RESEARCH IN LANGUAGE MAPPING

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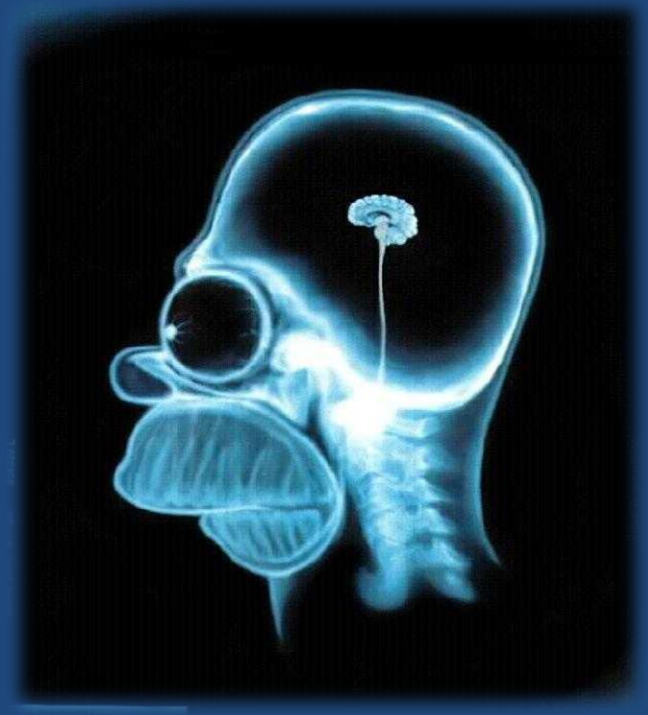
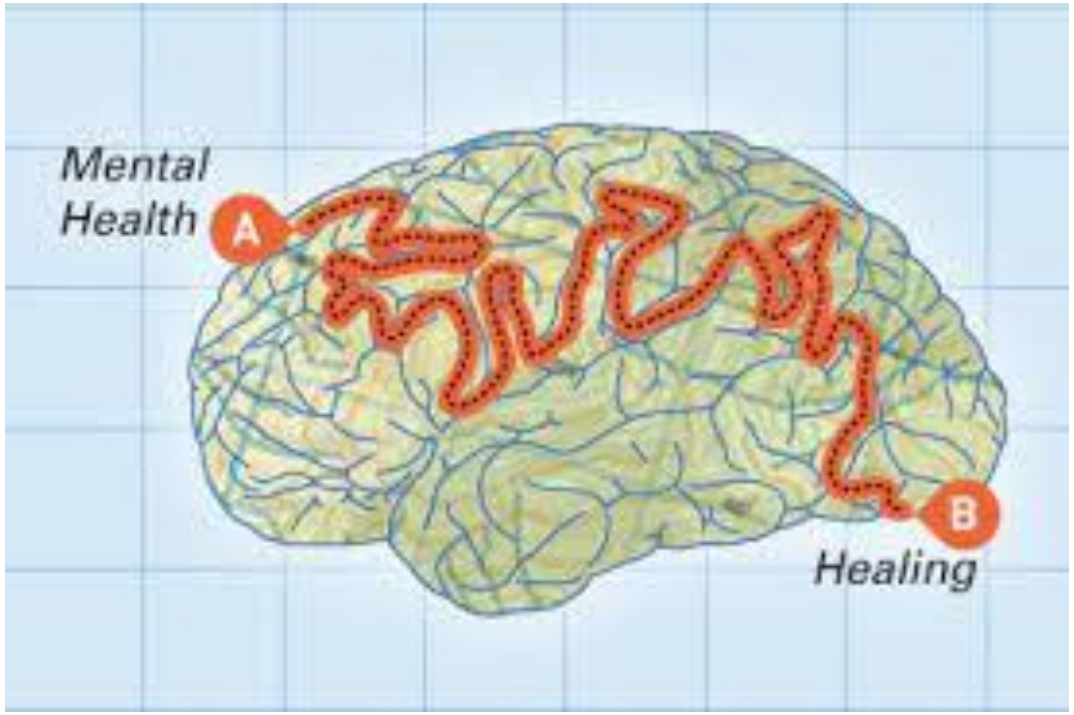
ICSS

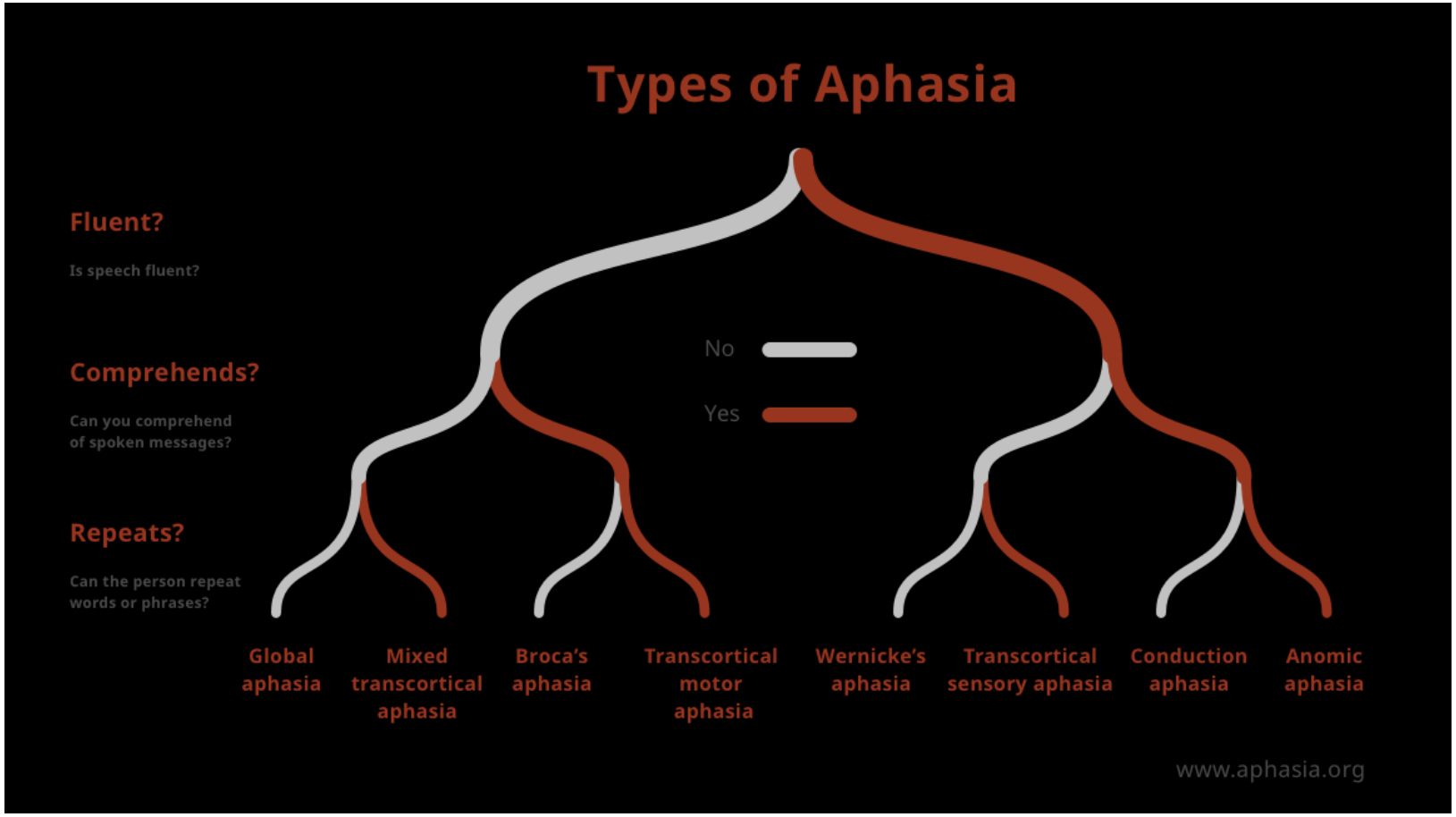


Brain mapping

Brain mapping



Aphasia

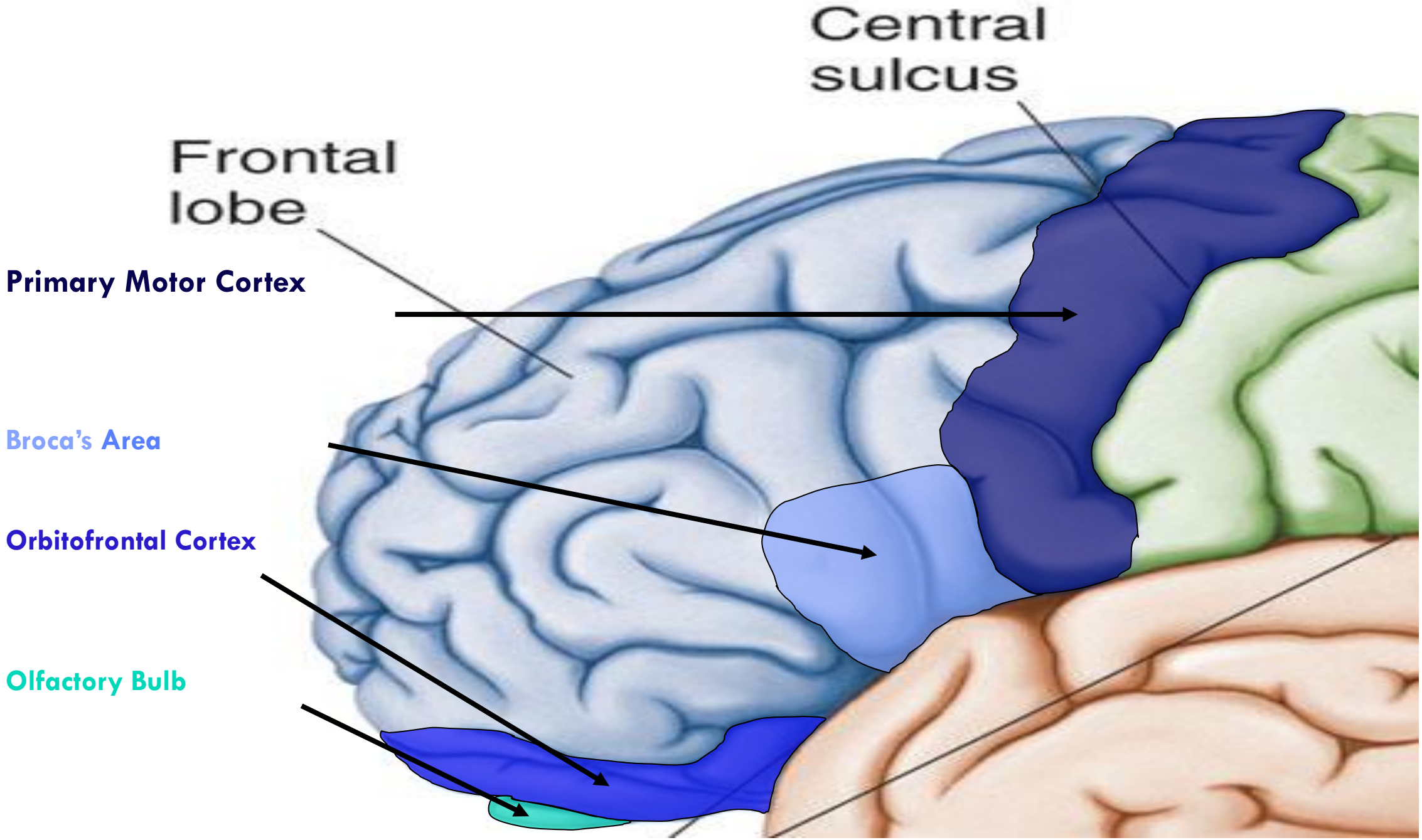

Types of Aphasia
Fluent?
Is speech fluent?
Comprehends?
Can you comprehend of spoken messages?
Repeats?
Can the person repeat words or phrases?
No
Yes
Global aphasia
Mixed transcortical aphasia
Broca's aphasia
Transcortical motor aphasia
Wernicke's aphasia
Transcortical sensory aphasia
Conduction aphasia
Anomic aphasia
www.aphasia.org

Broca’s (Expressive/non fluent) Aphasia

- speech output is severely reduced and is limited mainly to short utterances of less than four words.
- Vocabulary access is limited and the formation of sounds \is often laborious and clumsy.
- The person may understand speech relatively well and be able to read, but be limited in writing.

Wernicke's(receptive/ fluent) aphasia

- The ability to grasp the meaning of spoken words is chiefly impaired, while the ease of producing connected speech is not much affected.
- Speech is far from normal. Sentences do not hang together and irrelevant words intrude-sometimes to the point of jargon, in severe cases.
- Reading and writing are often severely impaired.

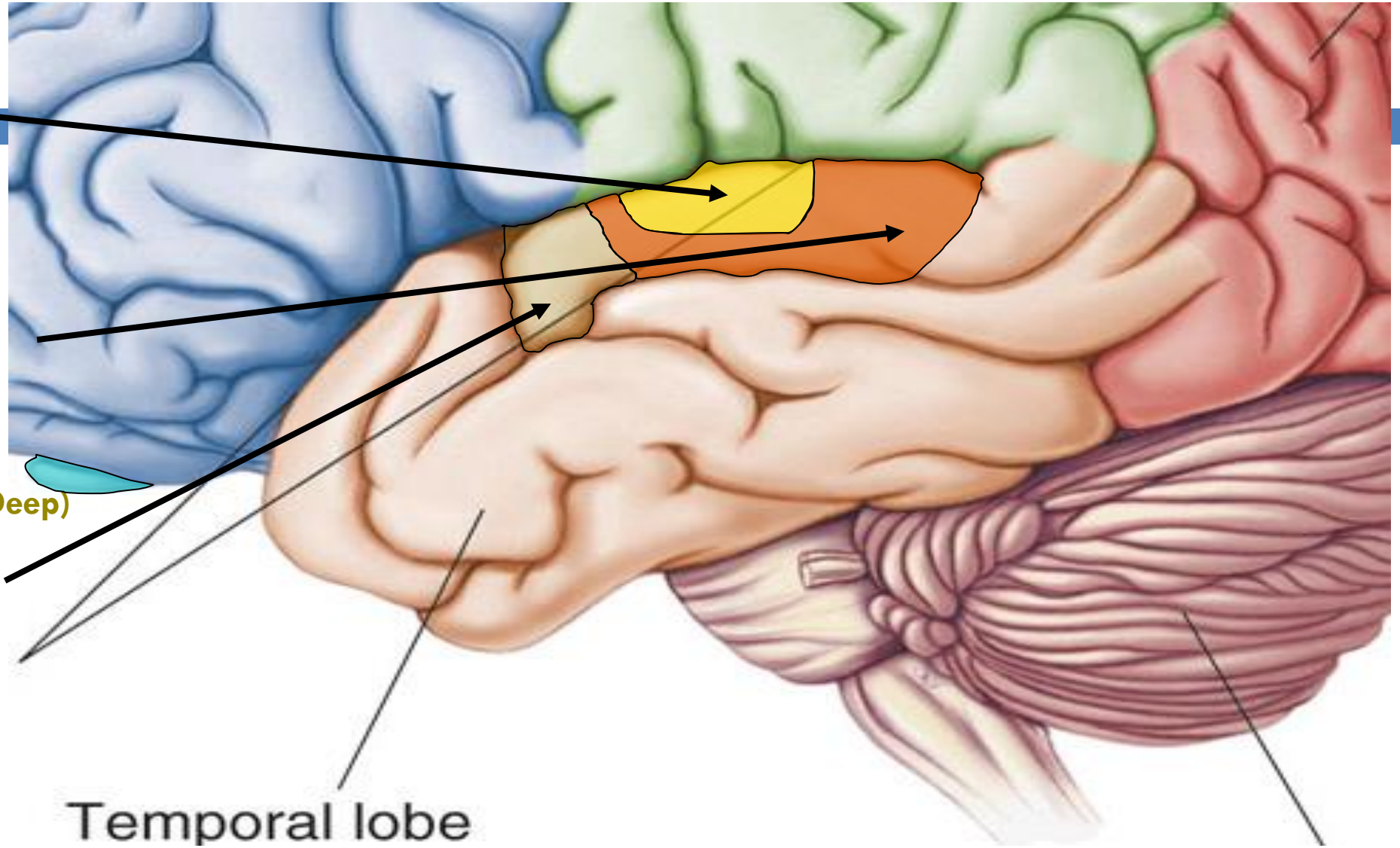

Central sulcus
Frontal lobe
Primary Motor Cortex
Broca's Area
Orbitofrontal Cortex
Olfactory Bulb

Primary Auditory Cortex

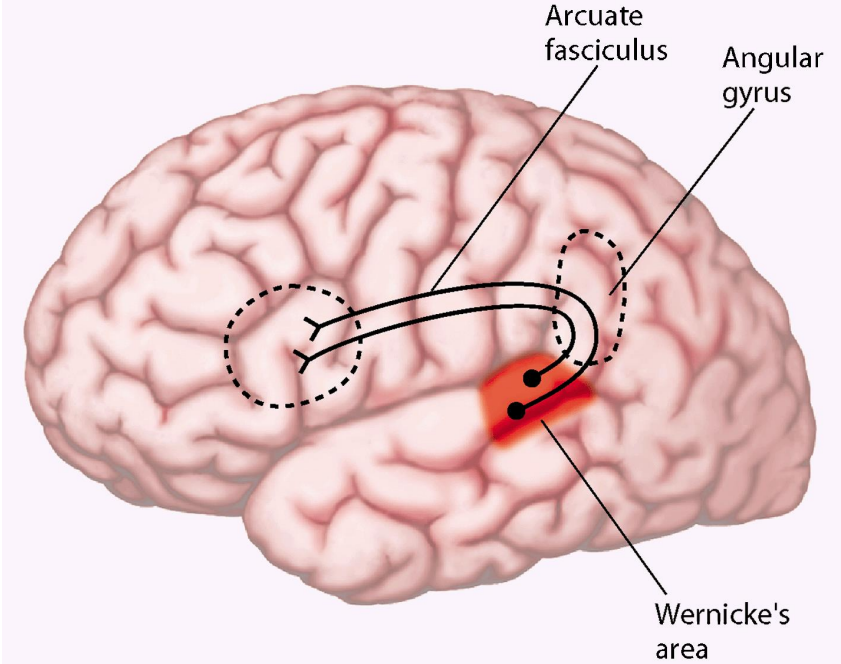
Wernike's Area

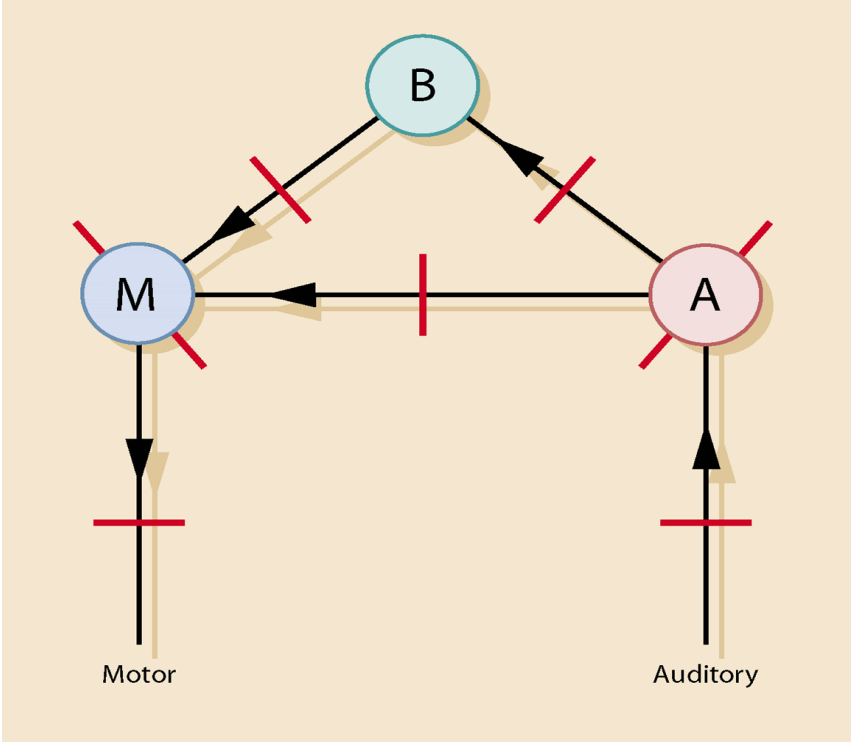
Primary Olfactory Cortex (Deep)

Conducted from Olfactory Bulb

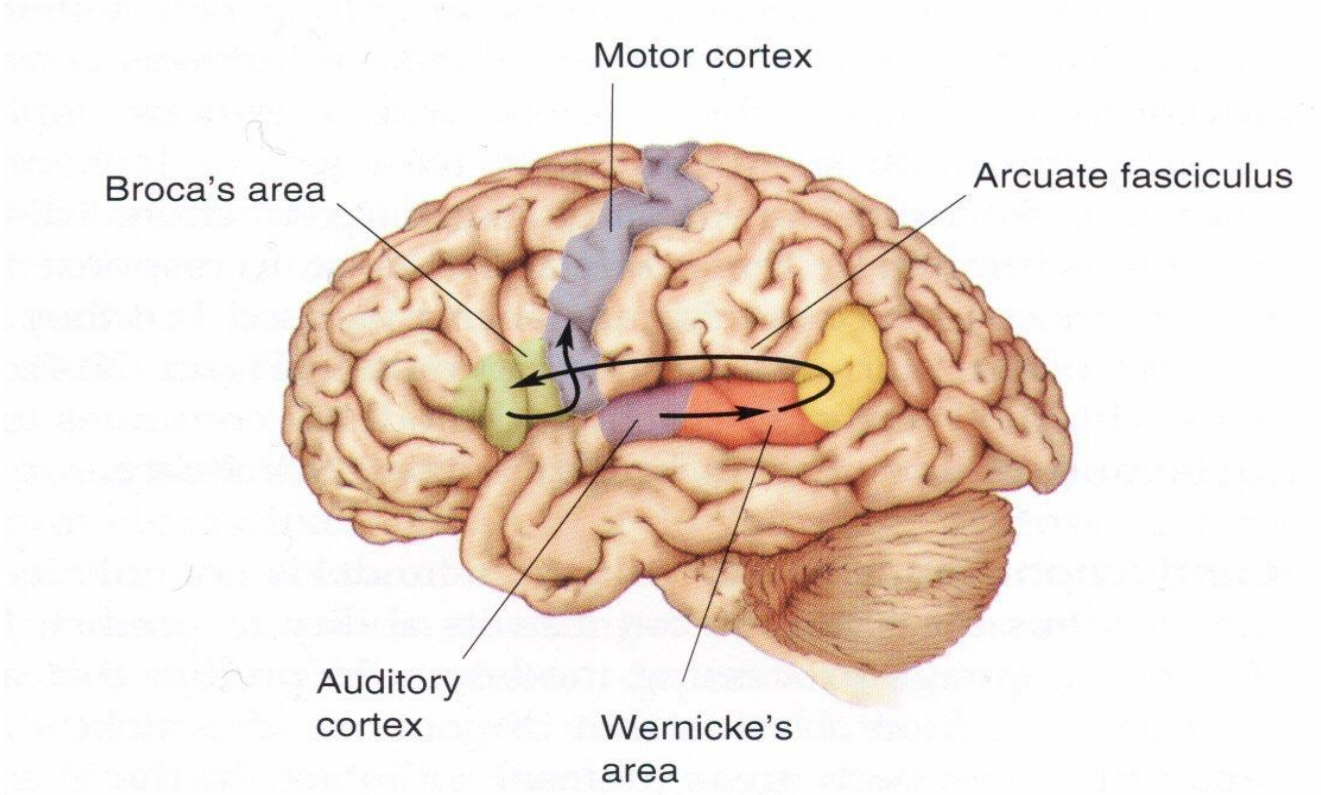


Wernicke-Lichtheim-Geschwind model

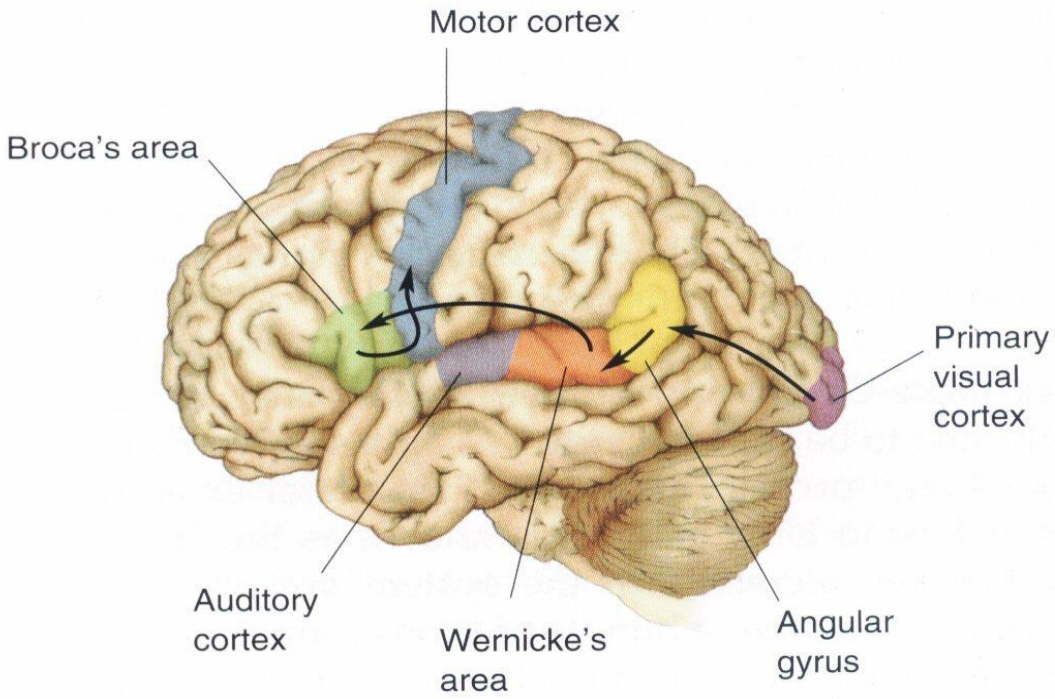




Geschwind's Model: Repeating a Spoken Word



Geschwind's Model: Repeating a written Word



Language mapping

Finding parts of the brain involved in language production and comprehension.

- complexity of these areas,
- shift of the functional area due to presence of the lesion
- plasticity of neurological functions.

Language mapping

Loss of language following a neurosurgery could lead to a great personal and social breakdown to a patient, and a surgeon always aims to preserve these eloquent areas.

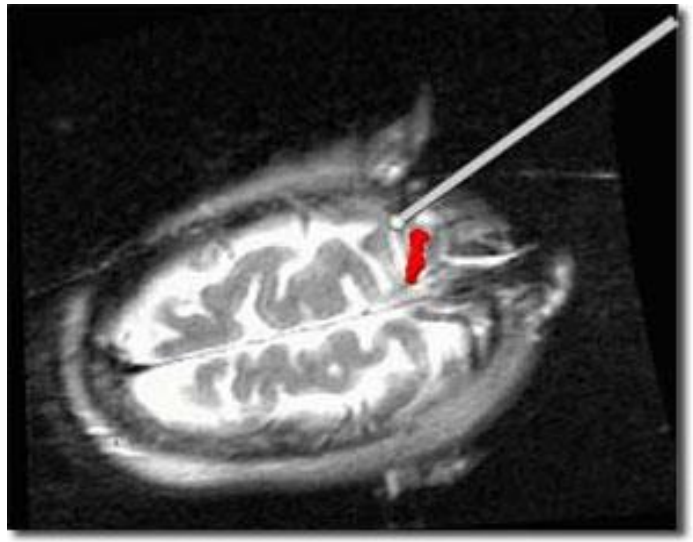
Language mapping help to protect language functions during surgery for **temporal lobe epilepsy** or **brain tumors**.

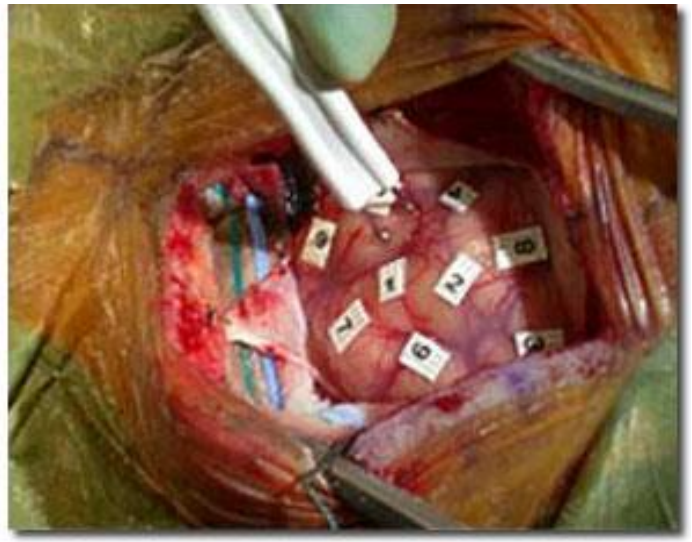
Language mapping techniques

- f MRI
- EEG
- MEG
- TMS
- DCS

Language mapping

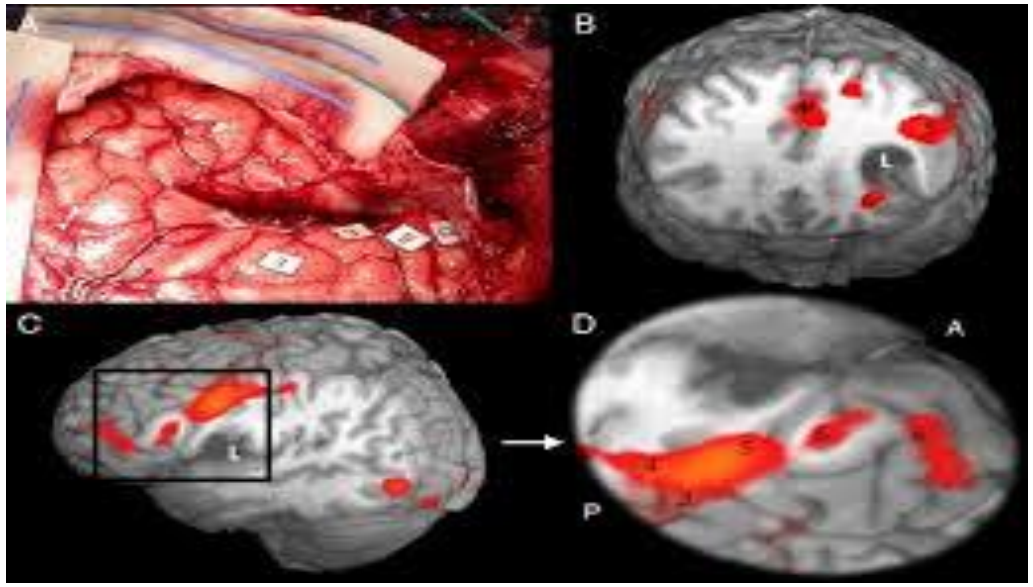
- Language mapping is done during surgery while the patient is awake and interactive. The patient is shown sequential pictures of common objects, while a region of the brain is electrically stimulated in one centimeter increments.





fMRI for language mapping

- Blood oxygen level-dependent (BOLD) imaging has been widely used for preoperative brain mapping of the functional cortex, including language and motor areas, in patients with brain tumors.



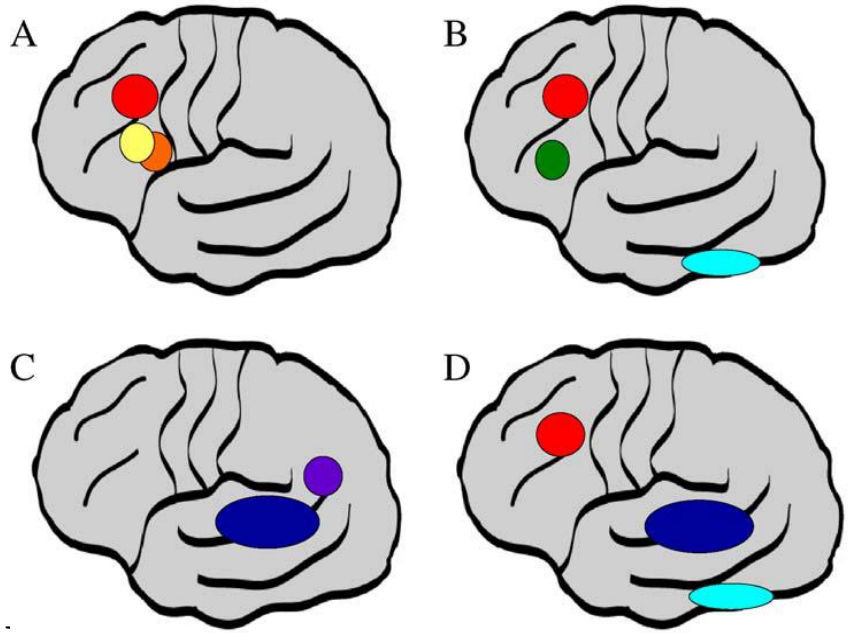
fMRI for language mapping

- paradigm planning and prerequisites to get good fMRI
  - Stimuli
    - Auditory
    - visual

fMRI for language mapping

- Task
  - Object naming
  - Word generation
  - Picture-verb generation
  - Comprehension
  - Semantic discrimination
  - Story listening

Language tasks and brain activation



(A) verbal fluency; (B) semantic decision; (C) listening comprehension; (D) reading comprehension (Gaillard, 2004)

Language tasks and brain activation

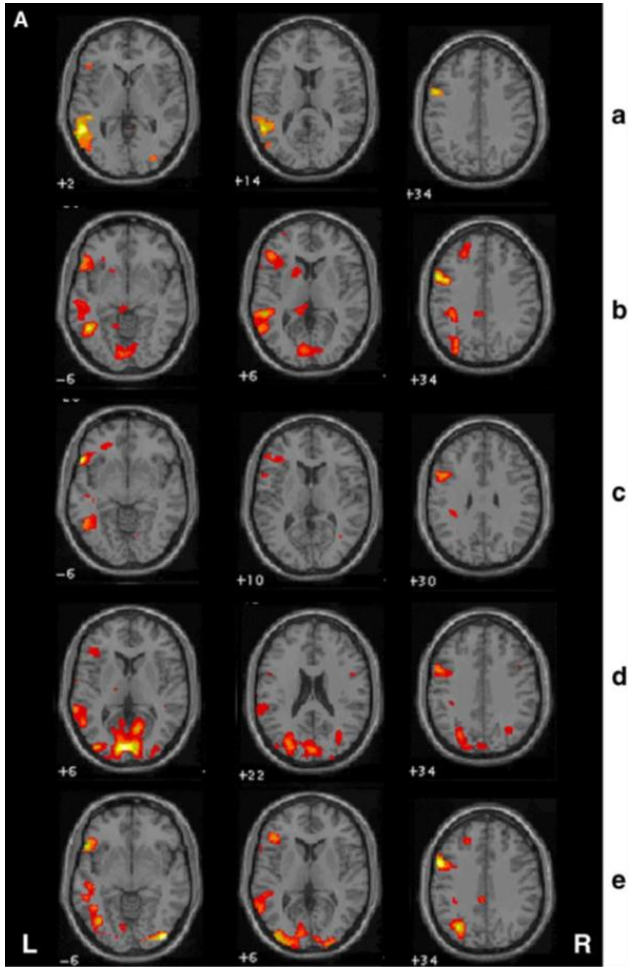
a: listening to stories

b: auditory task, naming to description

c: covert verbal fluency to categories

d: reading stories

e: reading task, naming to description

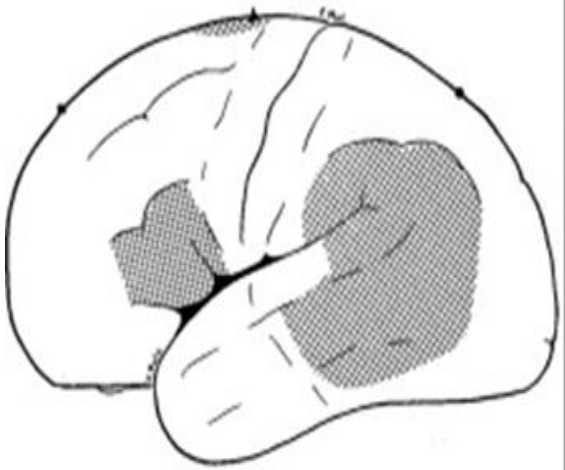


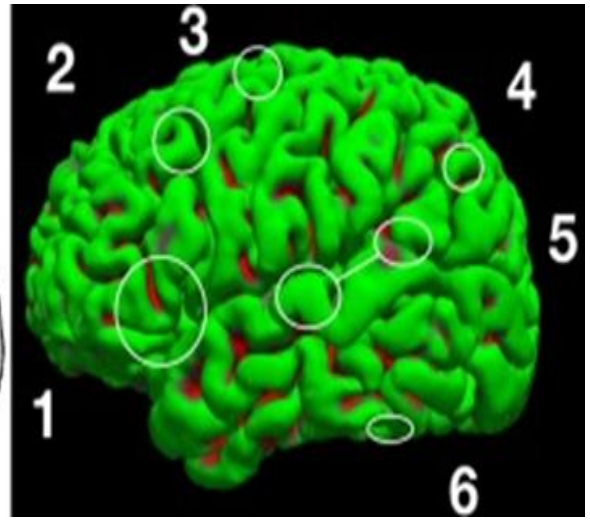
fMRI for language mapping

- Patient preparation
- acquisition of fMRI data
- post-processing of the data
  - FSL
  - SPM
- reporting pertaining to clinical neurosurgical cases

Neural correlates of language

1) Broca’s area
2) Exner’s area
3) Supplementary motor area
4) Angular gyrus
5) Wernicke's area
6) Basal temporal language areas
(Benjamine et al, 2017)

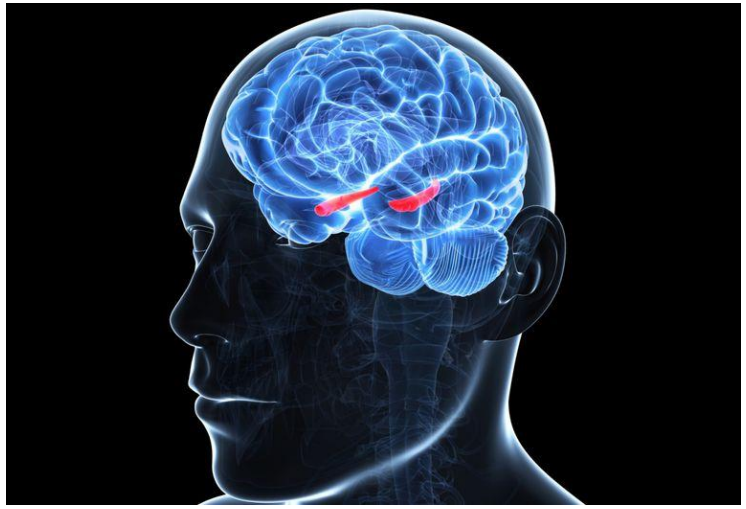




Neural correlates of language

There is also considerable evidence from cortical stimulation and fMRI studies that support the role of hippocampus in naming functions

(Hamberger et al., 2007).

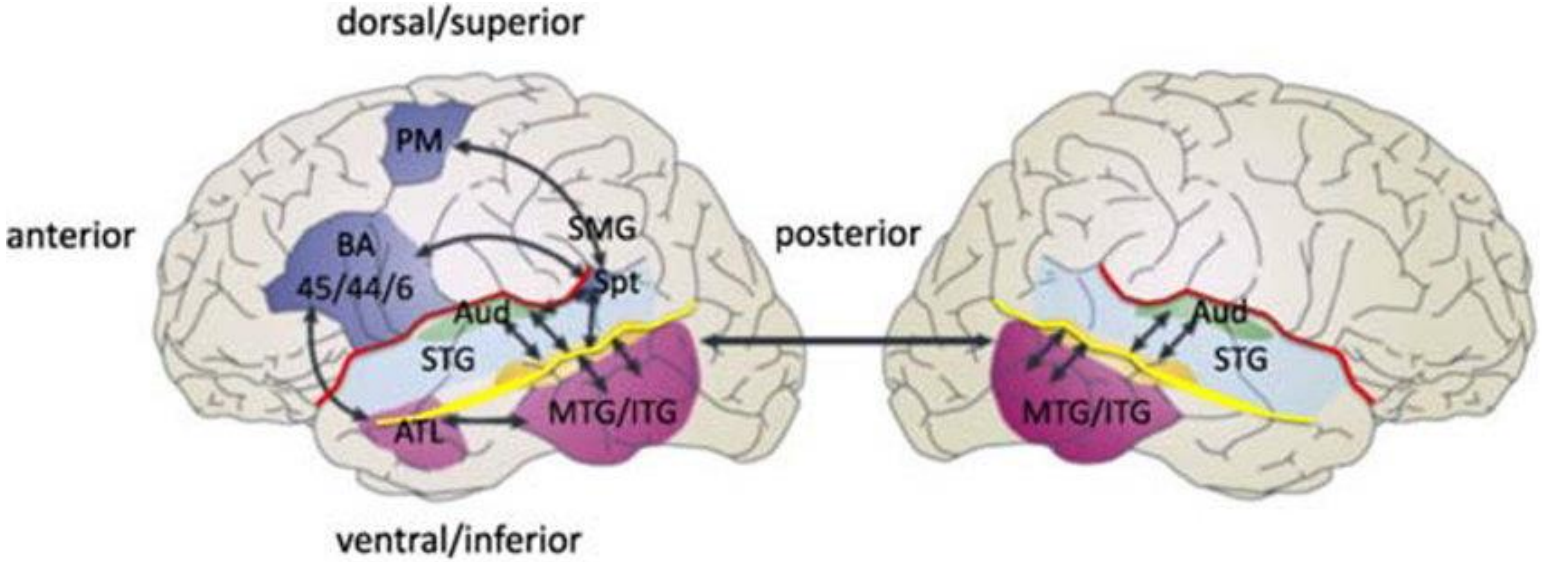


Neural correlates of language

It seems that segregated fronto-cerebellar circuits potentially play a role in cognitive processes, such as language (Krienen, and Buckner, 2009).

Ventral and dorsal stream

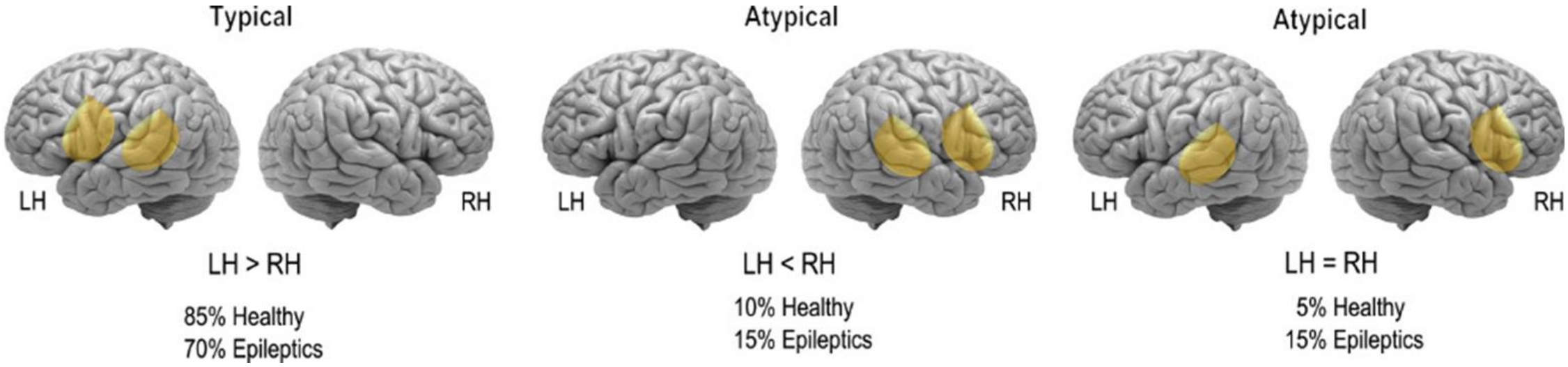
The ventral stream is implicated in semantic processing while dorsal stream is involved in phonological processing, syntactic processing and working memory (Croft, 2014).

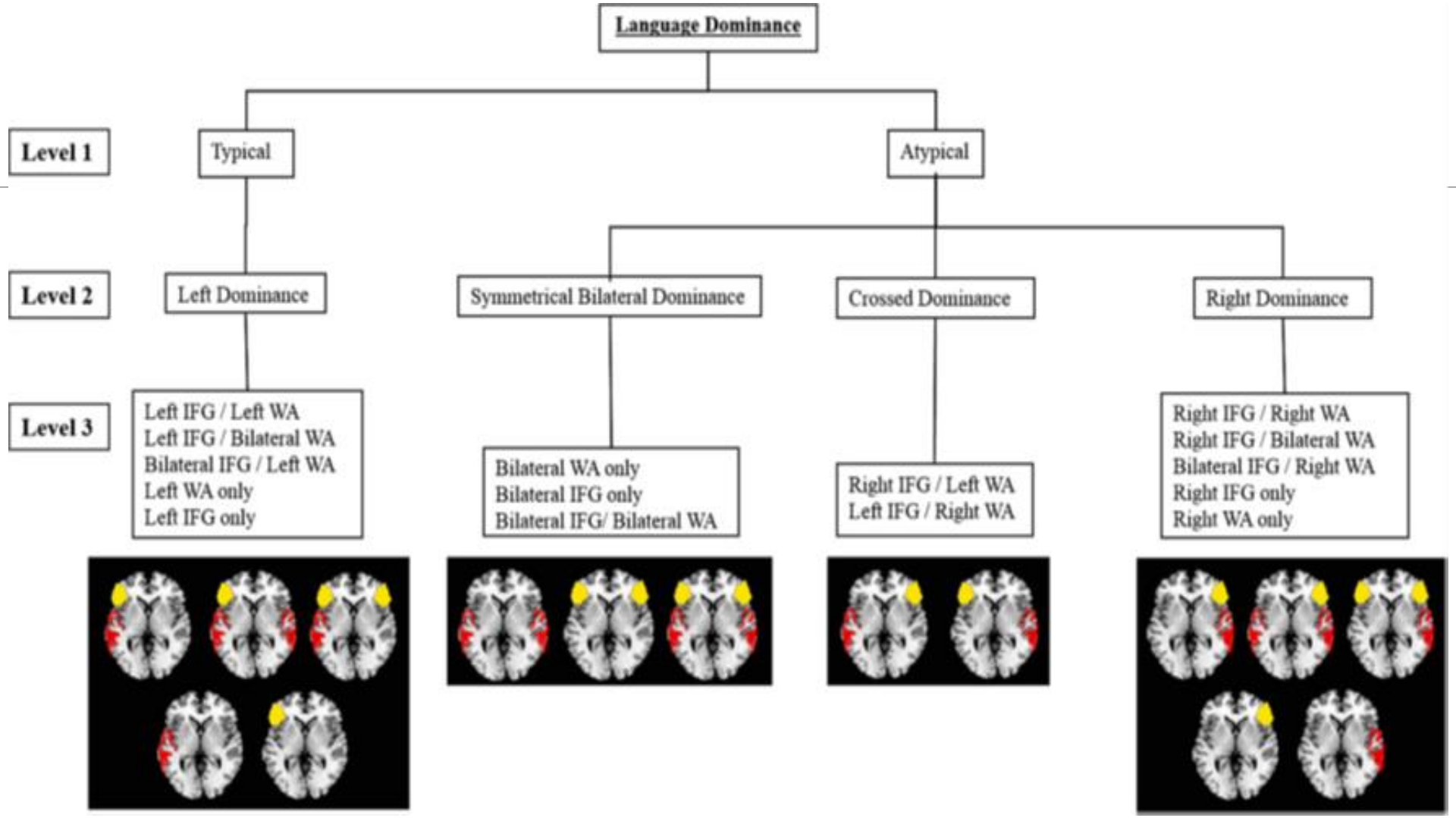


Language laterality

The phenomenon in which one hemisphere shows greater involvement in language functions than the other (Bradshaw et al., 2017).

language laterality




Language Dominance
Level 1
Typical
Atypical
Level 2
Left Dominance
Symmetrical Bilateral Dominance
Crossed Dominance
Right Dominance
Level 3
Left IFG / Left WA
Left IFG / Bilateral WA
Bilateral IFG / Left WA
Left WA only
Left IFG only
Bilateral WA only
Bilateral IFG only
Bilateral IFG/ Bilateral WA
Right IFG / Left WA
Left IFG / Right WA
Right IFG / Right WA
Right IFG / Bilateral WA
Bilateral IFG / Right WA
Right IFG only
Right WA only

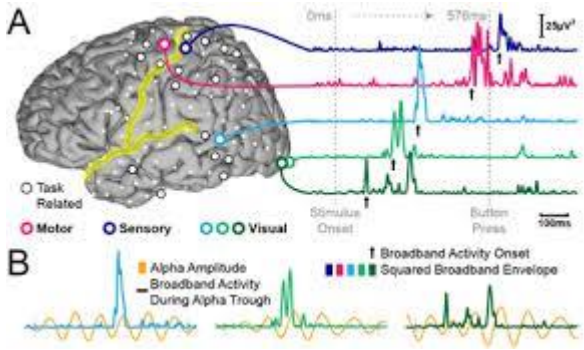
EEG and Linguistic studies

N400

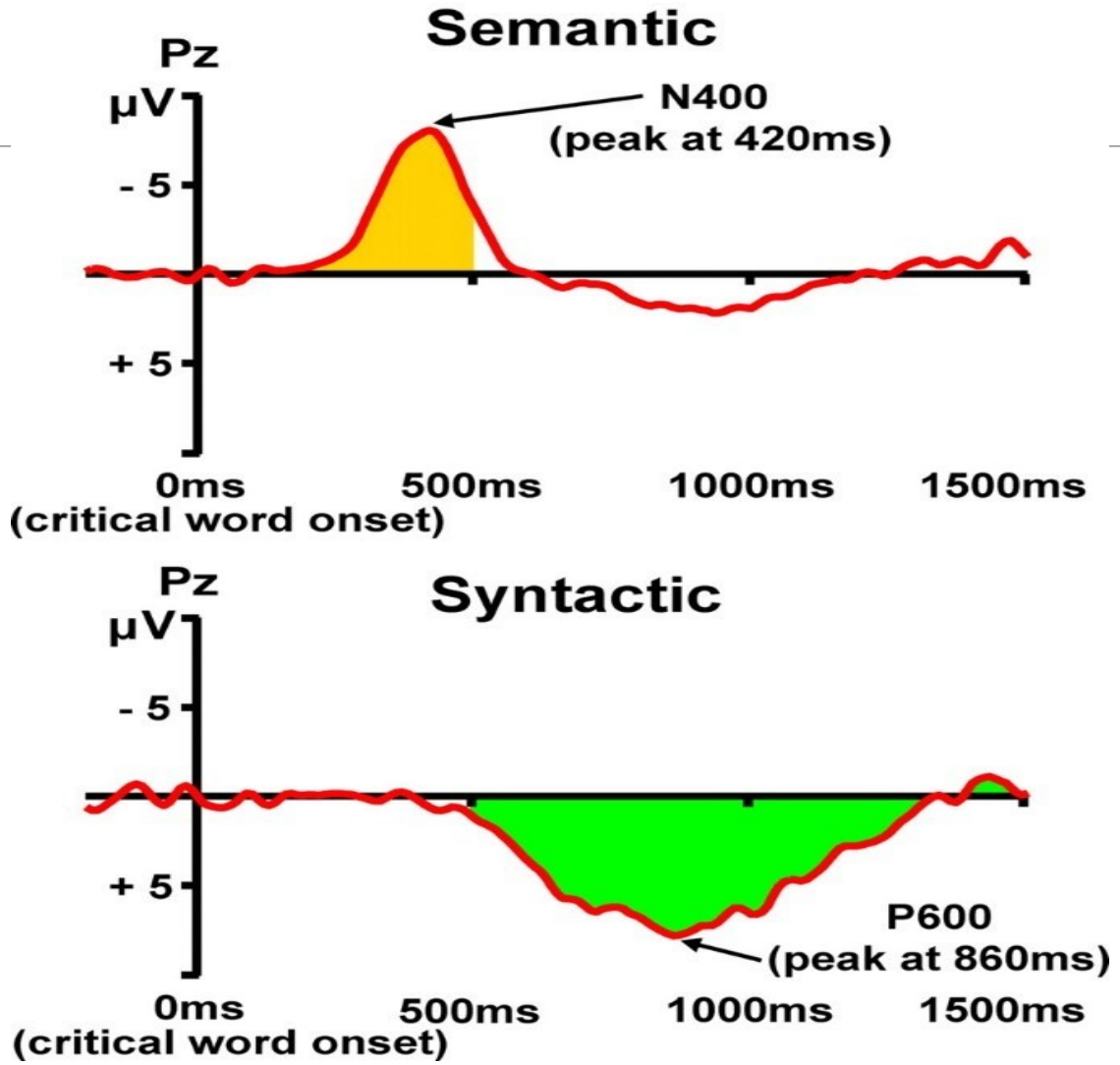
P600

LPN (Lexical Processing Negativity)

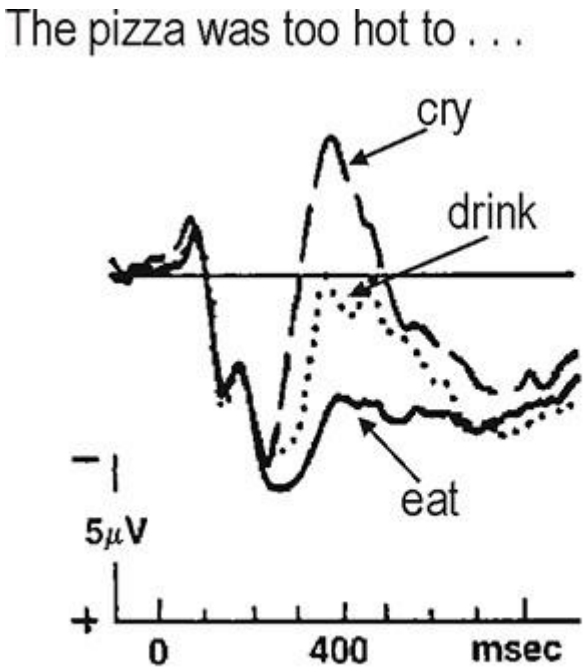
LAN (Left Anterior Negativity)



ERP Results


Semantic
Pz
µV
- 5
+ 5
N400
(peak at 420ms)
0ms
(critical word onset)
500ms
1000ms
1500ms
Syntactic
Pz
µV
- 5
+ 5
P600
(peak at 860ms)
0ms
(critical word onset)
500ms
1000ms
1500ms

N400



Churchland & Sejnowski (1993)

Conceptual metaphor

Our conceptual system relies heavily on conceptual metaphor, a keystone mechanism in meaning elaboration. We use conceptual metaphors continuously, intuitively, and unconsciously, in all possible human activities, including science, literature, and art.

Conceptual metaphor

نگاشت نظام مند

«موضع» → «عقیده/باور»

«حمله» → «انتقاد»

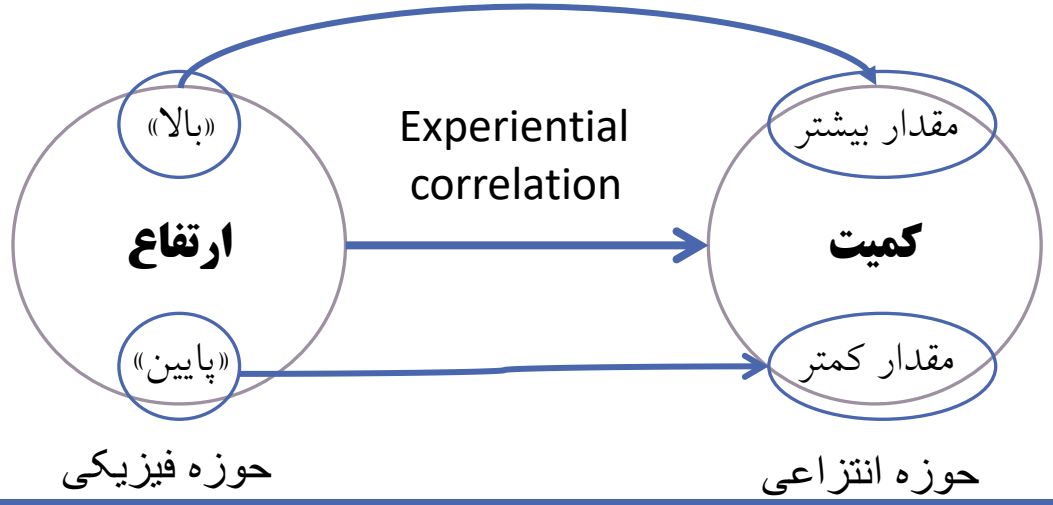
«عقب‌نشینی» → «پذیرفتن استدلال رقیب»

«دفاع» → «دلیل آوردن»

جنگ/نزاع

بحث

Conceptual metaphor



EEG and metaphor

Experimental design:

Two independent variables are manipulated, each having two levels:

Metaphoricity; literal (control) vs. figurative (experimental);

Complexity; primary vs. complex metaphors.

Primary metaphors

Grady (1997, 2005) coined the term “primary metaphors” for conceptual metaphors directly based on universal bodily experiences. He suggests that such primary conceptual metaphors are atoms or elementary metaphors. They are embodied, i.e. they result from the cooccurrence of everyday subjective and sensory-motor experiences,

“I see what you mean” [UNDERSTANDING is SEEING]

“they have a warm relation” [AFFECTION is HEAT SENSATION]

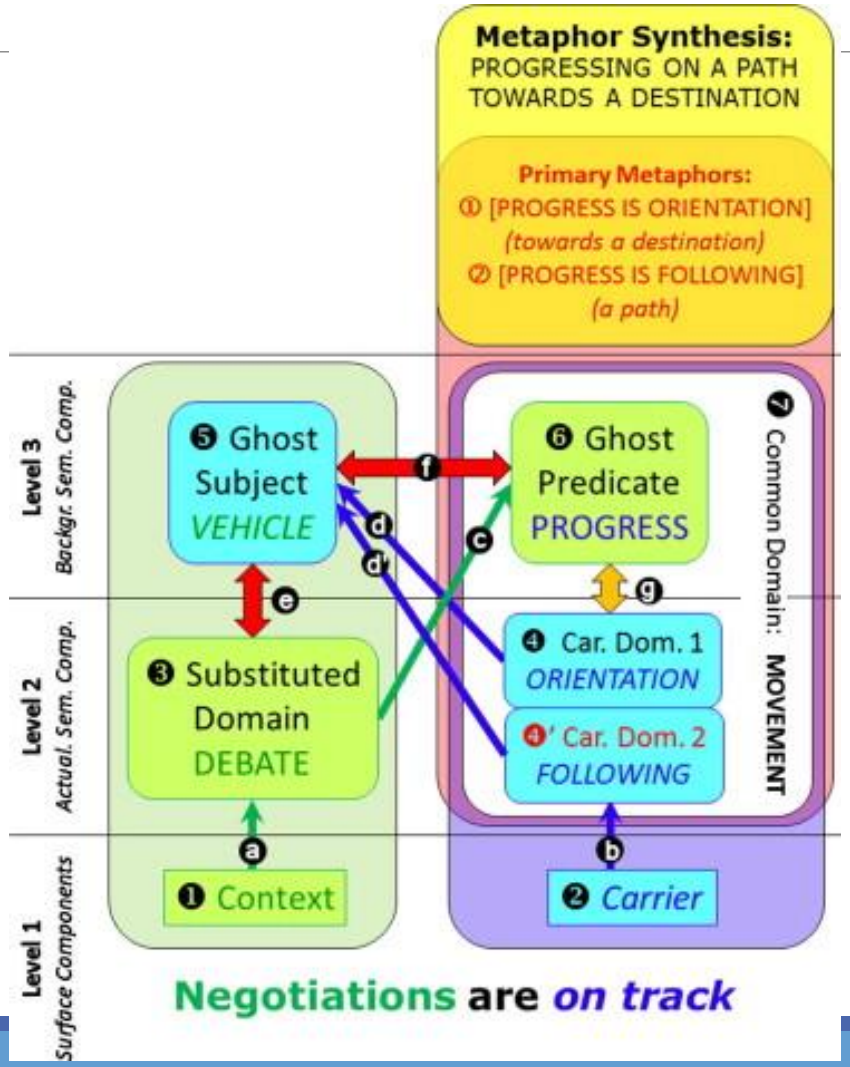
“my blood froze” [FEAR is COLD SENSATION].

Complex metaphors

Grady (1997, 2005) and Lakoff & Johnson (1999) have suggested that primary metaphors may be combined into complex conceptual metaphors. If primary conceptual metaphors are seen as atoms, complex conceptual metaphors can be understood as molecules.

“Negotiations are on track”:

Metaphor 1 [PROGRESSING is HEADING TOWARDS A DESTINATION] + **Metaphor 2** [PROGRESSING is FOLLOWING A PATH].


Metaphor Synthesis:
PROGRESSING ON A PATH TOWARDS A DESTINATION
Primary Metaphors:
① [PROGRESS IS ORIENTATION]
(towards a destination)
② [PROGRESS IS FOLLOWING]
(a path)
Level 3
Backgr. Sem. Comp.
Level 2
Actual. Sem. Comp.
Level 1
Surface Components
❺ Ghost Subject
VEHICLE
❻ Ghost Predicate
PROGRESS
❼ Common Domain: MOVEMENT
❸ Substituted Domain
DEBATE
❹ Car. Dom. 1
ORIENTATION
❹' Car. Dom. 2
FOLLOWING
❶ Context
❷ Carrier
a
b
c
d
d'
e
f
g
Negotiations are on track

Conceptual metaphors and brain

Although our daily experience makes it easy and natural for us to produce and understand both primary and complex conceptual metaphors, complex metaphors should be more difficult to process than primary metaphors because they integrate simultaneously more than one primary conceptual metaphor into a larger conceptual structure.

The brain does not appear to process primary conceptual metaphors as it processes complex conceptual metaphors. Understanding primary conceptual metaphors seems to involve **greater binding of neuron assemblies**, whereas understanding complex conceptual metaphors seems to rely on **increased information exchange between neuron assemblies.**

EEG and metaphor

EEG coherence is the oscillatory coupling between two channels occurring with several oscillations in a narrow frequency band for a given period of time.

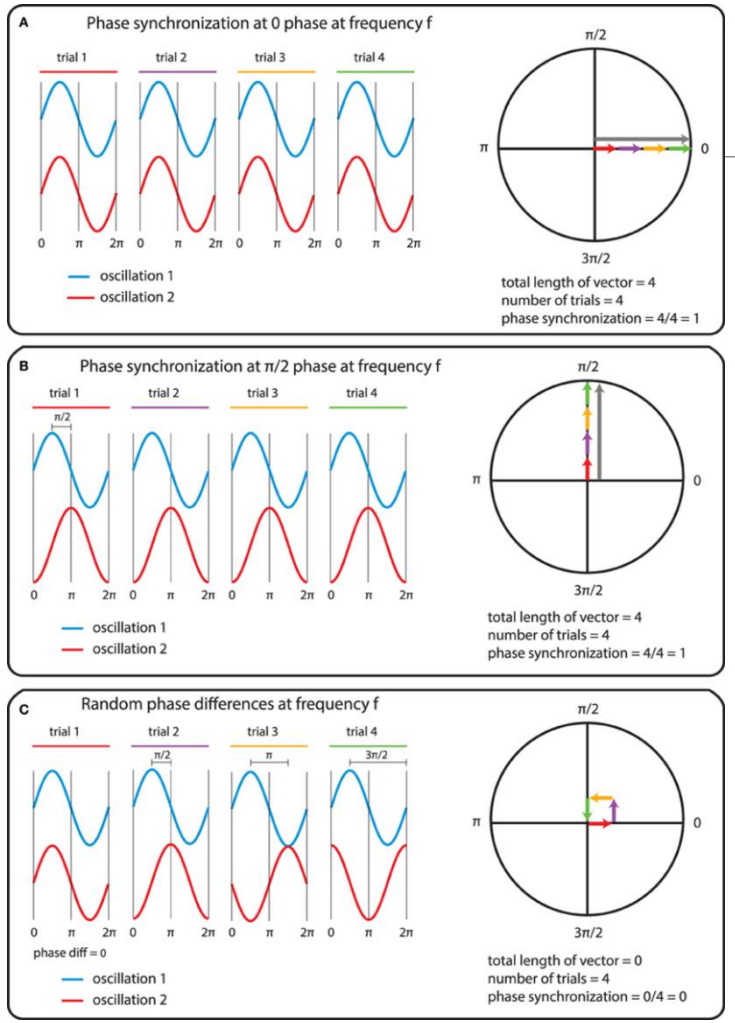
Coupling is assumed if oscillations are systematically correlated in amplitude and phase. Therefore, EEG coherence measures electric signal correlation between regions and over trials.

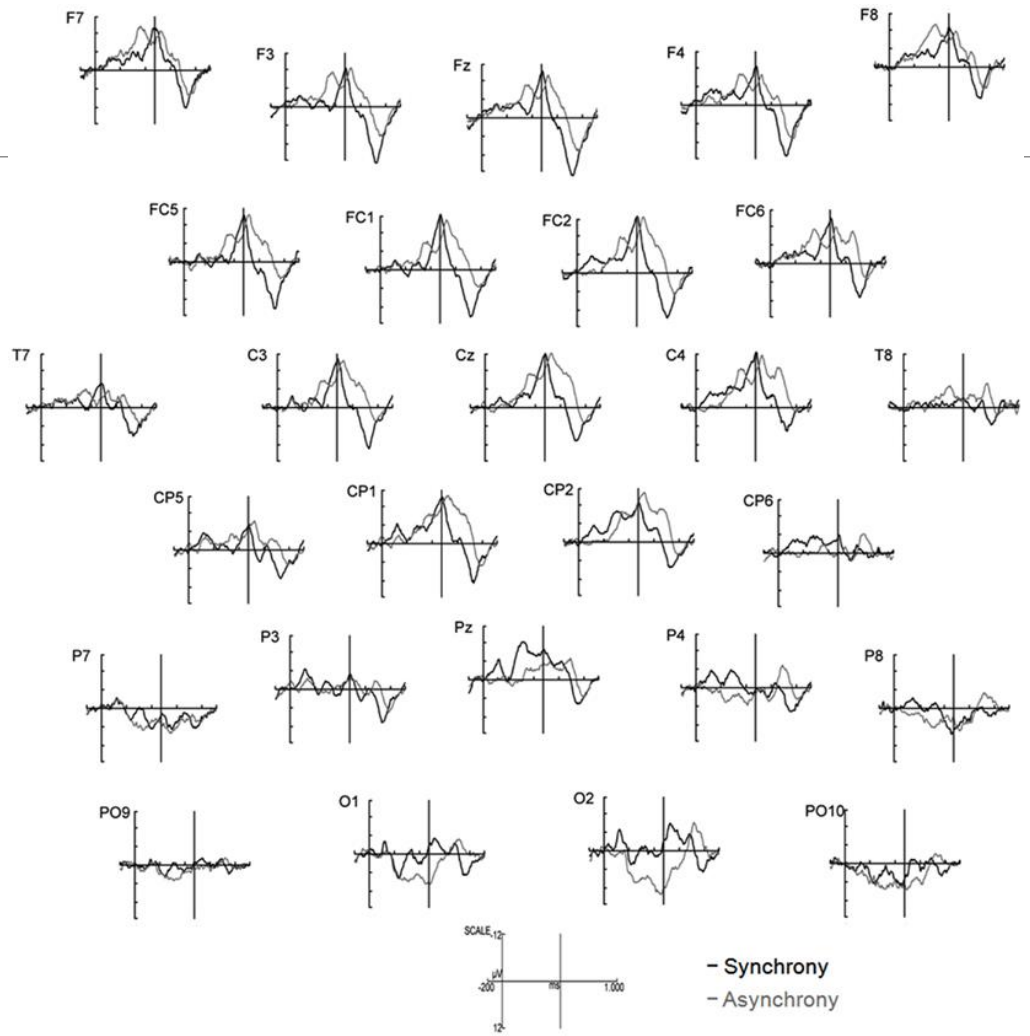
EEG and metaphor

Two types of coherent activity can be detected in oscillatory signals picked up from two brain or scalp areas: synchrony and asynchrony.

Synchrony involves systematic phase locking (i.e. phase delay equals 0) between two oscillatory signals during a given period of time n the other hand,

Asynchrony involves a systematic time gap (i.e. phase delay is different from 0) between the two oscillatory signals, during a given period of time.


A
Phase synchronization at 0 phase at frequency f
trial 1
trial 2
trial 3
trial 4
oscillation 1
oscillation 2
π/2
π
0
3π/2
total length of vector = 4
number of trials = 4
phase synchronization = 4/4 = 1
B
Phase synchronization at π/2 phase at frequency f
π/2
total length of vector = 4
number of trials = 4
phase synchronization = 4/4 = 1
C
Random phase differences at frequency f
3π/2
phase diff = 0
total length of vector = 0
number of trials = 4
phase synchronization = 0/4 = 0


F7
F3
Fz
F4
F8
FC5
FC1
FC2
FC6
T7
C3
Cz
C4
T8
CP5
CP1
CP2
CP6
P7
P3
Pz
P4
P8
PO9
O1
O2
PO10
Synchrony
Asynchrony

EEG and metaphor

Two operational hypotheses are opposed in the experimental settings:

(i) if complex conceptual metaphors were made out of primary metaphor bricks, coherent activity variations in primary and complex conditions would be similar at the beginning of the semantic integration but would differ later

(ii) if complex conceptual metaphors were based on verbal abstract concepts instead of procedural sensory-motor representations, coherent activity variations would more probably differ from the very beginning of the semantic integration.

Eye tracker

Eye tracking is the process of measuring either the point of gaze (where one is looking) or the motion of an eye relative to the head. An eye tracker is a device for measuring eye positions and eye movement.

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Eye tracker

Eye movement data provide valuable insight into written language comprehension. It helps understand language processing at various levels of analysis within the sentence: character, syllable, word, phrase, or sentence.

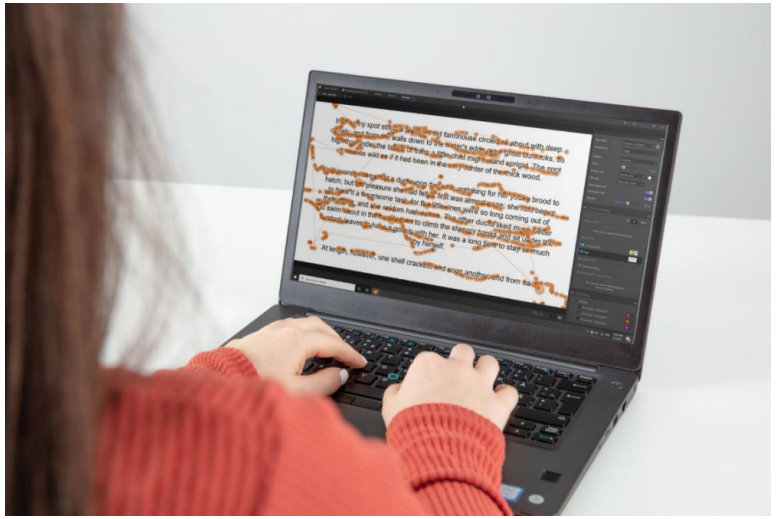
Eye tracker

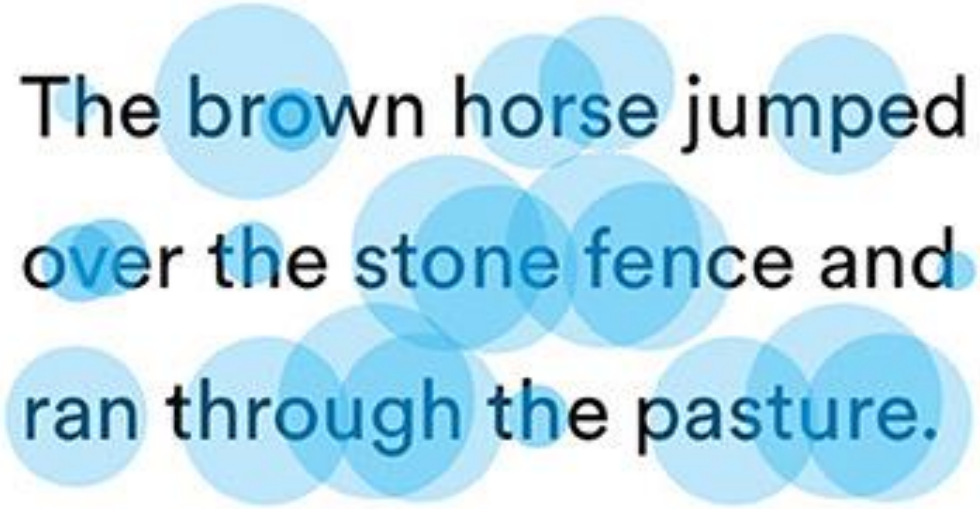
Eyes do not stream smoothly across a text during reading; instead, they fixate on a particular region for about 200-250 ms, jump ahead (saccade forward) about eight character spaces, and regress to previous words.

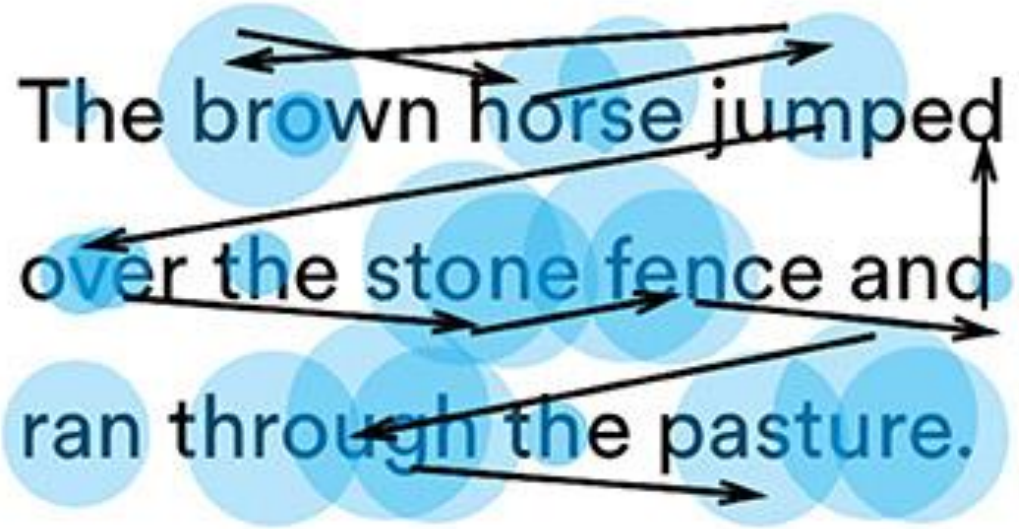
Eye tracking methodology can be used to reveal atypical reading patterns.

Eye tracker

Eye movement analysis allows for objective insight into text processing, by providing information about the duration of visual attention assigned to specific text parts at the level of phrase, word, or even character.




The brown horse jumped
over the stone fence and
ran through the pasture.


The brown horse jumped
over the stone fence and
ran through the pasture.

Eye tracker

For instance:

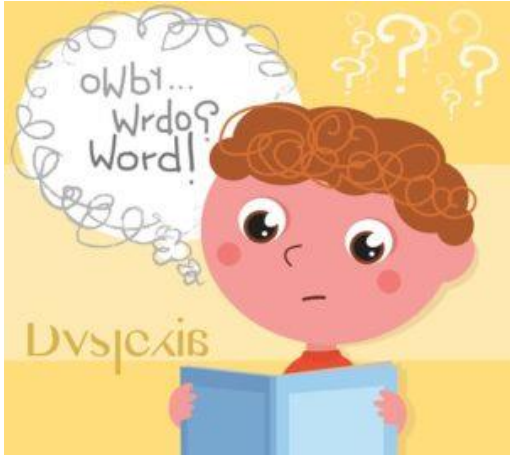
Skipping to read a unit may indicate ease of processing due to very high predictability in the given context.

Longer reading times may indicate confusion, or difficulty to comprehend.

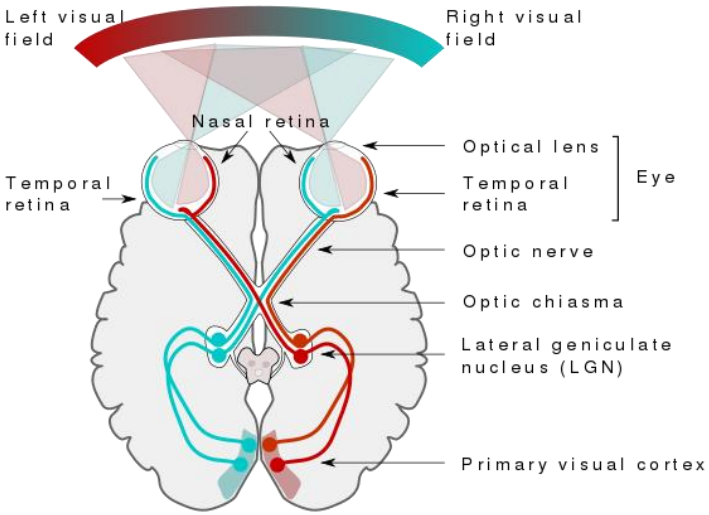
Long regressions (more than 10 letter spaces back along the line or to another line) may indicate difficulty in comprehending or incorporating a unit into the previous context.

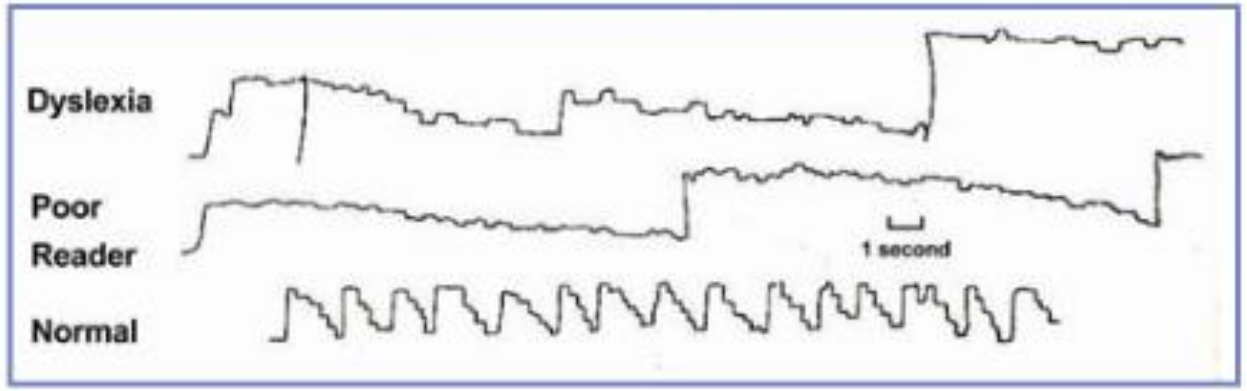
Dyslexia

Specific word reading difficulty, commonly termed ‘developmental dyslexia’, refers to the low end of the word reading skill distribution but is frequently considered to be a neurodevelopmental disorder.



Dyslexia





Eye movements during reading. Up and down movements of the pen recorder correspond to left and right.

Thanks for your attention