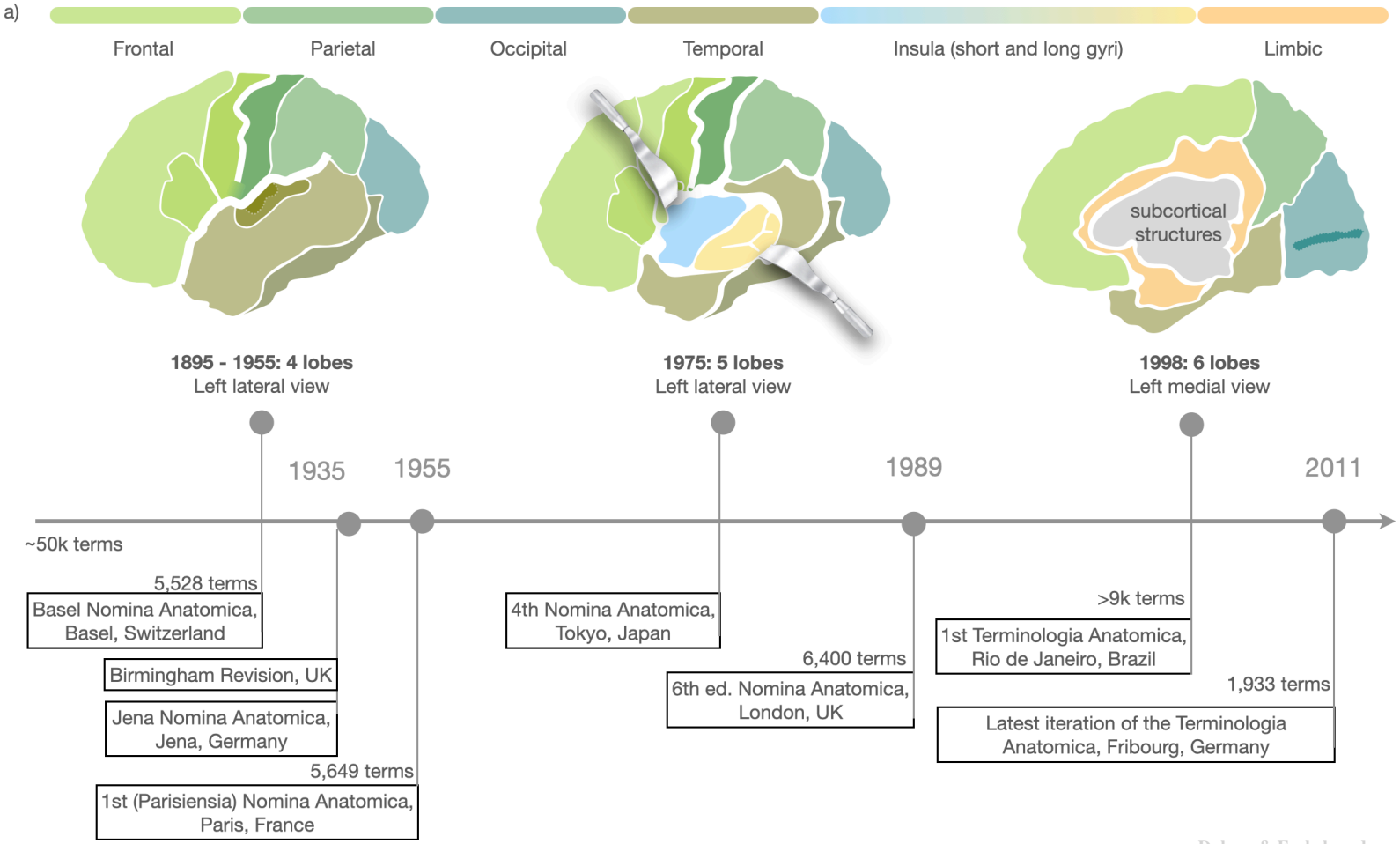


modified from Tremblay & Dick 2016

How many lobes does the brain have?

1 2 3 4 5 6 7

How many lobes does the brain have?

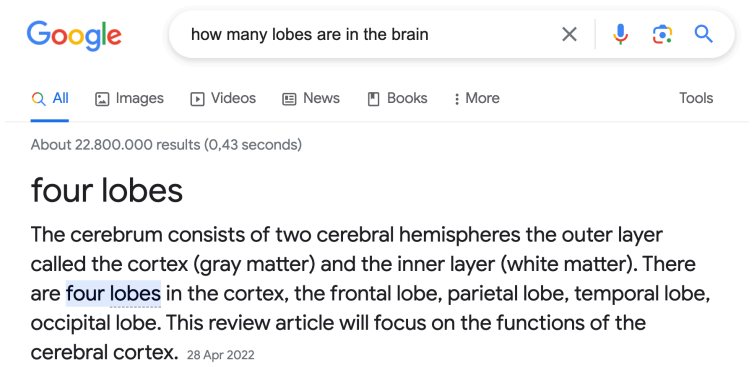


Dulyan & Forkel, under review

Is AI so much smarter than us?

b)

MAY 2023



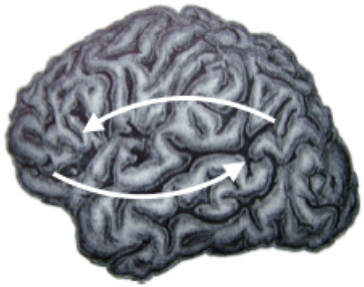
Dulyan & Forkel, under review

How many white matter tracts does the brain have?

10 20 30 40 50 60 70

How many white matter tracts does the brain have?

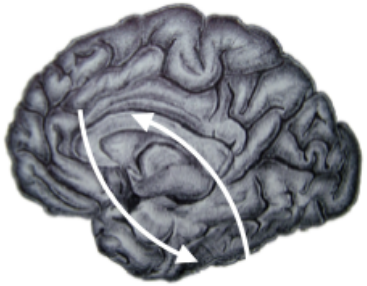
White matter classification



ASSOCIATION FIBERS

Theodor Meynert (1833-1892)

COMMISSURAL FIBERS

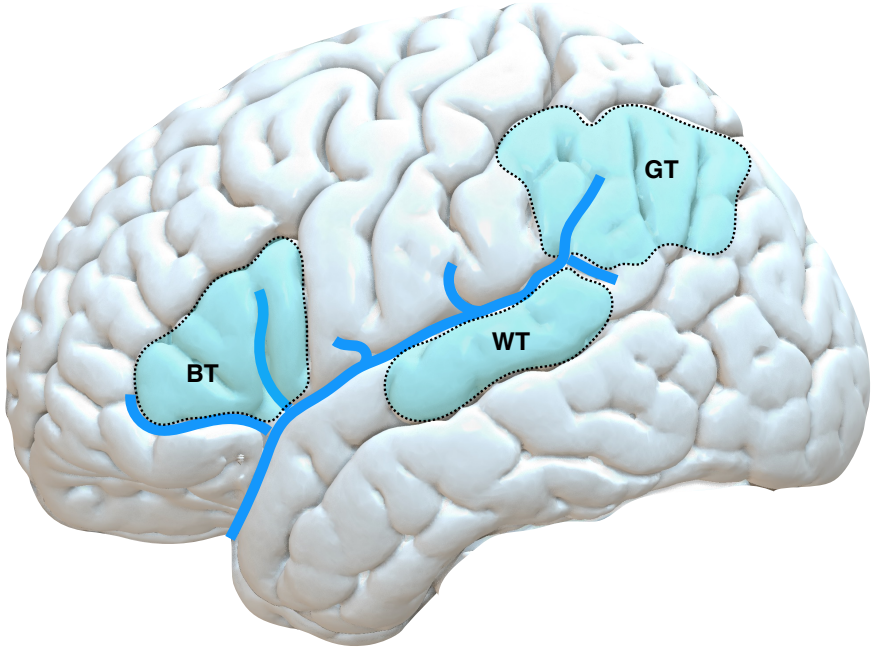


PROJECTION FIBERS

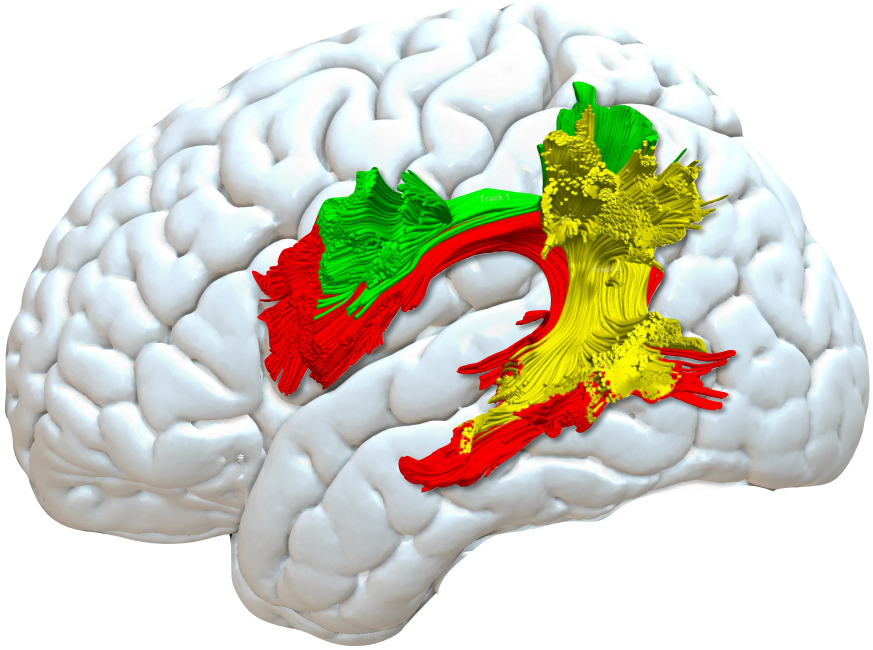
Catani, Forkel & Thiebaut de Schotten, 2010

Limitations of the language model

Cortical anatomy

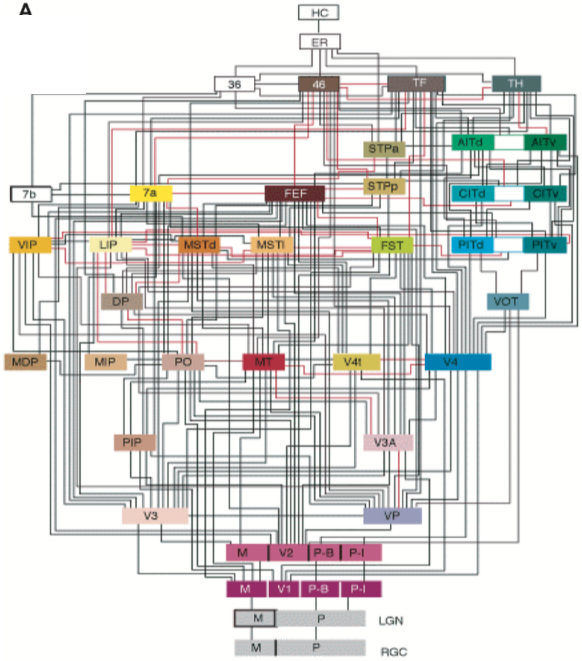


Connectional anatomy



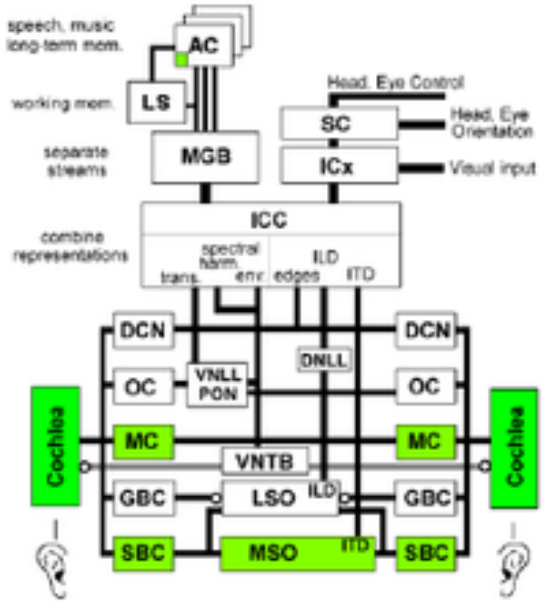
Naïveté?

Visual System



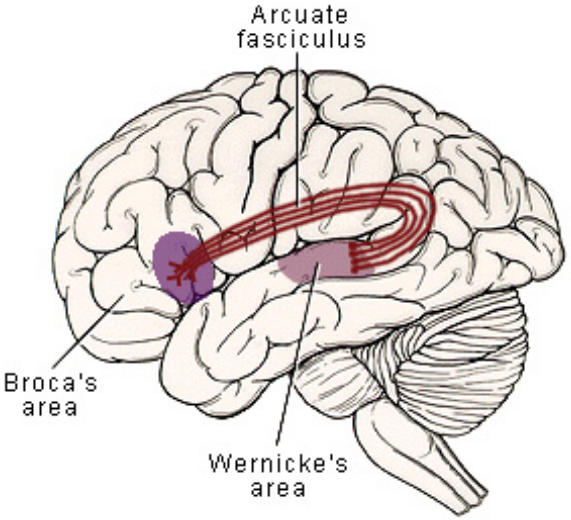
Van Essen 1991

Auditory System



Crick and Koch 1998

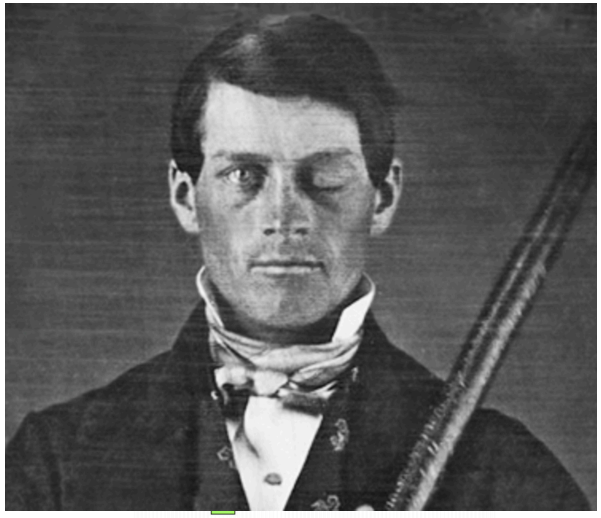
Language System



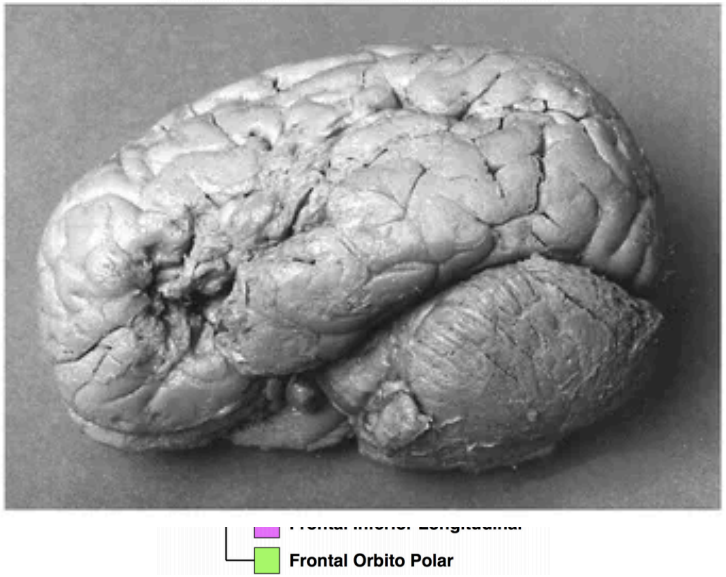
Most textbooks

Brain Model: Associationism

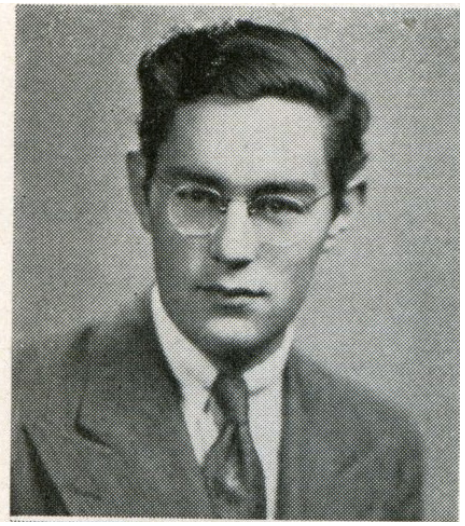
Phineas Gage (1823–1860)



Louis Victor Leborgne (1809–1861)



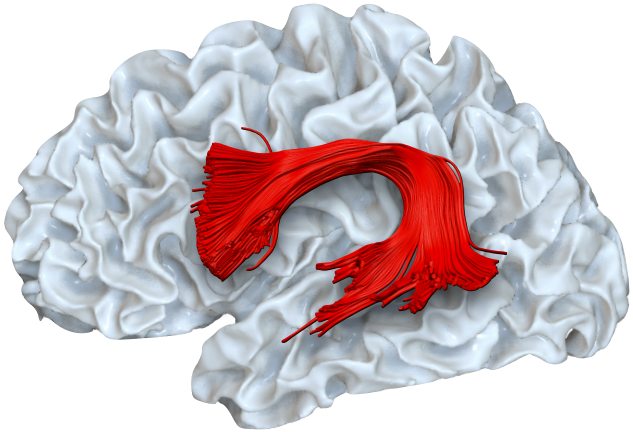
Henry Gustave Molaison (1926–2008)



Thiebaut de Schotten et al., 2015

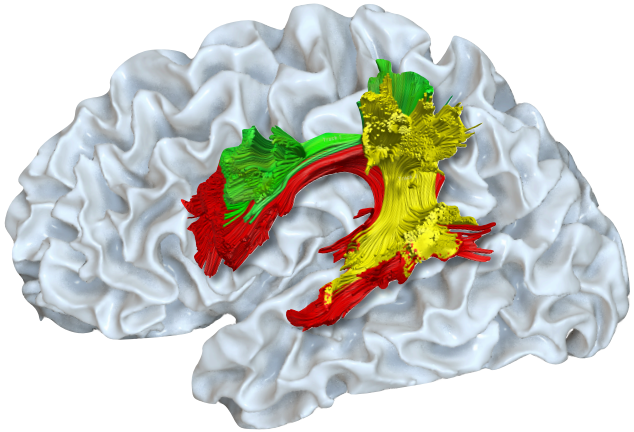
Language connectome: then and now

19th century



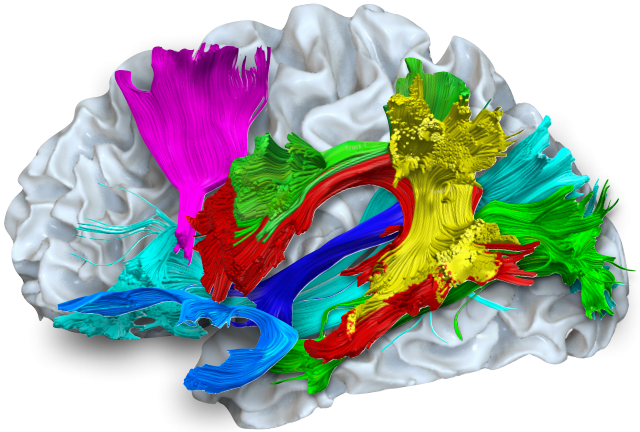
Arcuate fasciculus

Early 2000s



- Anterior segment
- Long segment
- Posterior segment

21st century

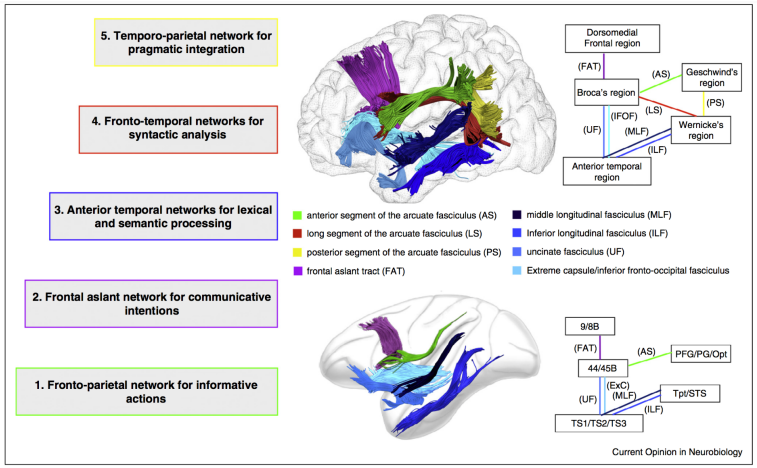


- Frontal Aslant Tract
- Uncinate fasciculus
- Temporal longitudinal fasciculus (TLF)
- Inferior fronto-occipital fasciculus (iFOF)
- Inferior longitudinal fasciculus (ILF)

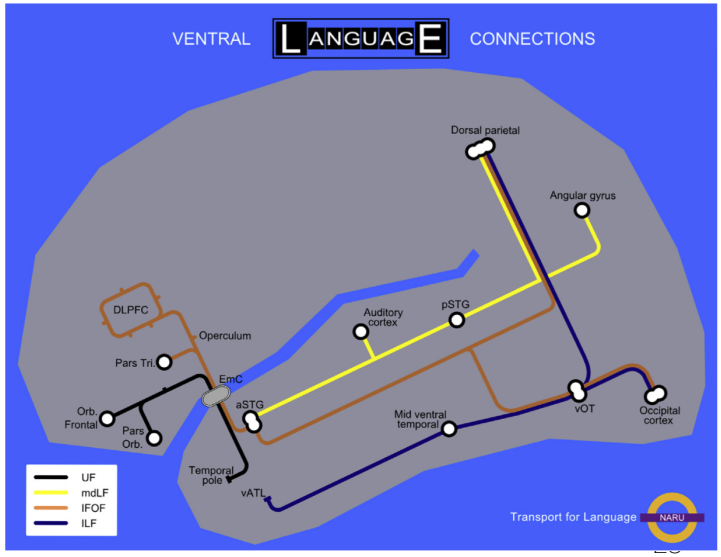
Forkel & Catani, Oxford Handbook of Neurolinguistics, 2018

Models of Language

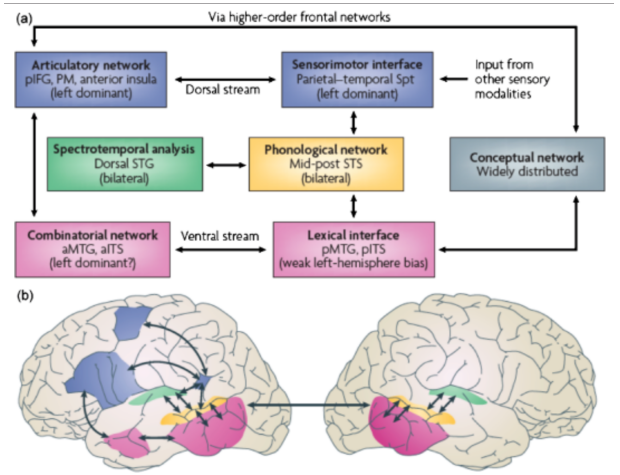
Psychiatry



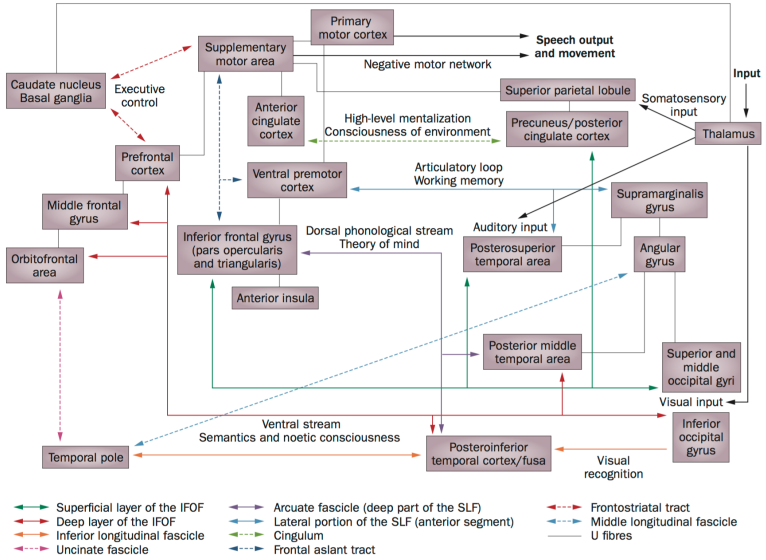
Neurology



Evolution



Neurosurgery

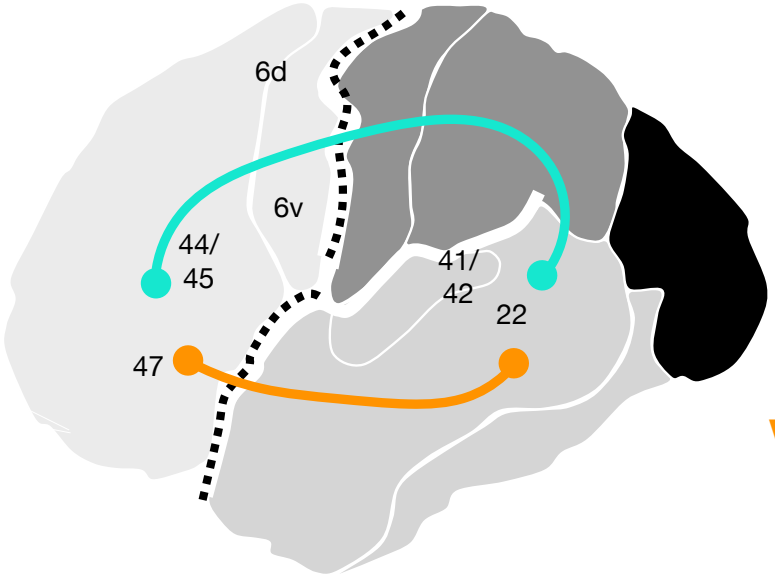


Brain storming

Why have these models not yet answered

how language works in the brain?

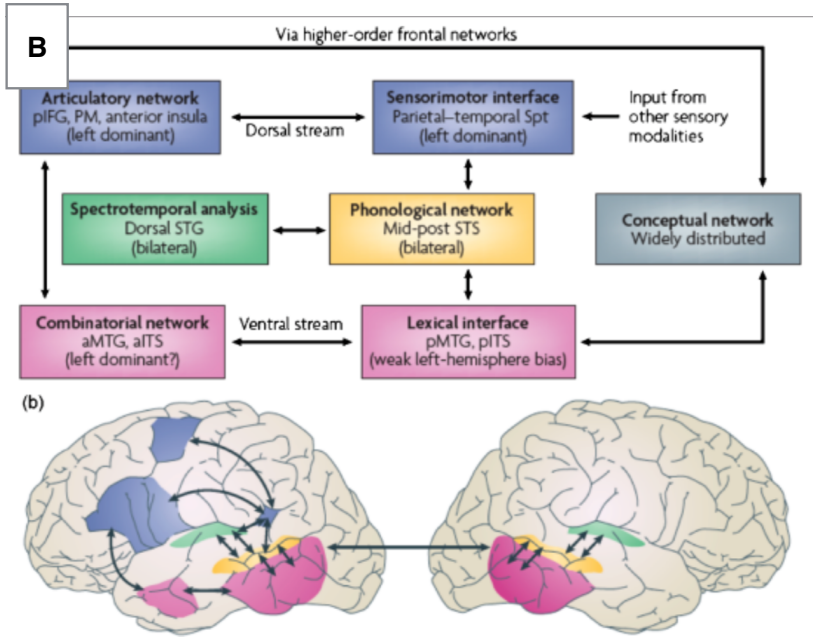
From Evolutionary Models to Anatomical Models



Dorsal Stream

vs.

Ventral Stream

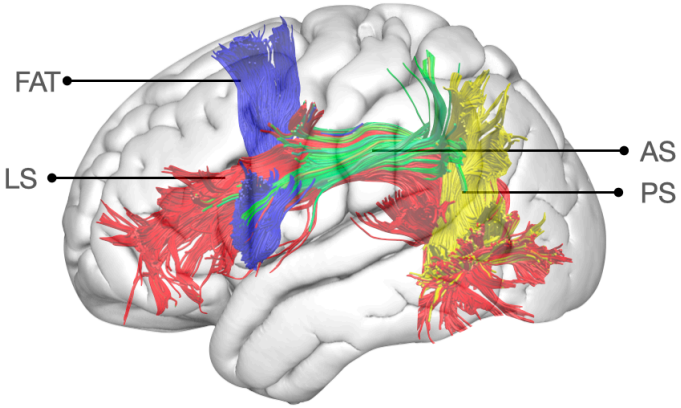


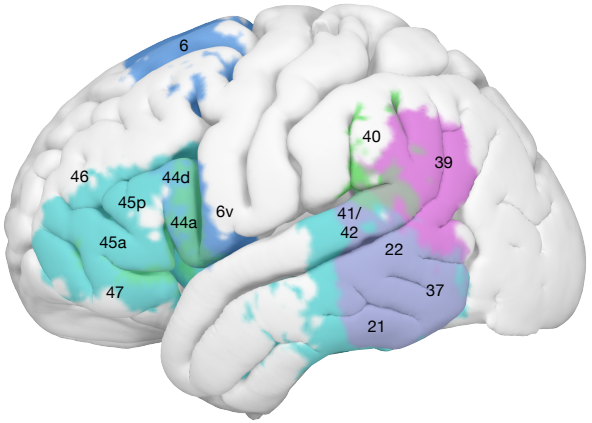
Q1. What does dorsal/ventral mean?

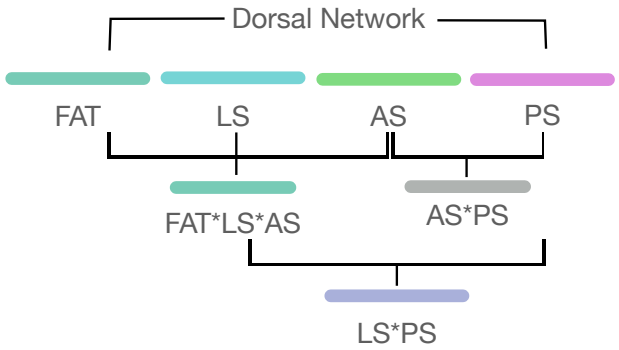
Q2. What defines the dorsal/ventral boundary?

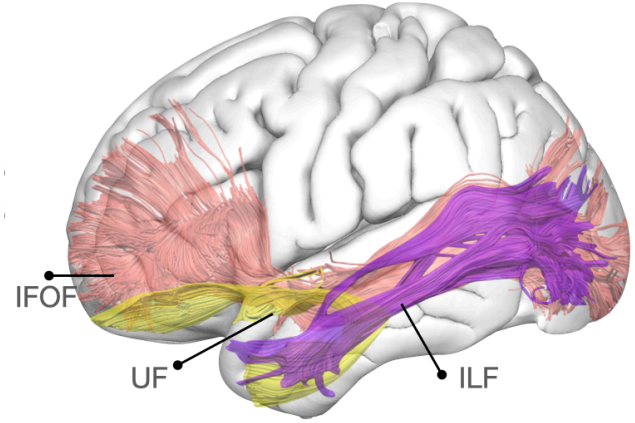
Dulyan & Forkel, under review

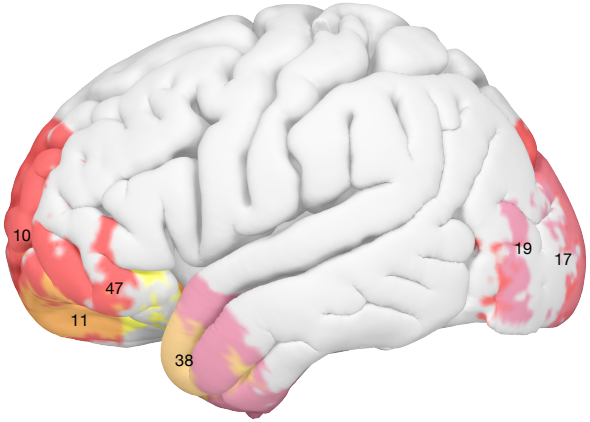
Language Associationism

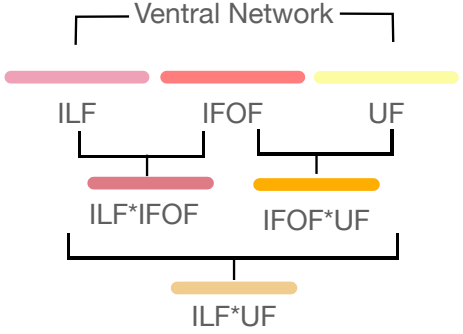












Dulyan & Forkel, under review

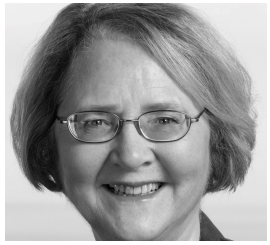
The Averaging Problem

1. Gerty Theresa Radnitz-Cori 1947

2. Rosalyn Sussman Yalow 1977

7. Linda Buck-Brent 2004

8. Françoise Barré-Sinoussi 2008



9. Elizabeth Helen Blackburn 2009

Elizabeth Blackburn London 2015

3. Barbara [Eleanor] McClintock 1983

4. Rita Levi-Montalcini 1986

10. Carolyn Widney Greider-Comfort 2009

11. May-Britt Moser 2014

5. Gertrude "Trudy" Belle Elion 1988

6. Christiane Nüsslein-Volhard 1995

12. Tú Yōuyōu 2015

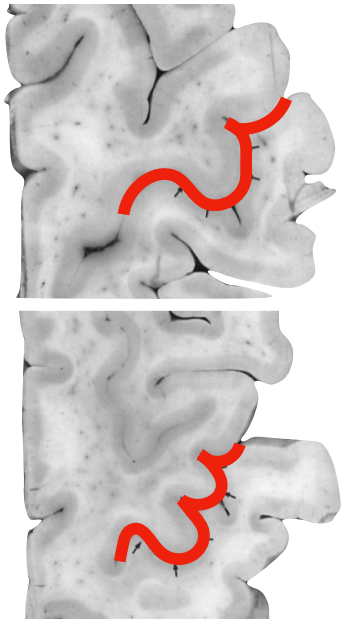
13. Katalin Karikó Francia 2023

LINDAU NOBEL LAUREATE MEETINGS

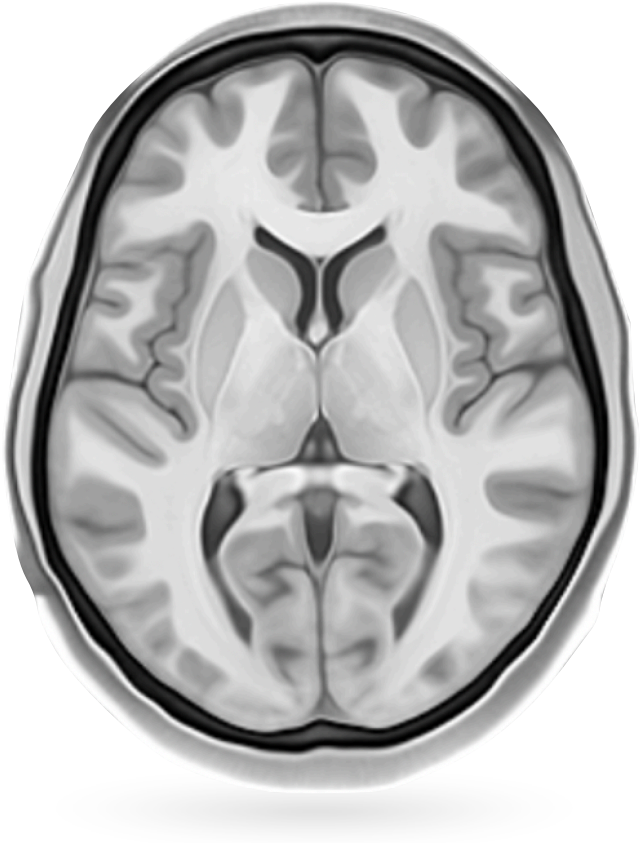
https://www.lindau-nobel.org/professor-elizabeth-blackburn-on-unconscious-biases/

Neurovariability

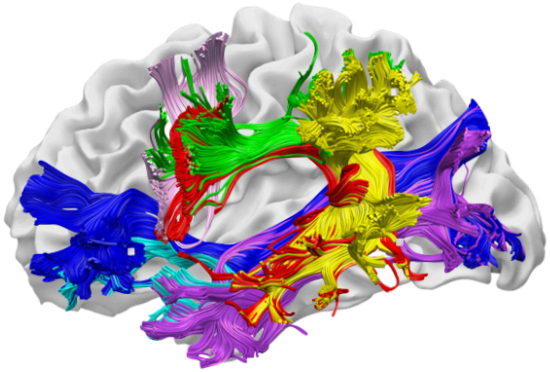
Motor cortex

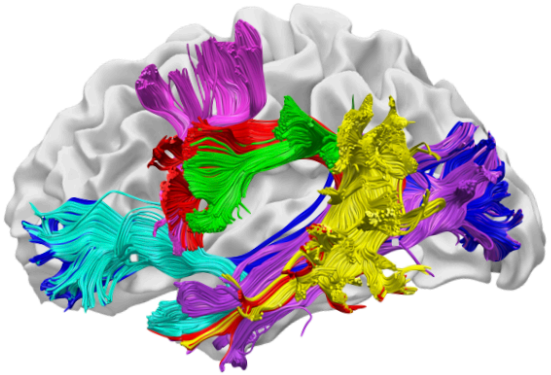


Yousry et al., 1997



Language System

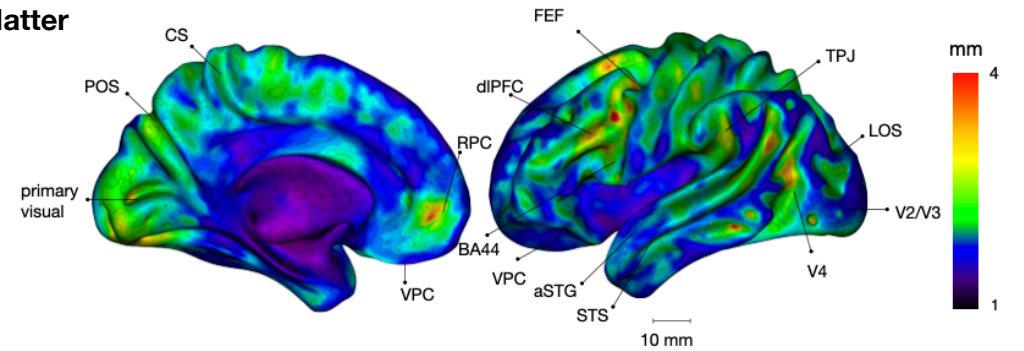




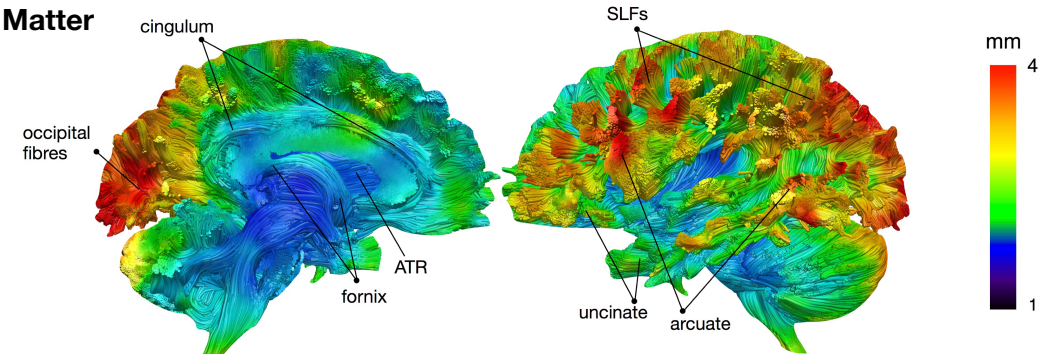
Inter-individual variability

HEALTHY VOLUNTEERS

Grey Matter



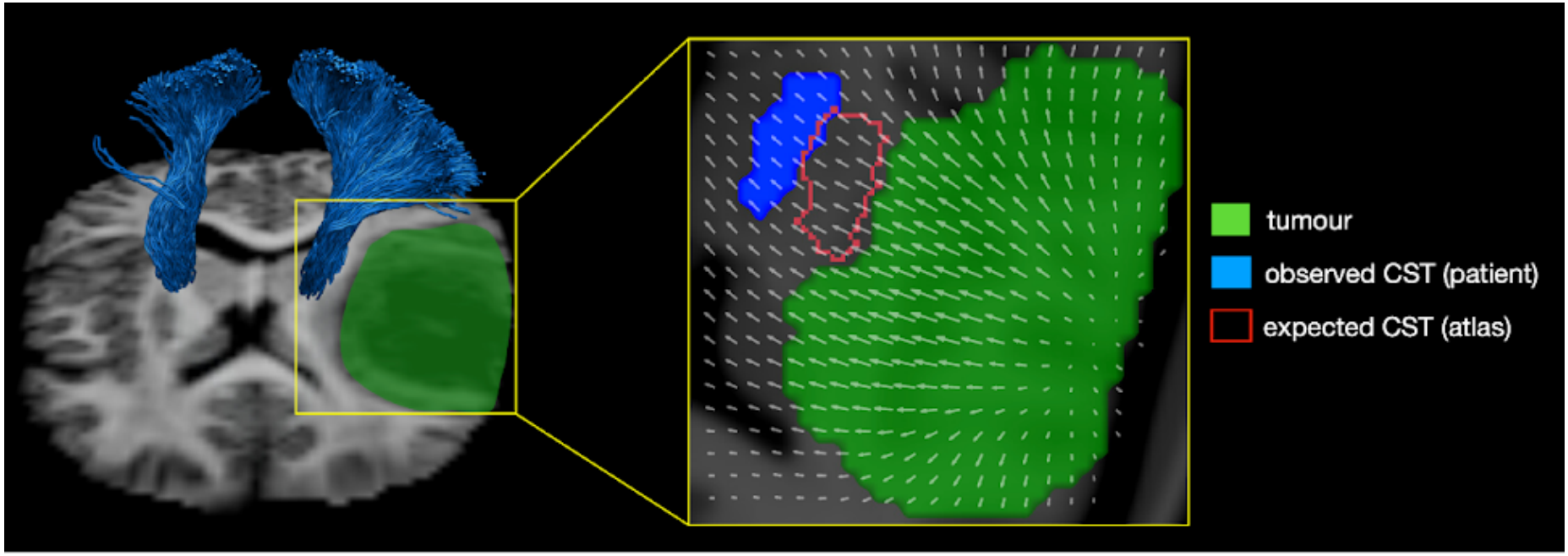
White Matter



Croxson, Forkel et al., 2018

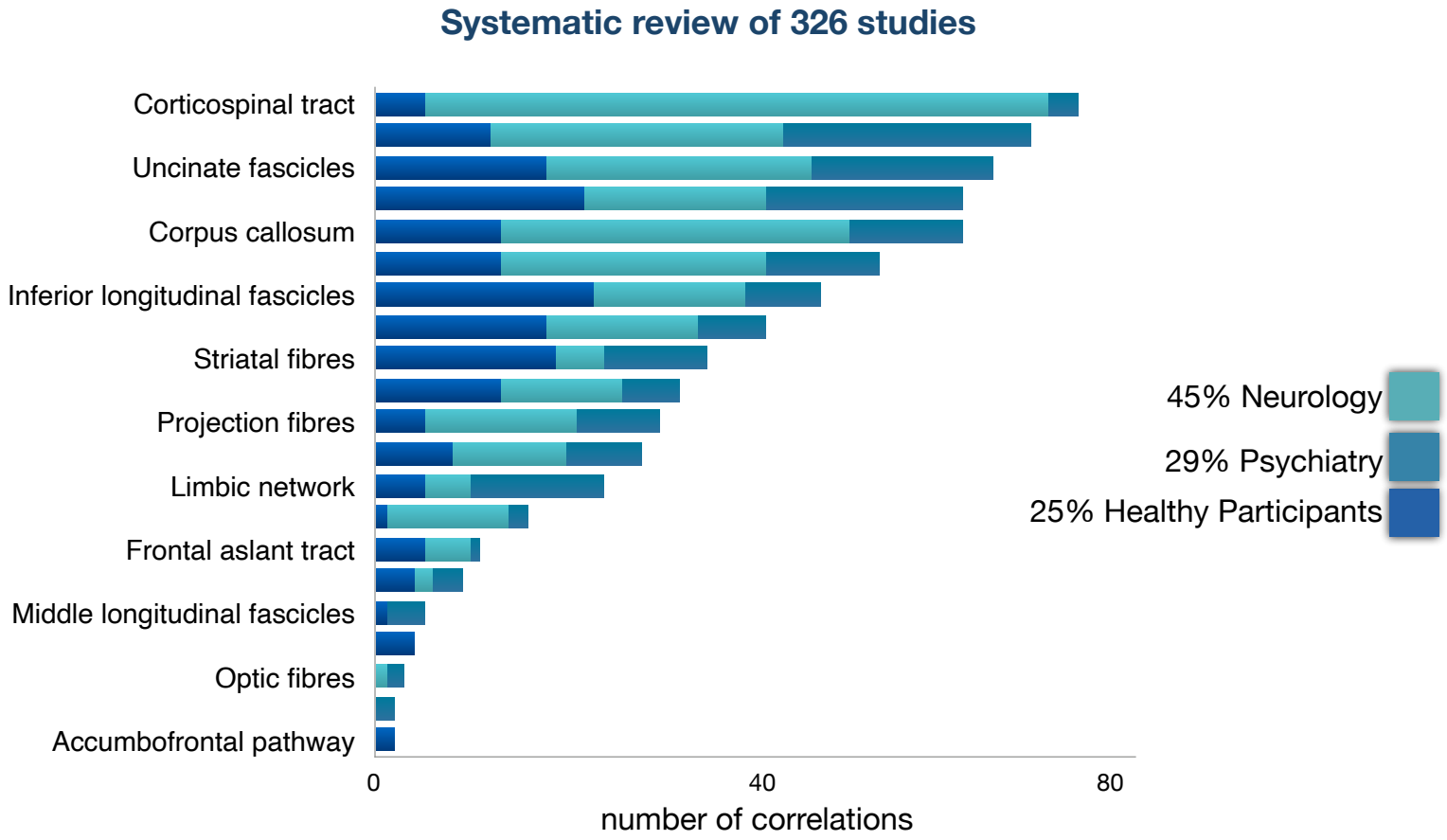
Watch talk on YouTube

Inter-individual variability



Forkel et al., forthcoming

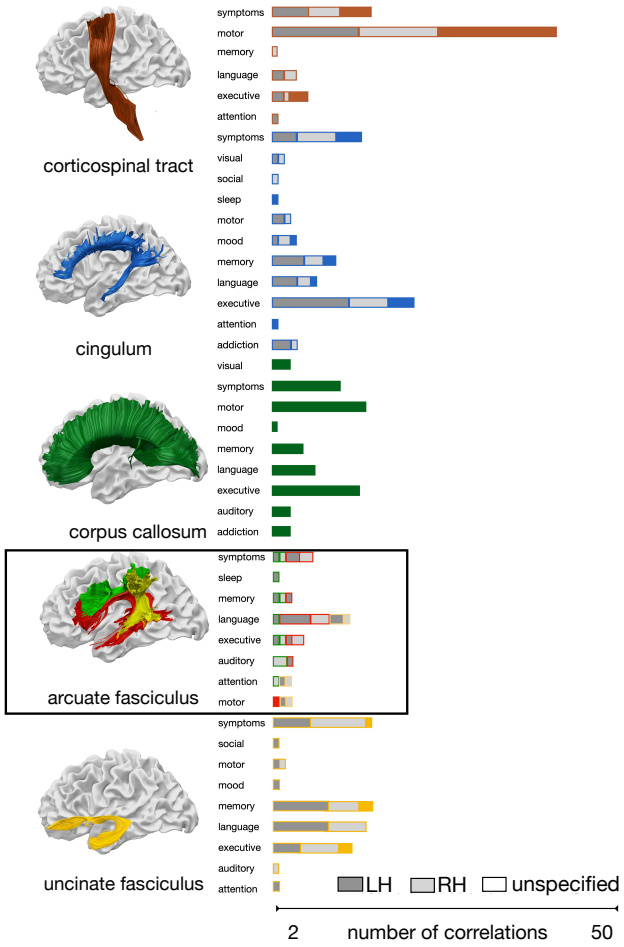
Variability in anatomy

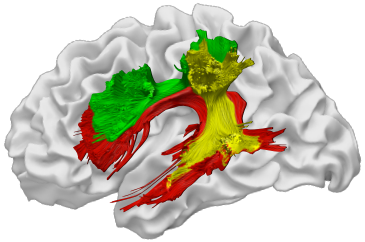


Forkel et al., BSAF 2022

Watch talk on YouTube

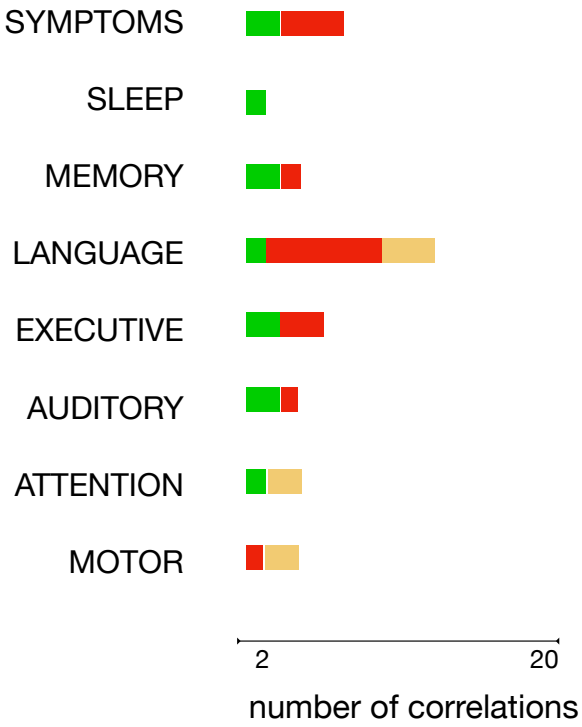
Variability in cognitive profiles





arcuate fasciculus

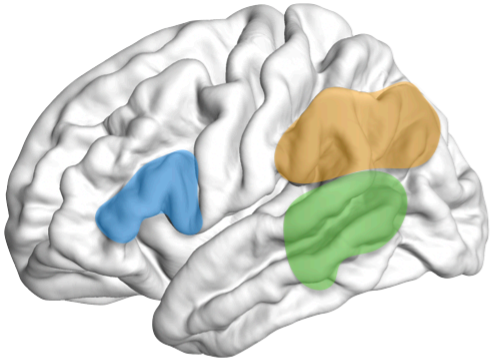
anterior segment
long segment
posterior segment



Forkel et al., BSAF 2022

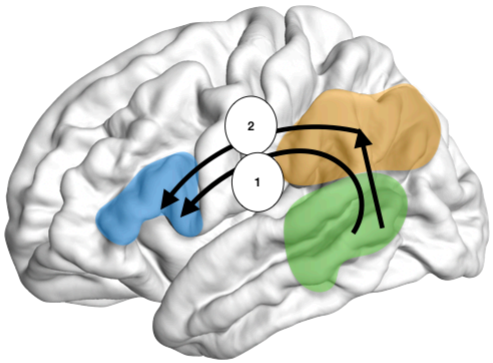
Watch talk on YouTube

Brain Model: Emerging propertise



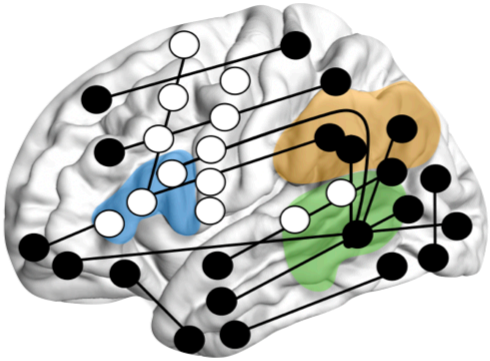
Modular model

- “Broca’s area’
- ‘Geschwind’s area’
- ‘Wernicke’s area’



Hierarchical model

1. Direct processing route
2. Indirect processing route



Integrative model

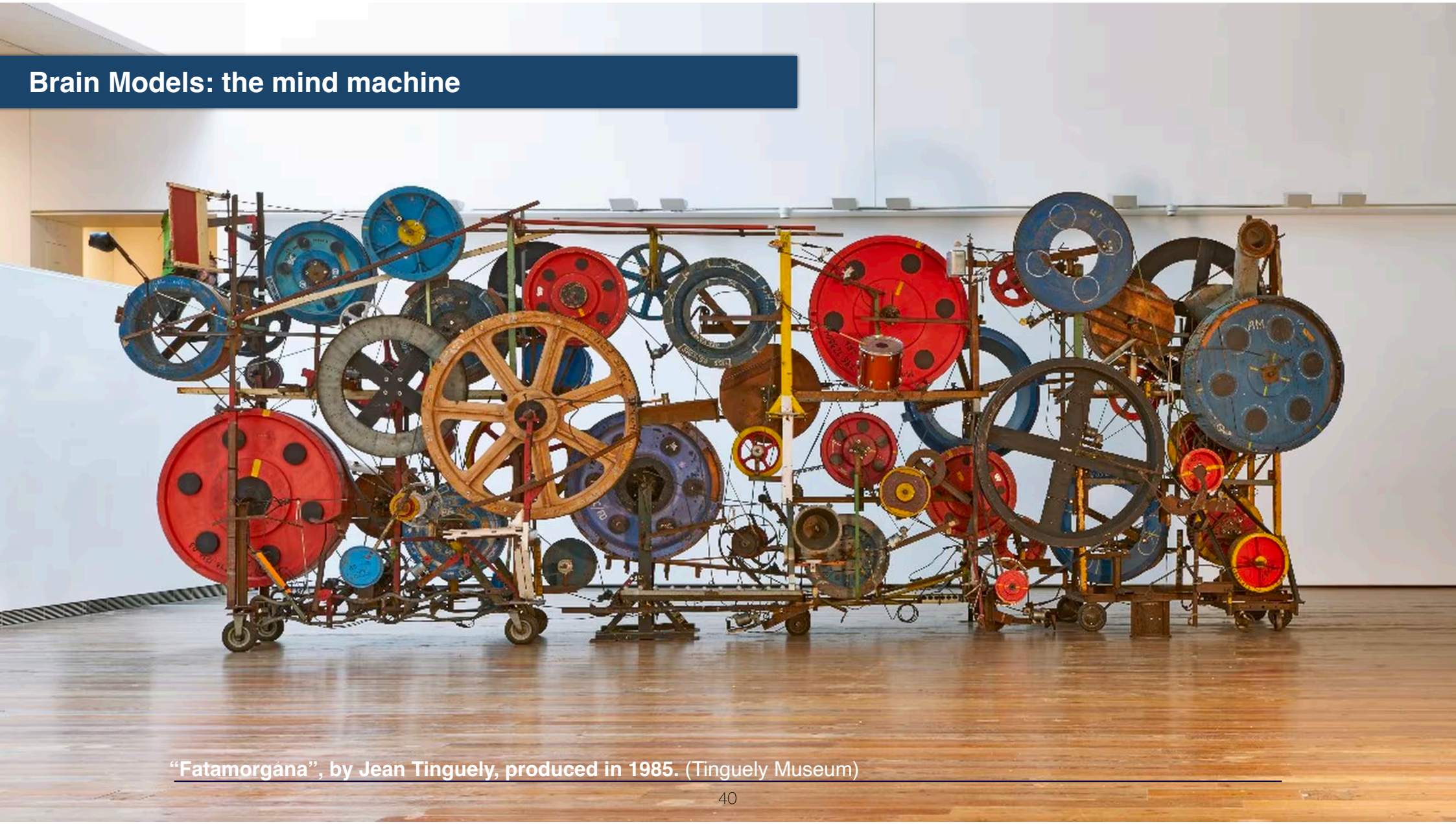
- Inactive
- Active

Thiebaut de Schotten & Forkel, 2022

The Language Orchestra

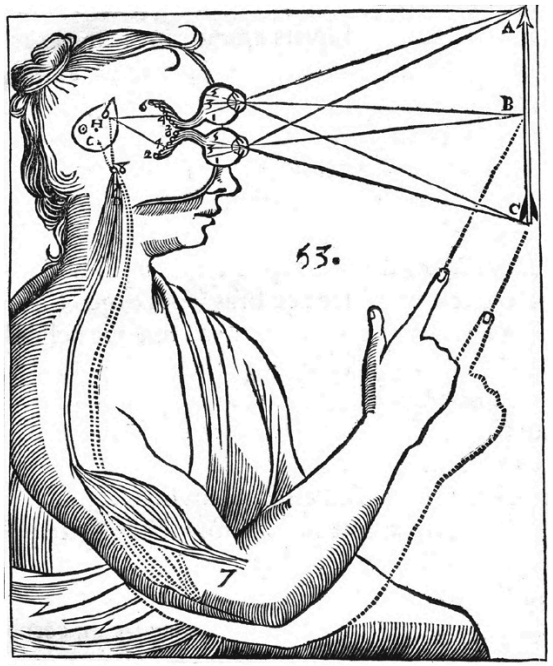
Thiebaut de Schotten & Forkel, 2022

Brain Models: the mind machine

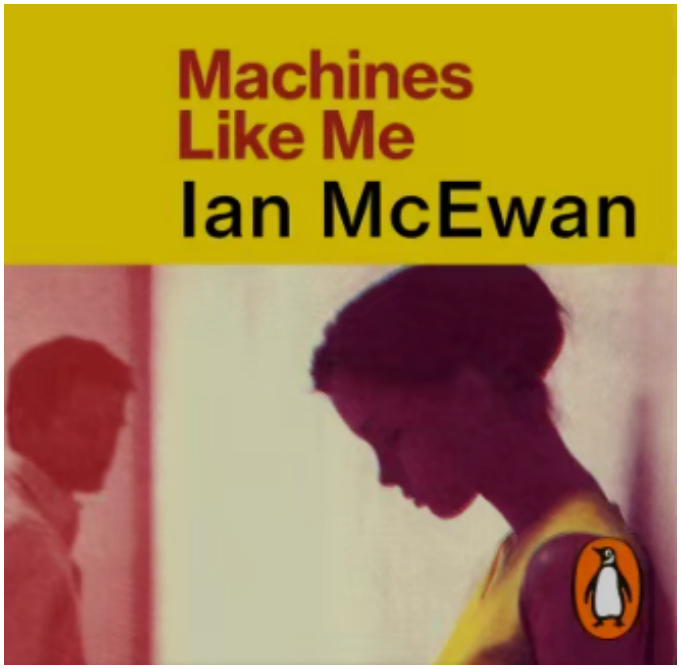


“Fatamorgana”, by Jean Tinguely, produced in 1985. (Tinguely Museum)

Brain Models: the mind machine



From L'homme de René Descartes , 2nd edn. (Paris: Girard, 1677), p. 74



Brain Models: the mind machine

nature

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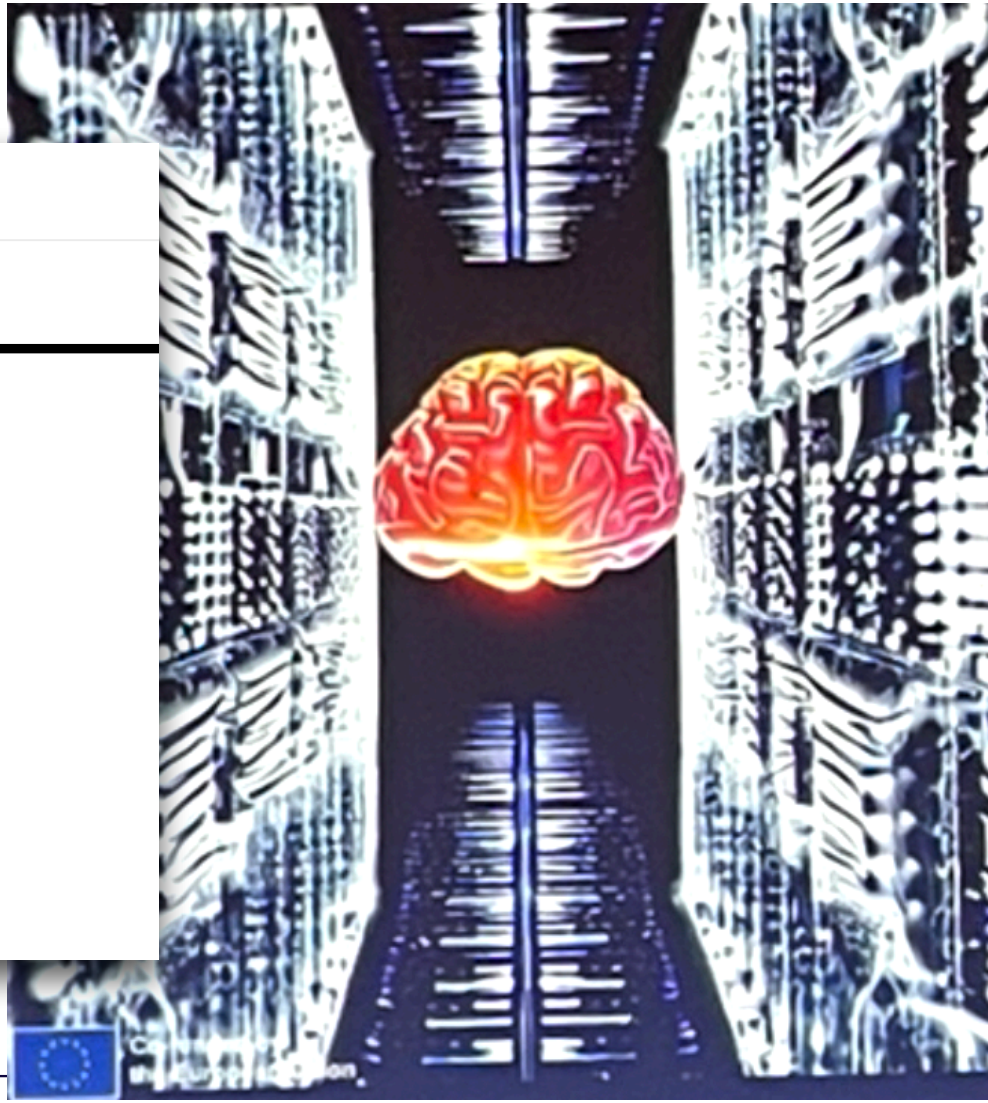
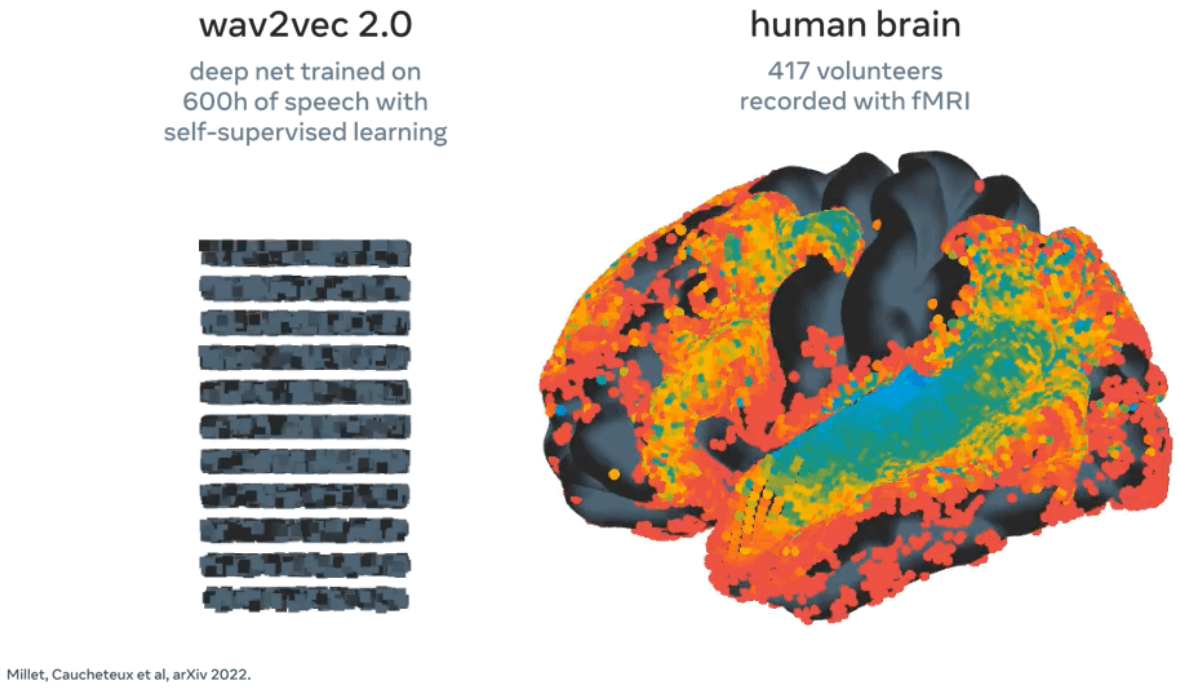
NEWS FEATURE | 22 August 2023 | Correction 22 August 2023

Europe spent €600 million to recreate the human brain in a computer. How did it go?



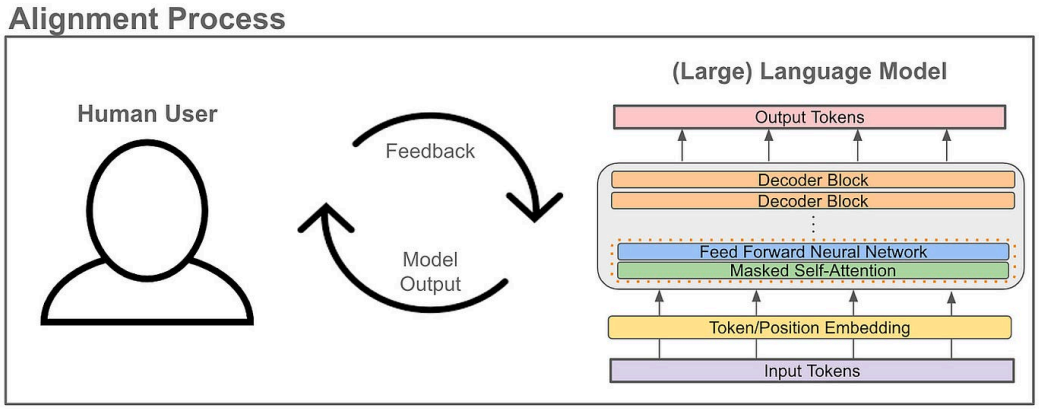
Brain Models: the mind machine

META: Using AI to decode speech from brain activity



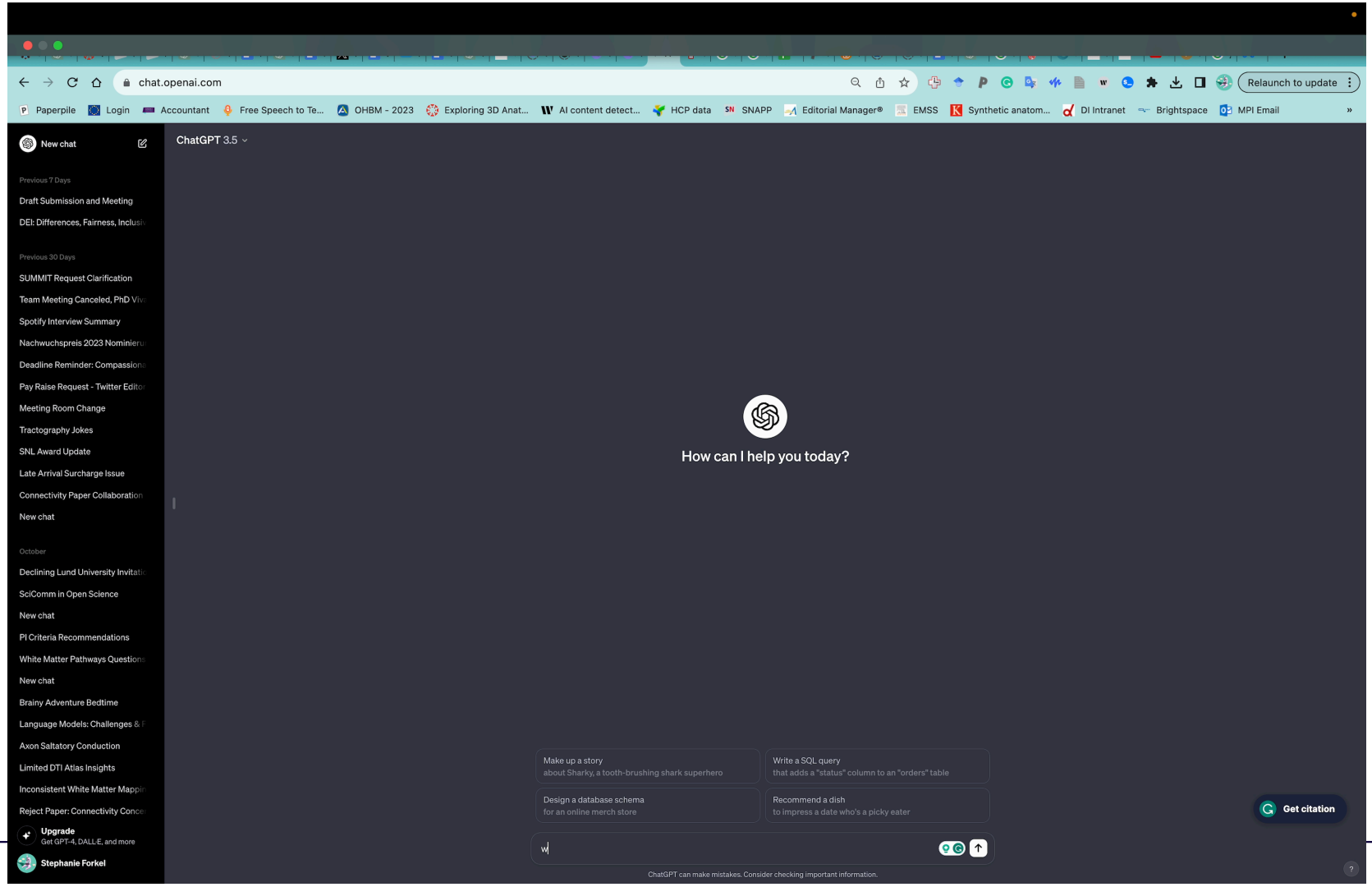
Jean Remi King, preprint

Brain Models: Large Language Models



Human language learning is a complex, dynamic process deeply embedded in social and cognitive experiences. LLMs, on the other hand, are algorithmic models trained on large datasets to generate language-like outputs but lack true understanding, consciousness, or the depth of human language acquisition.

Brain Models



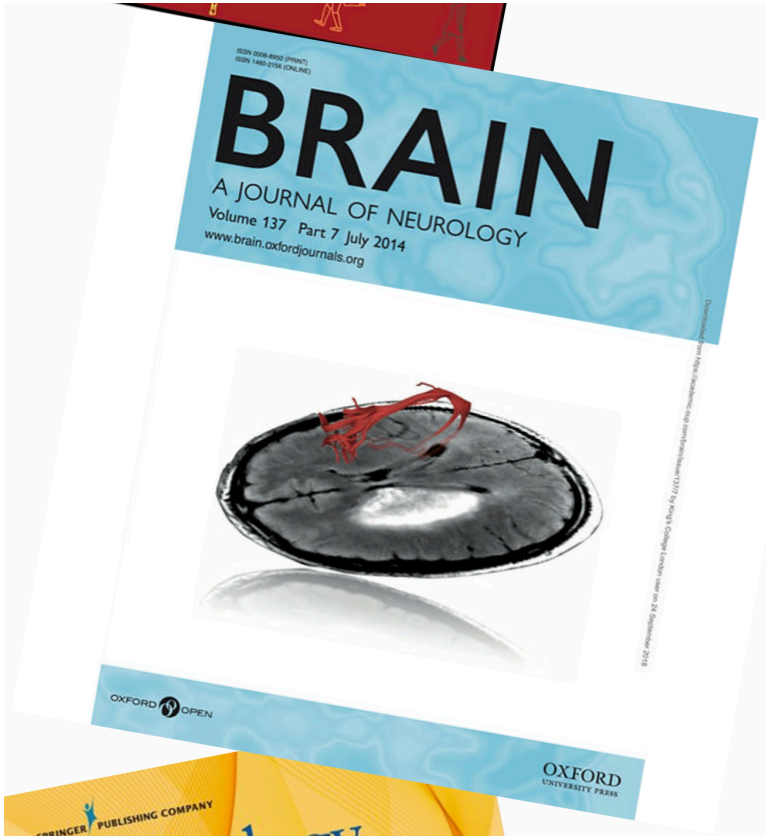
Consistently challenge what we think we know

‘Nous parlons avec l’hémisphère gauche’

(Broca, 1865)

Boraud & Forkel, BRAIN 2022

For tomorrow:



Read this paper for an in-depth discussion:

Anatomical predictors of aphasia recovery: a tractography study of bilateral perisylvian language networks.
Forkel SJ, Thiebaut de Schotten M, Dell'Acqua F, Kalra L, Murphy DG, Williams SR & Catani M. Brain 137(Pt7):2027-39, 2014. https://doi.org/10.1093/brain/awu113