

Brain, Connectivity & Behaviour

From anatomy to cognition

Stephanie Forkel

www.stephanieforkel.com

 @StephForkel



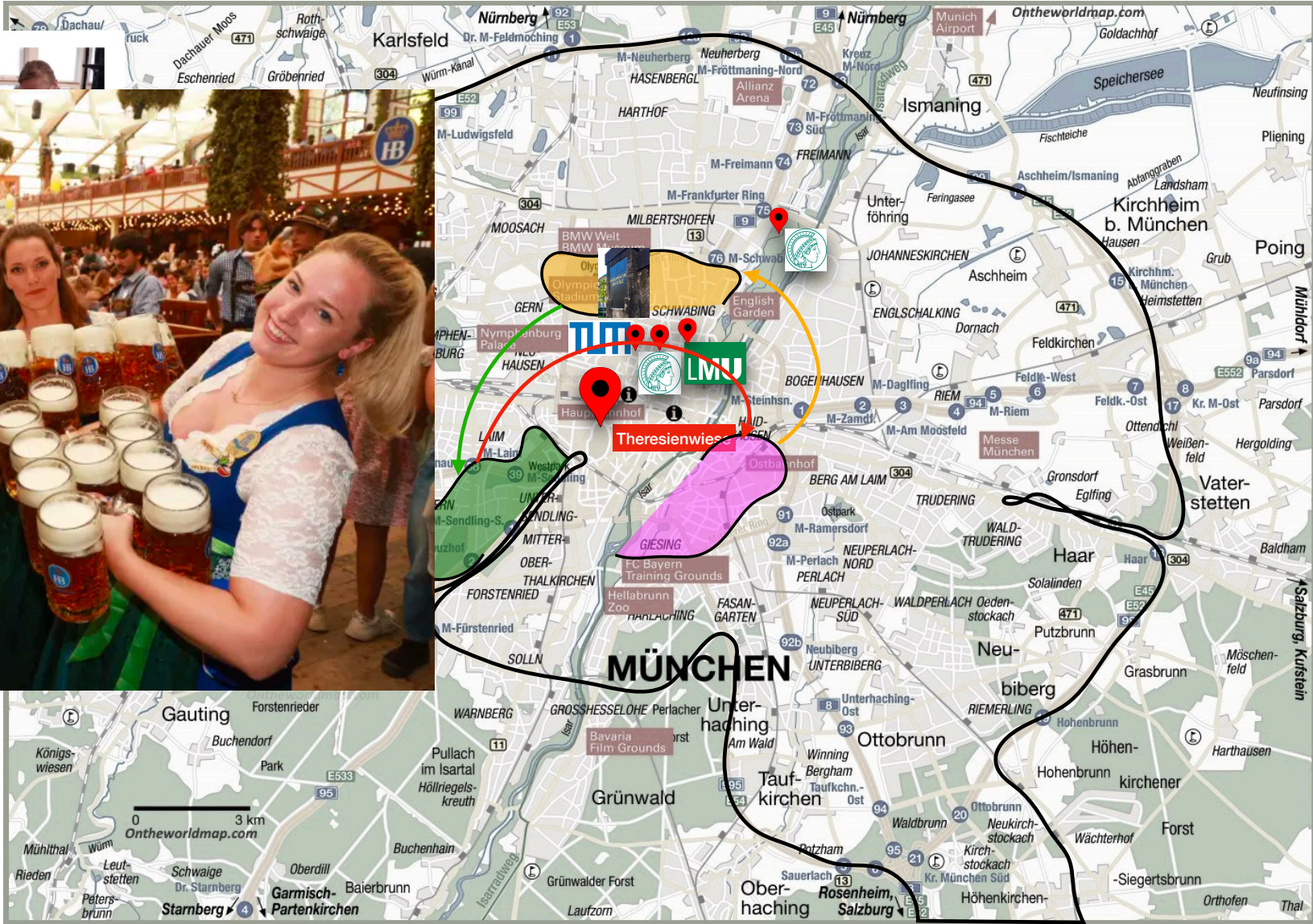
DONDERS
INSTITUTE



Radboud University
Nijmegen, the Netherlands



Historical detour – ‘A mecca for brain research’



VC



- Alois Alzheimer
 Neurodegenerative disorder
 Pick bodies



17 years of multidisciplinary neuroanatomy

post-mortem
dissections



2006
Munich



2017
Zurich



2018
Istanbul

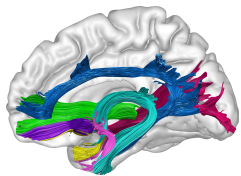


2019
London



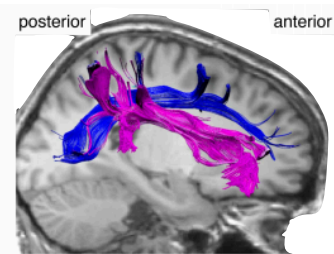
2021
YouTube Brain Anatomy Course
(Clinical Neuroanatomy Seminars)

&



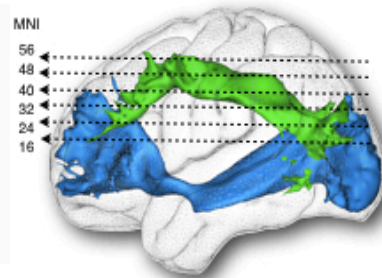
in vivo
tractography

Fronto-parietal



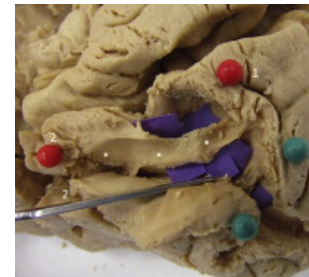
Nature Neuroscience, 2011

Fronto-occipital



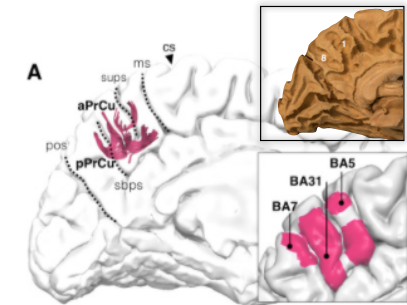
Cortex, 2014

Occipital U-shaped



Cortex, 2014

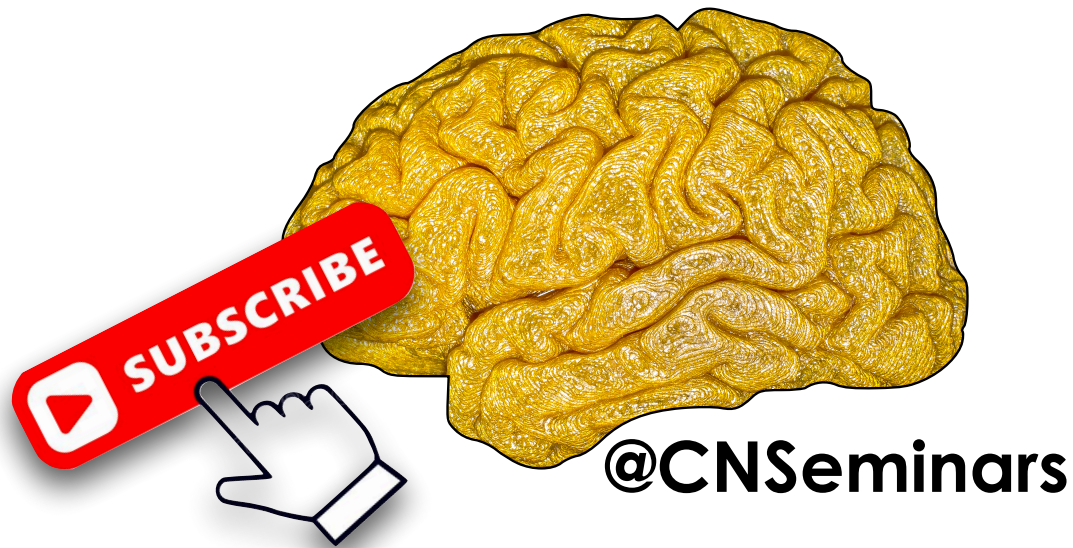
Comparative anatomy



Cortex, 2018

Discover & Discuss Exciting Science

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



@CNSeminars

Join us live:



Twitter: @CNSeminars

YouTube: ClinicalNeuroanatomySeminars

Website: www.clinicalneuroanatomyseminars.com



THIS WEEK:

Join us live:



WEDNESDAY
November 22nd
4pm Amsterdam time



@CNSeminars

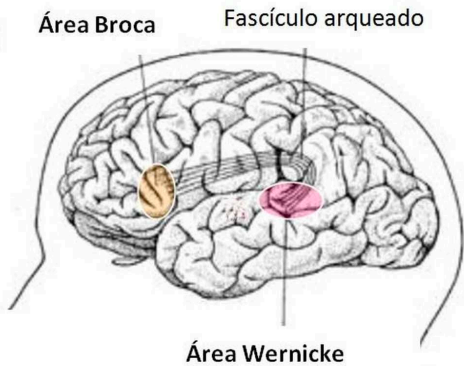


**Multi-species translational neuroimaging
strategies in psychiatry**

**Dr Mallar Chakravarty
Director, Brain Imaging Centre,
Douglas Research Centre**

@CNSeminars #CNStalk youtube.com/c/ClinicalNeuroanatomySeminars

FROM ANATOMY TO COGNITION



**Monday:
Brain Models**

References:
Science 2022,
OUP 2012



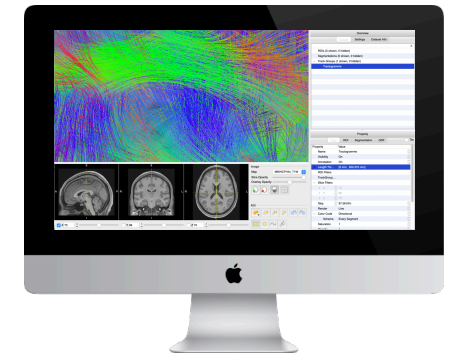
**Tuesday:
Methods to study connectional
anatomy of language**

References:
Brain 2014
Neurology 2020



**Wednesday:
CNStalks at 4pm on YouTube**

References:
n/a



**Thursday:
Tractography Practical**

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

[*'ste.fə.ni.'fo:kəl*]

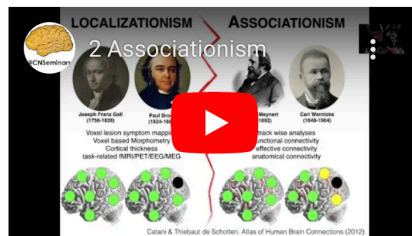
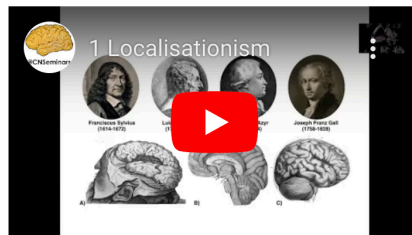
HDR PhD CPsychol SFHEA



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.](https://doi.org/10.1126/science.abq2591) 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](https://doi.org/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 Workshon'. Please download the folder ahead

Brain Models

From anatomy to cognition

Stephanie Forkel

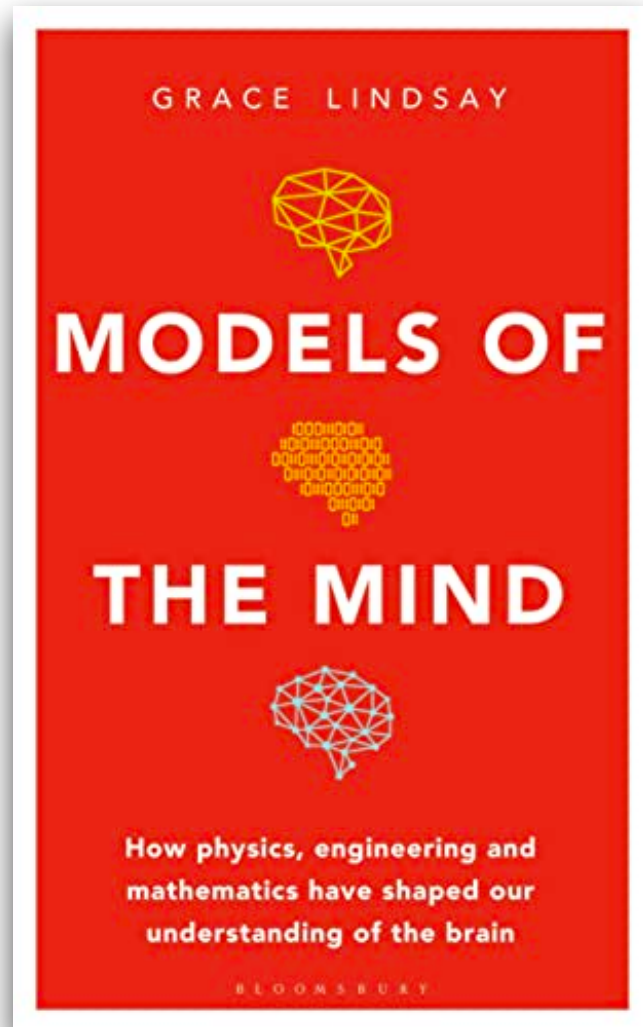
www.stephanieforkel.com

 @StephForkel



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Nijmegen, the Netherlands





"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)

What Brain models do you know already?

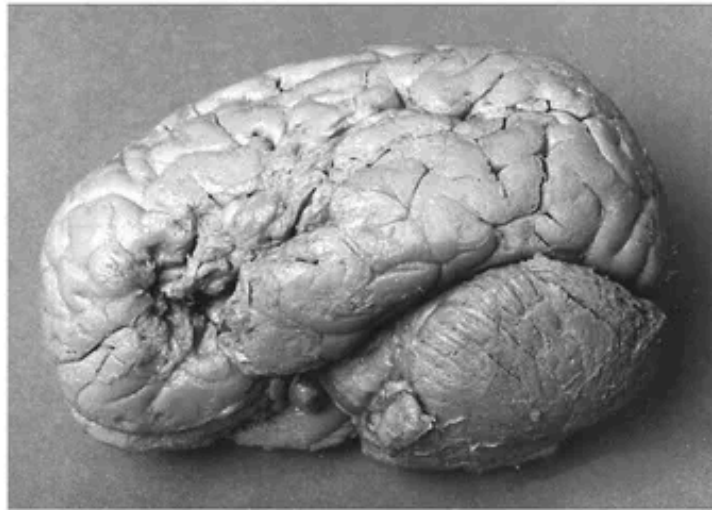
Brain Model: Localisationism

**Phineas Gage
(1823–1860)**



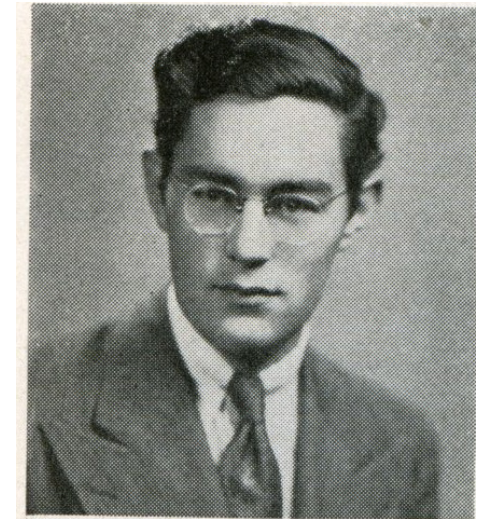
Source: Wikipedia

**Louis Victor Leborgne
(1809–1861)**



Dronkers et al., Brain 2007

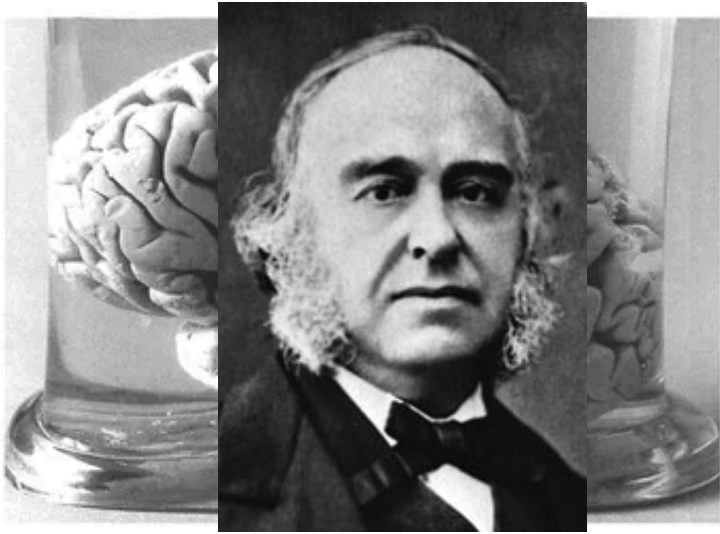
**Henry Gustave Molaison
(1926–2008)**



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

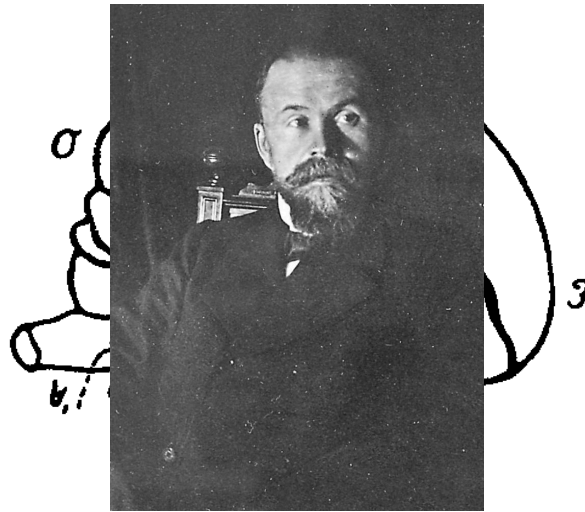
Brain Model: Localisationism

**Paul Broca
(1824–1880)**



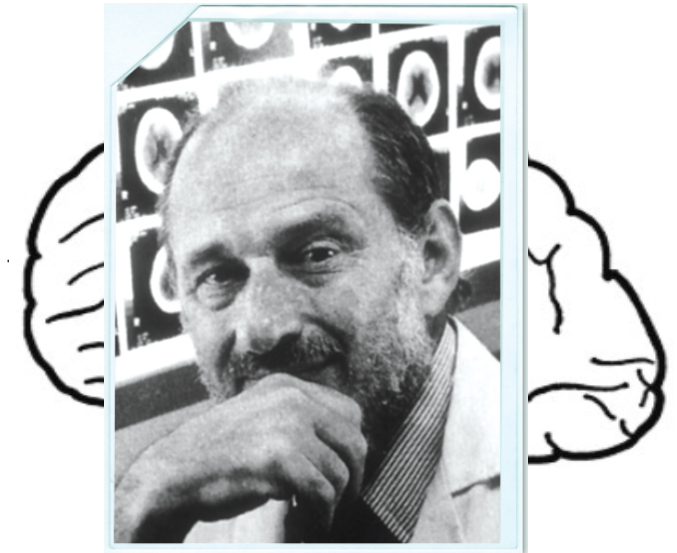
Dronkers et al., Brain 2007

**Carl Wernicke
(1848–1905)**



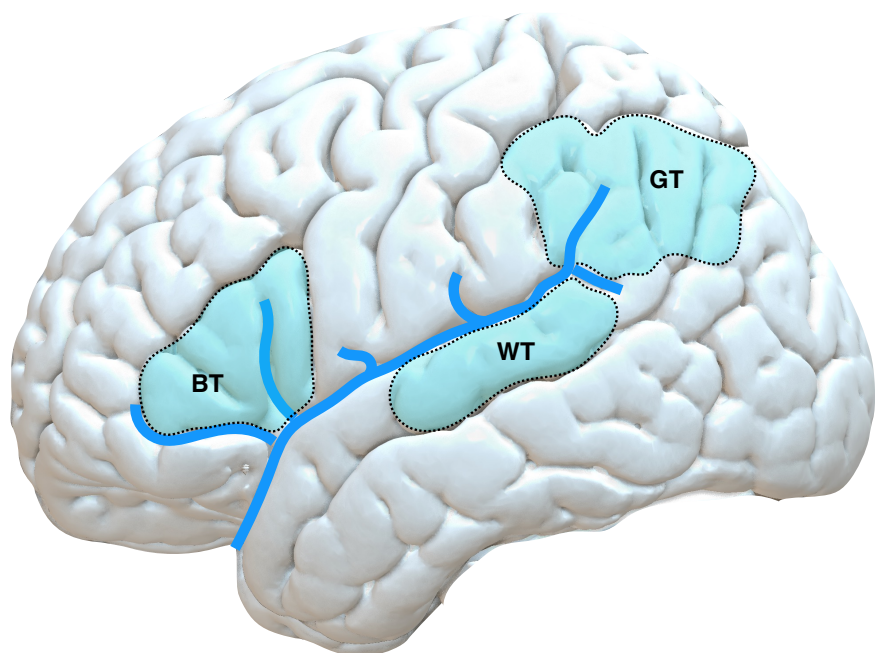
Wernicke, 1874

**Norman Geschwind
(1926–1984)**

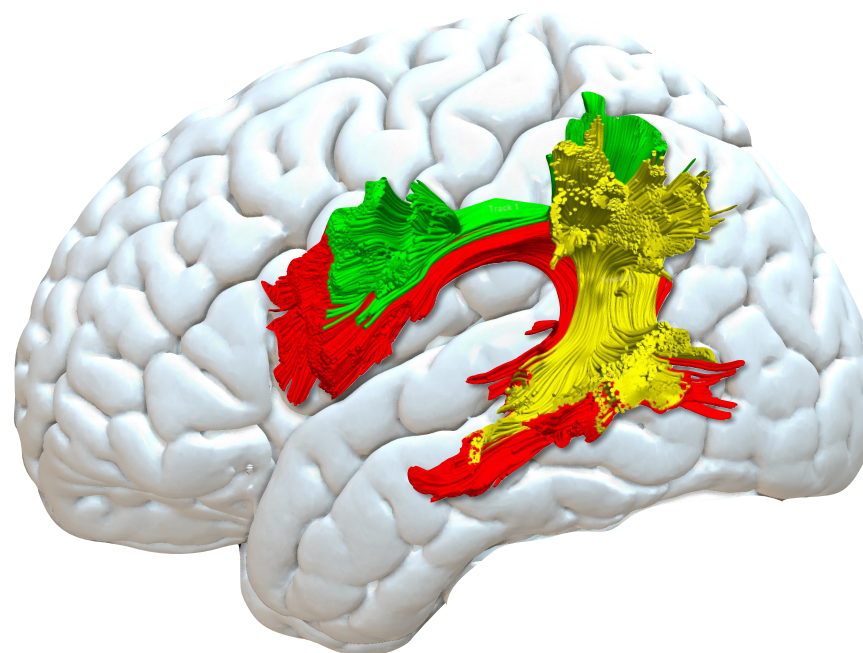


Geschwind, Science 1970

Cortical anatomy



Connectional anatomy

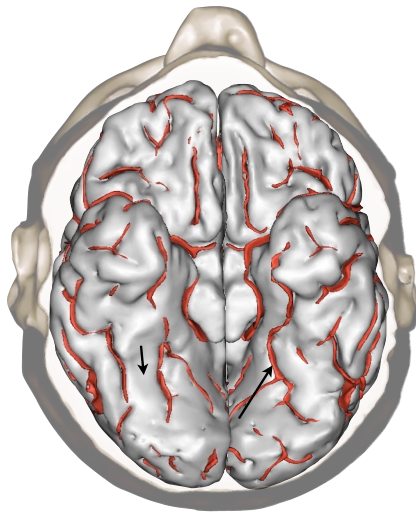


BUT...



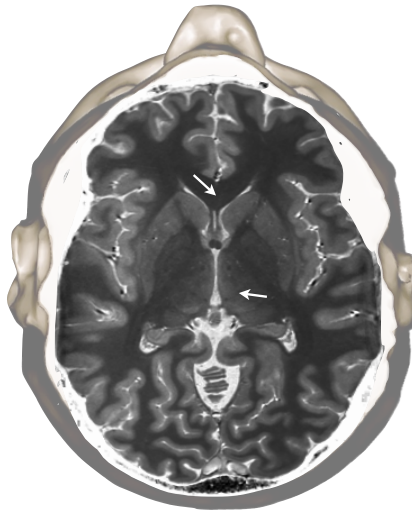
Different Neuroanatomies

SURFACE ANATOMY



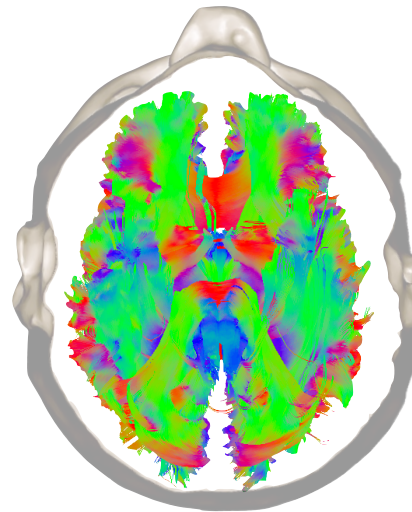
Expl. precentral gyrus

SECTIONAL ANATOMY



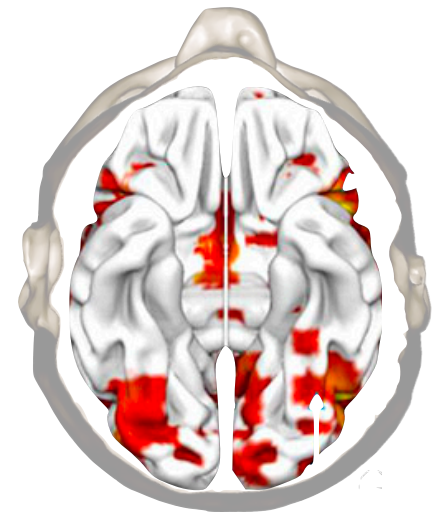
BA6

CONNECTIONAL ANATOMY



U-shaped fibres

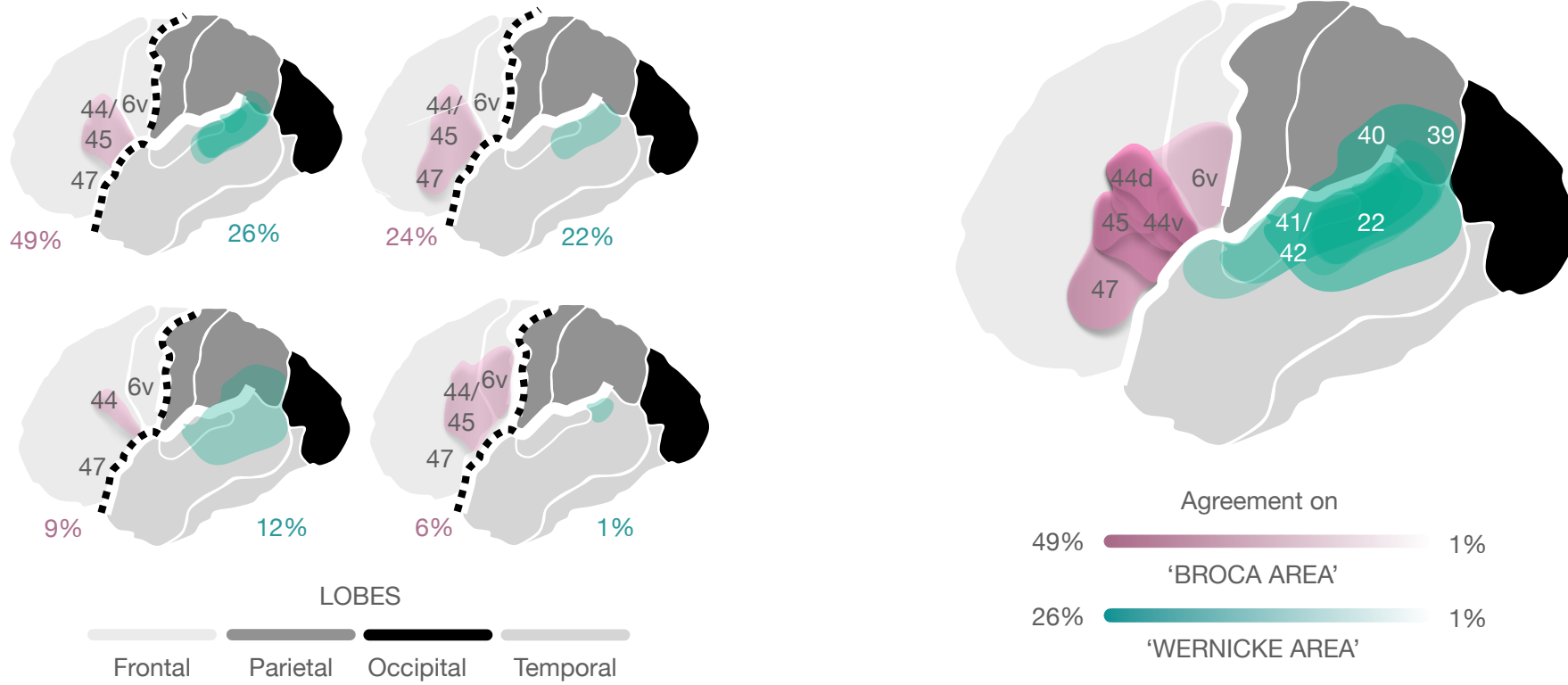
FUNCTIONAL ANATOMY



Catani & Thiebaut de Schotten, 2012

M1

Where is language in the brain?

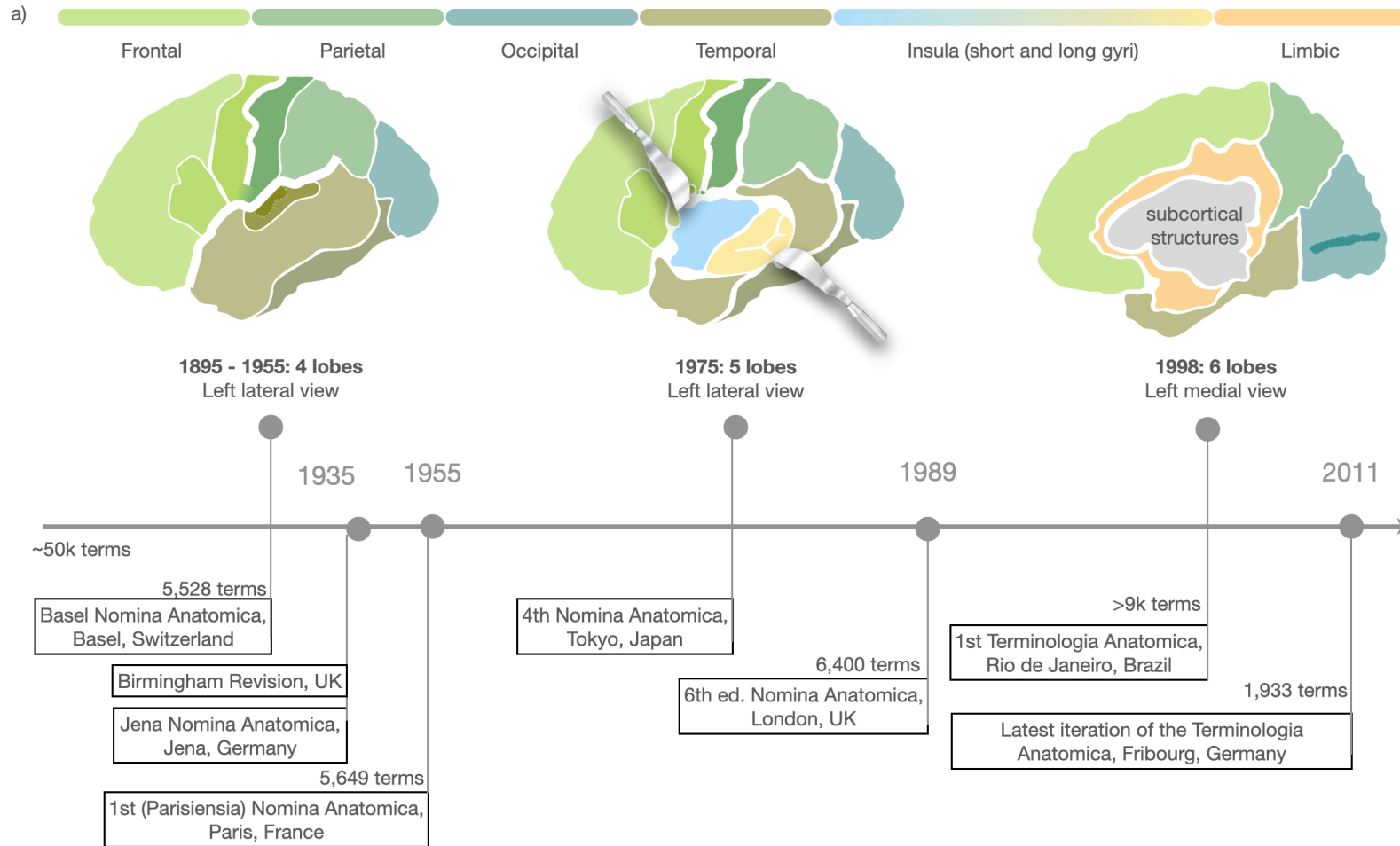


modified from Tremblay & Dick 2016

How many lobes does the brain have?

1 2 3 4 5 6 7

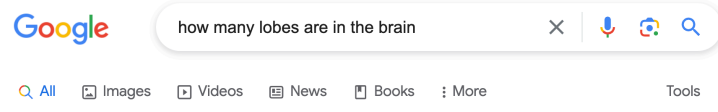
How many lobes does the brain have?



Dulyan & Forkel, under review

Is AI so much smarter than us?

b)



About 22.800.000 results (0,43 seconds)

four lobes

The cerebrum consists of two cerebral hemispheres the outer layer called the cortex (gray matter) and the inner layer (white matter). There are four lobes in the cortex, the frontal lobe, parietal lobe, temporal lobe, occipital lobe. This review article will focus on the functions of the cerebral cortex. 28 Apr 2022

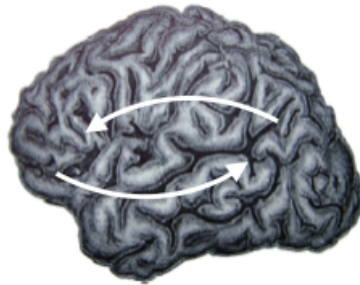
MAY 2023

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?

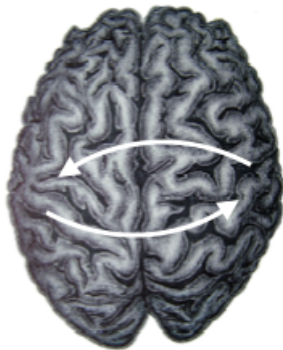
White matter classification



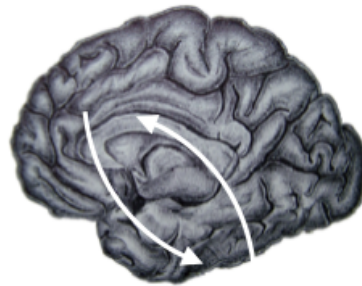
ASSOCIATION FIBERS



Theodor Meynert
(1833-1892)



COMMISSURAL FIBERS

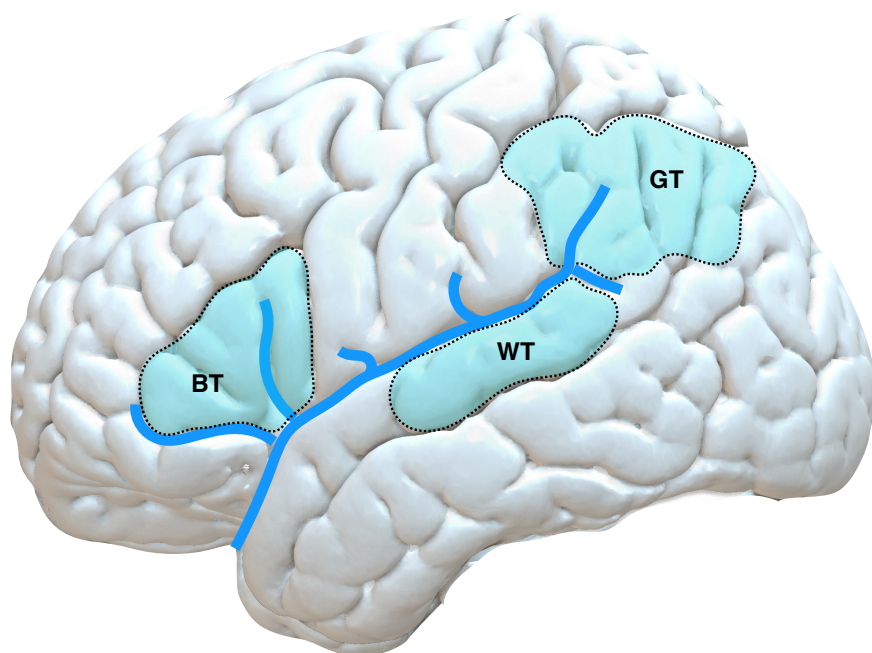


PROJECTION FIBERS

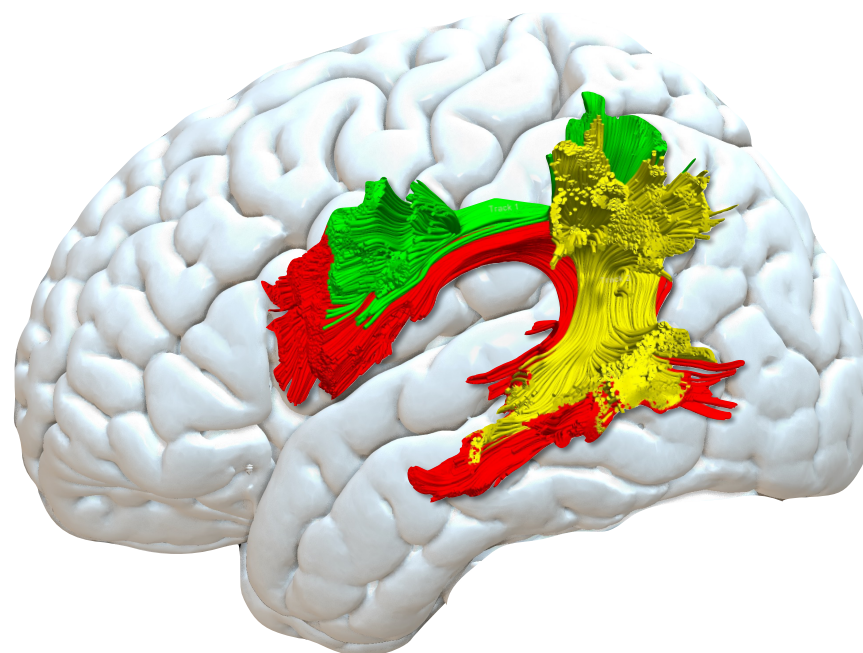
Catani, Forkel & Thiebaut de Schotten, 2010

Limitations of the language model

Cortical anatomy

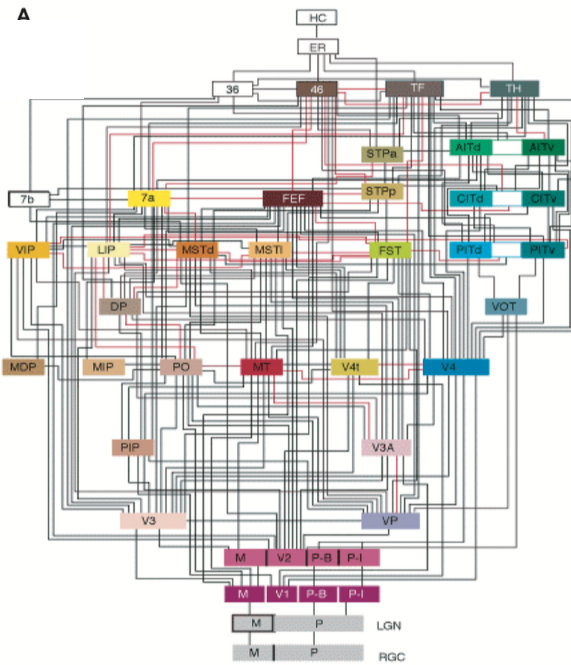


Connectional anatomy



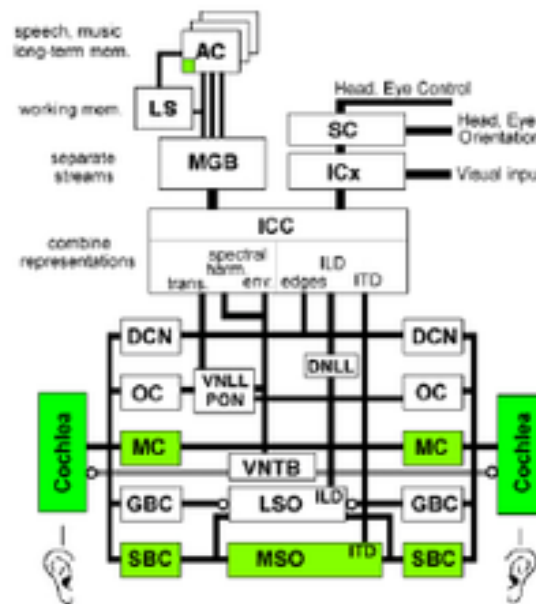
Naïveté?

Visual System



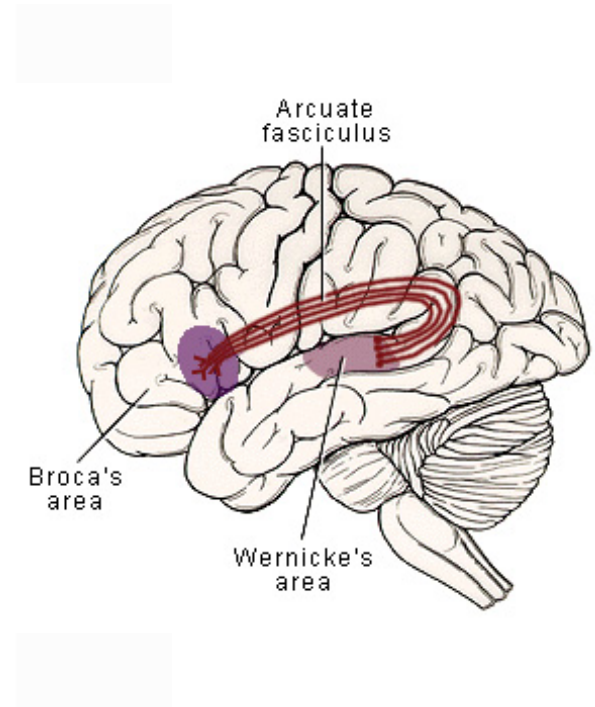
Van Essen 1991

Auditory System



Crick and Koch 1998

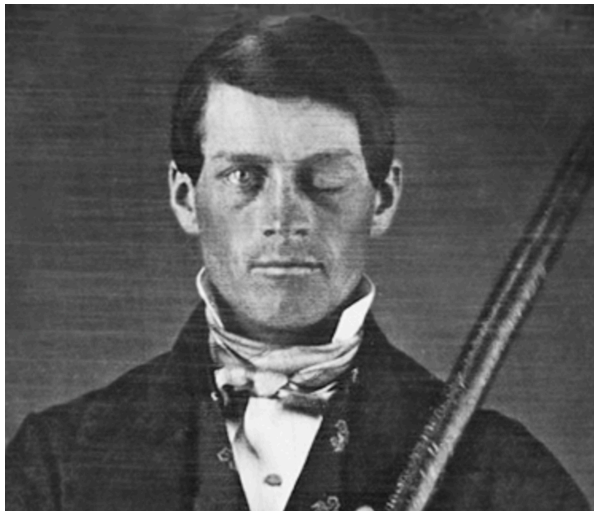
Language System



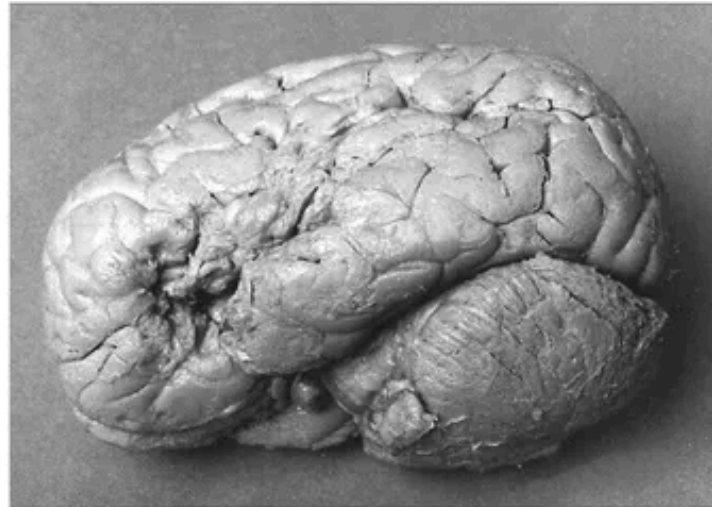
Most textbooks

Brain Model: Associationism

**Phineas Gage
(1823–1860)**

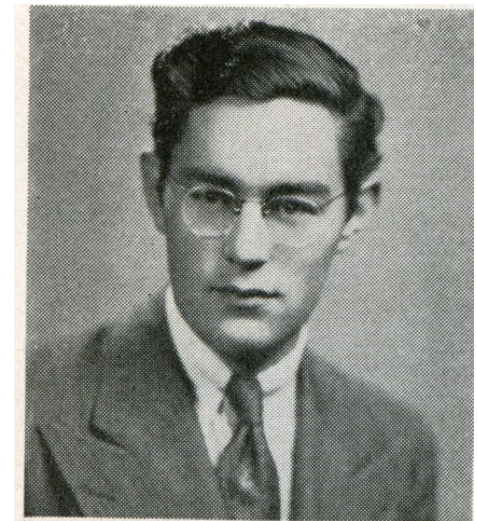


**Louis Victor Leborgne
(1809–1861)**



Frontal Insular Region
Frontal Orbito Polar

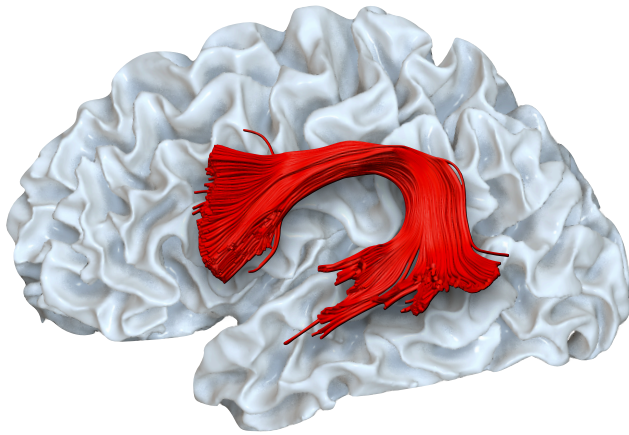
**Henry Gustave Molaison
(1926–2008)**



Thiebaut de Schotten et al., 2015

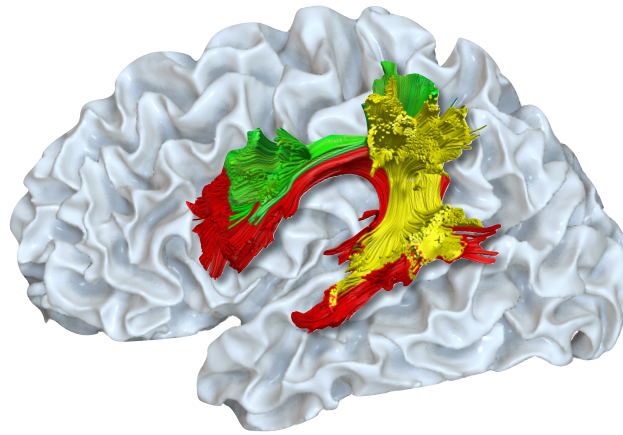
Language connectome: then and now

19th century



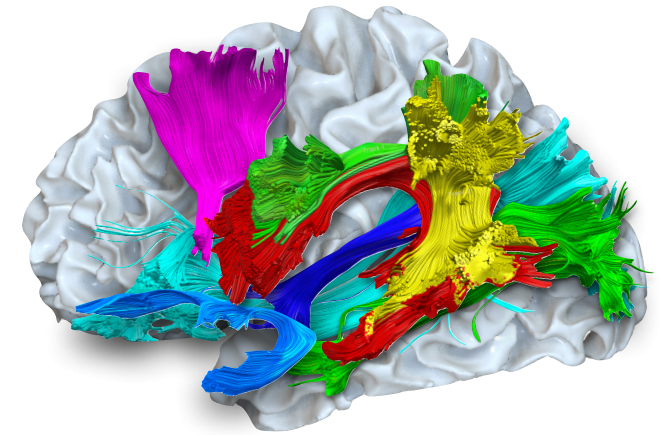
Arcuate fasciculus

Early 2000s



- Anterior segment
- Long segment
- Posterior segment

21st century

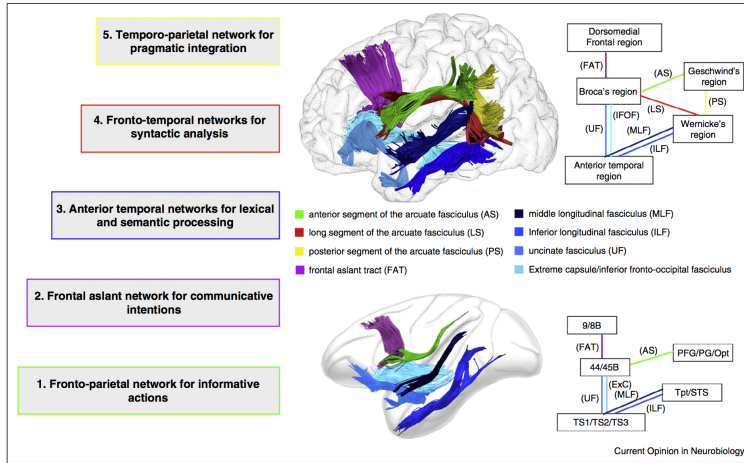


- Frontal Aslant Tract
- Uncinate fasciculus
- Temporal longitudinal fasciculus (TLF)
- Inferior fronto-occipital fasciculus (iFOF)
- Inferior longitudinal fasciculus (ILF)

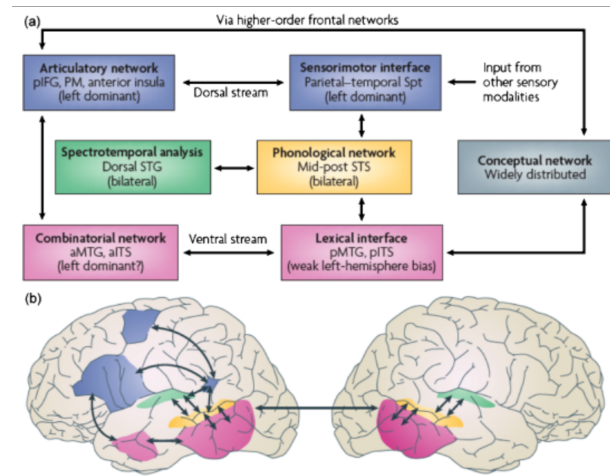
Forkel & Catani, Oxford Handbook of Neurolinguistics, 2018

Models of Language

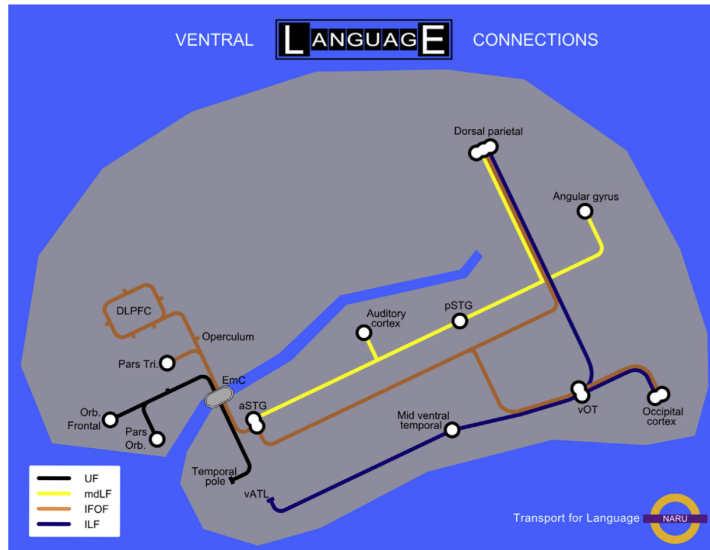
Psychiatry



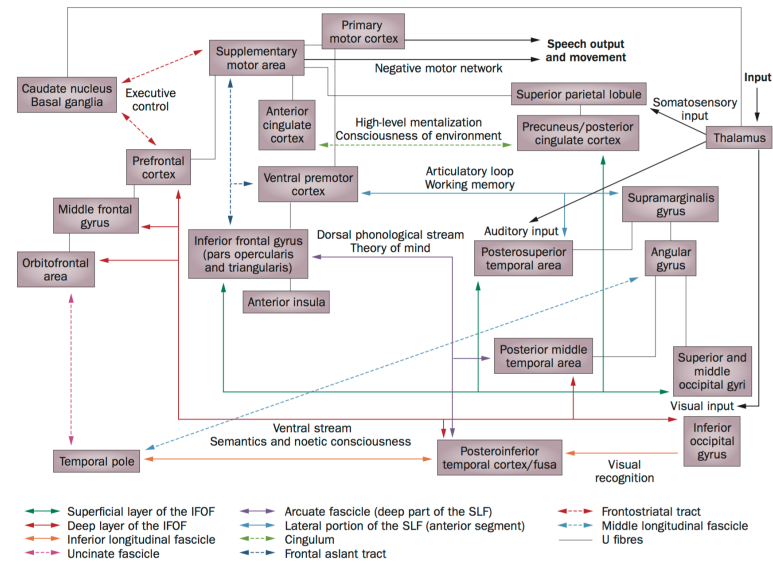
Evolution



Neurology

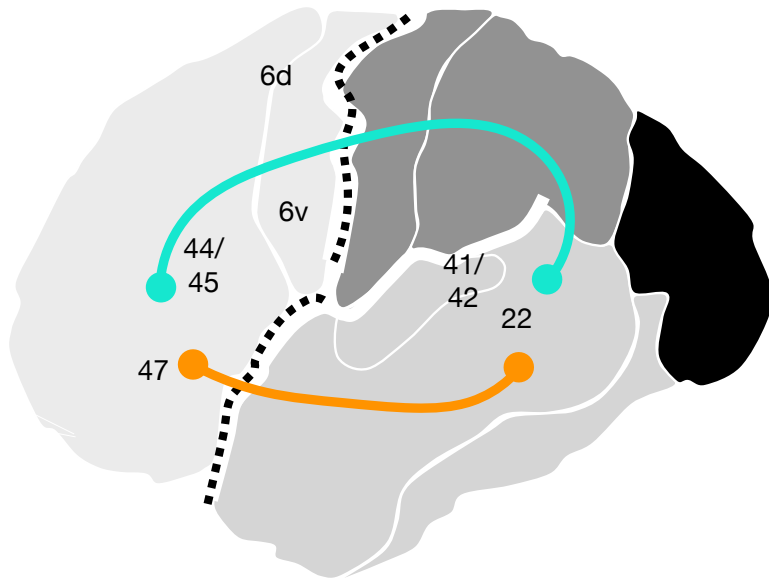


Neurosurgery



Why have these models not yet answered
how language works in the brain?

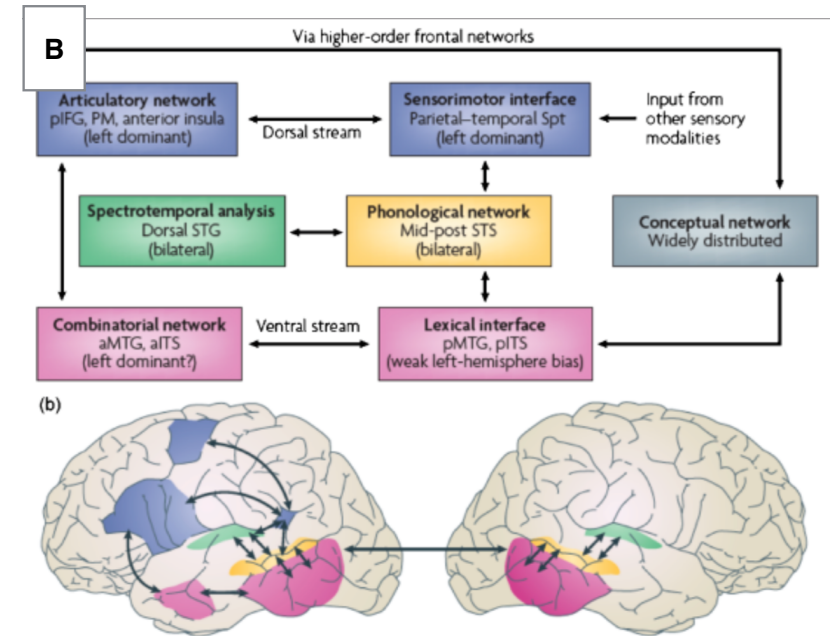
From Evolutionary Models to Anatomical Models



Dorsal Stream

vs.

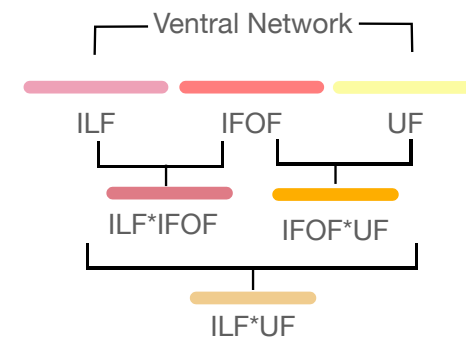
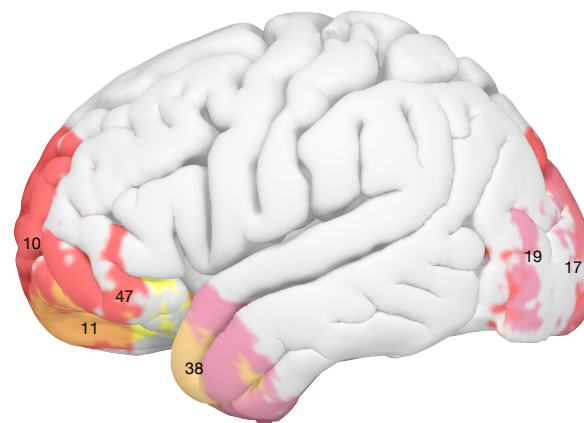
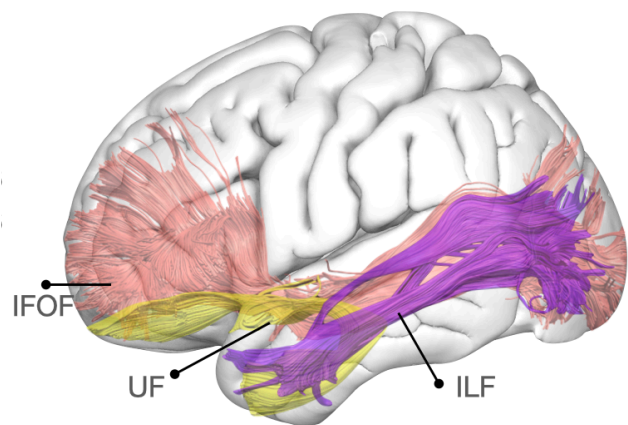
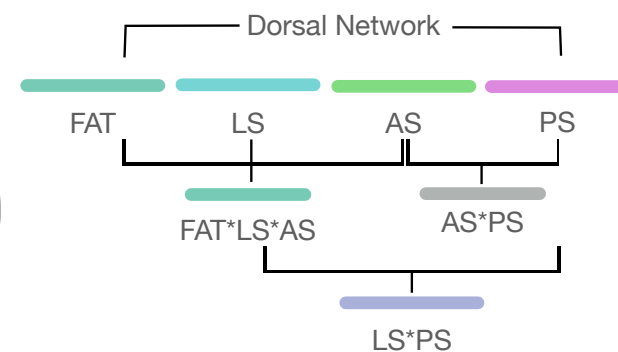
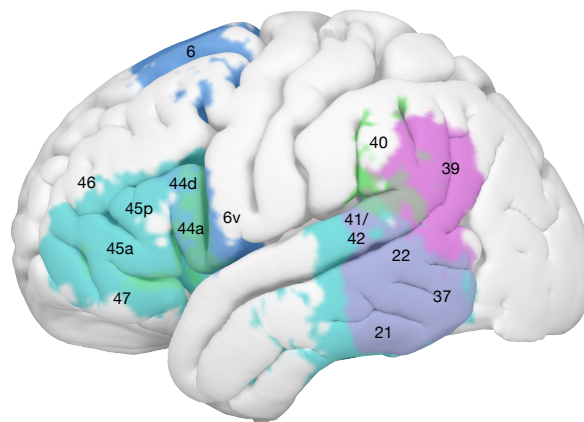
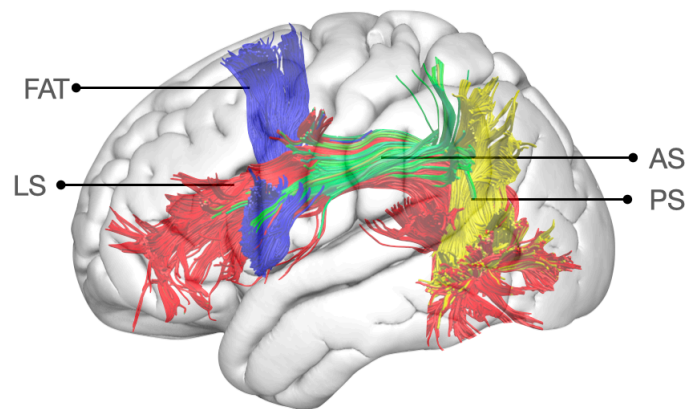
Ventral Stream



Q1. What does dorsal/ventral mean?

Q2. What defines the dorsal/ventral boundary?

Language Associationism



The Averaging Problem



1. Gerty Theresa Radnitz-Cori 1947



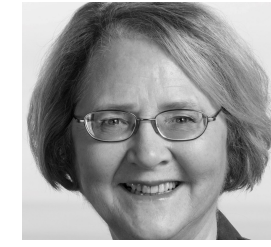
2. Rosalyn Sussman Yalow 1977



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



Credit Eva Guzman Chacon, BSc



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

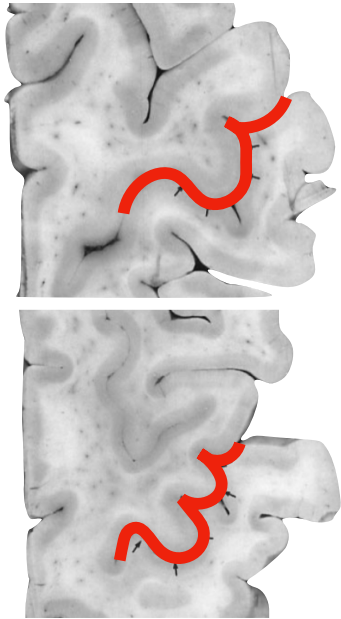


13. Katalin Karikó Francia 2023

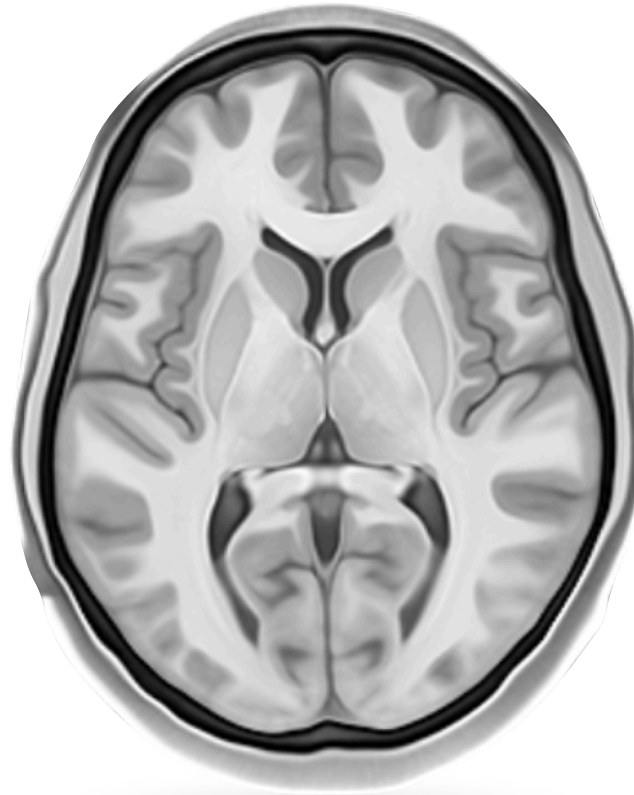
<https://www.lindau-nobel.org/professor-elizabeth-blackburn-on-unconscious-biases/>

Neurovariability

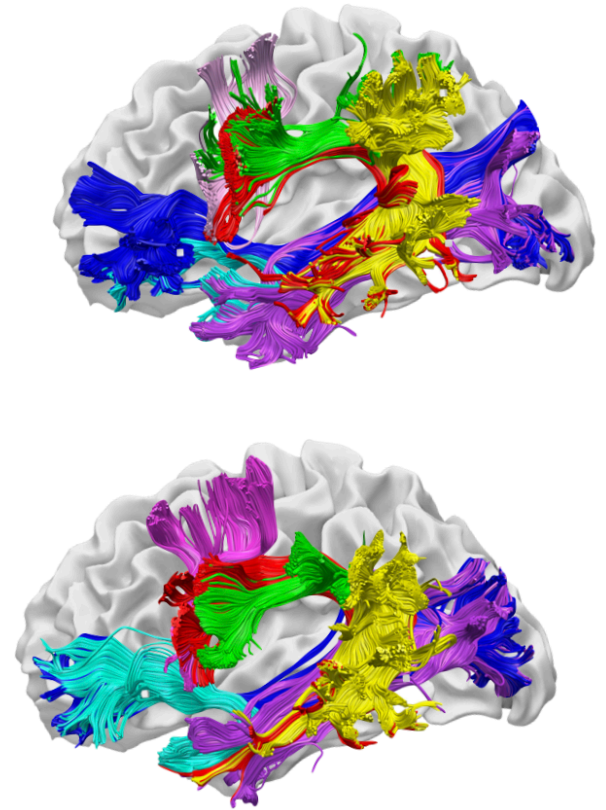
Motor cortex



Yousry et al., 1997



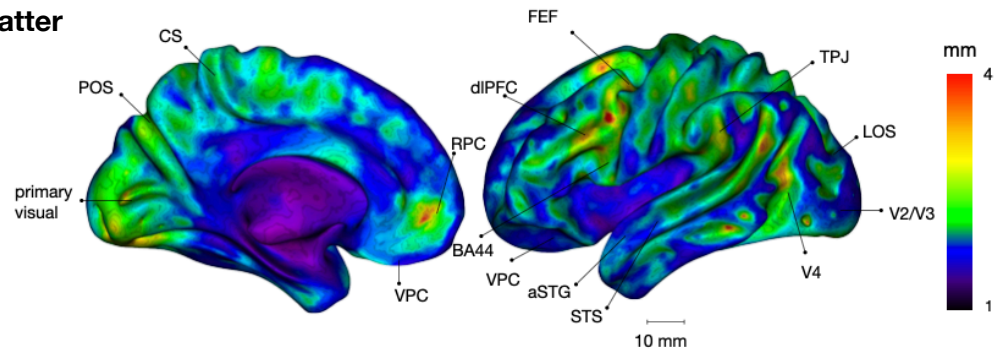
Language System



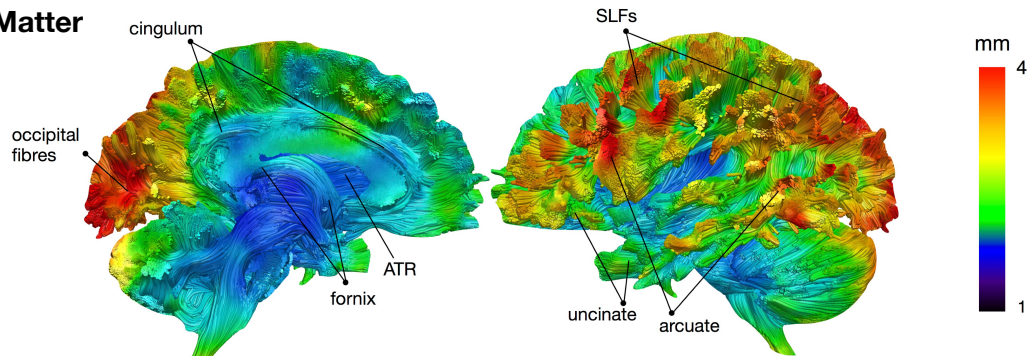
Inter-individual variability

HEALTHY VOLUNTEERS

Grey Matter



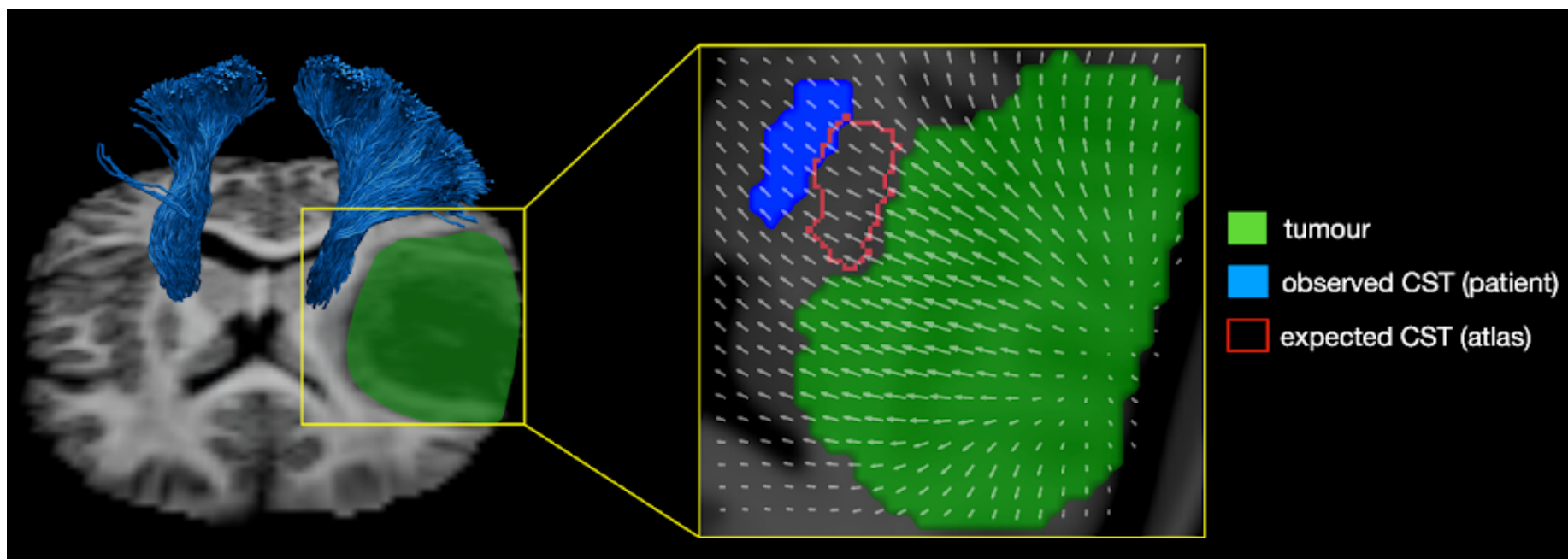
White Matter



Croxson, Forkel et al., 2018



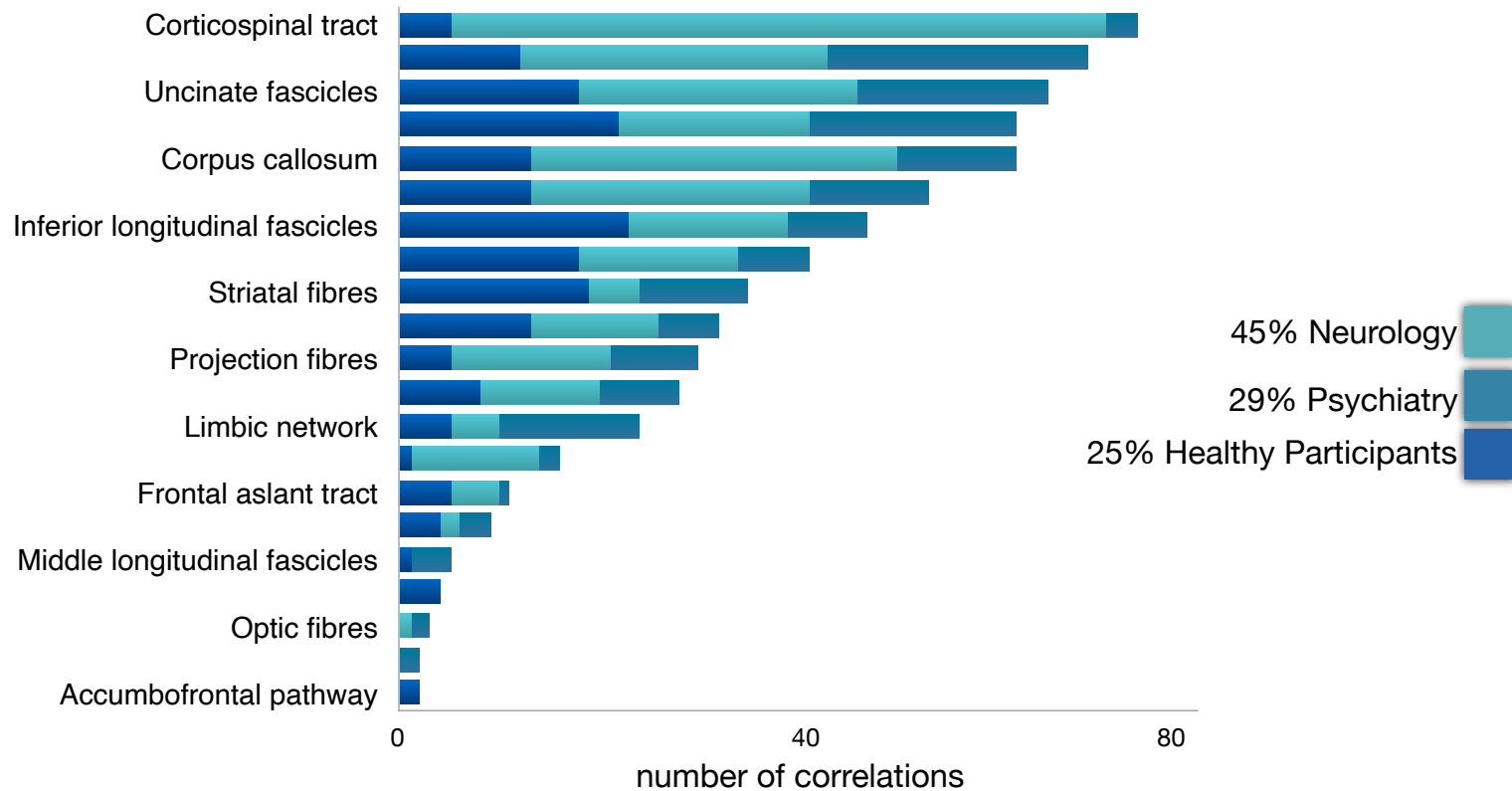
Inter-individual variability



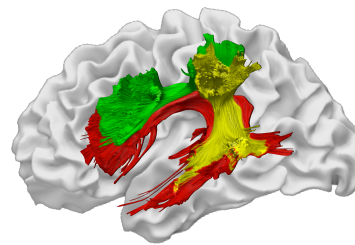
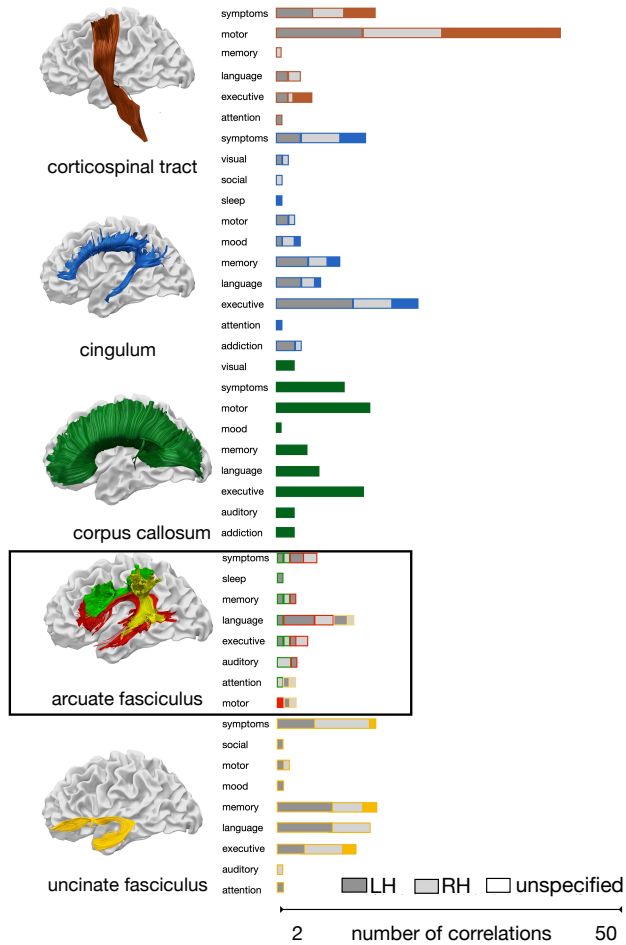
Forkel et al., forthcoming

Variability in anatomy

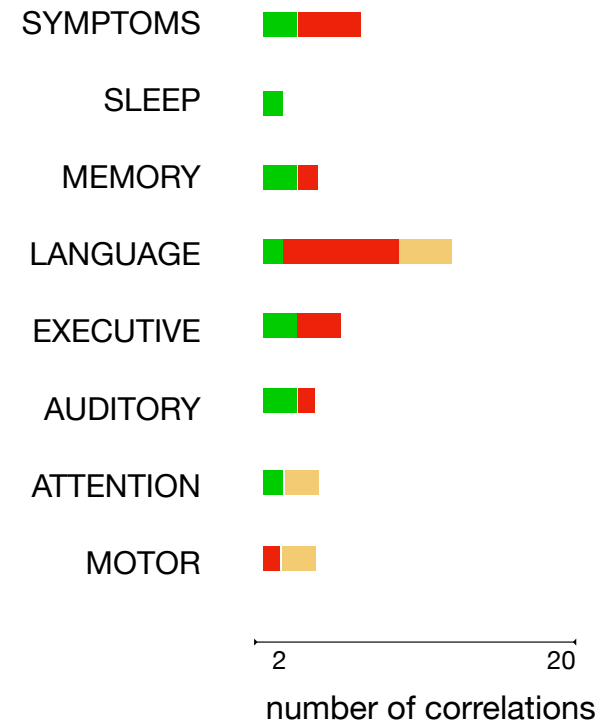
Systematic review of 326 studies



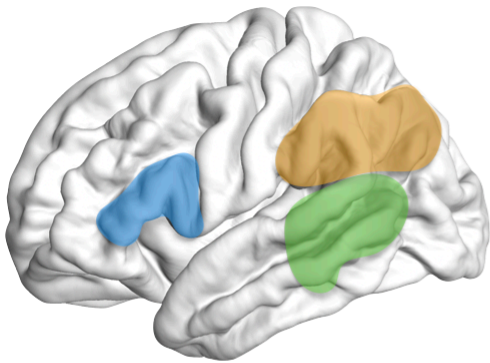
Variability in cognitive profiles



• arcuate fasciculus
 ■ anterior segment
 ■ long segment
 ■ posterior segment

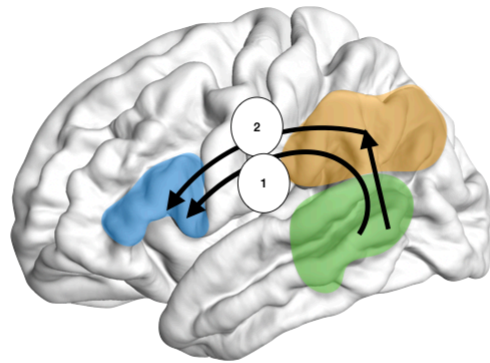


Brain Model: Emerging propertise



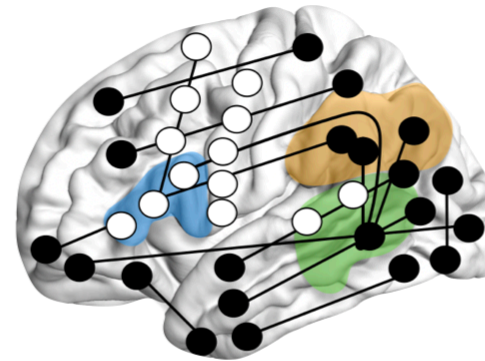
Modular model

- "Broca's area"
- 'Geschwind's area'
- 'Wernicke's area'



Hierarchical model

- ① Direct processing route
- ② Indirect processing route



Integrative model

- Inactive
- Active



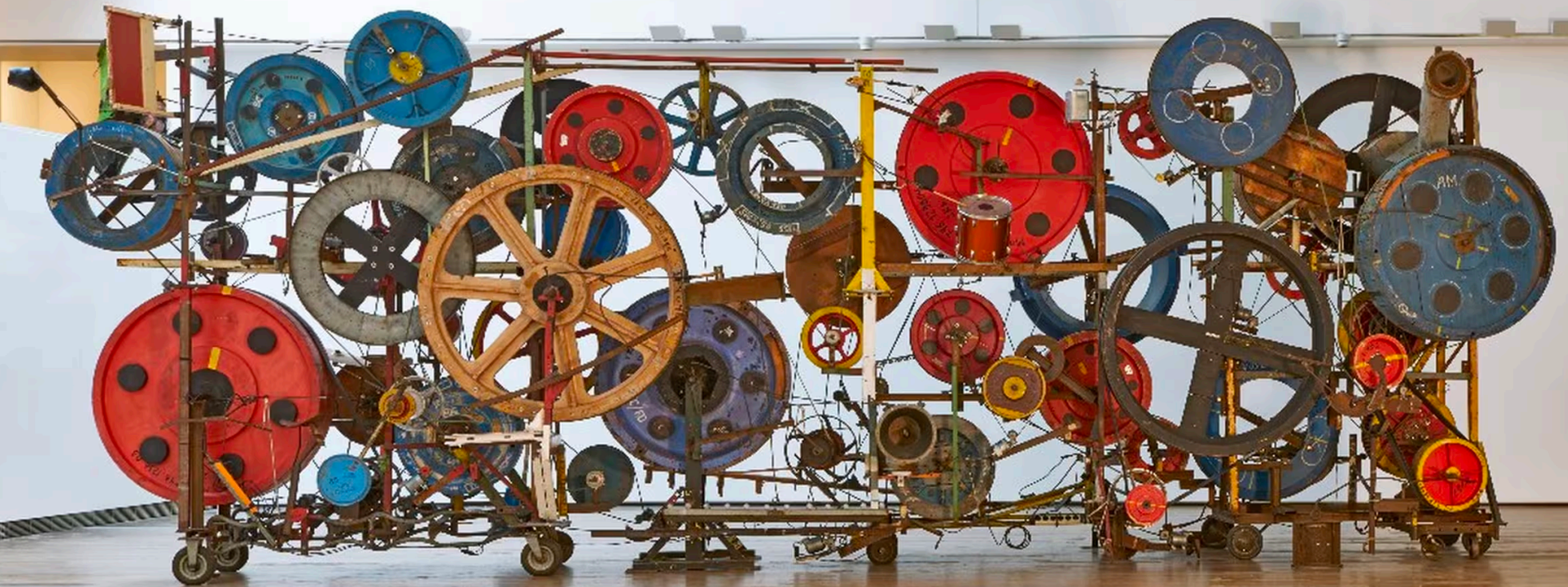
Thiebaut de Schotten & Forkel, 2022

The Language Orchestra



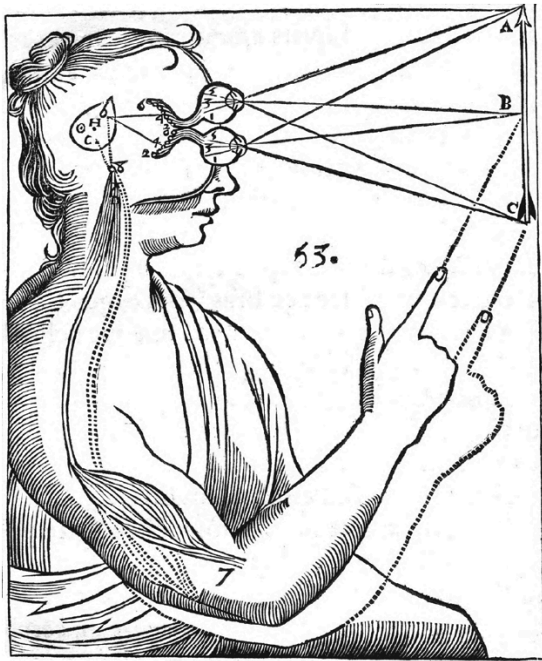
Thiebaut de Schotten & Forkel, 2022

Brain Models: the mind machine

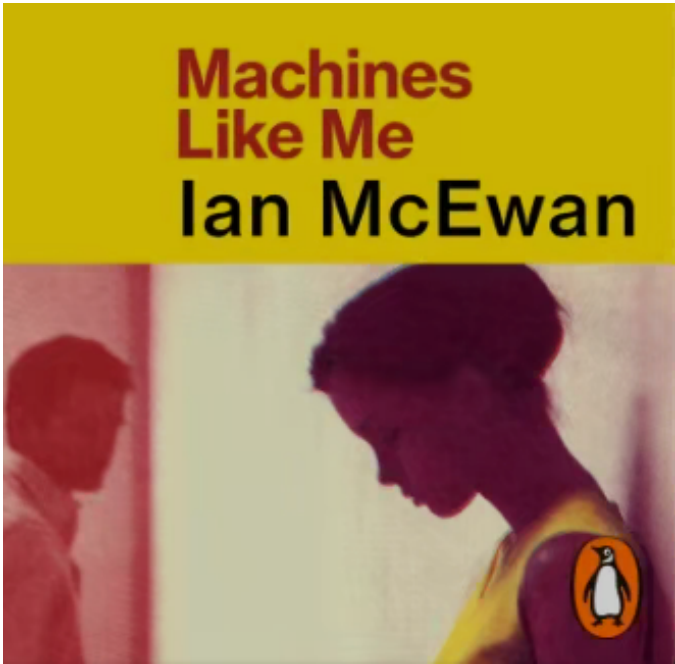


"Fatamorgána", by Jean Tinguely, produced in 1985. (Tinguely Museum)

Brain Models: the mind machine



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



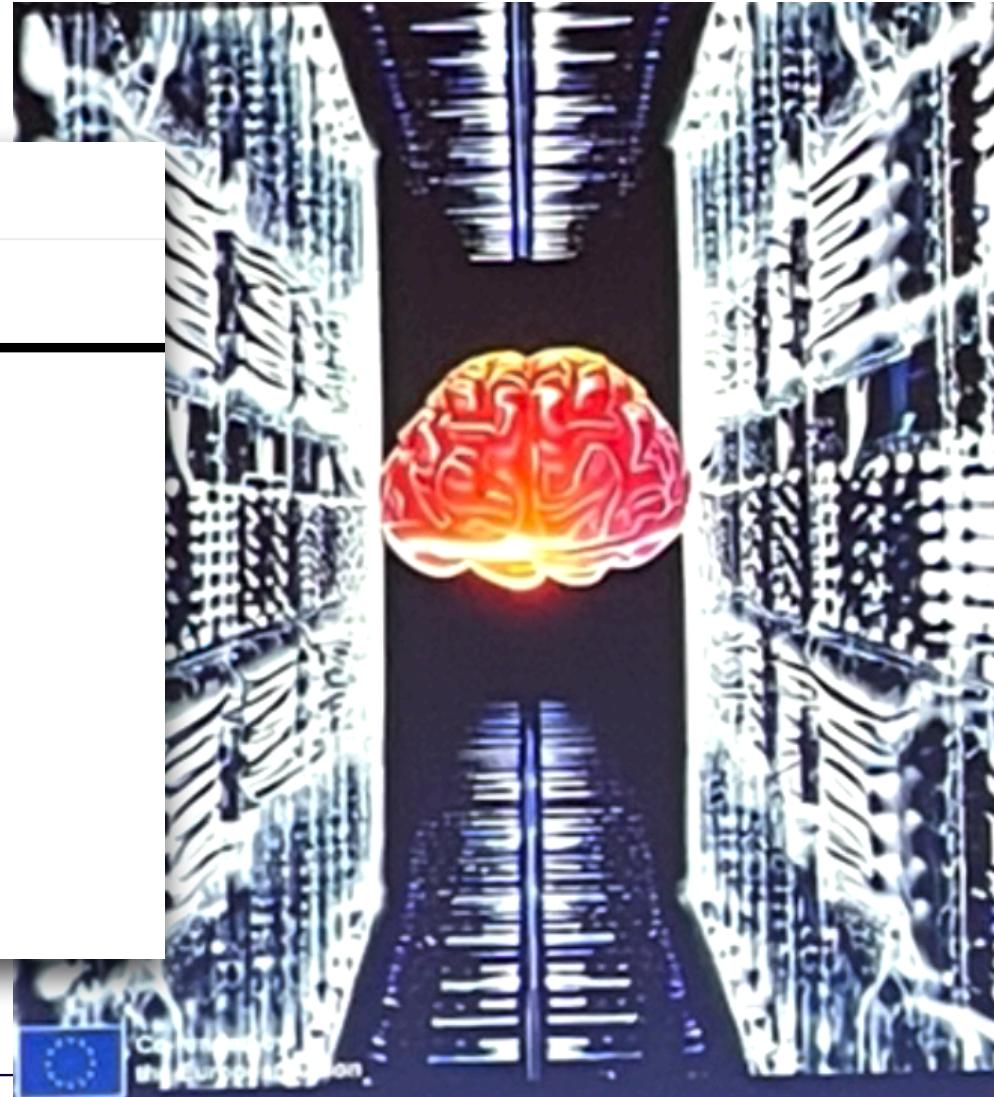
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NEWS FEATURE | 22 August 2023 | Correction [22 August 2023](#)

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



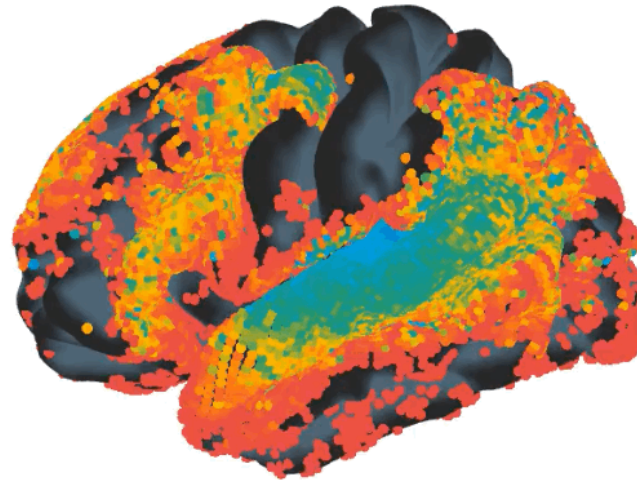
Brain Models: the mind machine

META: Using AI to decode speech from brain activity

wav2vec 2.0
deep net trained on
600h of speech with
self-supervised learning



human brain
417 volunteers
recorded with fMRI



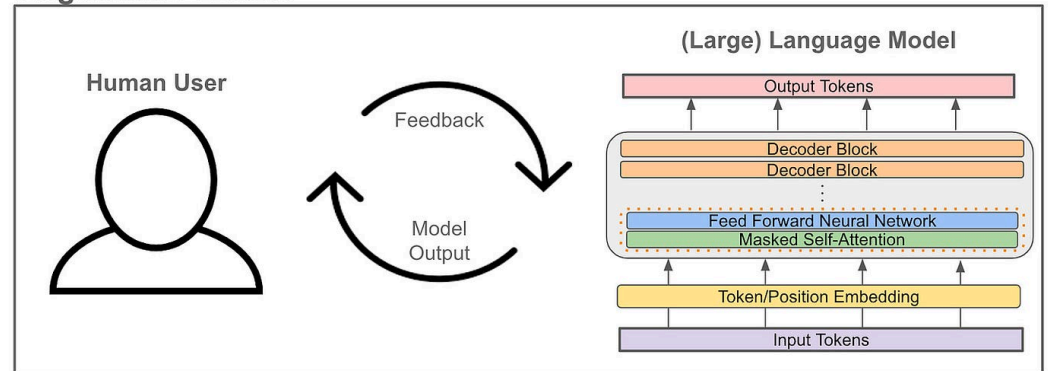
Millet, Caucheteux et al, arXiv 2022.

Jean Remi King, preprint

Brain Models: Large Language Models



Alignment Process



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

The screenshot shows the ChatGPT web interface. The browser address bar is `chat.openai.com`. The sidebar on the left contains a list of chat sessions under various time filters: "Previous 7 Days" (Draft Submission and Meeting, DEI: Differences, Fairness, Inclusi...), "Previous 30 Days" (SUMMIT Request Clarification, Team Meeting Canceled, PhD Viv..., Spotify Interview Summary, Nachwuchspreis 2023 Nominieru..., Deadline Reminder: Compassion..., Pay Raise Request - Twitter Edit..., Meeting Room Change, Tractography Jokes, SNL Award Update, Late Arrival Surcharge Issue, Connectivity Paper Collaboration), "October" (Declining Lund University Invitati..., SciComm in Open Science), and "Upgrade" (Get GPT-4, DALL-E, and more). At the bottom of the sidebar is the user profile for "Stephanie Forkel".

The main chat area displays the OpenAI logo and the text "How can I help you today?". Below this are four suggested prompts:

- Make up a story about Sharky, a tooth-brushing shark superhero
- Write a SQL query that adds a "status" column to an "orders" table
- Design a database schema for an online merch store
- Recommend a dish to impress a date who's a picky eater

At the bottom of the main area is a text input field containing the letter "w", a "Get citation" button, and a footer note: "ChatGPT can make mistakes. Consider checking important information."

Consistently challenge what we think we know

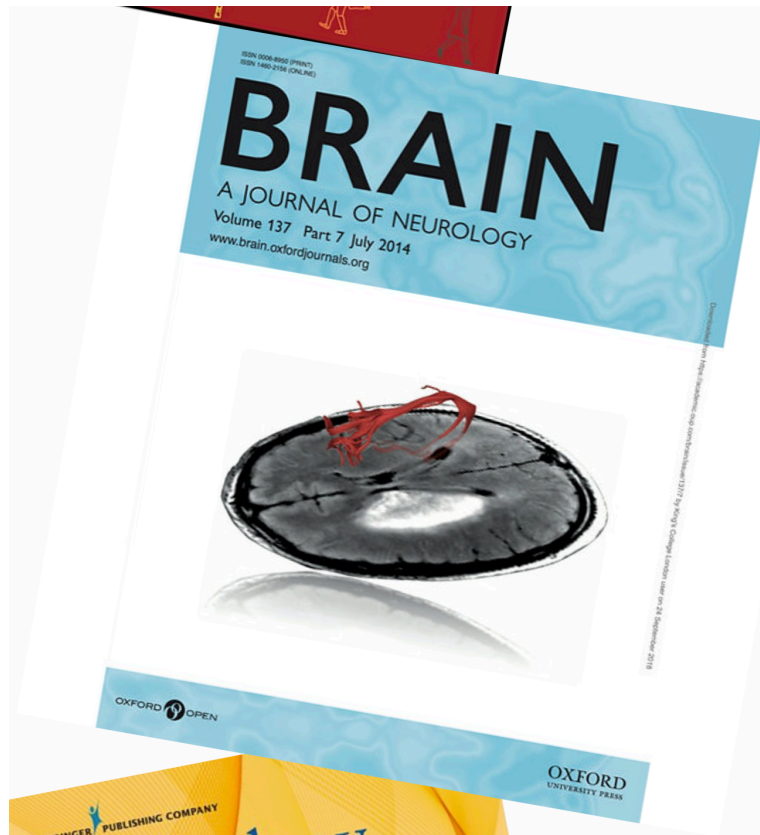


‘Nous parlons avec
l’hémisphère gauche’

(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>