Parkjase

Presentation
March 26, 2017

Neuroscience Workshop

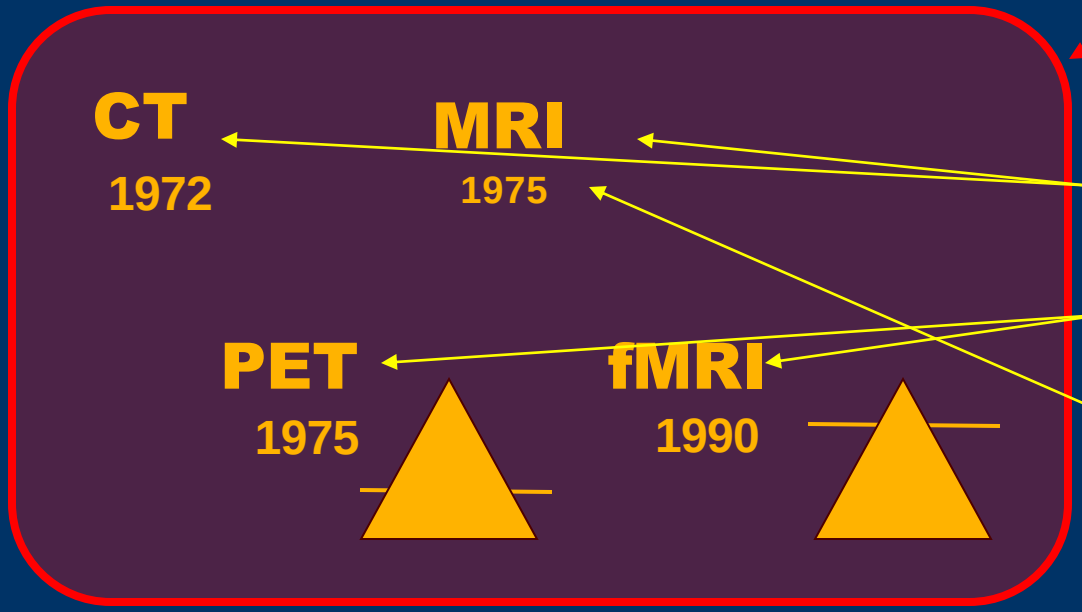
Language and Cognition

조장희
융합기술연구원
서울대학교

In-vivo Human Imaging

Language
Cognition
Behavior

Cadaver **Patient** **Animal**



I. Structural **Anatomy**

II. Functional **Anatomy**

III. Connectional **Anatomy**

EEG

1930

OPTO-GEN

2000

Resolution

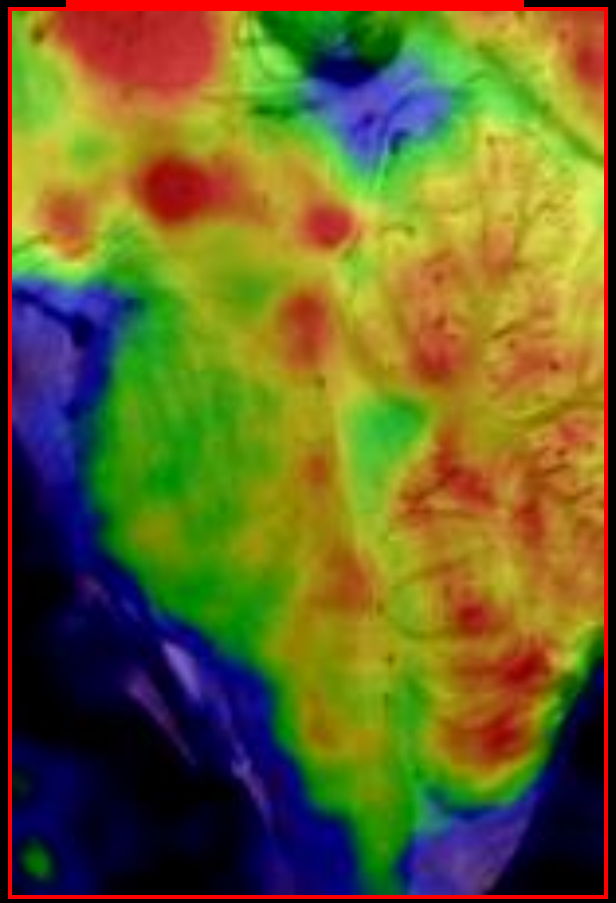
Brainstem Image

Molecular Image

1.5 T

7.0 T

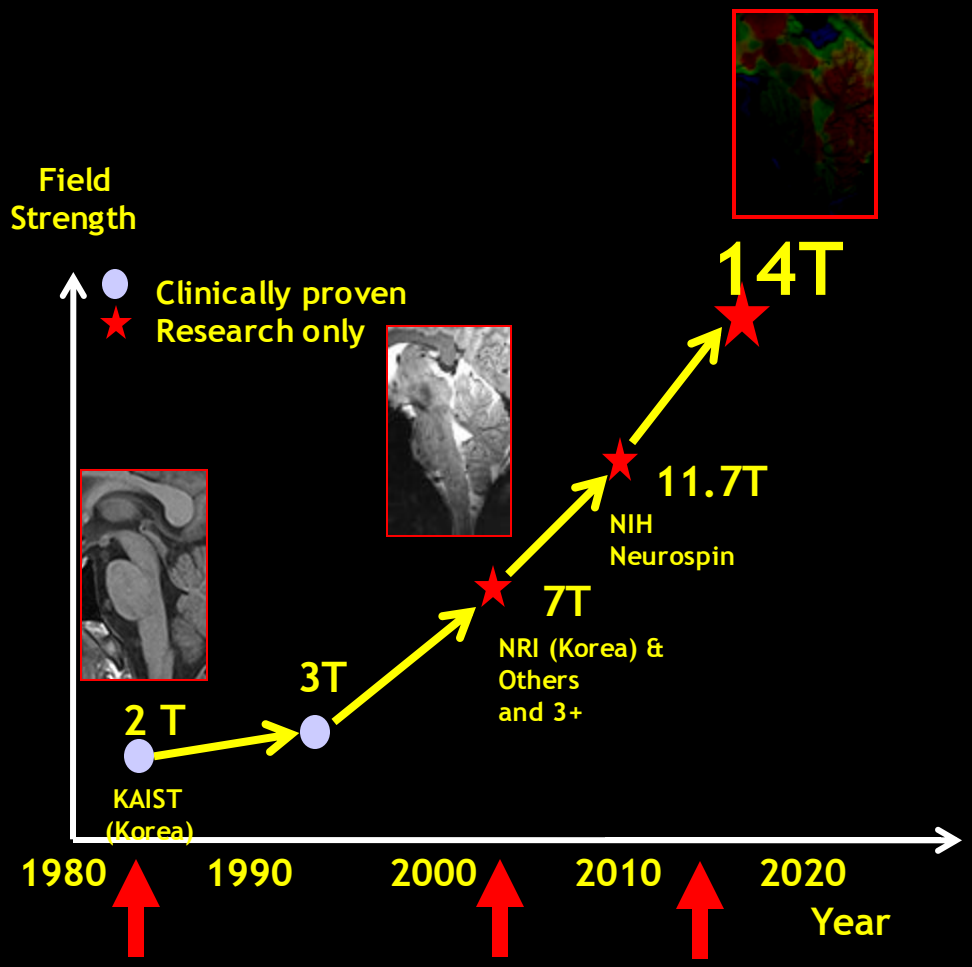
7.0 T + PET



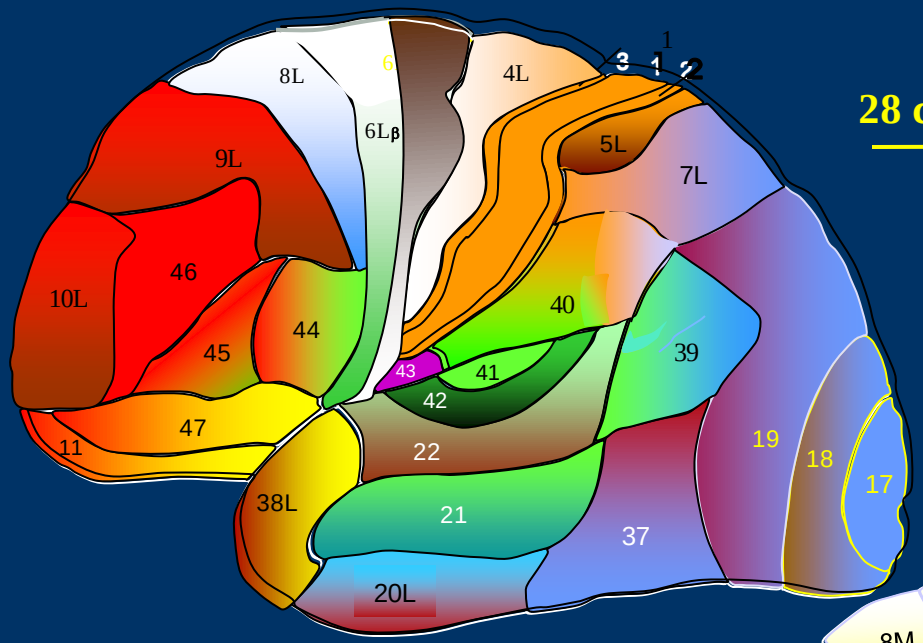
We will map the " Imagining Brain "
By Big Data Mining or Deep Learning with Superb Resolution Never Before Imagined !

Next Generation Super Resolution PET

DECA Tesla Era + New Gen. PET

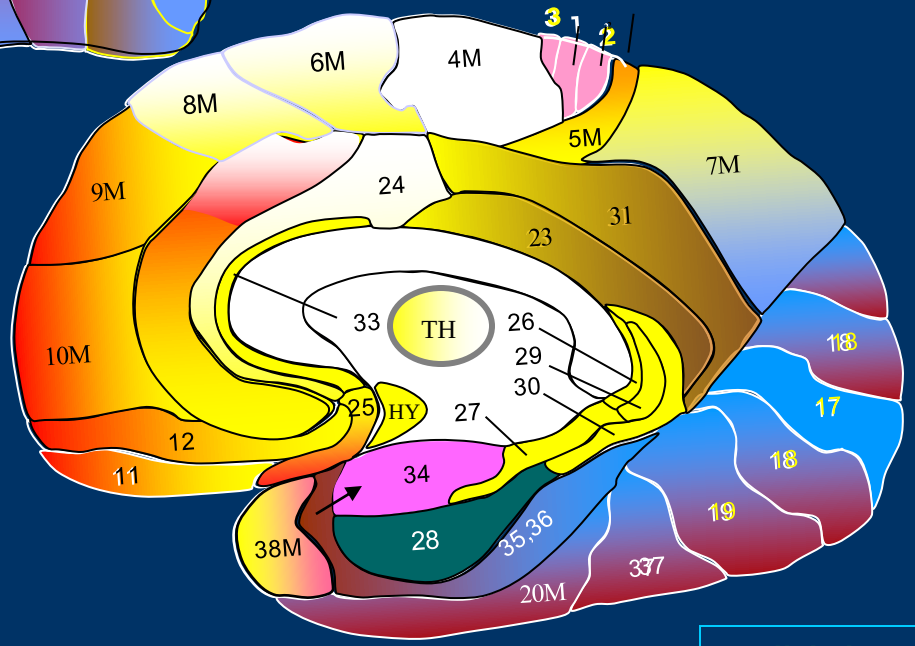


Color Coded Brodmann's Areas



28 colors are presently used for the map

Lateral view



Medial view

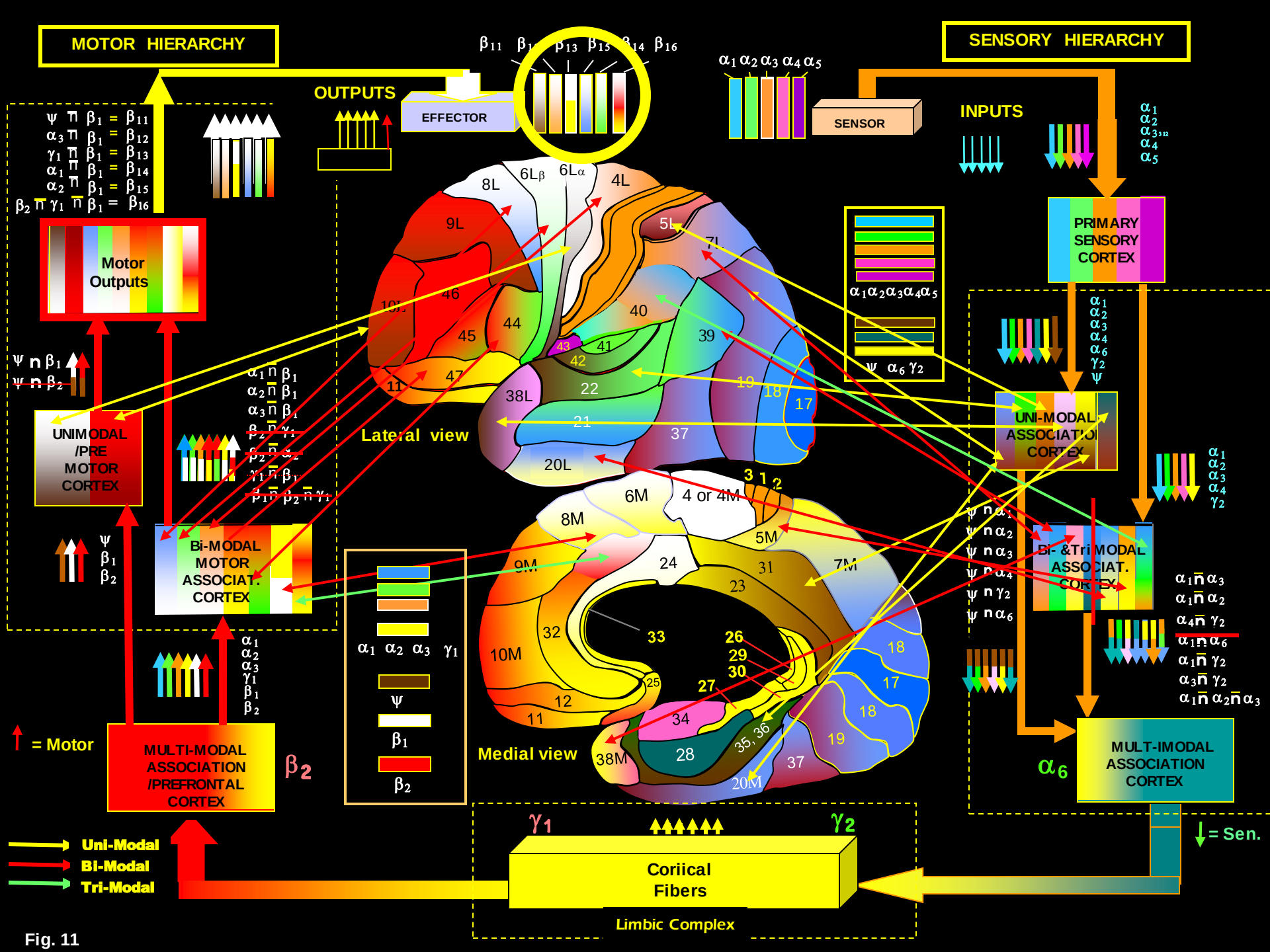
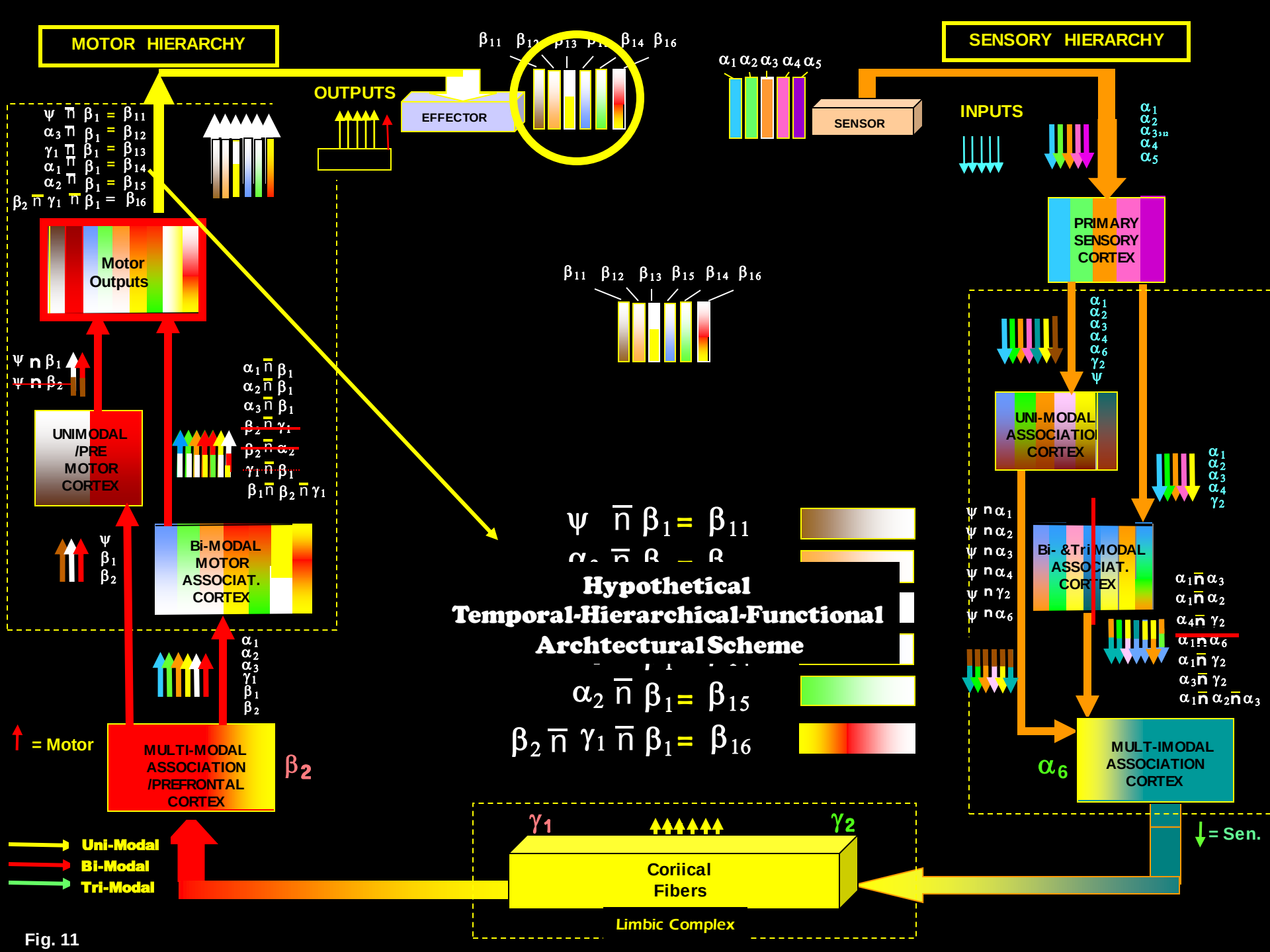

MOTOR HIERARCHY
SENSORY HIERARCHY
OUTPUTS
EFFECTOR
SENSOR
INPUTS
Motor Outputs
PRIMARY SENSORY CORTEX
UNIMODAL /PRE MOTOR CORTEX
Bi-MODAL MOTOR ASSOCIAT. CORTEX
UNI-MODAL ASSOCIATION CORTEX
Bi- &Tri MODAL ASSOCIAT. CORTEX
MULTI-MODAL ASSOCIATION /PREFRONTAL CORTEX
MULT-IMODAL ASSOCIATION CORTEX
Lateral view
Medial view
Coriical Fibers
Limbic Complex
= Motor
= Sen.
Uni-Modal
Bi-Modal
Tri-Modal

Fig. 11


MOTOR HIERARCHY
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OUTPUTS
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PRIMARY SENSORY CORTEX
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UNI-MODAL ASSOCIATIO CORTEX
Bi-MODAL MOTOR ASSOCIAT. CORTEX
Bi- &Tri MODAL ASSOCIAT. CORTEX
MULTI-MODAL ASSOCIATION /PREFRONTAL CORTEX
MULT-IMODAL ASSOCIATION CORTEX
Hypothetical
Temporal-Hierarchical-Functional
Archtectural Scheme
= Motor
= Sen.
Uni-Modal
Bi-Modal
Tri-Modal
Coriical Fibers
Limbic Complex

Fig. 11

3. 18, 2017

Connectional Anatomy

1. Fiber Tractography
2. Language
3. “ Engram “ and “ Langram “

3. 7, 2017

1. Fiber Tractography

2. Language

3. “ Engram “ and “ Langram “

Paul Emile Flechsig
(1847–1929)

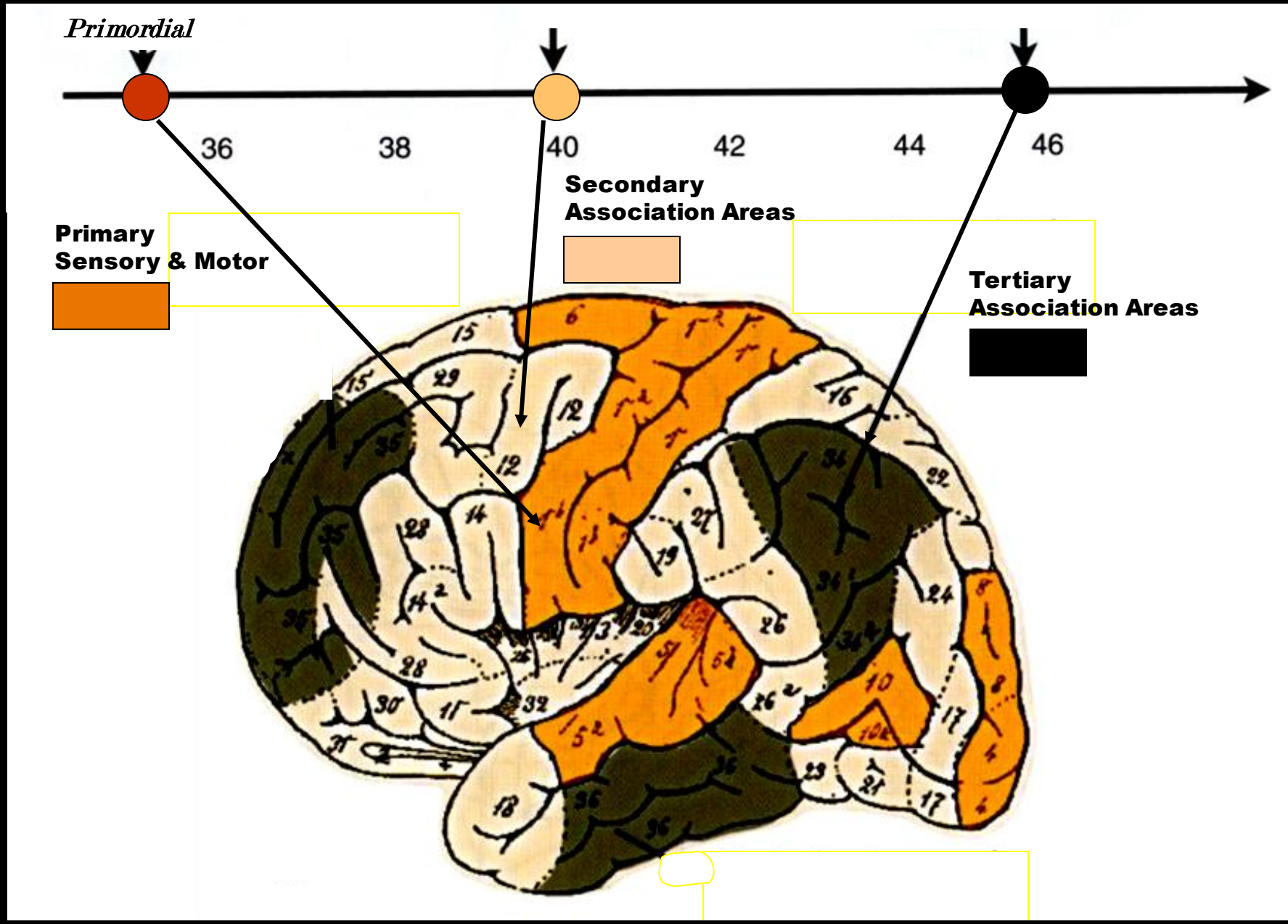
Develomental Myeloarchtectonic Map

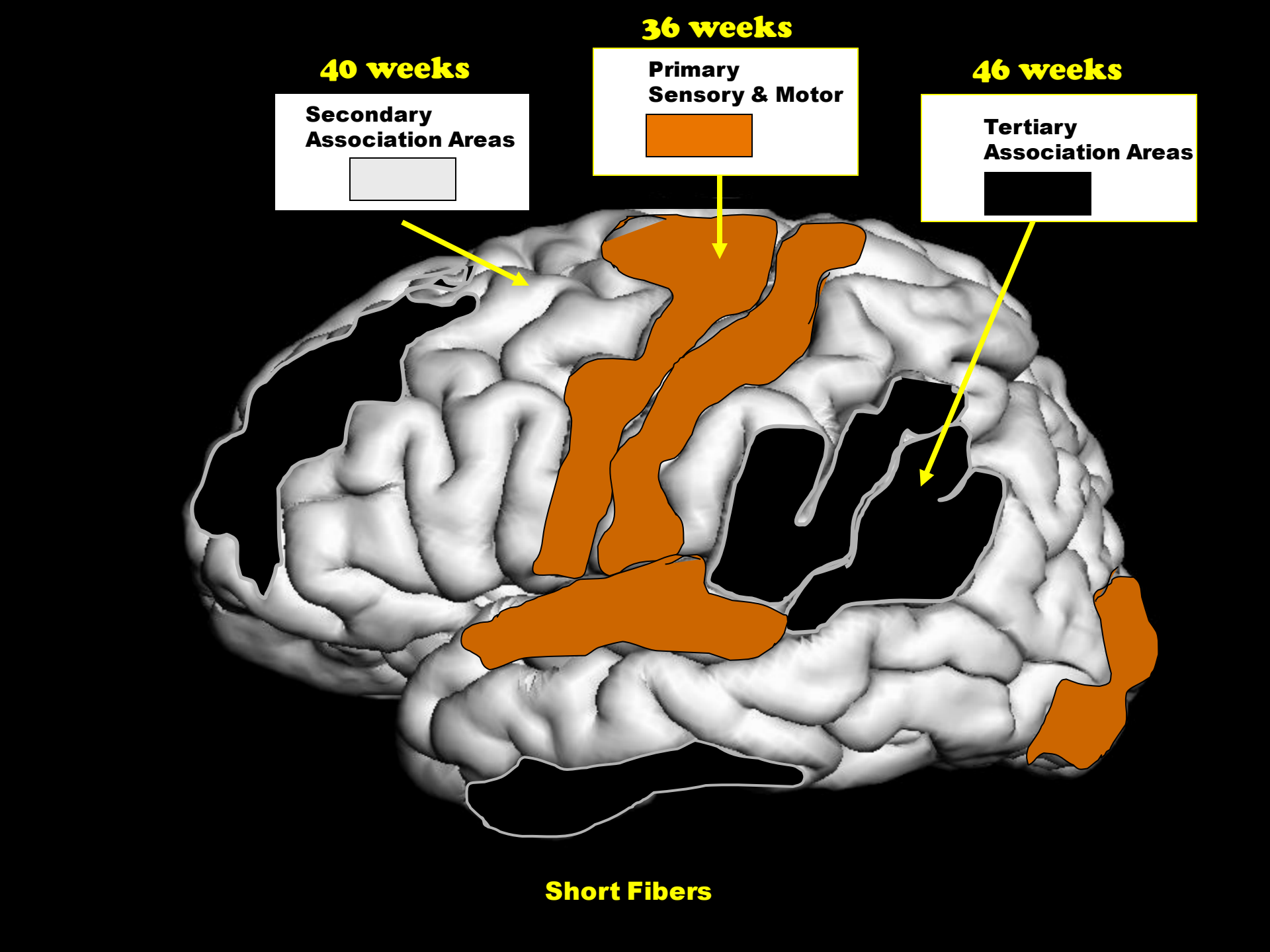
Group 1—*areas (from 1 to 10) showing signs of myelination at birth*

Group 2—*areas (from 11 to 31) of intermediate myelination*

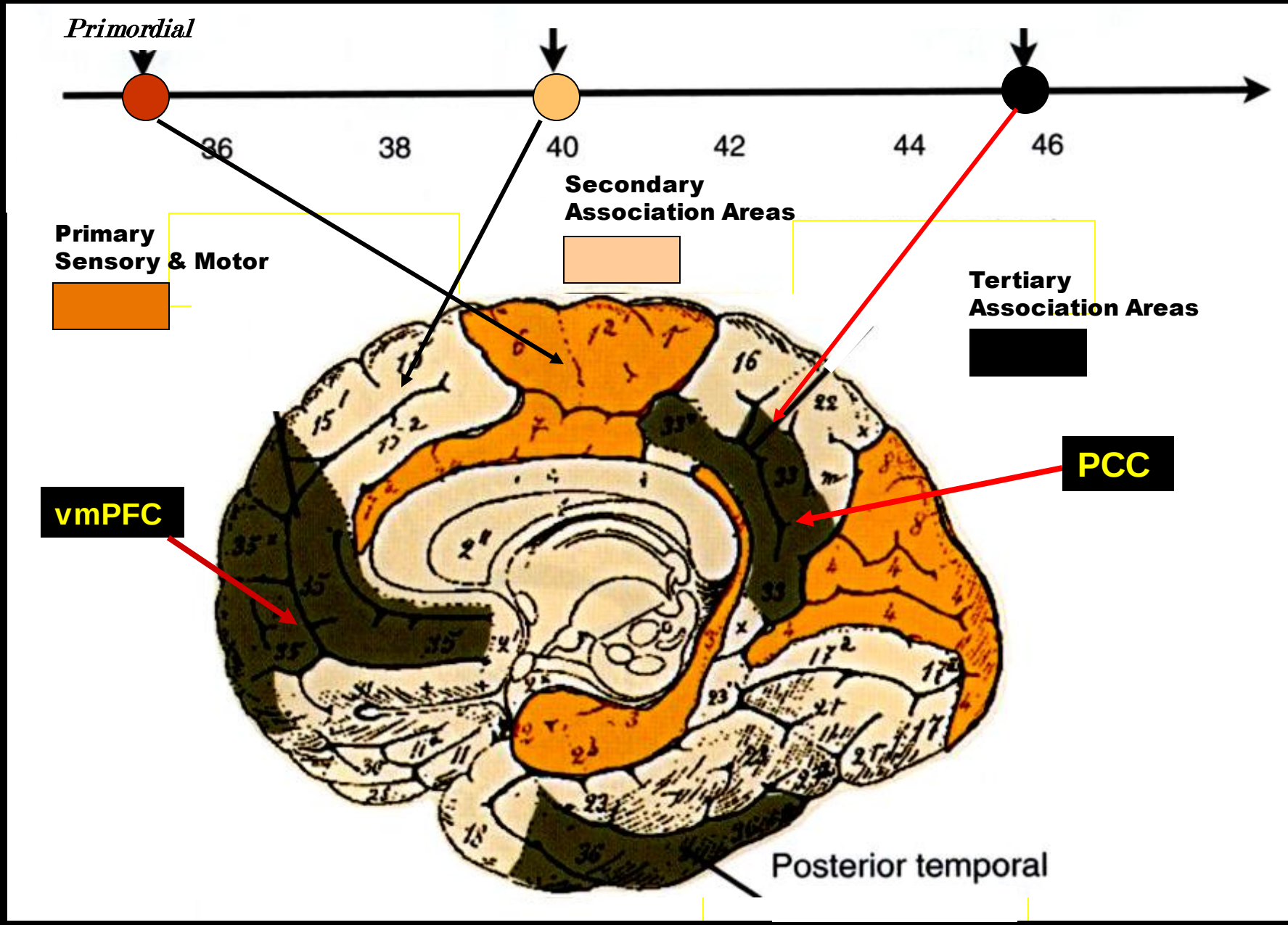
Group 3—*areas (from 32 to 36) showing myelination after birth*

Myelogenetic Map



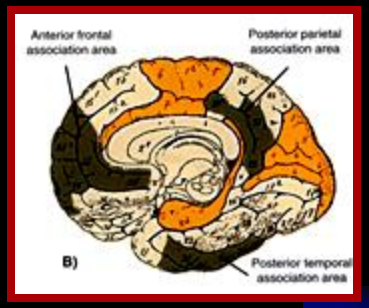

36 weeks
Primary
Sensory & Motor
40 weeks
Secondary
Association Areas
46 weeks
Tertiary
Association Areas
Short Fibers

Myelogenetic Map

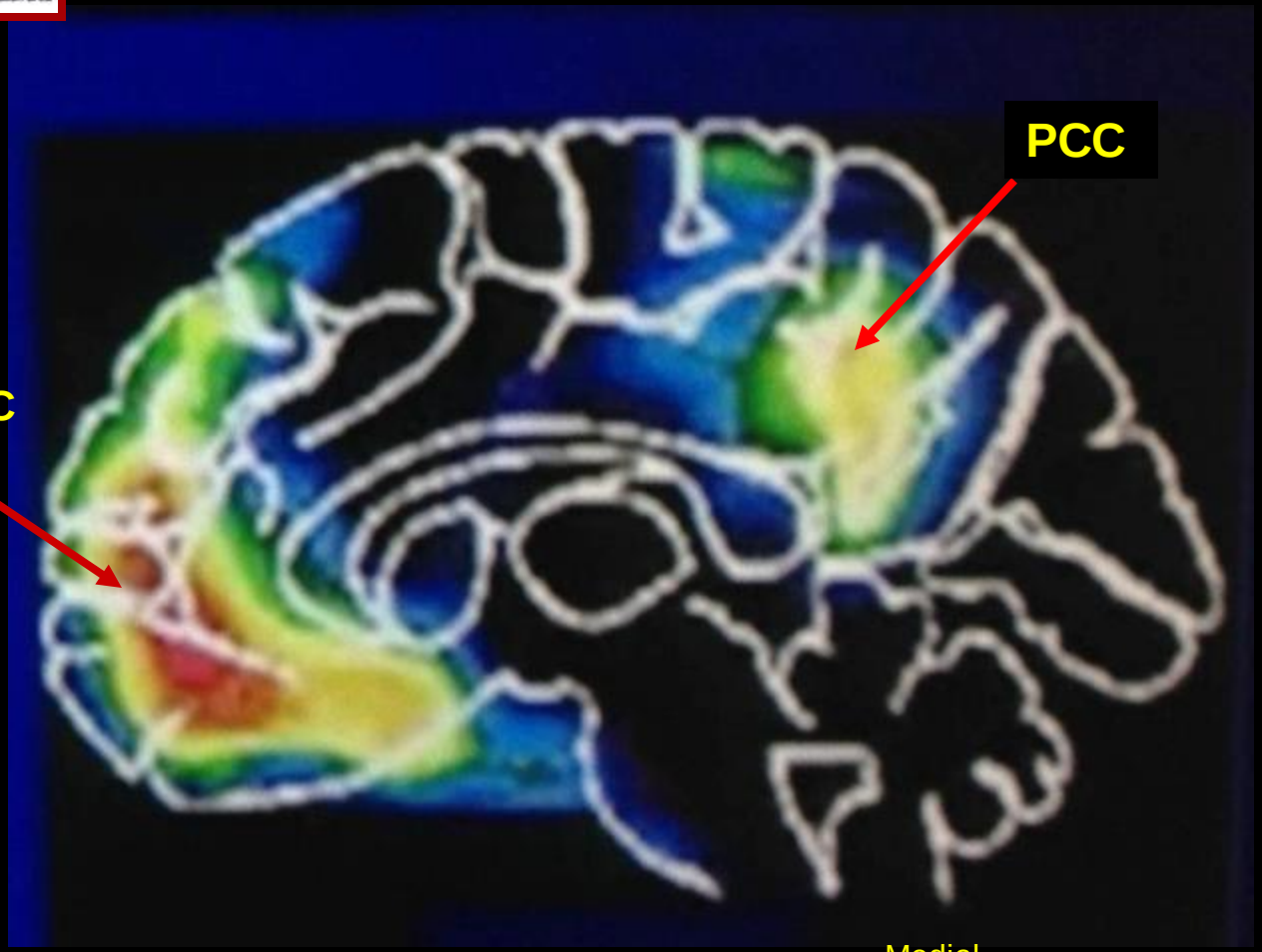


"No Thinking" Cortical Areas

Activation and Deactivation – PET Study



Medial view

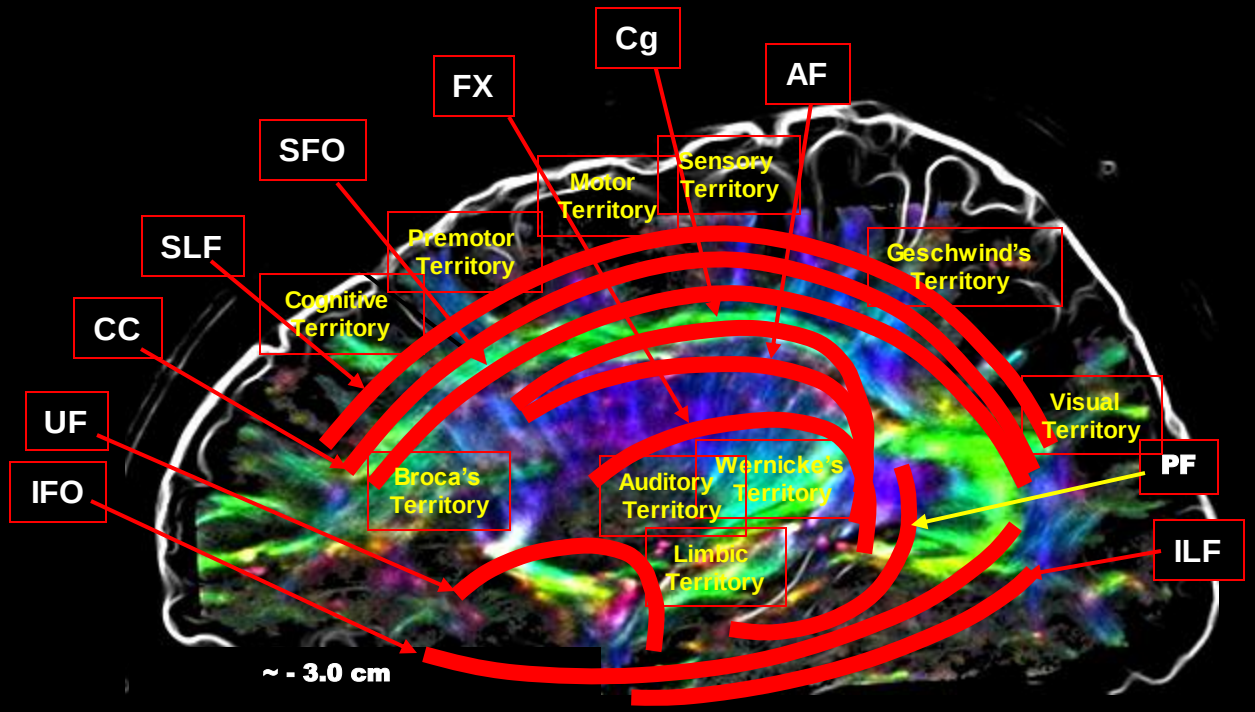


Medial

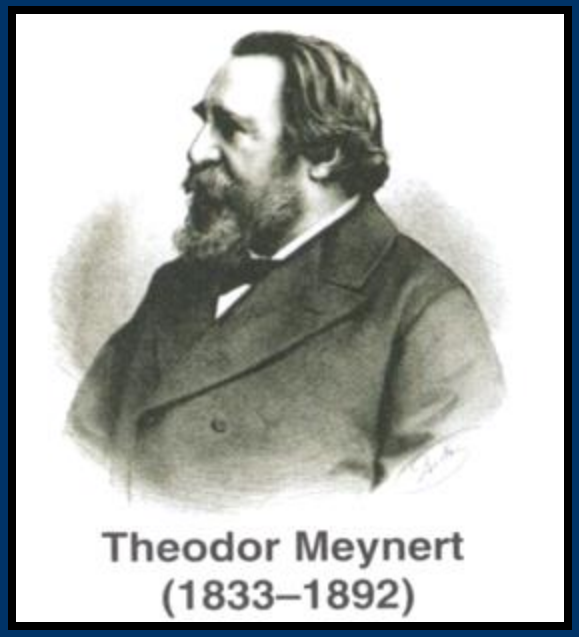
PET Study

M. Raichle 2000

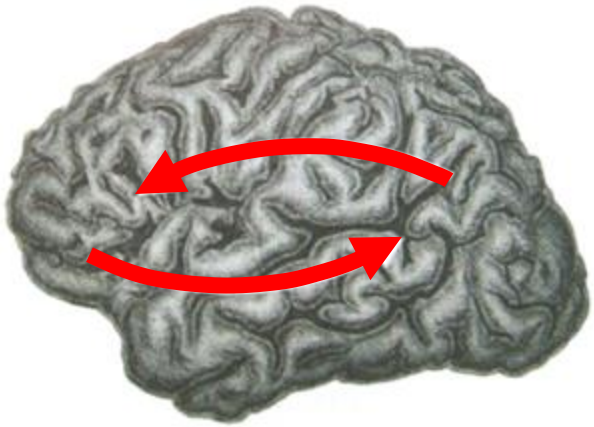
Neural Functional Flow Anatomy with Connectivity - II



Long Fibers

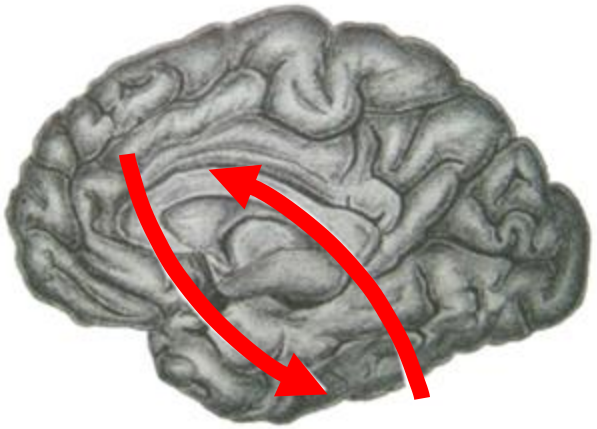


Theodor Meynert
(1833–1892)

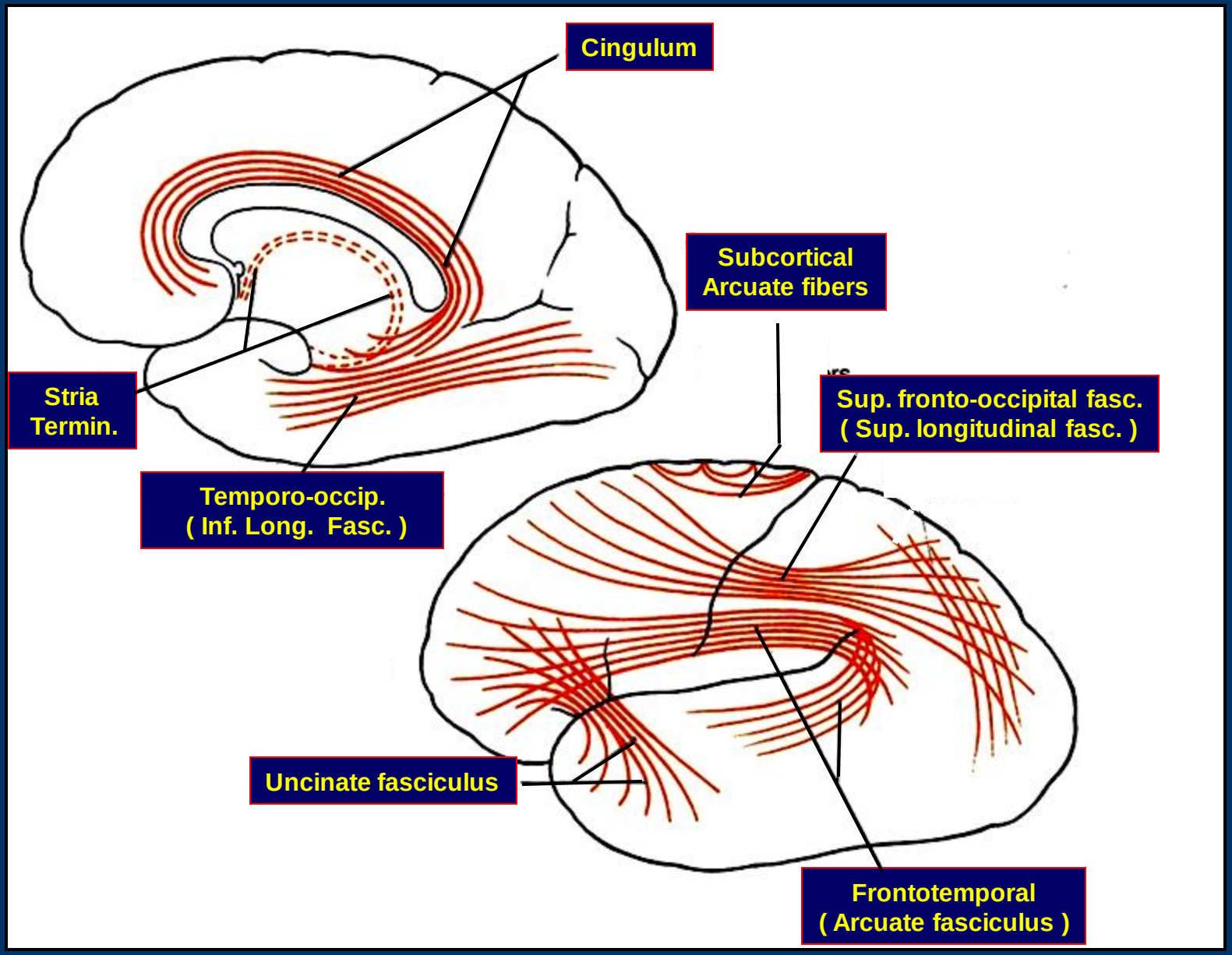


ASSOCIATION FIBRES

COMMISSURAL FIB ES



PROJECTION FIBRES


Cingulum
Subcortical
Arcuate fibers
Stria
Termin.
Sup. fronto-occipital fasc.
(Sup. longitudinal fasc.)
Temporo-occip.
(Inf. Long. Fasc.)
Uncinate fasciculus
Frontotemporal
(Arcuate fasciculus)

21st Century

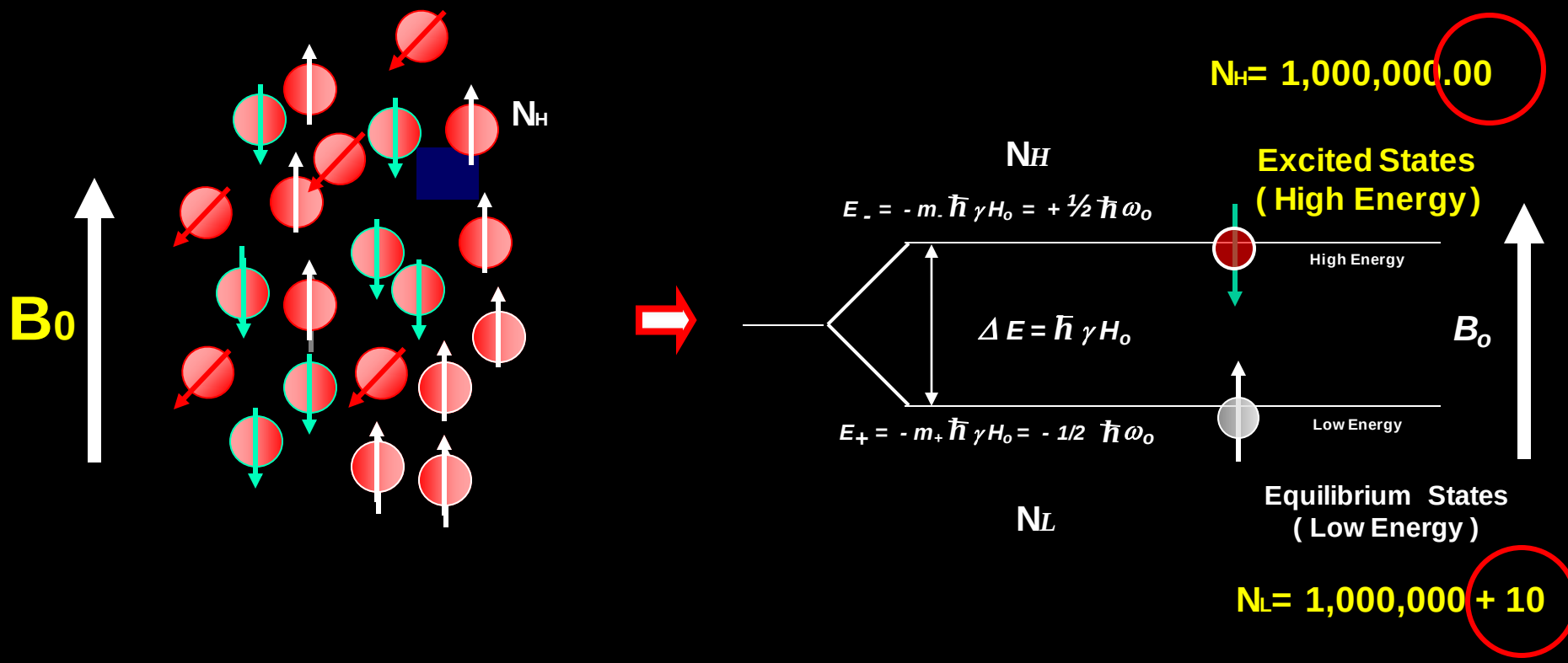
7.0 Tesla

$$N_L = N_H e^{E/KT}$$

Where $E = h\nu = \hbar\gamma H$

More than linear !

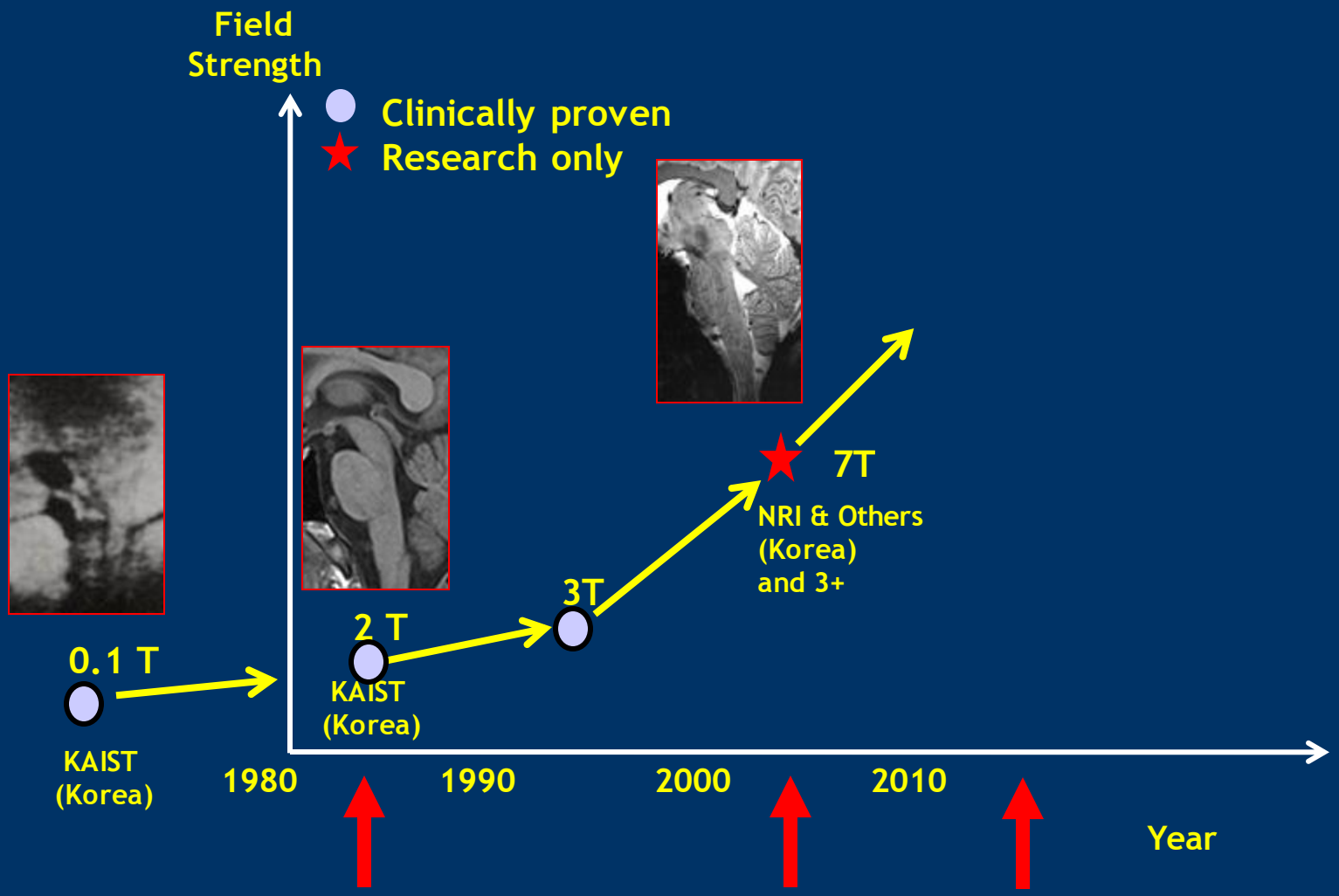
MRI & Zeeman Split



$$\frac{N_L}{N_H} = e^{E / kT} = 1.000.000.10$$ ..... Boltzmann's Distribution

$E = h\nu$, $k = 1.38 \times 10^{-23}$ J/K , $T = 300$ Kelvin, $N_H = 1.000.000.00$

Summary

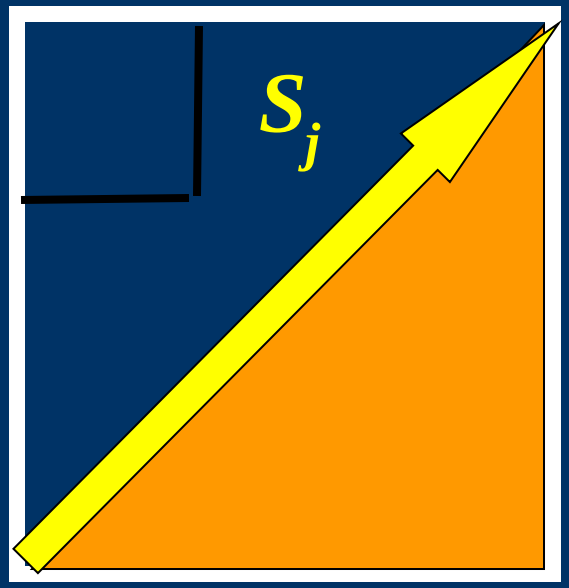

Field
Strength
Clinically proven
Research only
0.1 T
KAIST
(Korea)
2 T
KAIST
(Korea)
3T
7T
NRI & Others
(Korea)
and 3+
1980
1990
2000
2010
Year

1. Fractional Volume Technique – FVT-1

j_{th} *Voxel*

D

Original Diffusion Tensors



$\hat{g}_j^T$, $\hat{g}_j$

Original DTI

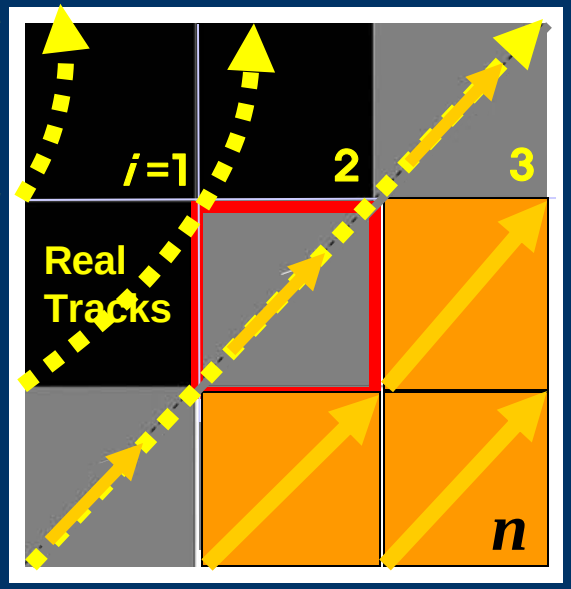
High Res. DTI

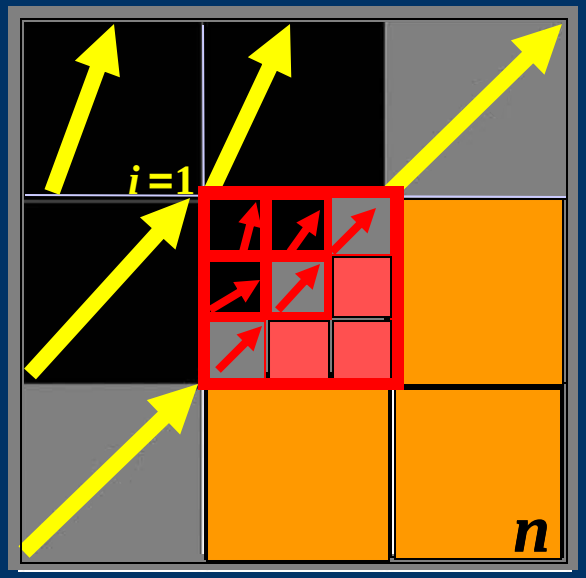
1st Order FVT

f_i

i_{th} *Fractional Volume*

$$\sum_{i=1}^{n} f_i$$





II. Spherical Deconvolution

$$S(\theta, \varphi) = R(\theta) \otimes FOD(\theta, \varphi)$$: Diffusion Weighted Signal

$FOD(\theta, \varphi)$: Spherical distribution of fibre orientations in the voxel

$R(\theta)$: Diffusion profile

Recovered Original

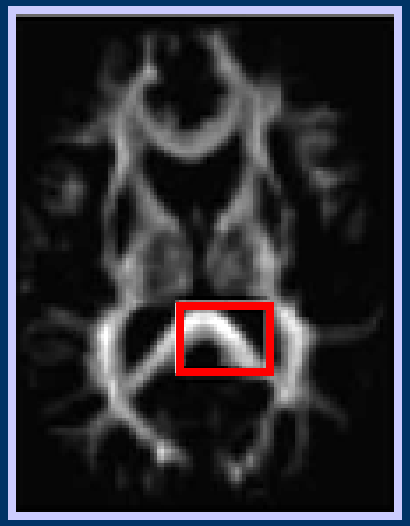
$$\therefore \quad S(\theta, \varphi) \otimes \bar{R}(\theta) = FOD(\theta, \varphi)$$

Deconvolved Signal

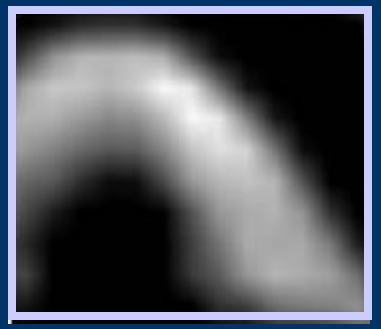
Deconvolution

FOD : Fiber Orientation Direction

Super - Resolution TDI Image Processing - 3



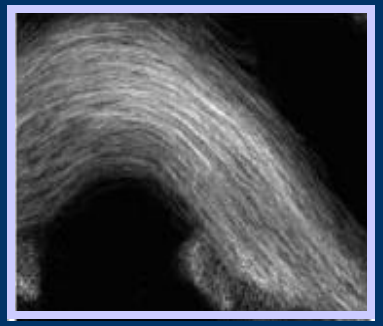
FA – DWI



Simple
Interpolated Data

New Tract-Density Imaging

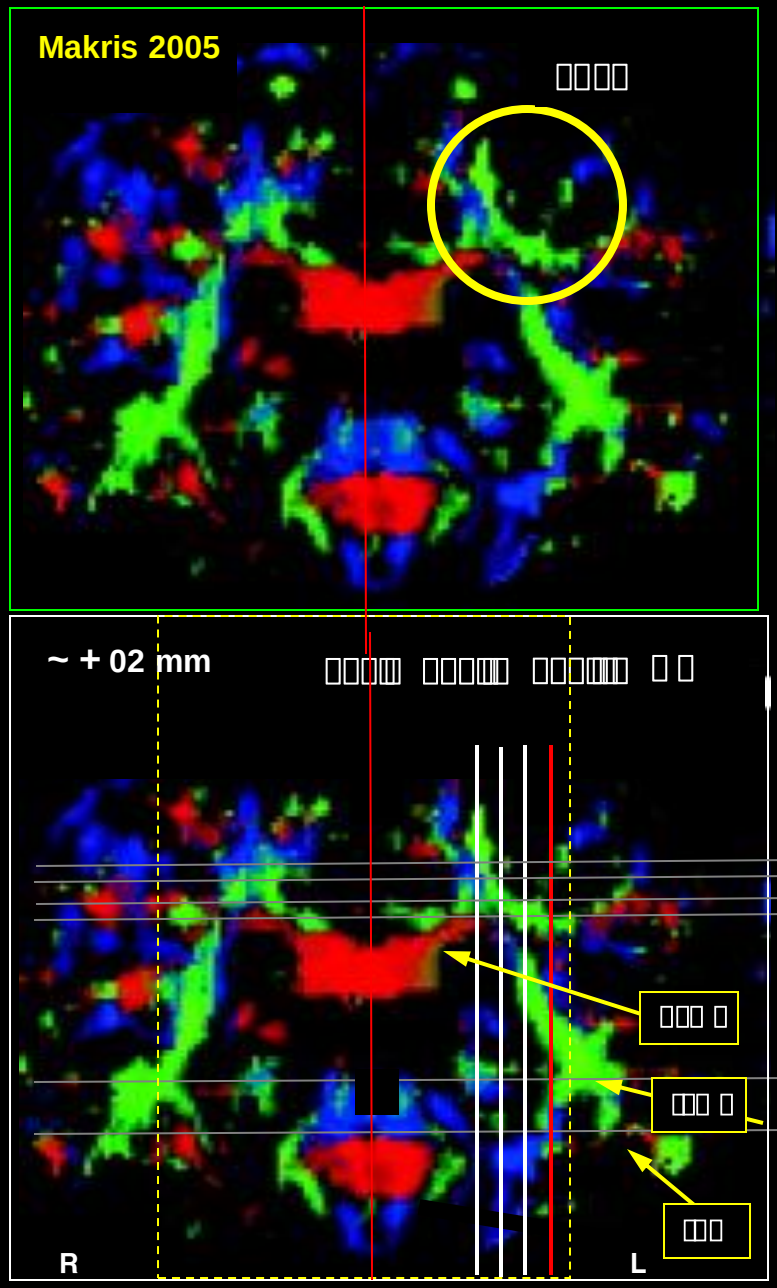
New TDI



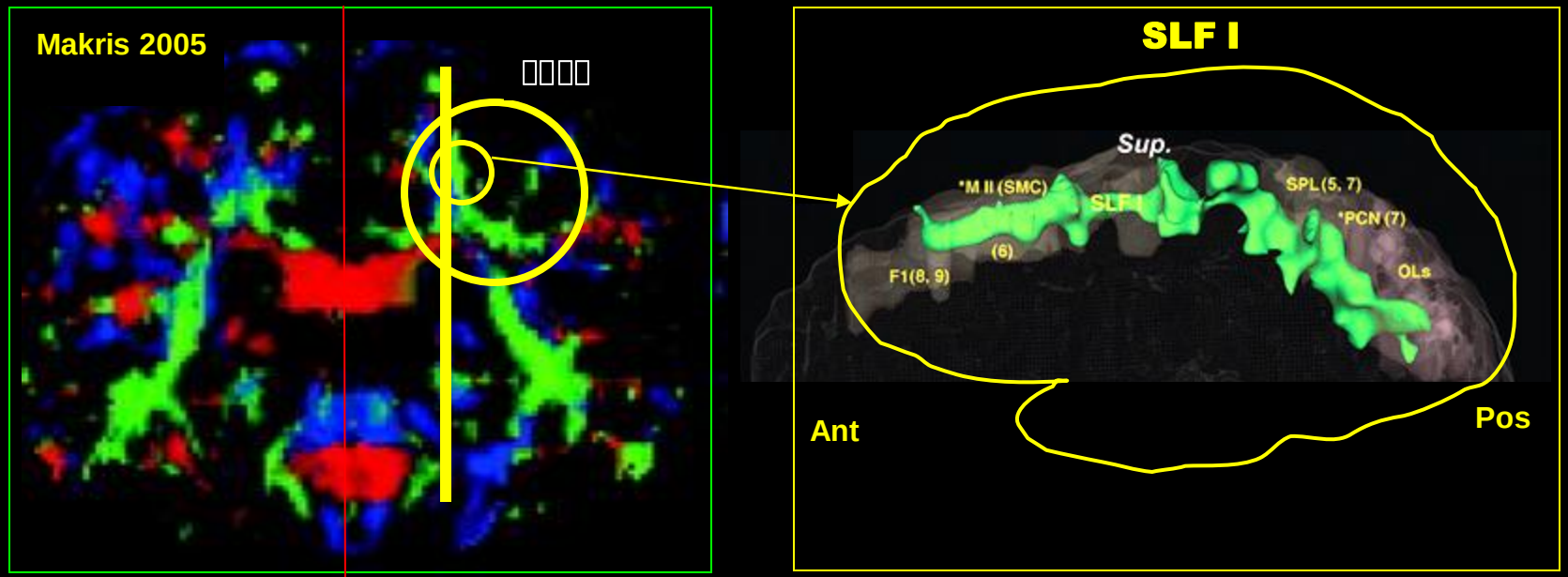
Super-Resolution
Tract Density Imaging
(TDI)

Calamante., Tournier et al in ISMRM 2010

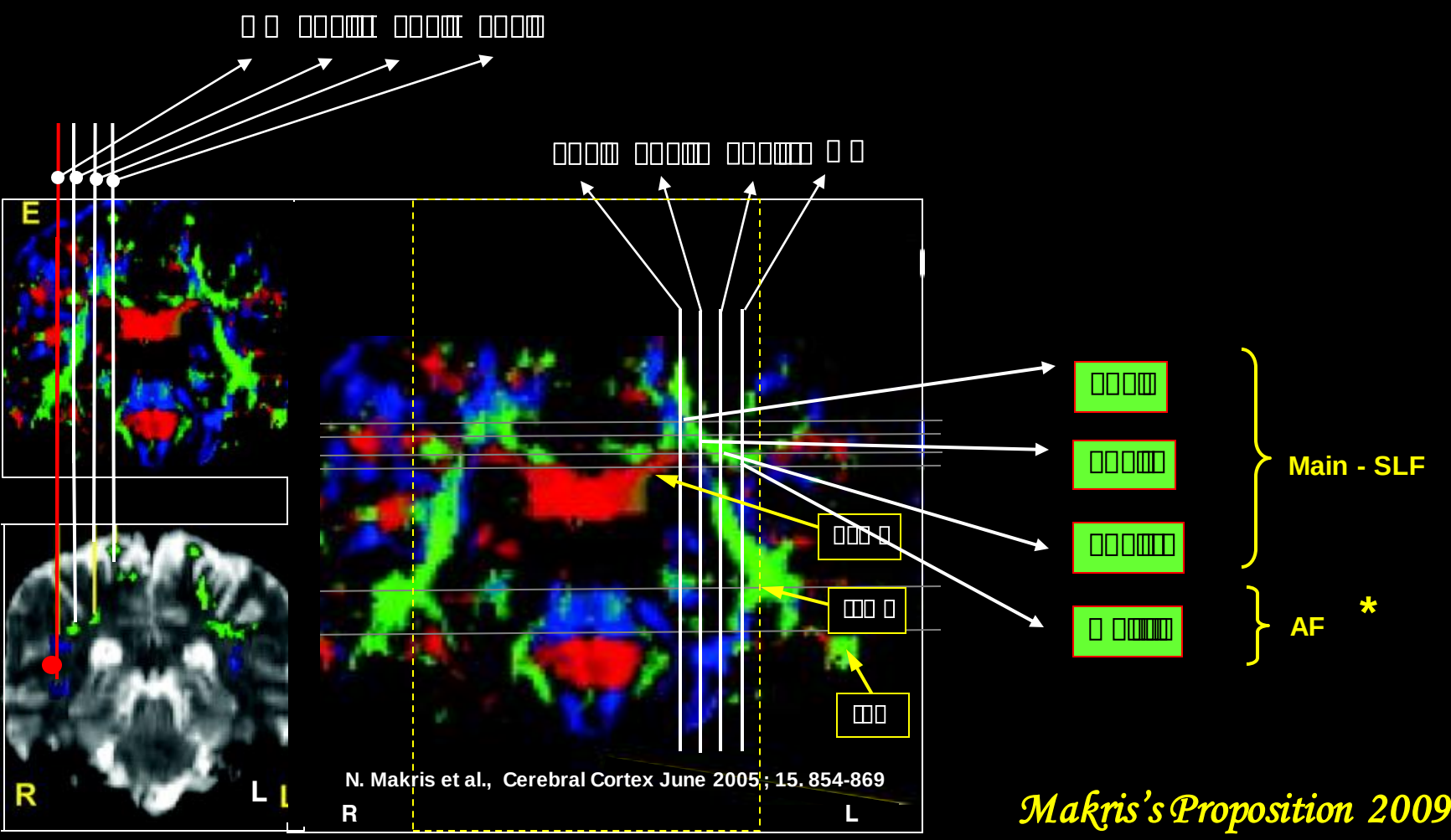
N. Makris et al., Cerebral Cortex June 2005 ; 15. 854-869



N. Makris et al., Cerebral Cortex June 2005, - 9 ; 15. 854-869



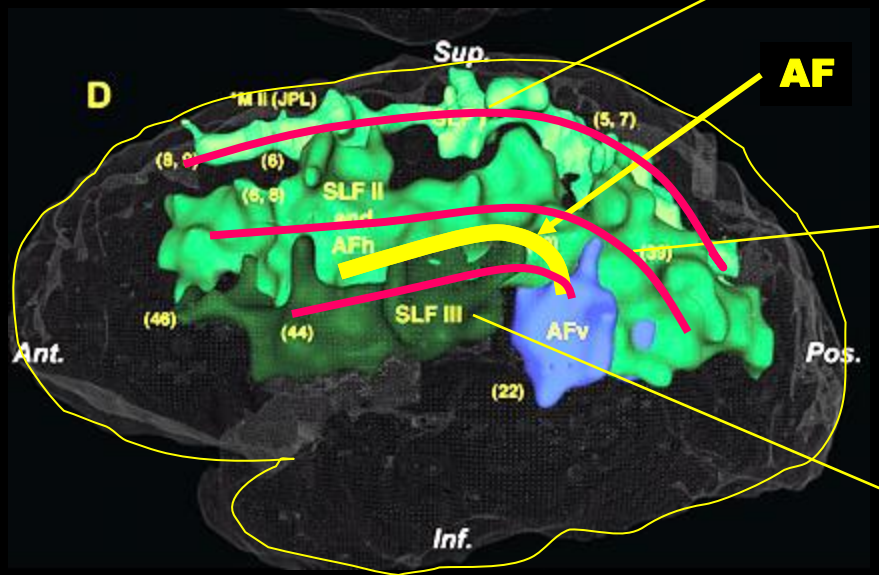
N. Makris Original Assignment of SLF – 2005, 2009

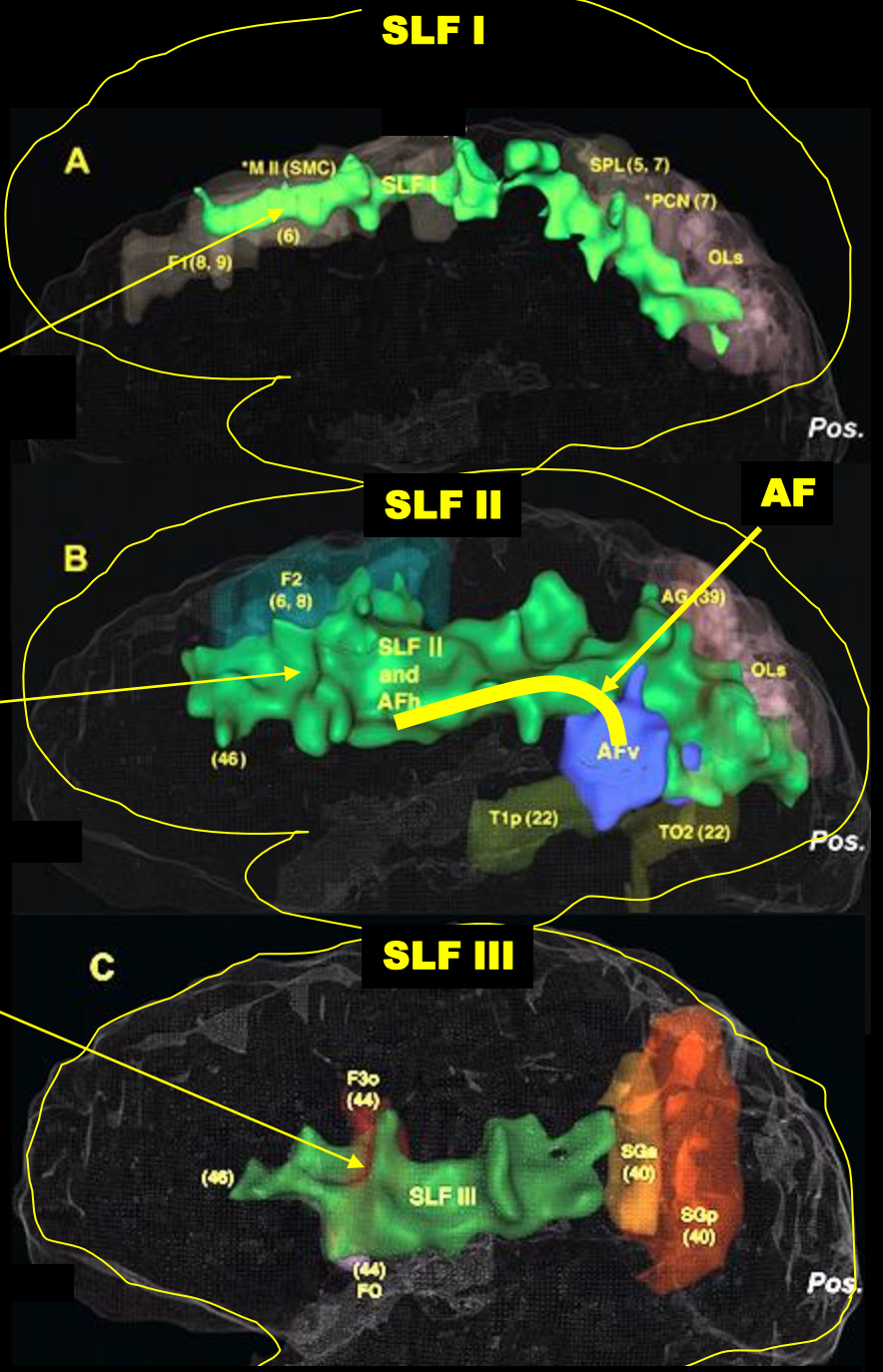


Makris's Proposition 2009

(a). SLF Sub components proposed and used by N. Makris et al., 2005, 2009

2005, 2009 by Makris et al

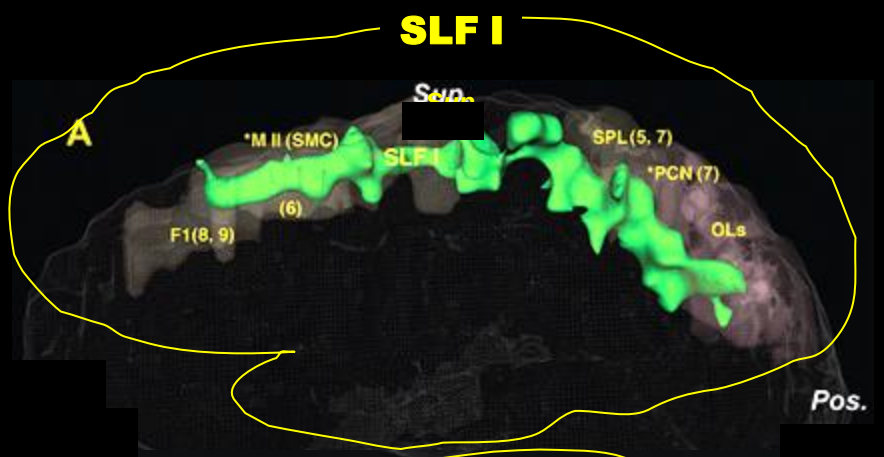


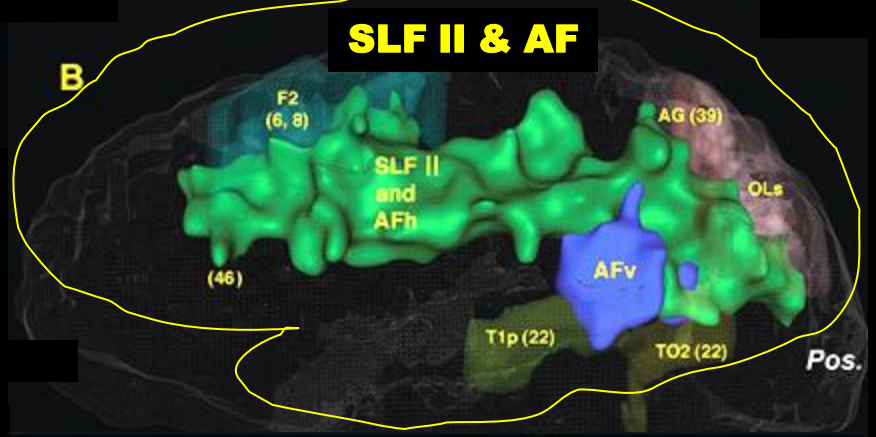


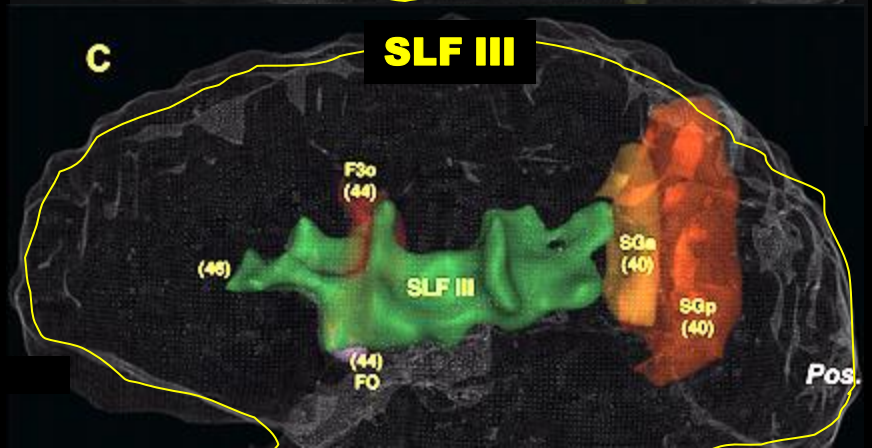
Nikos Makris1,2, David N. Kennedy1, Sean McInerney1, A. Gregory Sorensen3, Ruopeng Wang3, Verne S. Caviness, Jr1 and Deepak N. Pandya2

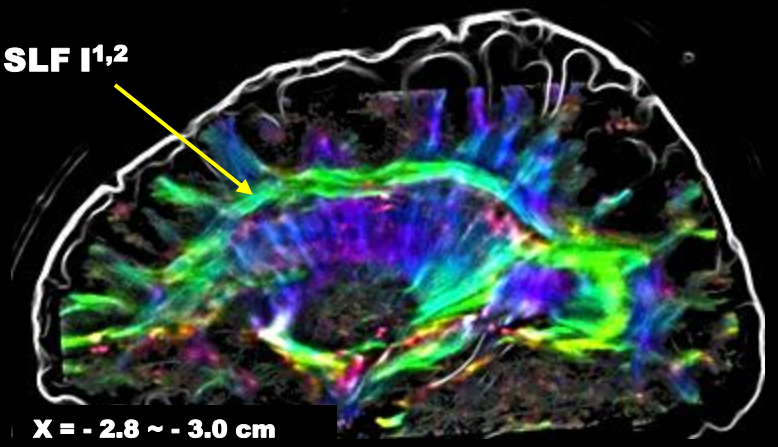
2005, 2009 by Makris et al

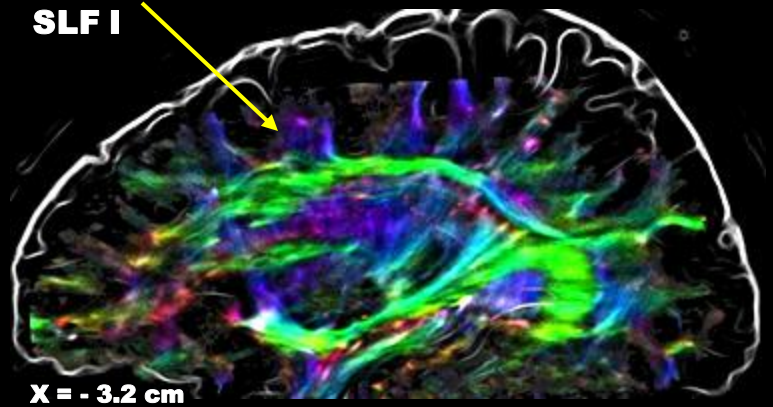
New 7.0T MRI Human Brain Fiber Tractography 2015

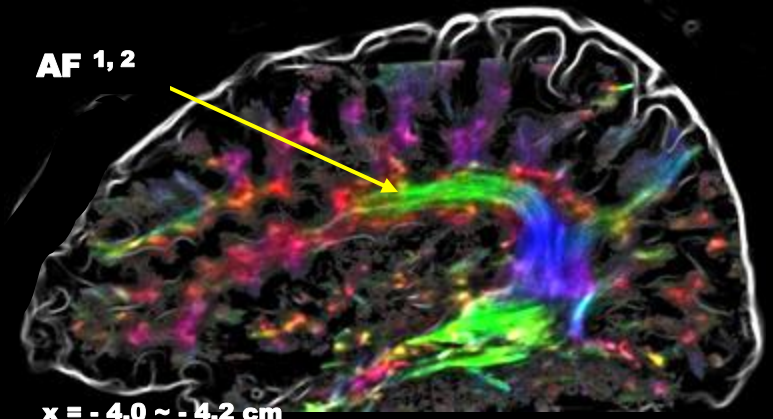








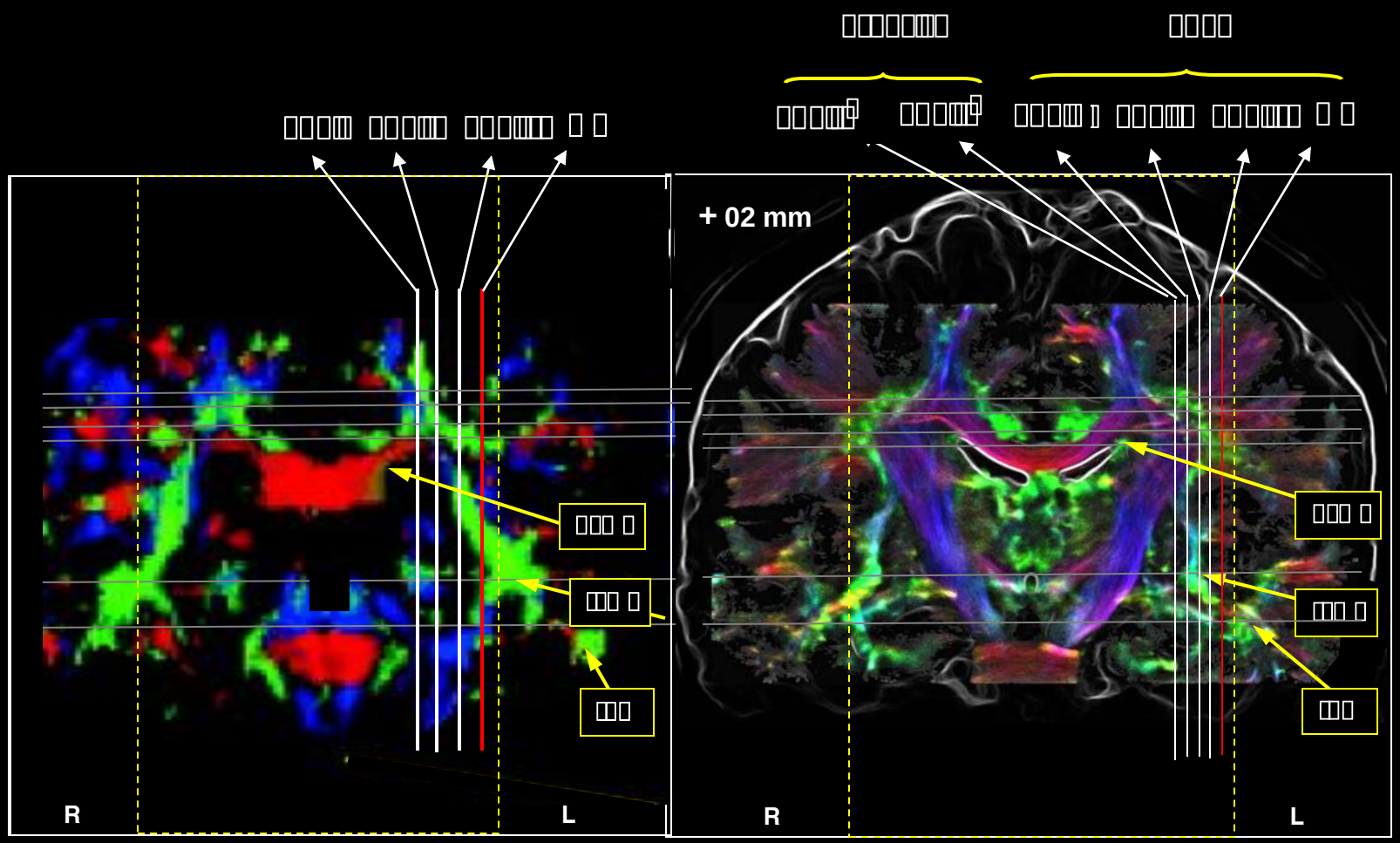




New Proposed SLF Group

S-SLF Group : SLF I [1], SLF I [2] ;

New SLF Group : SLF I, II, III, AF



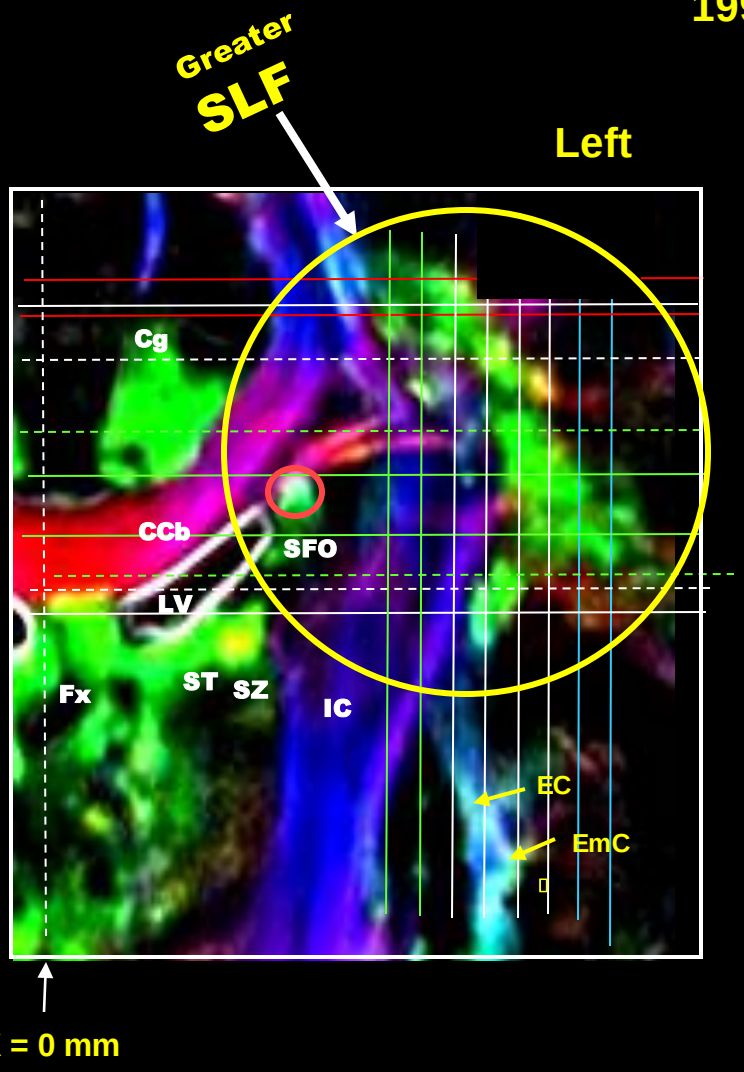
Modified from : N. Makris et al., Cerebral Cortex June 2005 ; 15. 854-869

Modified from : Z. H. Cho et al. (Edit.) 7.0 T MRI Brain White Matter Atlas. Springer, 2015

Classic Model 1 of SLF in Coronal View

I

1995



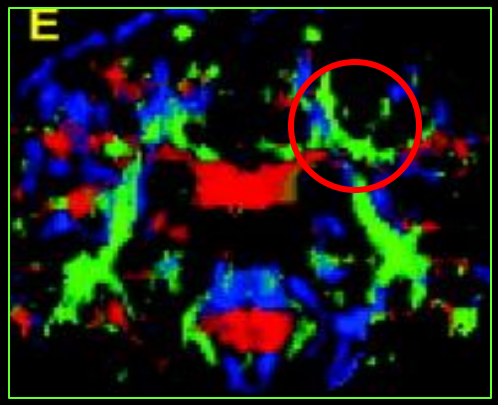


Fig. 3.

New SLF in Coronal View

N. Makris Original Assignment of SLF – 2005, 2009

II

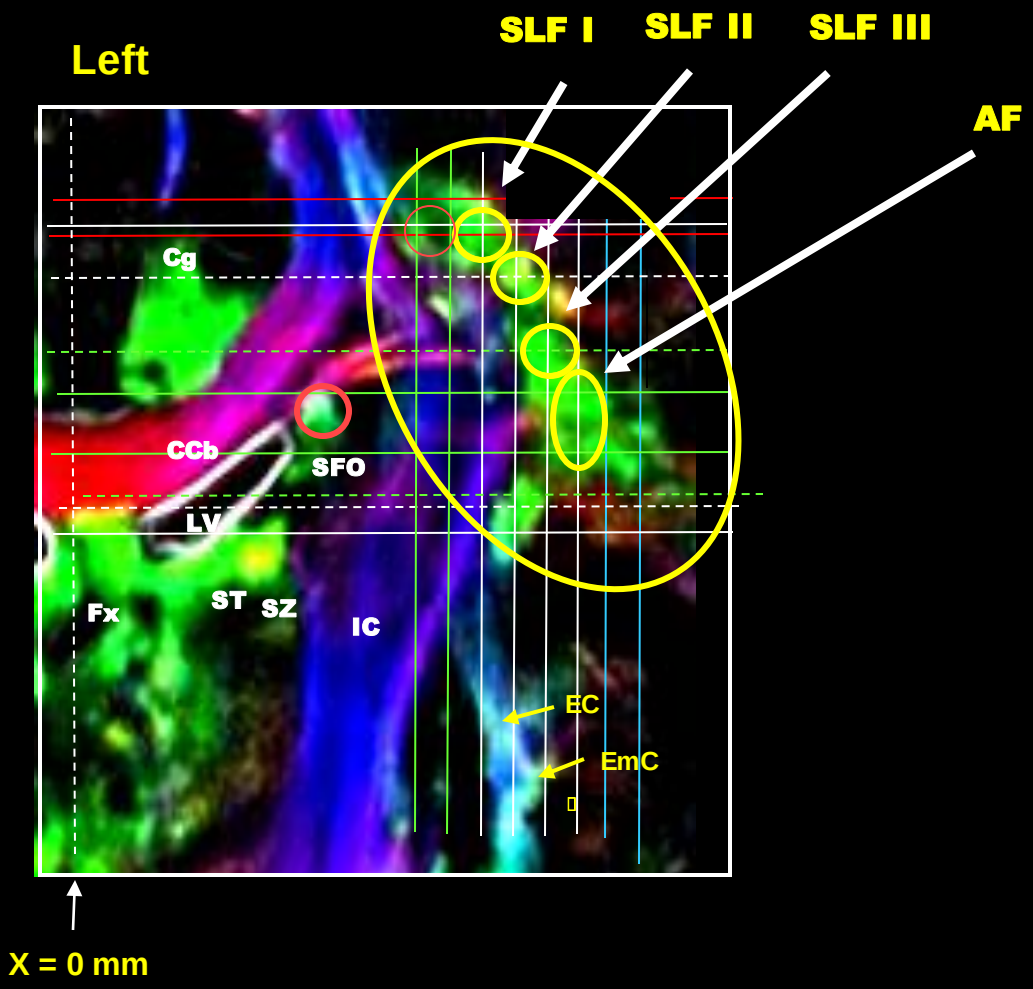


Fig. 3.

New Proposed 10-Division Model of SLF in Coronal View

2015

III

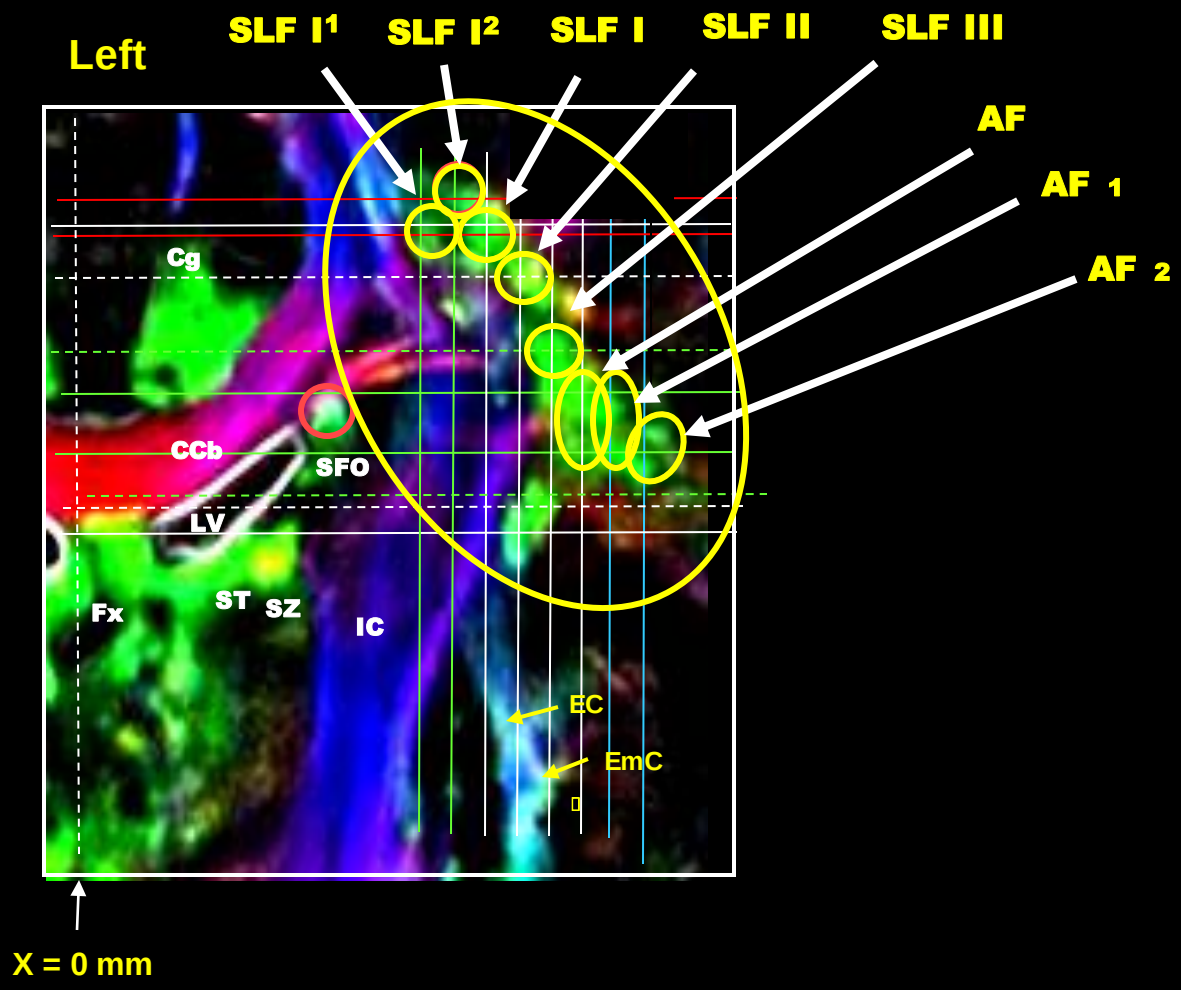


Fig. 3.

Cho et al to be published 2016

New Proposed 10-Division Model of SLF in Coronal View

2016

IV

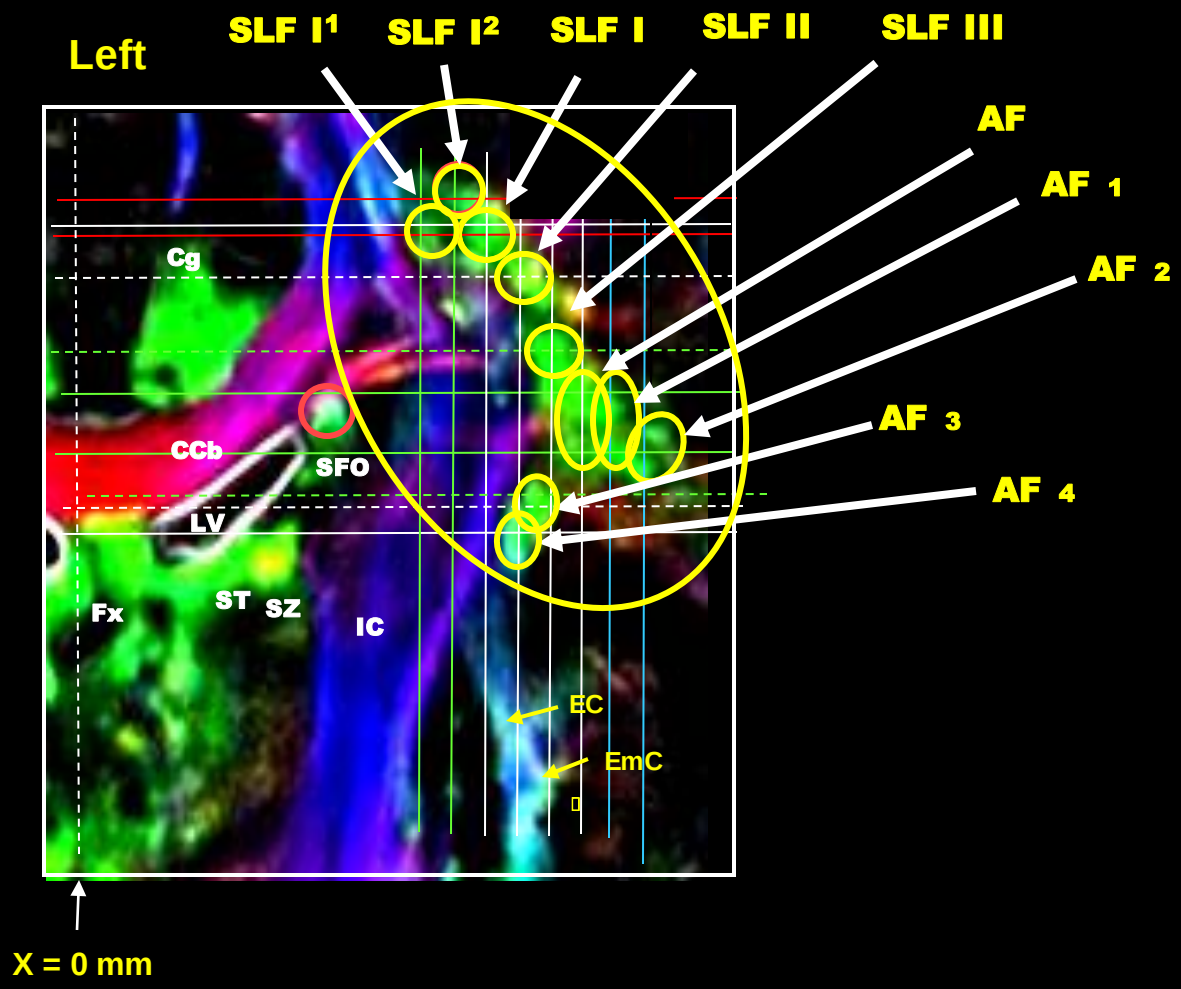
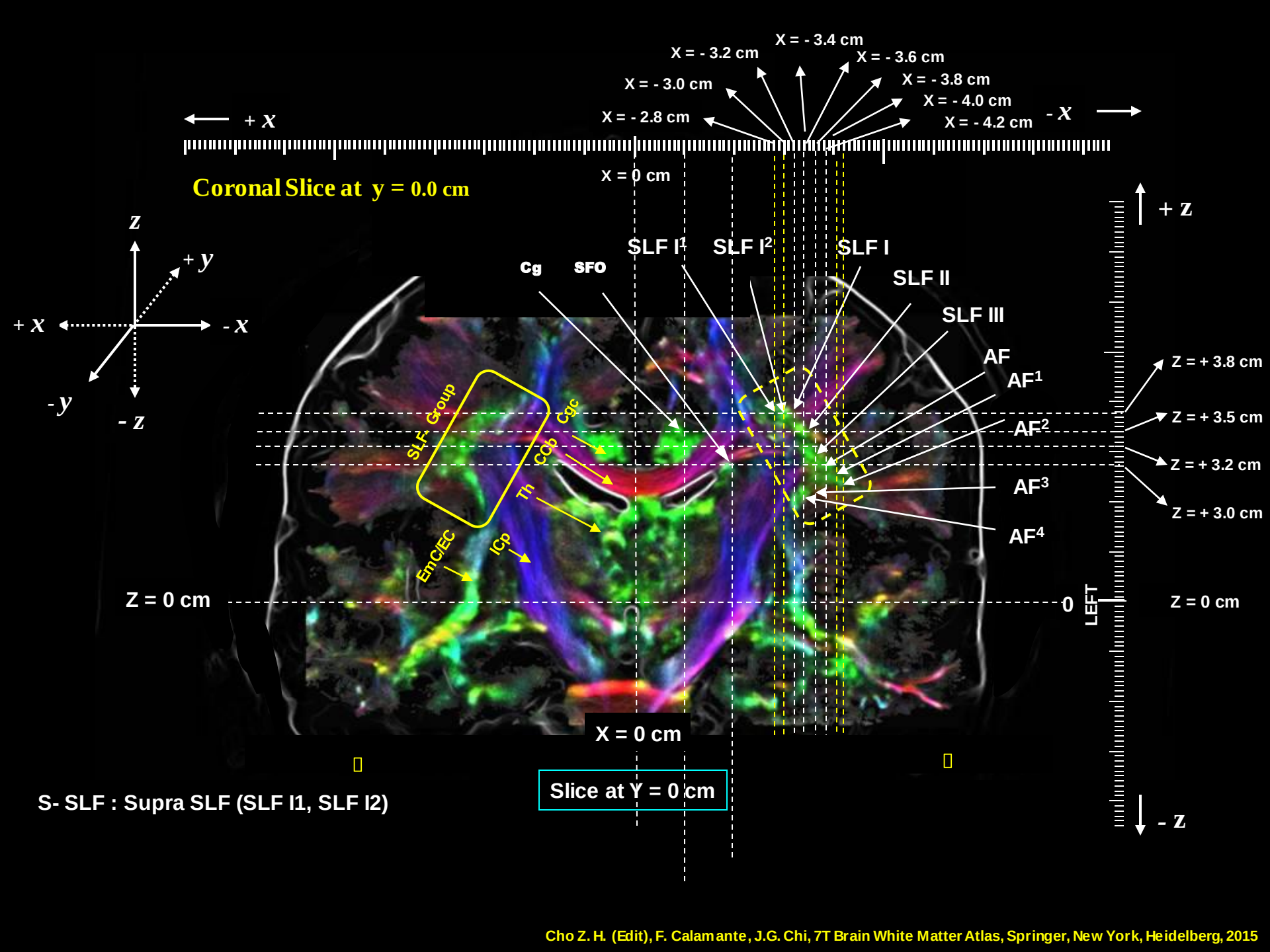


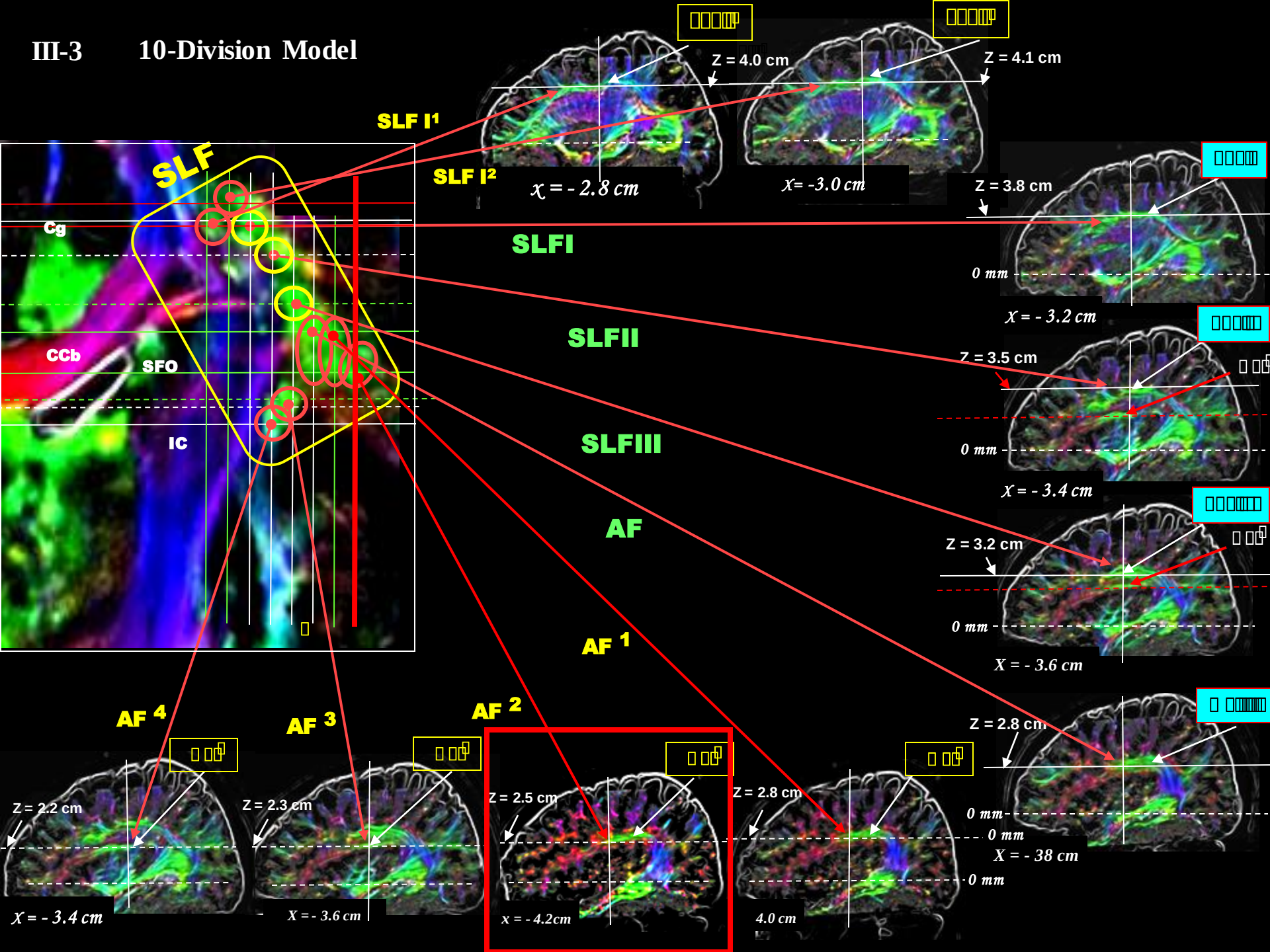
Fig. 3.

Cho et al to be published 2016

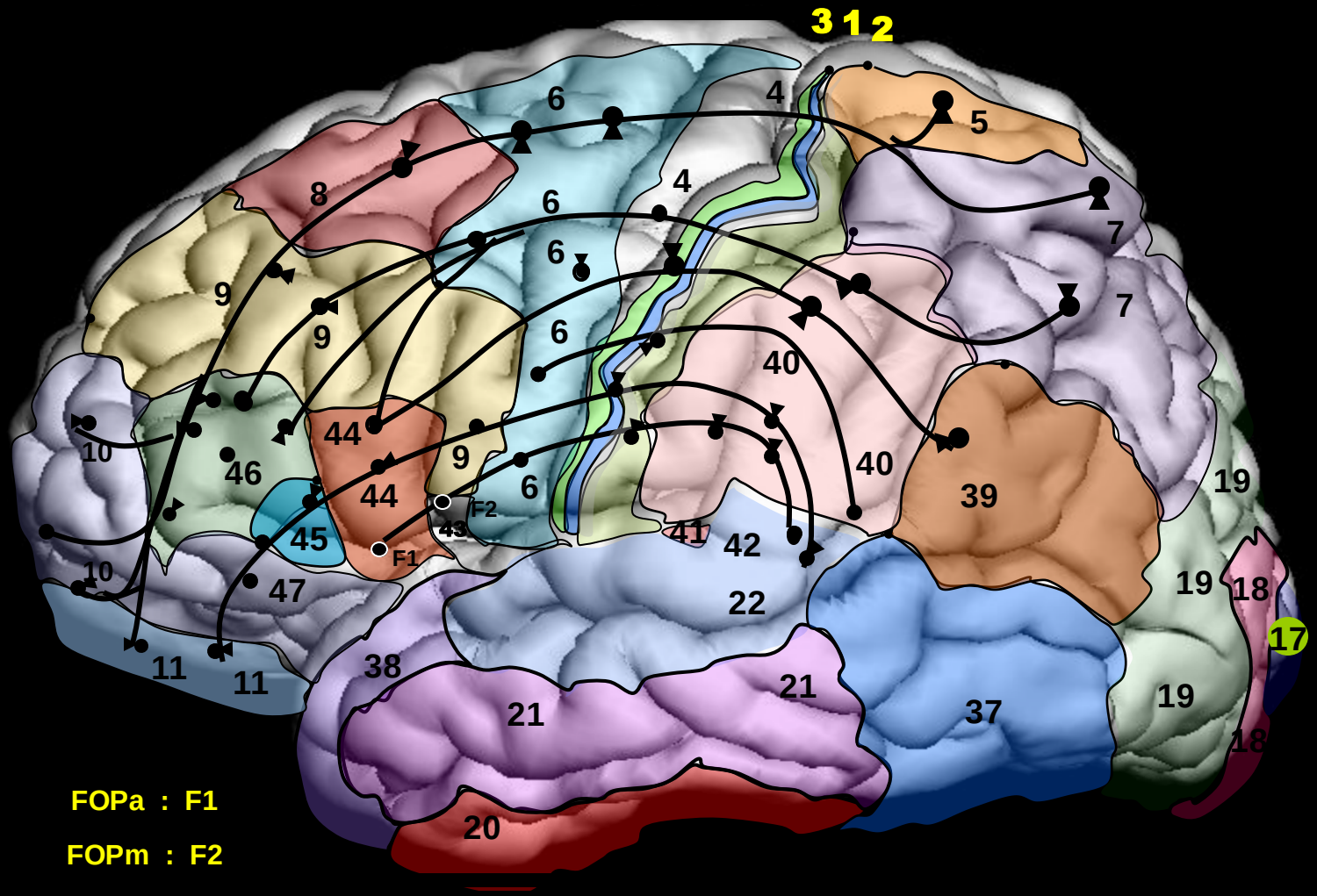


Cho Z. H. (Edit), F. Calamante, J.G. Chi, 7T Brain White Matter Atlas, Springer, New York, Heidelberg, 2015

III-3 10-Division Model



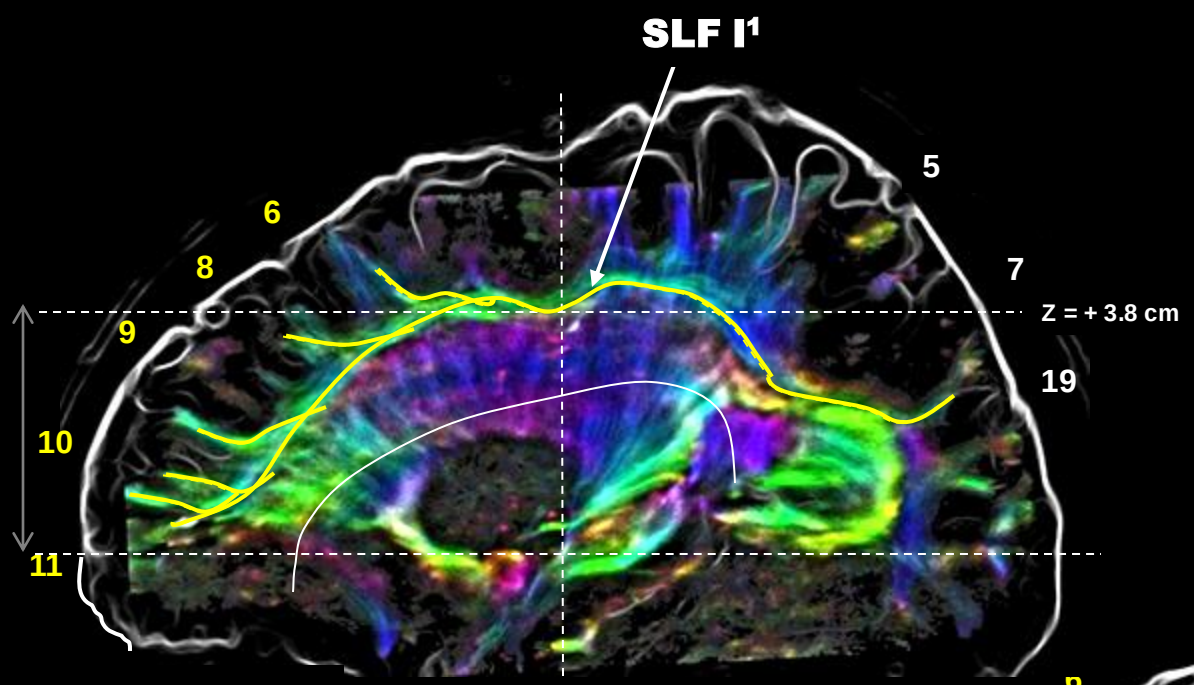
Lateral View of Brodmann's Areas and Tractographs

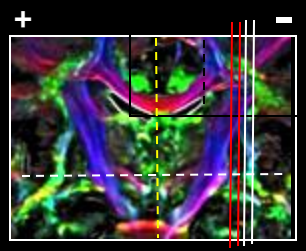


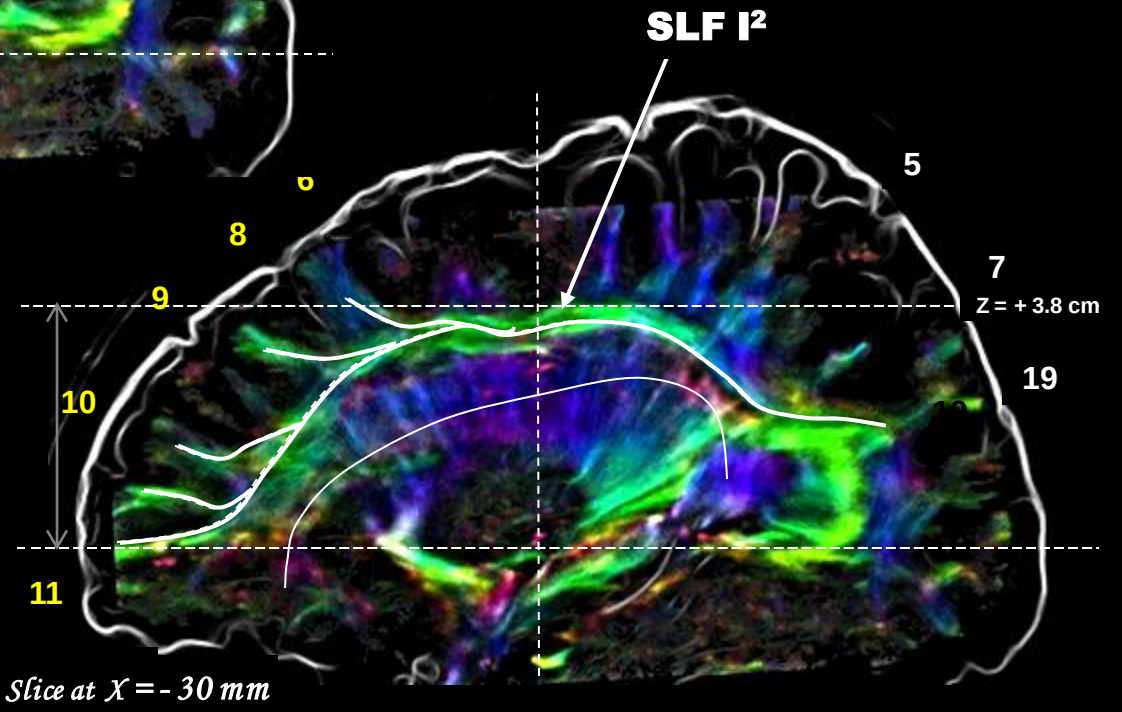
FOPa : F1

FOPm : F2

Supra SLF

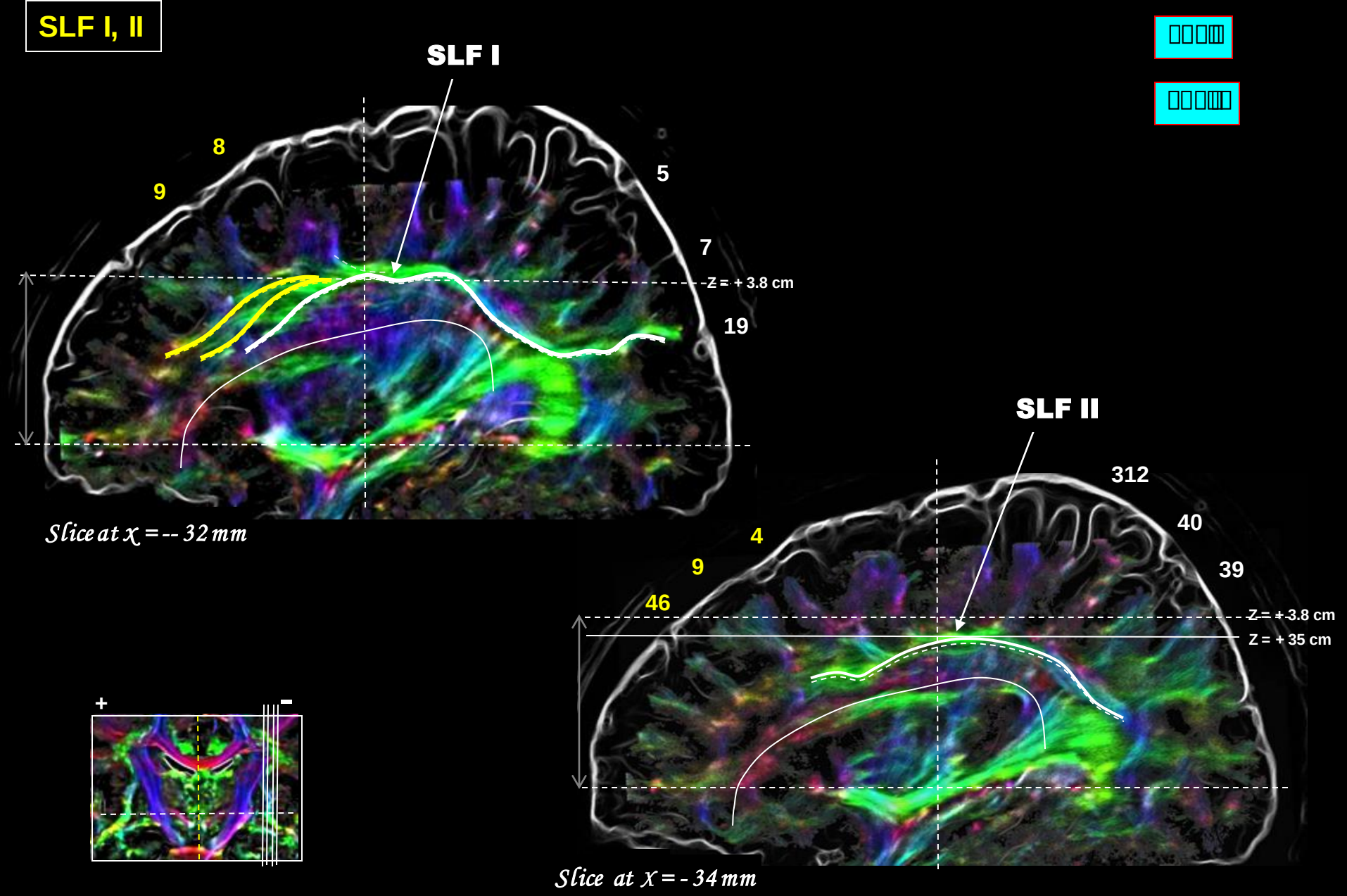




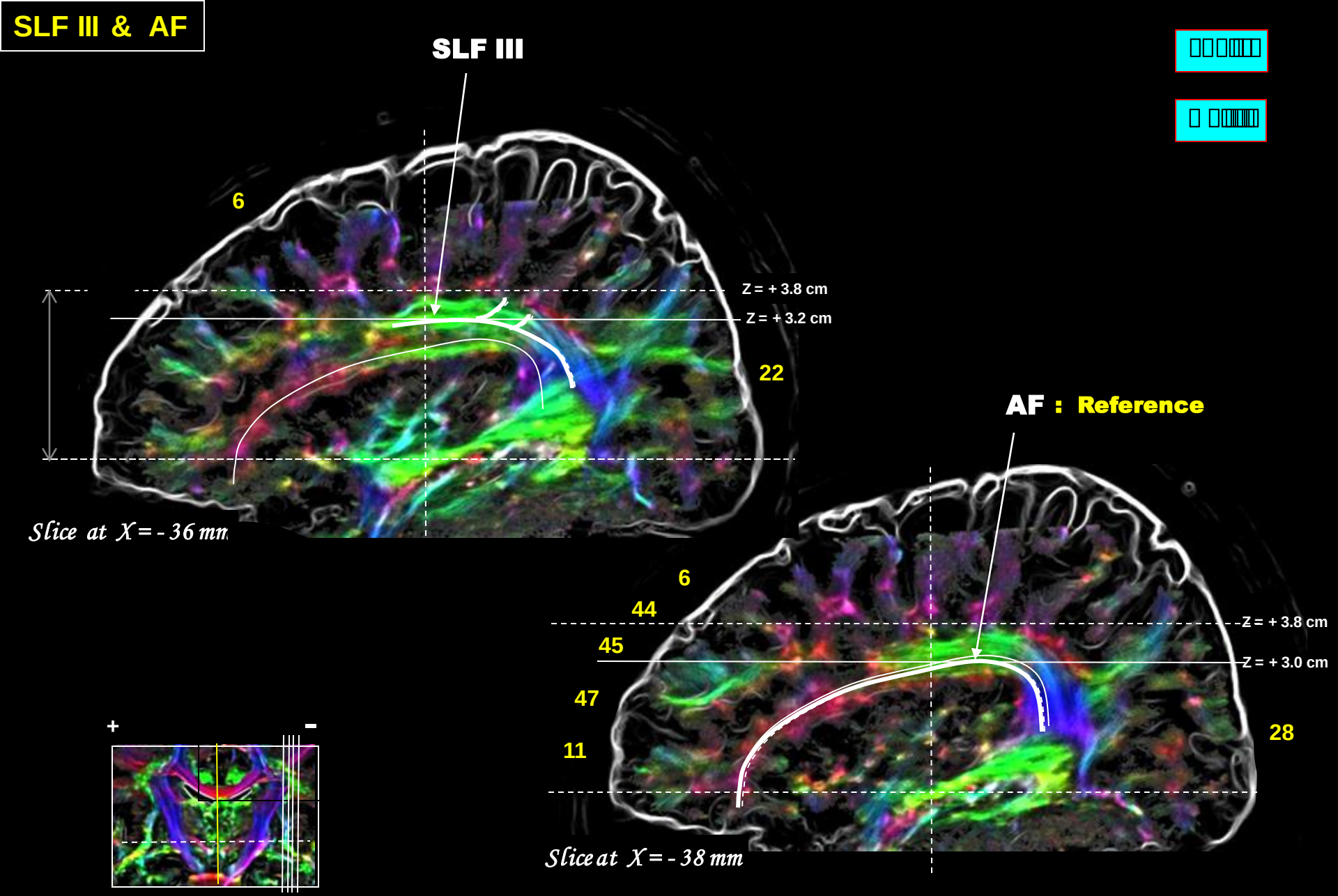


Sppl. Fig. 4 (a) Enlarged tracks of SLF Sub-Components – SLF I¹ and SLF I².

SLF I, II

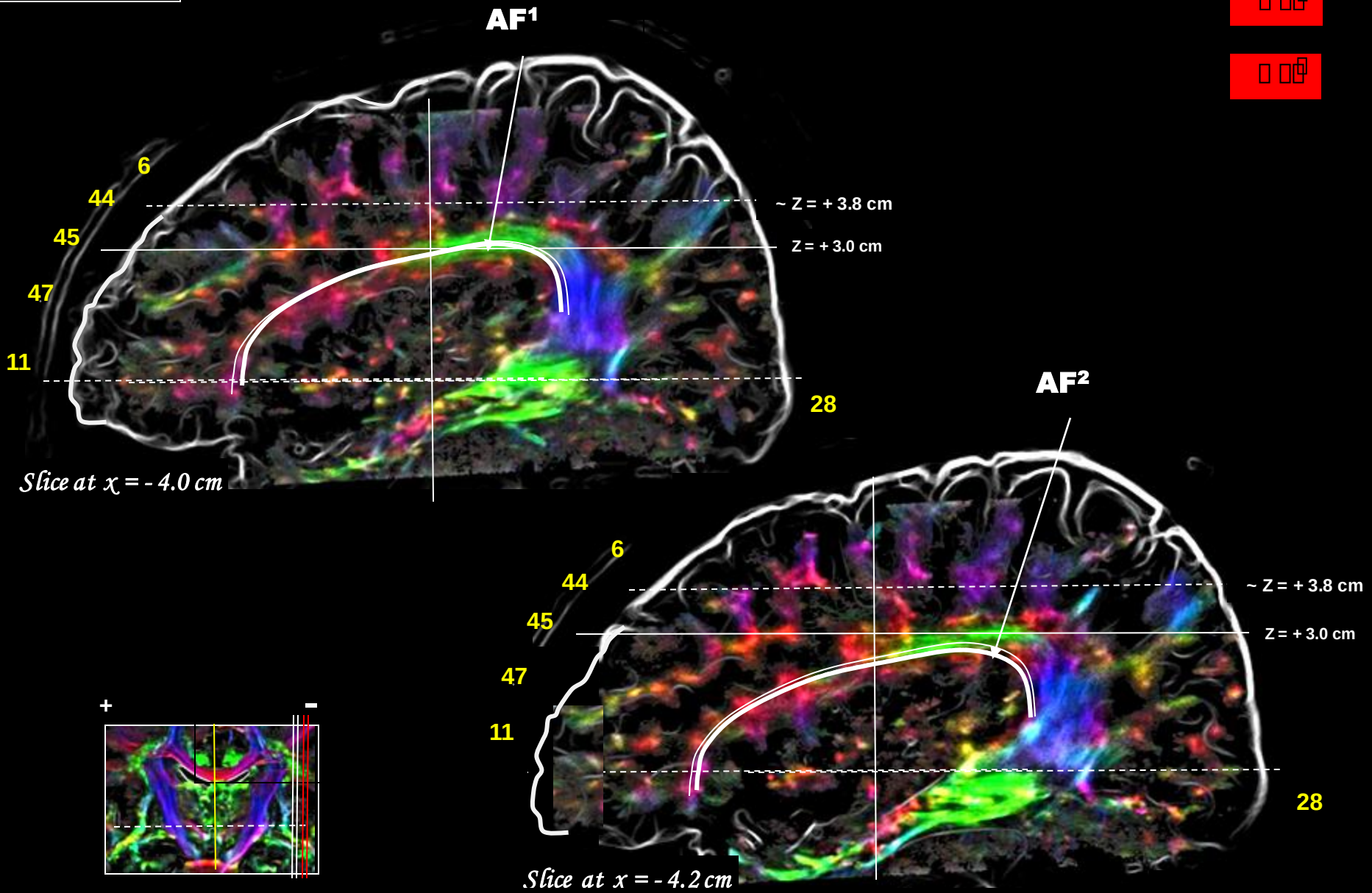


Sppl. Fig. 4 (b) Enlarged tracks of SLF Sub-Components – SLF I and SLF II.



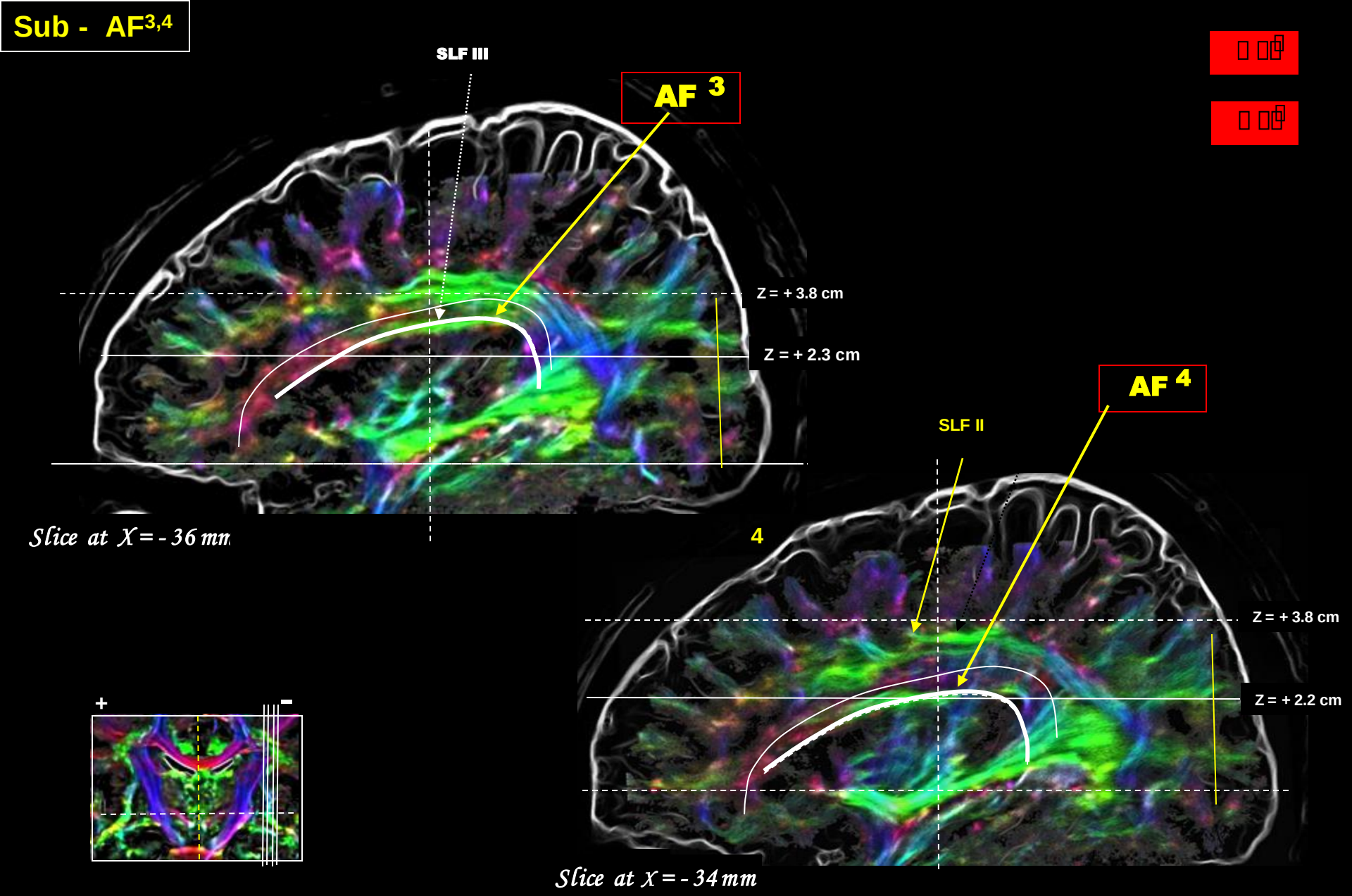
Sppl. Fig. 4 (c) Enlarged tracks of SLF Sub-Components – SLF III and AF.

Sub - AF[1,2]



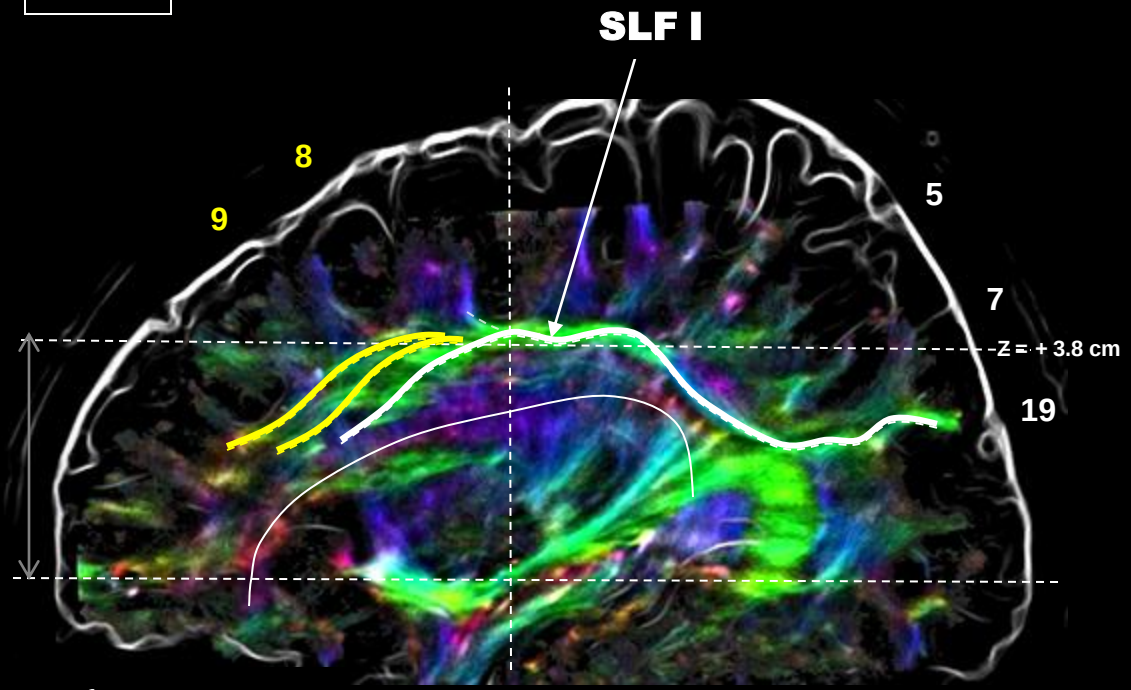
Lateral Most Slice – Sum of Lateral Projections (Reference Slice)

Sppl. Fig. 4 (d) Enlarged tracks of SLF Sub-Components – AF[1] and AF[2].

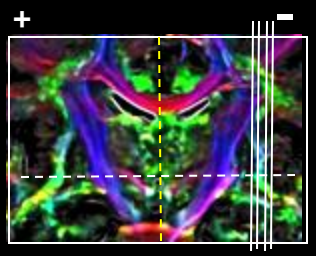


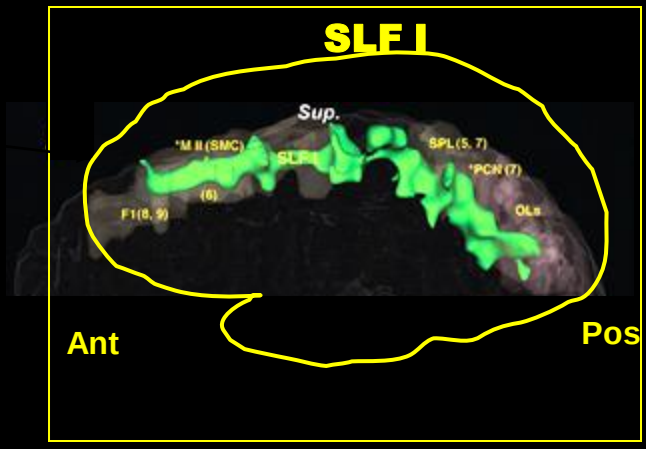
Sppl. Fig. 4 (b) Enlarged tracks of SLF Sub-Components – SLF I and SLF II.

SLF I



Slice at x = -- 32 mm





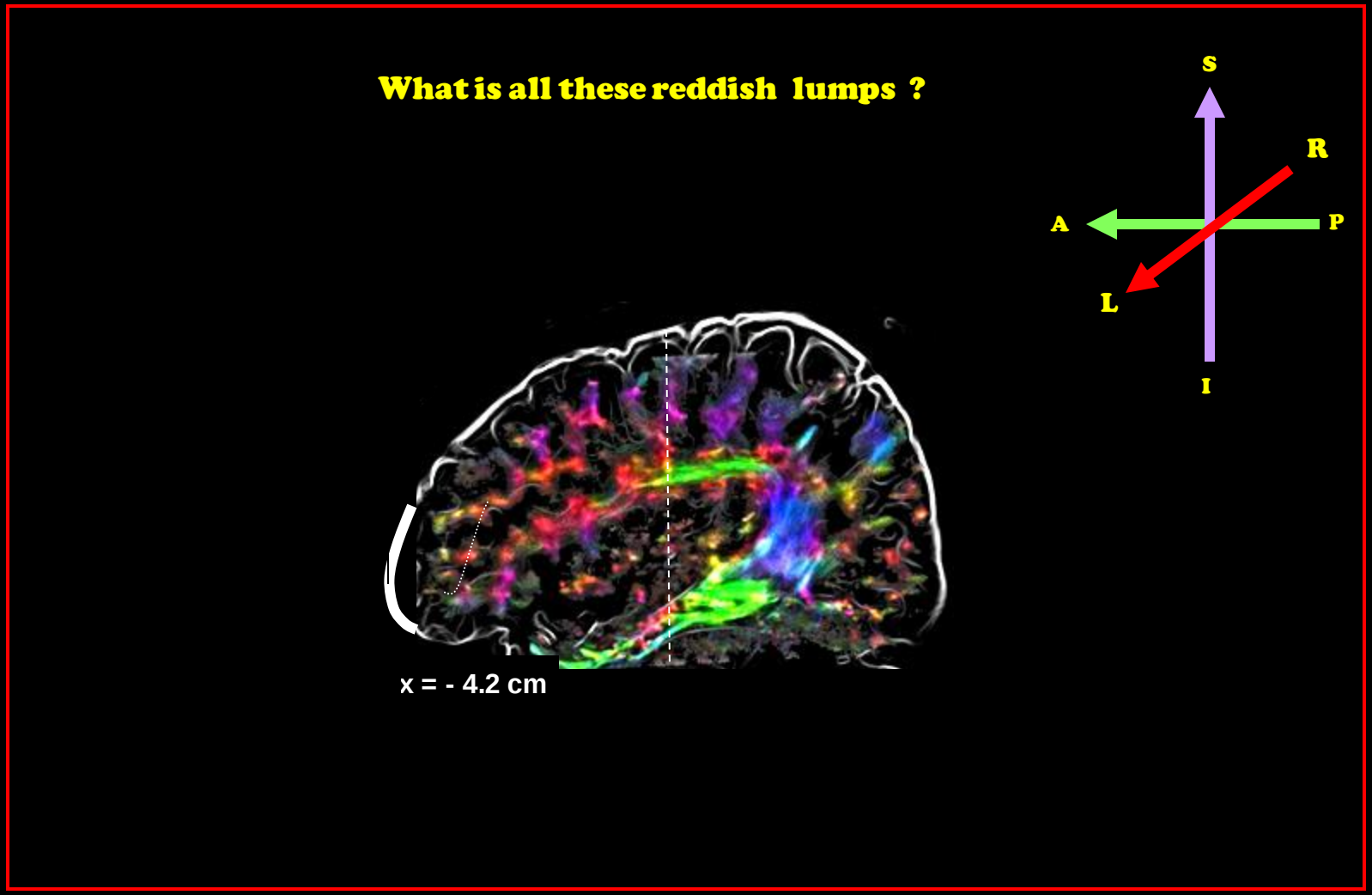
Sppl. Fig. 4 (b) Enlarged tracks of SLF Sub-Components – SLF I and SLF I

Sagittal View

Great thought begins
by seeing something differently

Einstein

IV-1. Lateral Most Slice (10-Division Model)



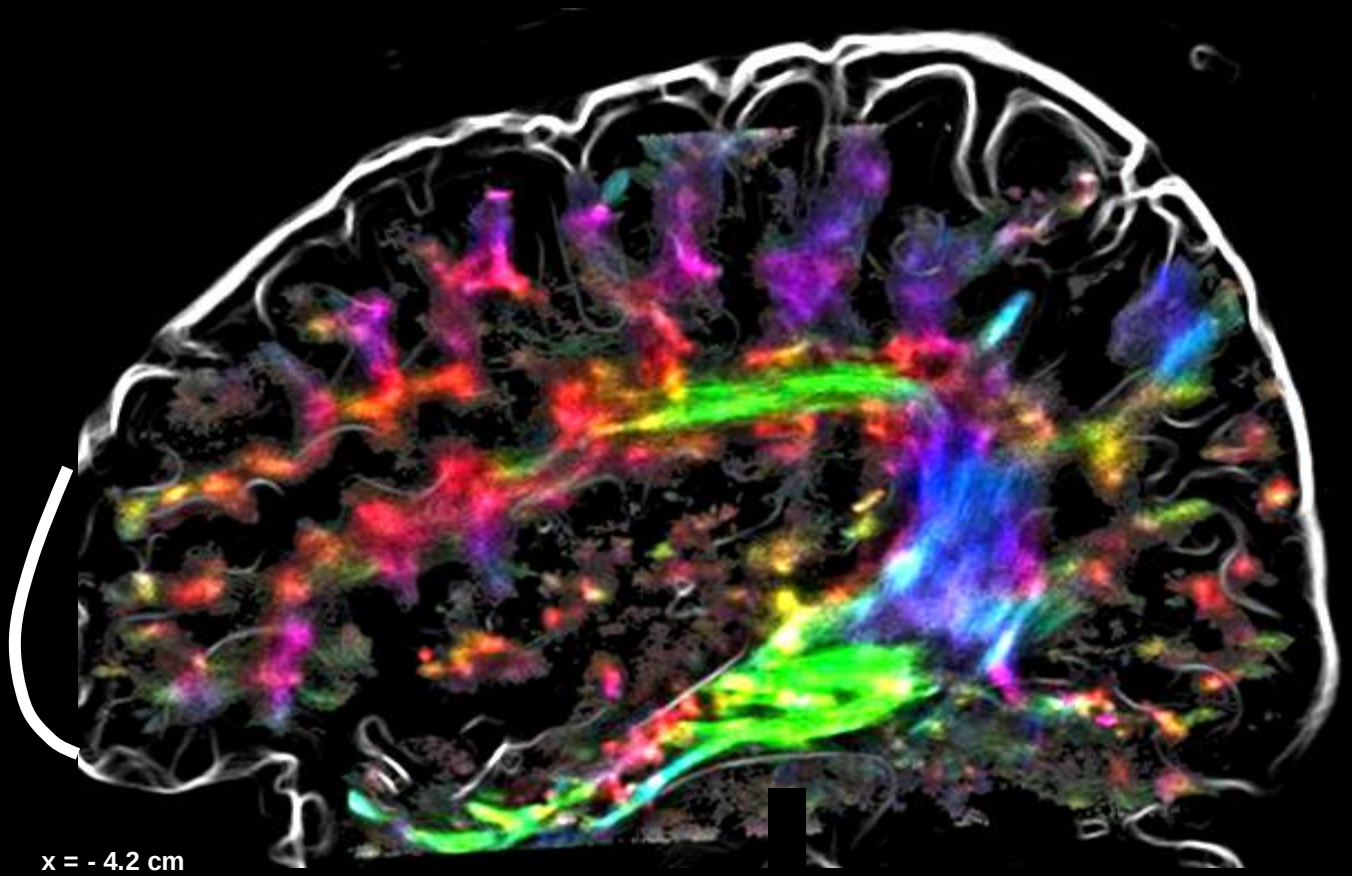
Tractographic Image 2015

Fig. 4-a. Collateral Branches or Lateral extensions (reddish spot like areas) that are originated from the medial slices which are projected onto the present slice (at x= - 4.2 cm) that will eventually be projected onto the lateral cortical surface of the left hemisphere.

Fig. 5-a.

Lateral Most Tractograph

1. Tractography



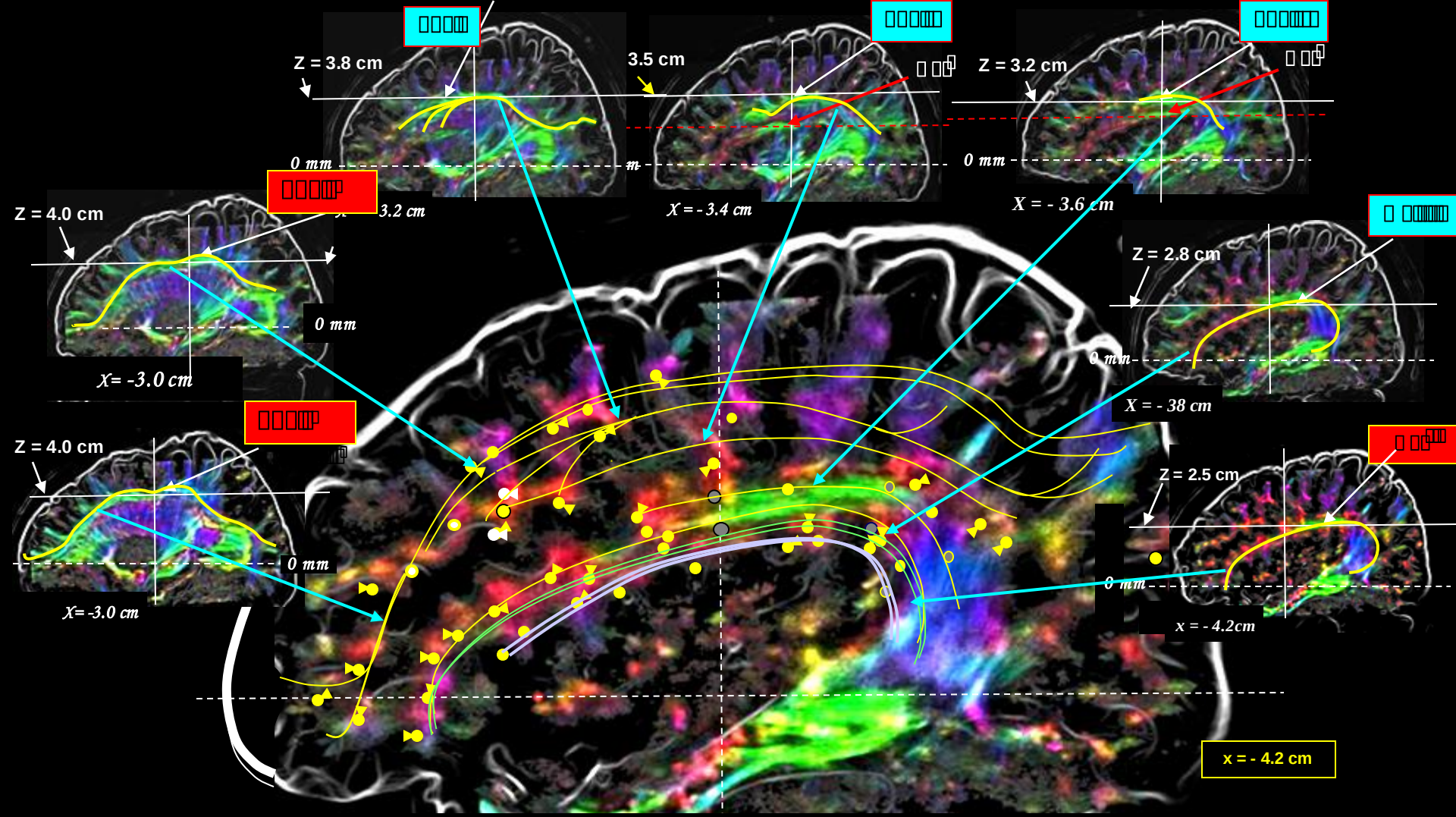
With this Super-Resolution Tractographic Data :

We could do two things :

1. **Finding the Fiber Tracks, such as SLF I, II, III**
2. **Finding the involved Brodmann's areas, such as BA44, 45, and 46**

With above two, we could derive the functional roles of each fiber track

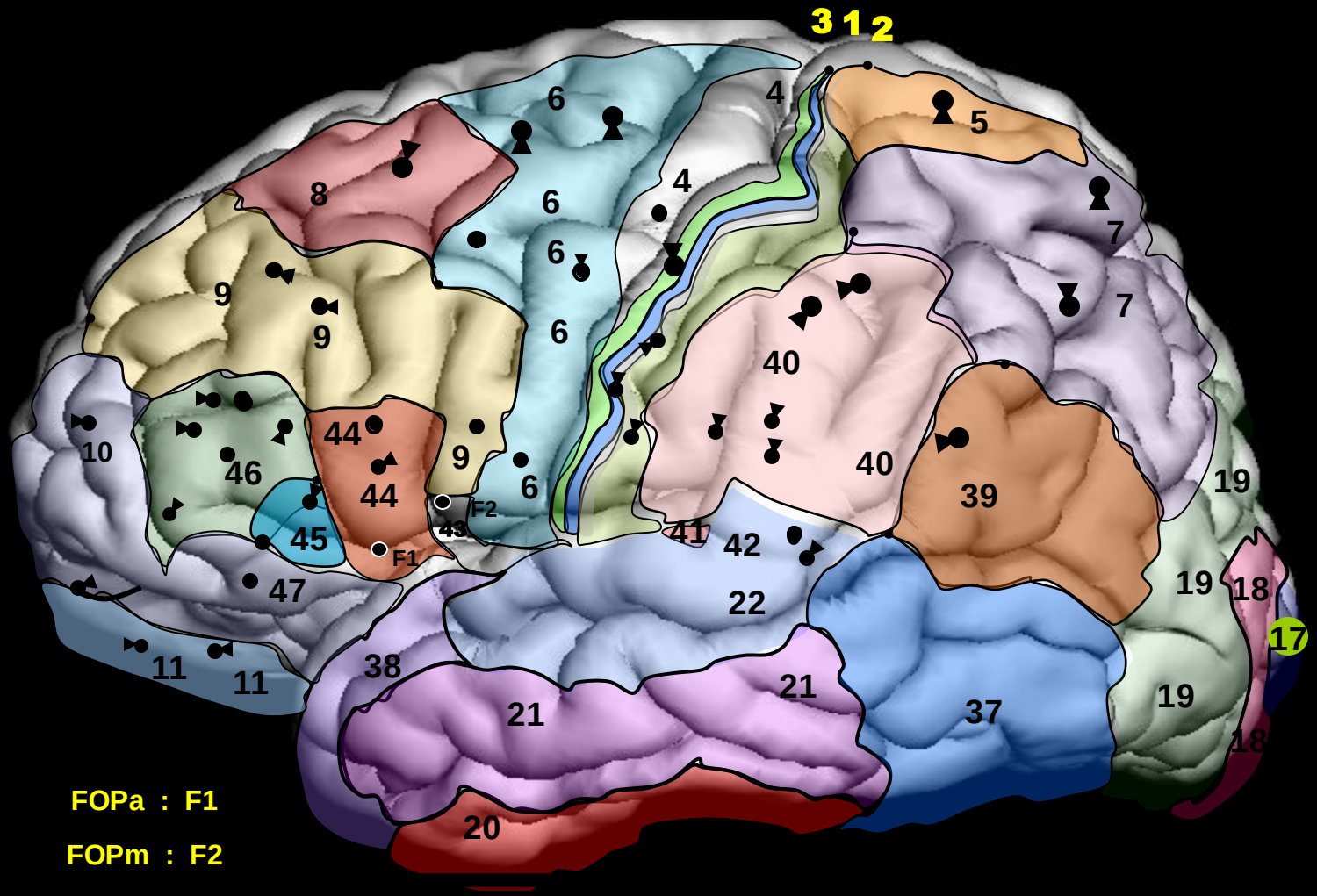
3. **Estimate the Functional roles of fiber tracks**



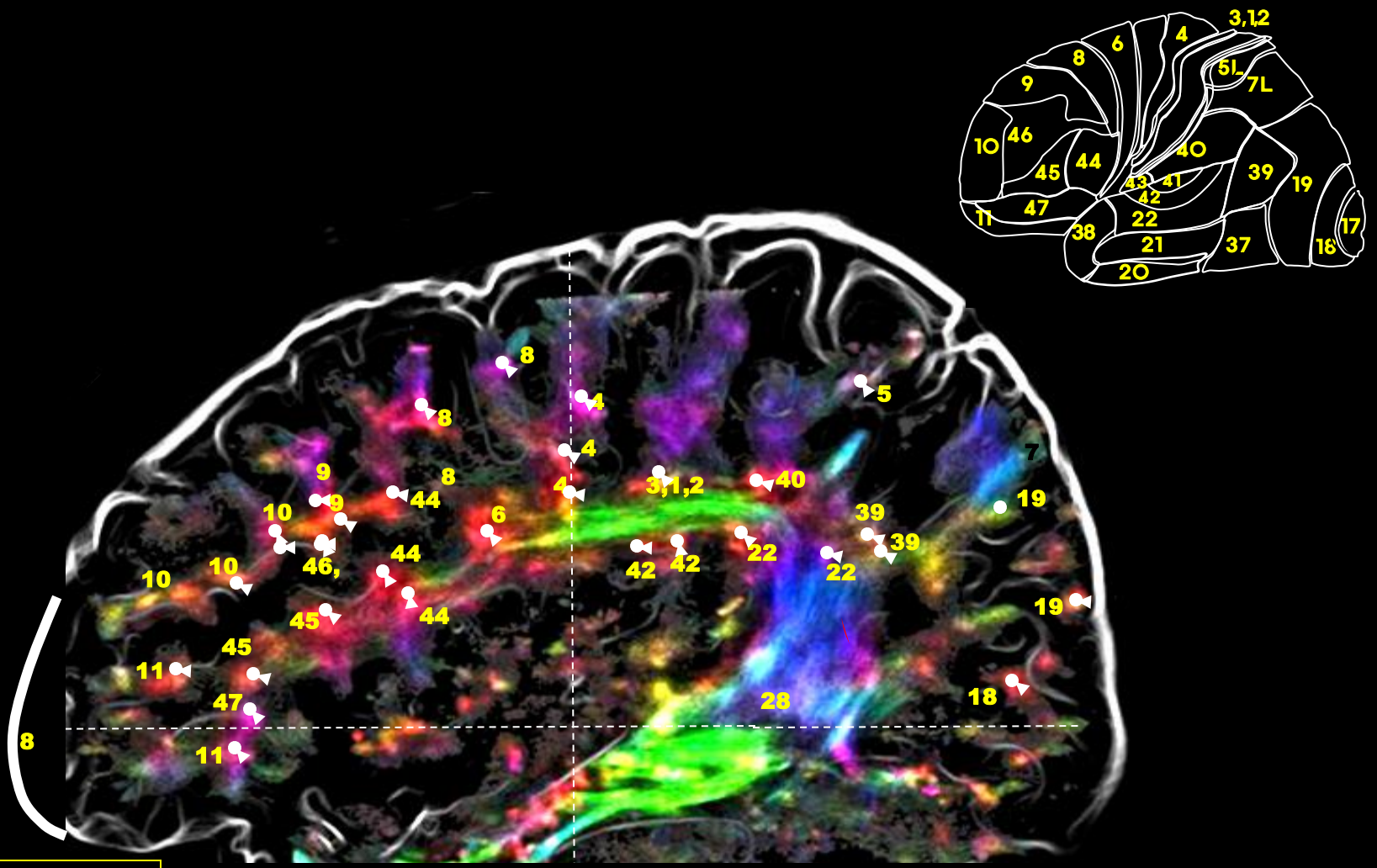
1. Estimate the Fiber Tracks, such as SLF I, II, III

Supplement Fig. 2

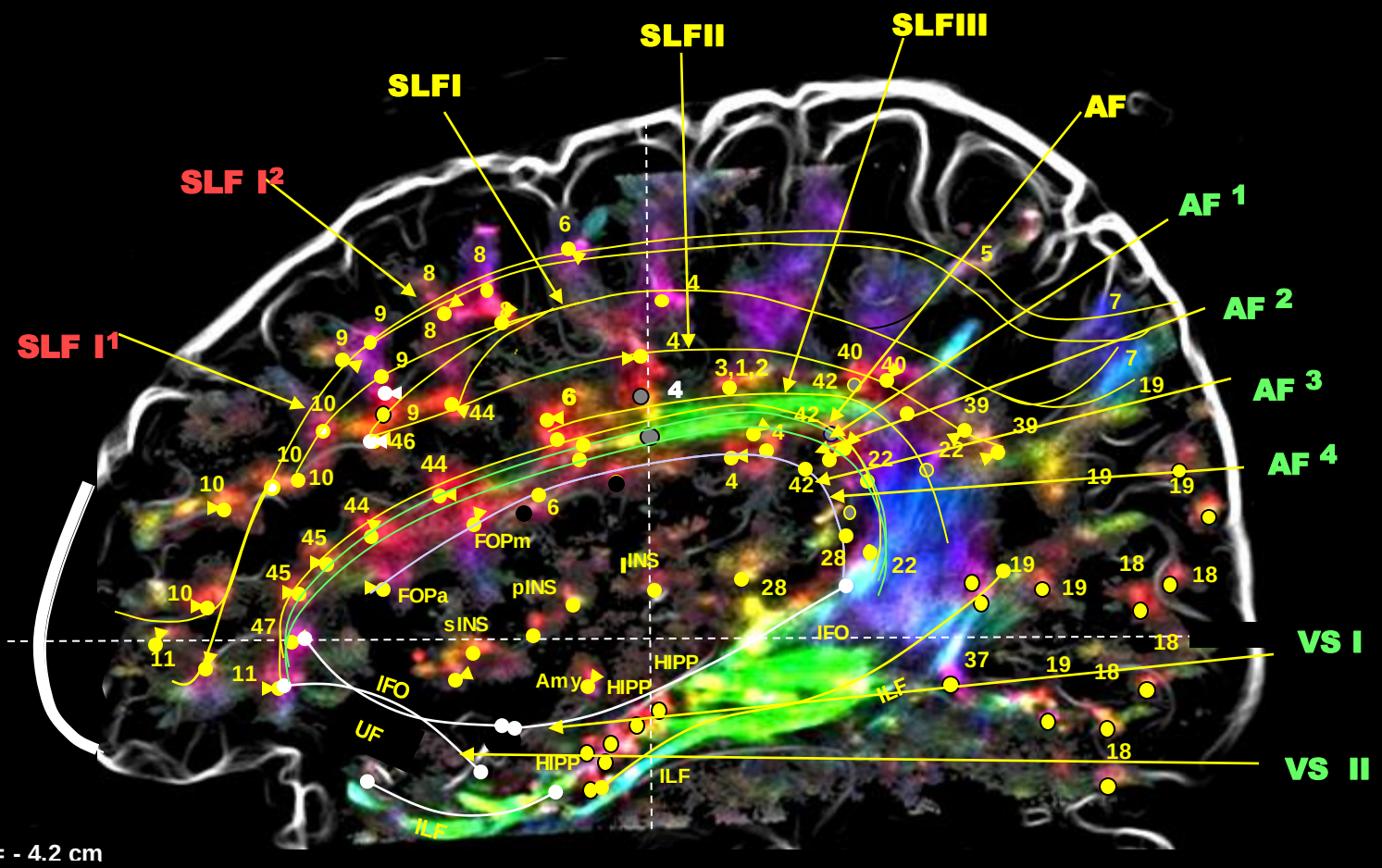
Lateral View of Brodmann's Areas and Tractographs



2. Find the involved Brodmann's areas, such as BA44, 45, and 46



3. Estimate the Functional roles of fiber tracks



Supplement Fig. 3

3.-2 Estimate the Functional roles of fiber tracks (Brodmann Areas)

Fiber Tracks	Pathway	Connected Brodmann's Areas Motor - Sensory	Notes
SLF I[1]	Supra Dorsal	BA 11, 10, 10, 10, 9, 9, 8, 8, 6 – 5, 7	Visual
SLF I[2]		BA 11, 10, 10, 10, 9, 9, 8, 8, 6 – 5, 7	
SLFI	Dorsal Pathway I	BA 10, 10, 9, 9, 46, 9, 44, 8, 4 – 7, 19	Visuo-Language
SLFII		BA 46, 44, 4 - 40, 40, 39, 39	Audito-Language
SLFIII	Local	BA 6, 4 – 312, 42, 40, 40, 39, 39, 22	Phonologic
AF	Dorsal Pathway II	BA 11, 47, 45, 45, 44, 44, 6, 4 - 42, 22, 22, 28	Classic-Language
AF [1]		BA 11, 47, 45, 45, 44, 44, 6, 4 - 42, 22, 22, 28	
AF [2]		BA 11, 47, 45, 45, 44, 44, 6, 4 - 42, 22, 22, 28	
AF [3]	Local	BA FOPa, FOPm - 6, 4, - 42, 22, 28	Unclear
AF [4]		BA FOPa, FOPm - 6, 4, - 42, 22, 28	
VS I	Ventral Pathway I	BA47, IFO – Amy, HIPP, HIPP, 28, IFO, 22	Emotion-Memory
VS II	Ventral Pathway II	BA 11, UF – HIPP, ILF, ILF, 19	Visuo-Cognitive

Supplement Fig. 3

3. 7, 2017

1. Fiber Tractography

2. Language

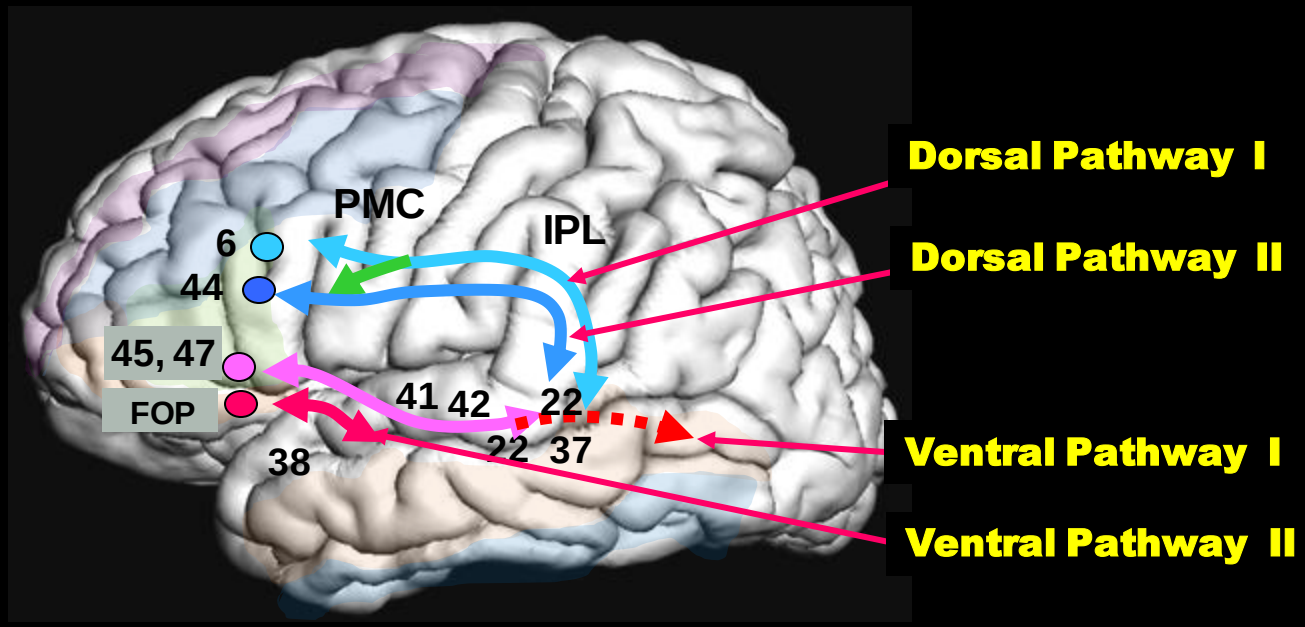
3. “ Langram “

“ Language and Human “

Most Recent Attempt, 2015

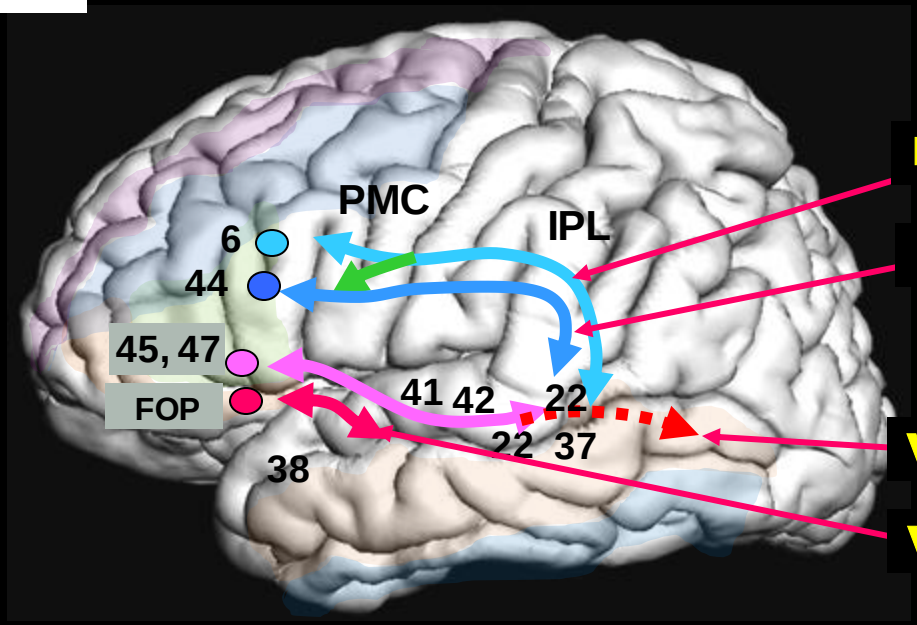
Lets Look at the Language Pathways

AD Friederici, 2011, 15



AD Friederici, 2015

2015



Dorsal Pathway I
pSTG to premotor cortex
via AF/SLF

: **Sound to Motor Mapping**

BA6 – pSTG/MTG (BA22/37)

Dorsal Pathway II
pSTG to BA 44
via AF/SLF

: **High Level Syntactic and Semantic Language Proce.**

BA44 - pSTG (BA22)

Ventral Pathway I
STG to BA 45
via EFCS

: **Memory & Emotional Components**

BA45/47 – STG/MTG (BA22/37)

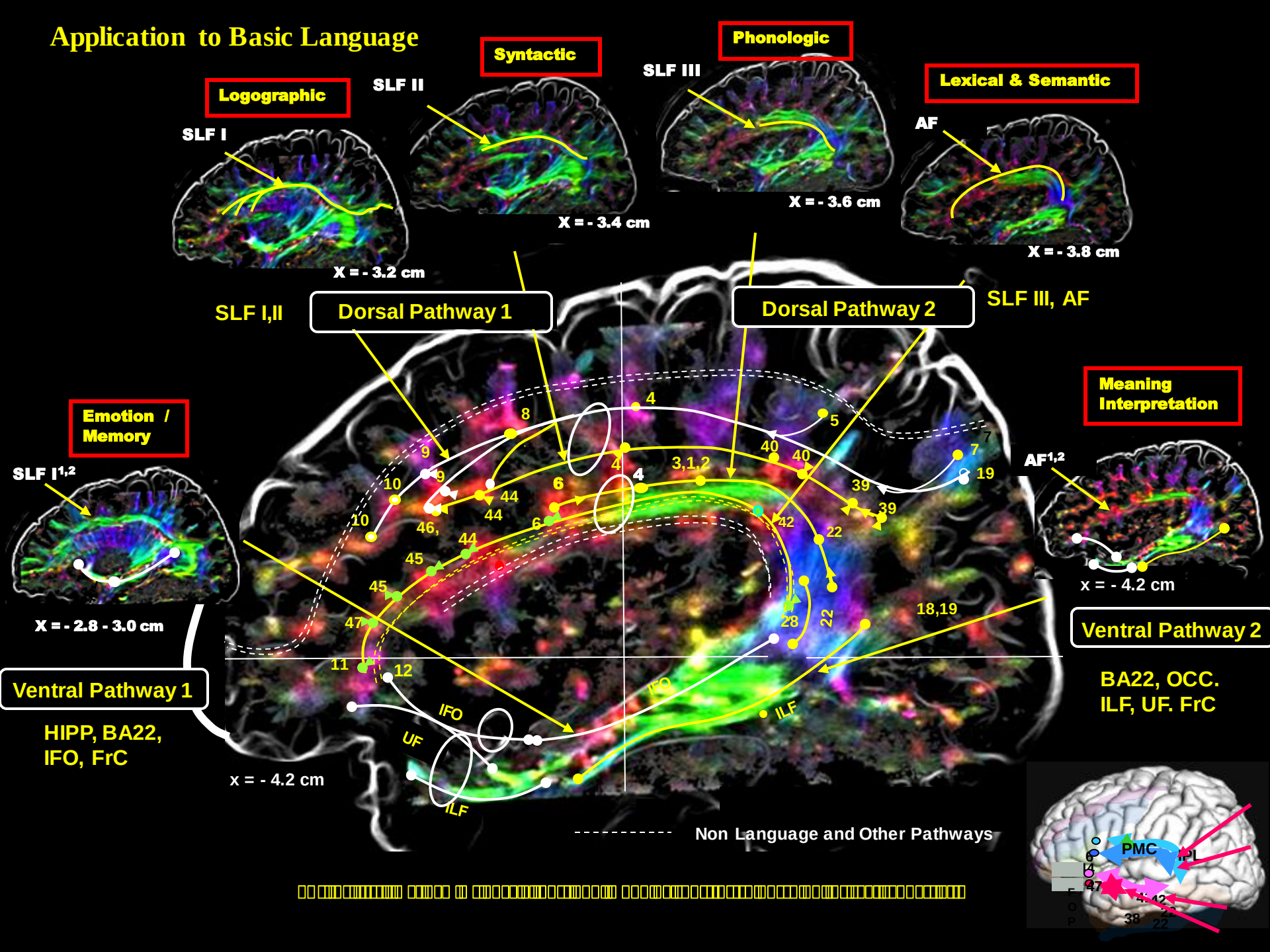
Ventral Pathway II
antSTG to FOP
via UF

: **Sound to Meaning Mapping**

FOP - aSTG (BA22)

This, still requires "Functional & Connectional Anatomical Details "

Application to Basic Language

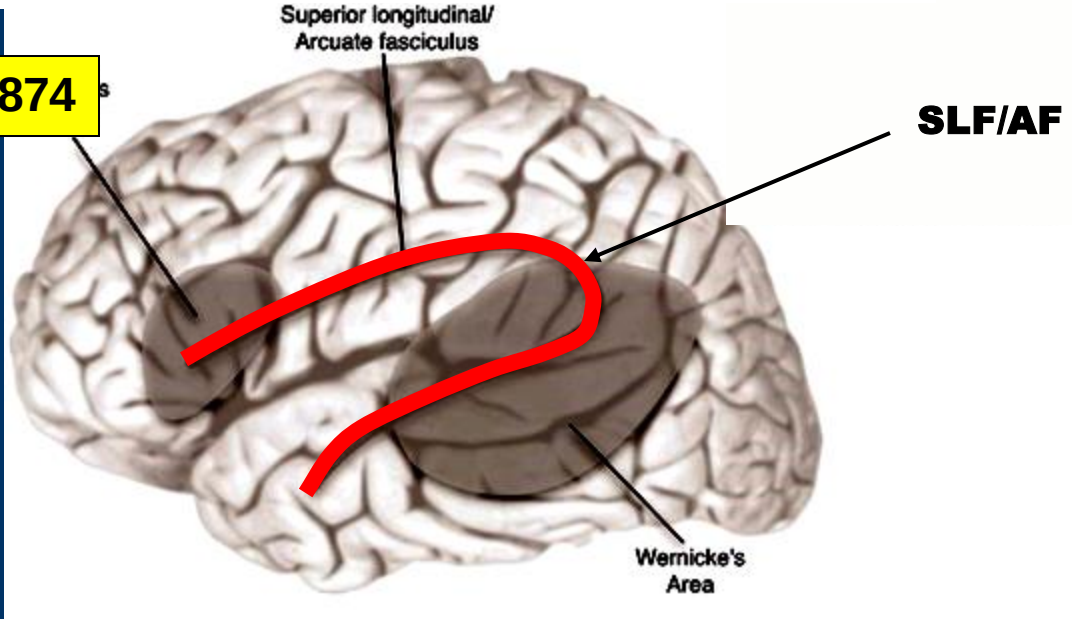


Catani's Work and
Gescchwind's Territory 2005

A

Broca, Wernicke, & Lichtheim (1861, 1874, 1885)

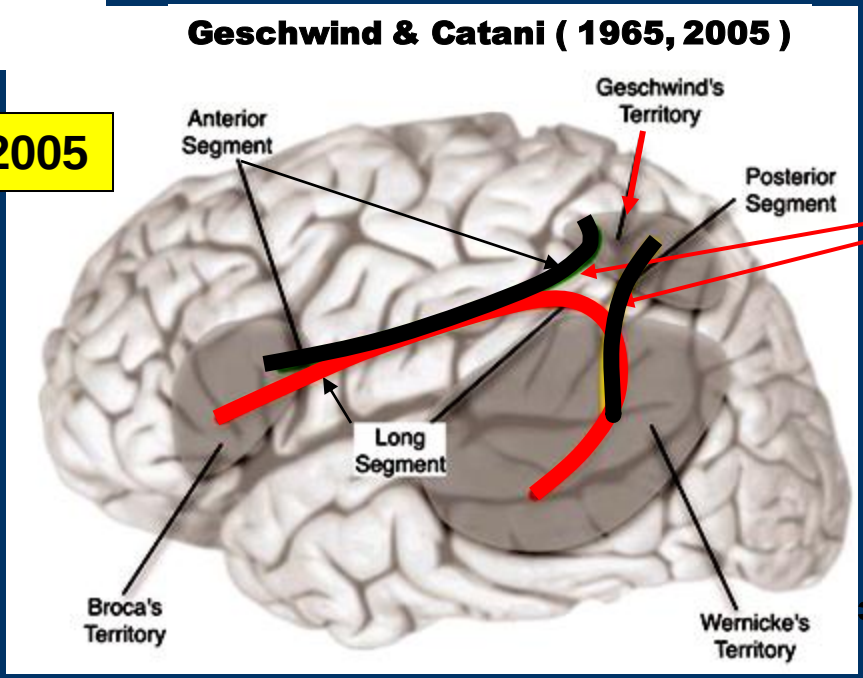
1861, 1874



B

Geschwind & Catani (1965, 2005)

1965, 2005



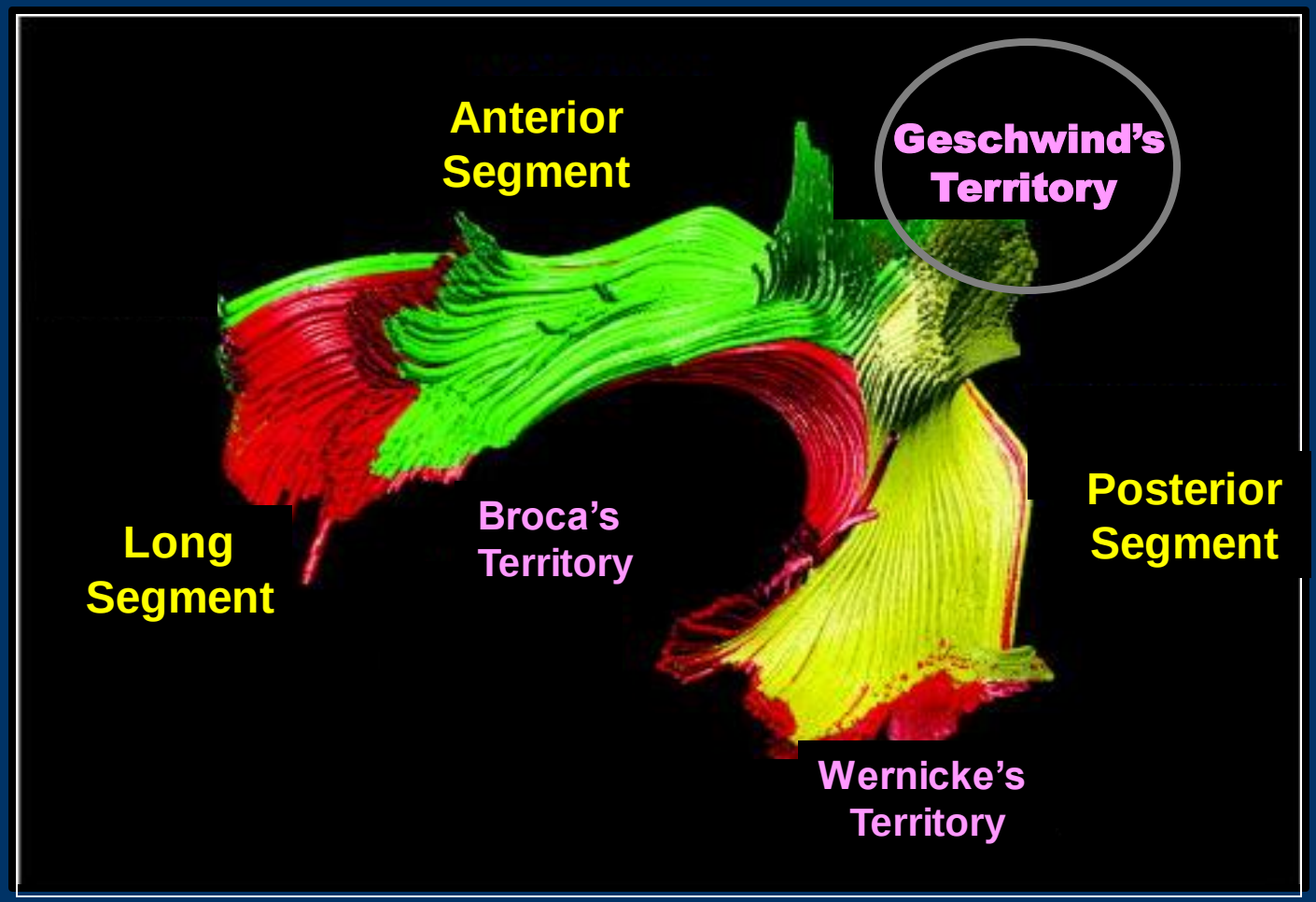
3529-3550, 2012

A.S. Dick & P. Tremblay. Brain 135, 3529-3550, 2012

Perisylvian language networks of the human brain

2005 By Catani's Two Segment Theory with DTI

40 years after Geschwind's Theory in 1965 !

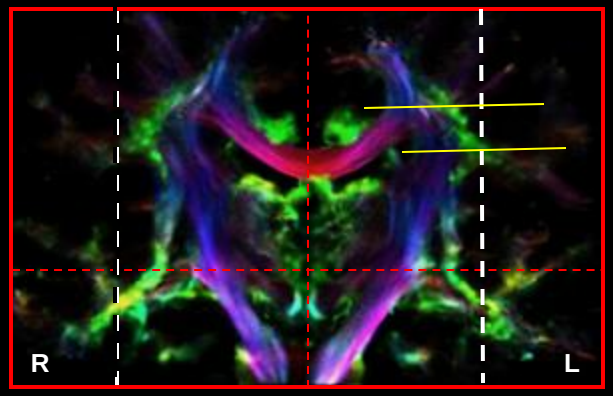


But this Tractography is too POOR Resolution !

Sagittal – TDI (- 44 & - 28mm)

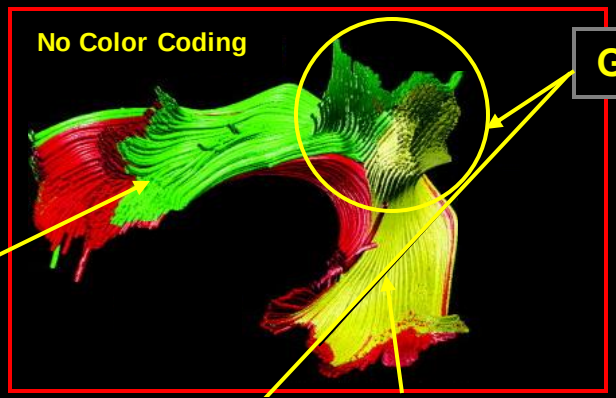
Left Hemisphere

New 2015



(a)

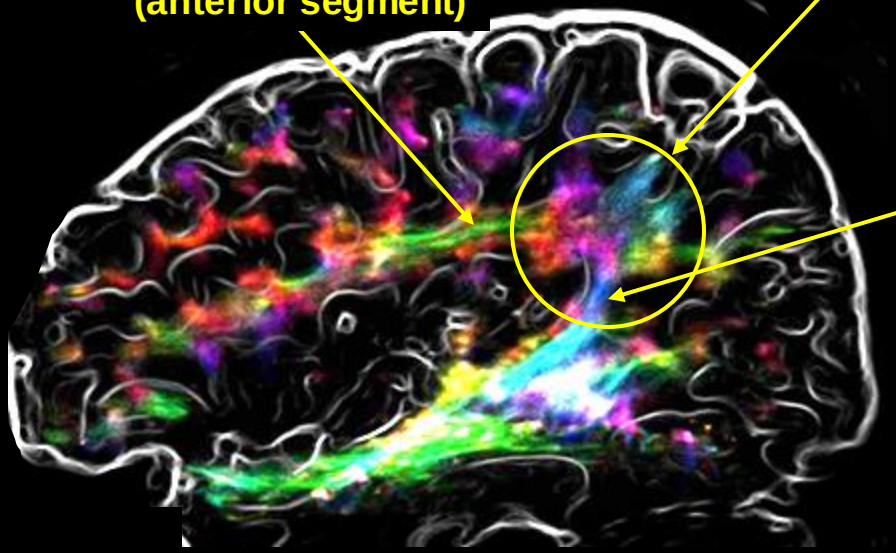
Catani's SLF & AF



Geschwind's Territory

Arcuate Fasciculus (anterior segment)

Arcuate Fasciculus (posterior segment)



New Tractography with Color and Directionality !

(a) *TDI (- 44mm)*

3. 7, 2017

1. Fiber Tractography

2. Language

3. “Engram” and “Langram“

“Engram” and “Langram“

SM-LCDA Hypothesis

Sensory, Memory, Language, Cognition, Decision, and Action

-

SM-LCDA Pathways

* *LCD – Liquid Crystal Display ?*

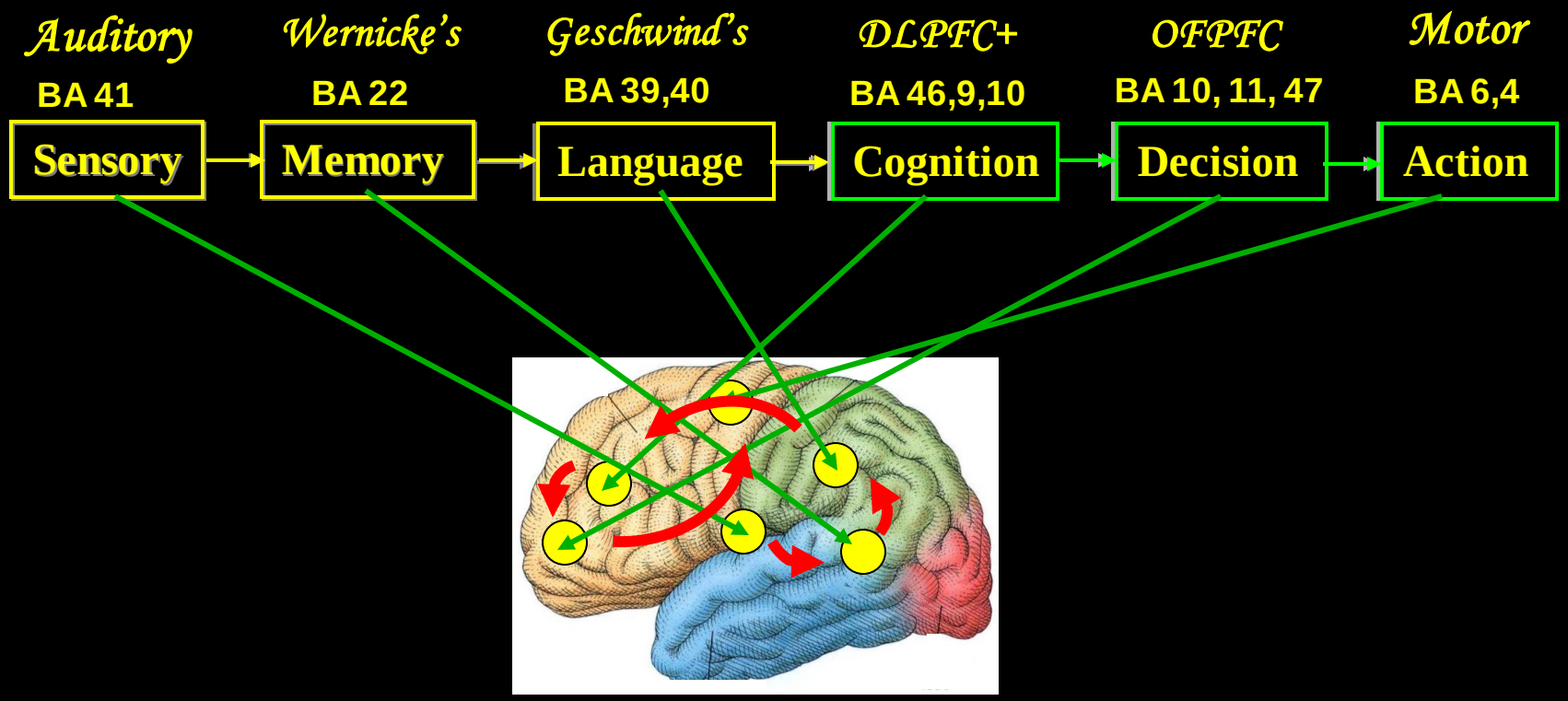
SM-LCDA Hypothesis

Sensory, Memory, Language, Cognition, Decision, and Action

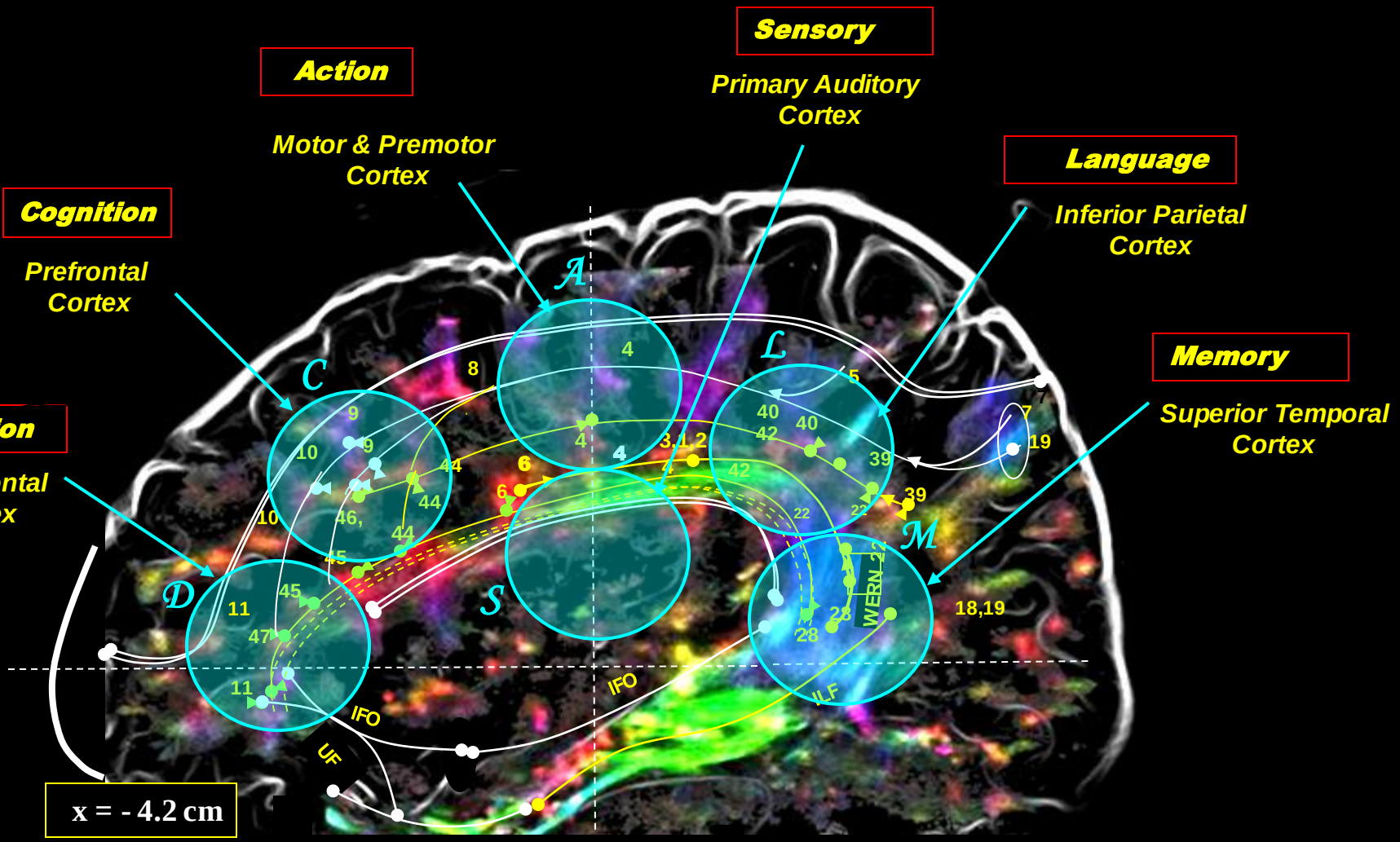
-

SM-LCDA Pathways

For Auditory



SM-LCDA Hypothesis



Sensory, Memory, Language, Cognition, Decision, and Action : SM-LCDA Pathways (Ex. Auditory)

SM-LCDA Hypothesis

Langram

SLF I, II

Language - Cognition

(39, 40) – (44, 46, 9, 10)

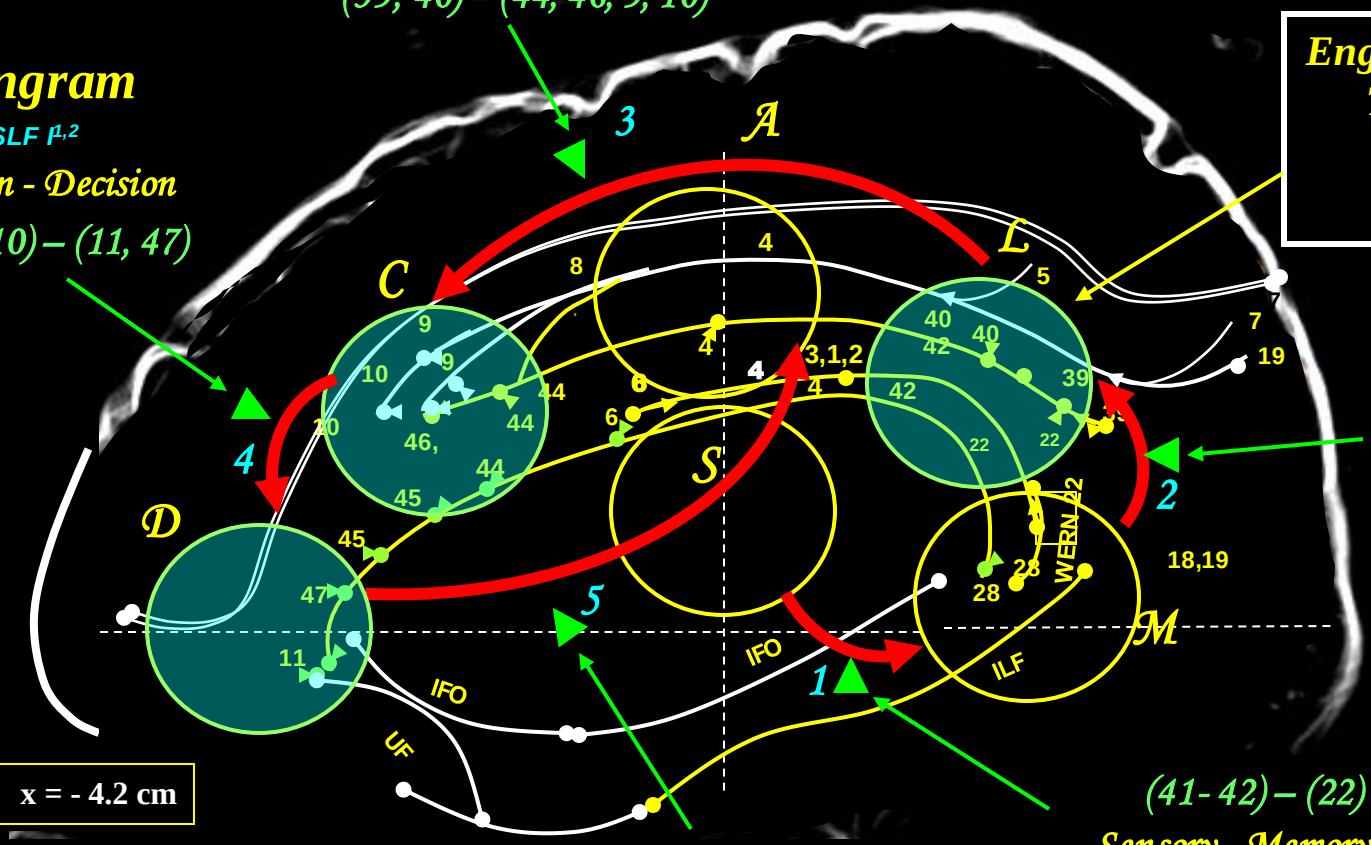
Langram

SLF I[1,2]

Cognition - Decision

(46, 44, 9, 10) – (11, 47)

Engram-Langram Translation With Lexicon



x = - 4.2 cm

Engram

(22) – (39, 40)

Memory - Language

AF, Post. Seg.

(41- 42) – (22)

Sensory - Memory

AF, Post. Seg.

(11, 47) – (6, 4)

Decision - Action

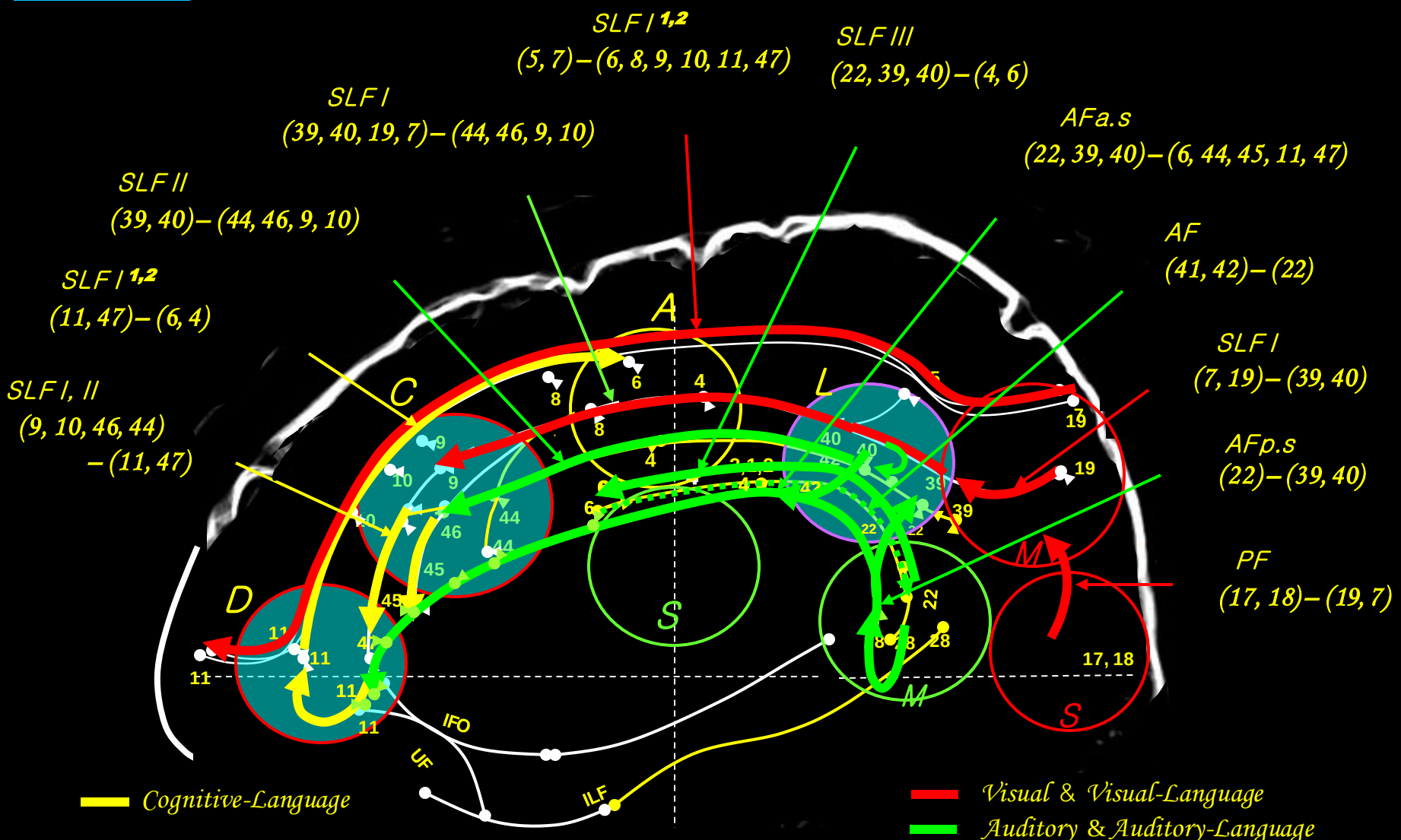
Langram S-SLF,

Engram

Complex System Requires Language !

Pathway Tracing with Tractographic Data and Estimated Brodmann's Area

Real Pathways



On Real Pathways

Pathway Tracing with Tractographic Data and Estimated Brodmann's Area – Language

Langram
Visual Language Ch.
SLF I
(39, 40, 19, 7)– (44, 46, 9, 10)

Langram
Auditory Language Ch.
SLF II
(39, 40)– (44, 46, 9, 10)

Langram
Phonoloic Channel
SLF III
(22, 42)– (4, 6)

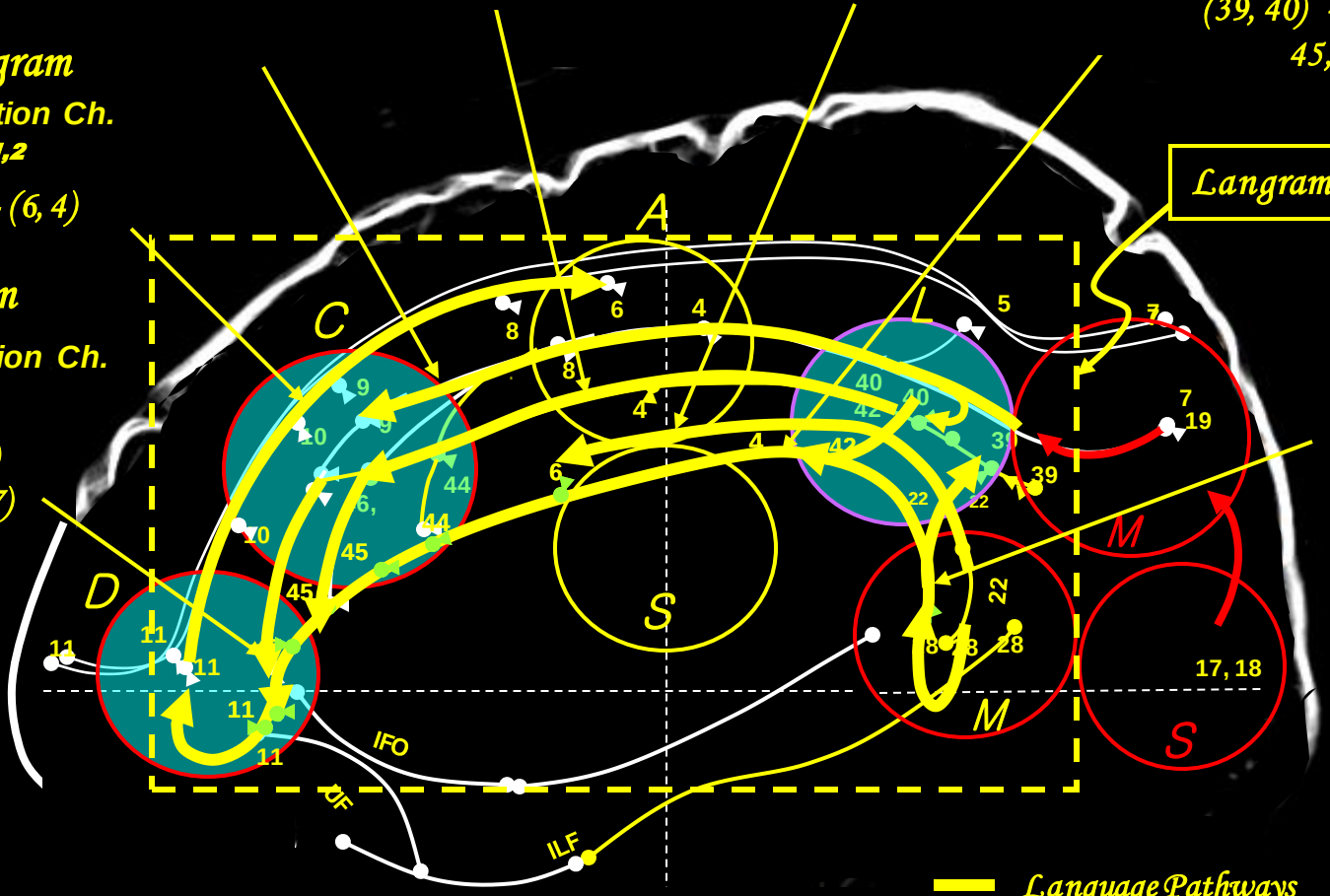
Langram
Language Ch II
AFa.s.
(39, 40) - (6, 44, 45, 11, 47)

Langram
Decision/Action Ch.
SLF I 1,2
(11, 47)– (6, 4)

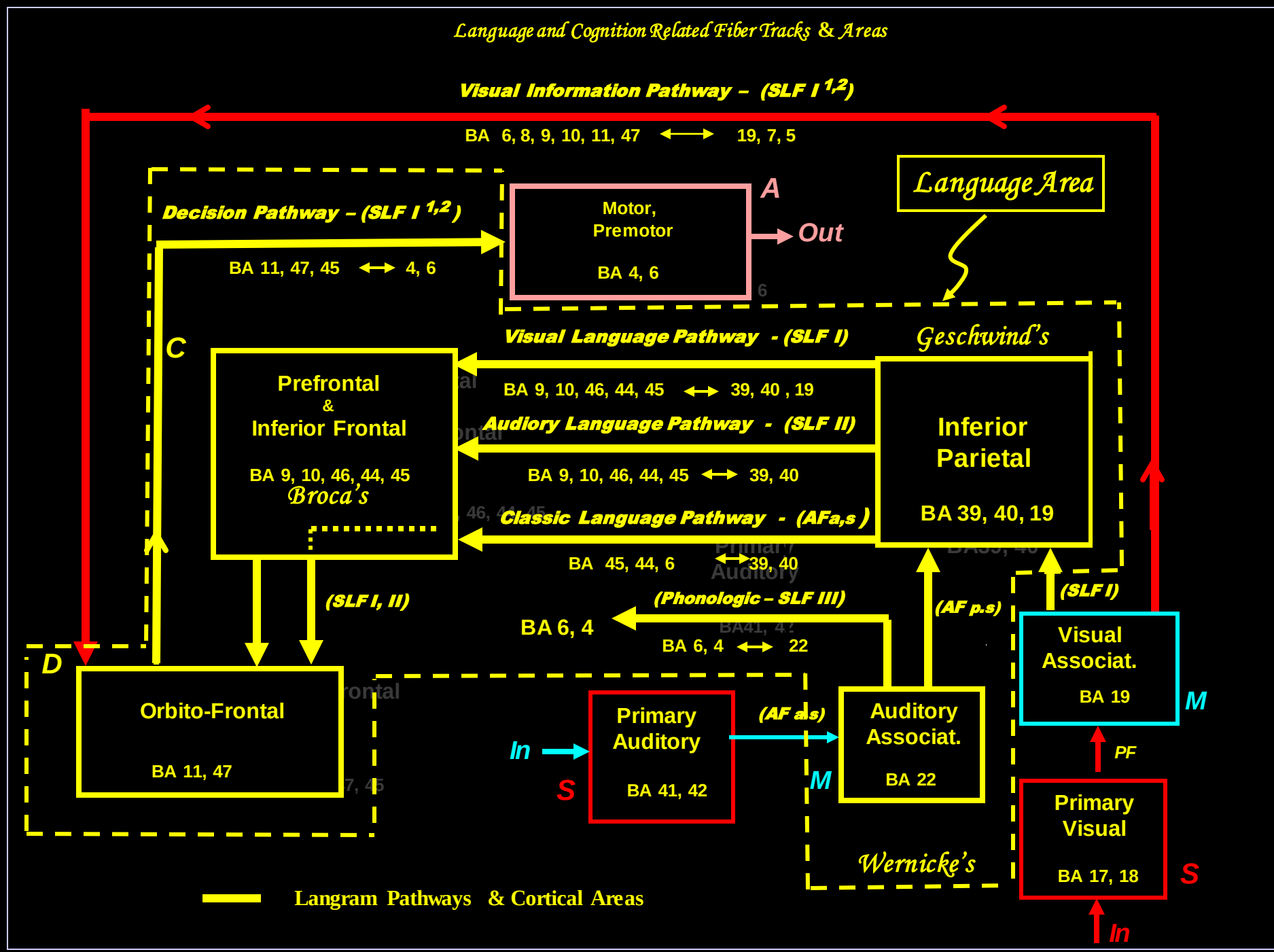
Langram
Cognition/Decision Ch.
SLF I, II
(9, 10, 46, 44) – (11, 47)

Langram Territory

Engram
Language Ch I
AFp.s.
(22)– (39, 40)
(6, 44, 45, 11, 47)



Language Pathways


Language and Cognition Related Fiber Tracks & Areas
Visual Information Pathway – (SLF I 1,2)
BA 6, 8, 9, 10, 11, 47 ⟷ 19, 7, 5
Language Area
Decision Pathway – (SLF I 1,2)
BA 11, 47, 45 ⟷ 4, 6
Motor, Premotor
BA 4, 6
A
Out
C
Visual Language Pathway - (SLF I)
Geschwind's
Prefrontal & Inferior Frontal
BA 9, 10, 46, 44, 45
Broca's
BA 9, 10, 46, 44, 45 ⟷ 39, 40 , 19
Audiory Language Pathway - (SLF II)
BA 9, 10, 46, 44, 45 ⟷ 39, 40
Classic Language Pathway - (AFa,s)
Inferior Parietal
BA 39, 40, 19
BA 45, 44, 6 ⟷ 39, 40
(SLF I, II)
(Phonologic – SLF III)
(AF p.s)
(SLF I)
BA 6, 4
BA 6, 4 ⟷ 22
D
Visual Associat.
BA 19
M
Orbito-Frontal
BA 11, 47
In
S
Primary Auditory
BA 41, 42
(AF a,s)
M
Auditory Associat.
BA 22
PF
Primary Visual
BA 17, 18
S
Wernicke's
In
Langram Pathways & Cortical Areas

“Neurons” and “ Synaps “

Engram

Semon R., Die mneme. Leipzig: Wilhelm Engelmann; 1904

Tonegawa S, M. Pignatelli, et al . Memory engram storage and retrieval. Current Opinion in Neurobiology, 35:101-109, 2015

Resonance Absorption or Excitation

B. Hutcheon and Y. Yarom. Trends in Neuroscience, TINS Vol. 23, No. 5, 216-222, 2000

A Neural Basics

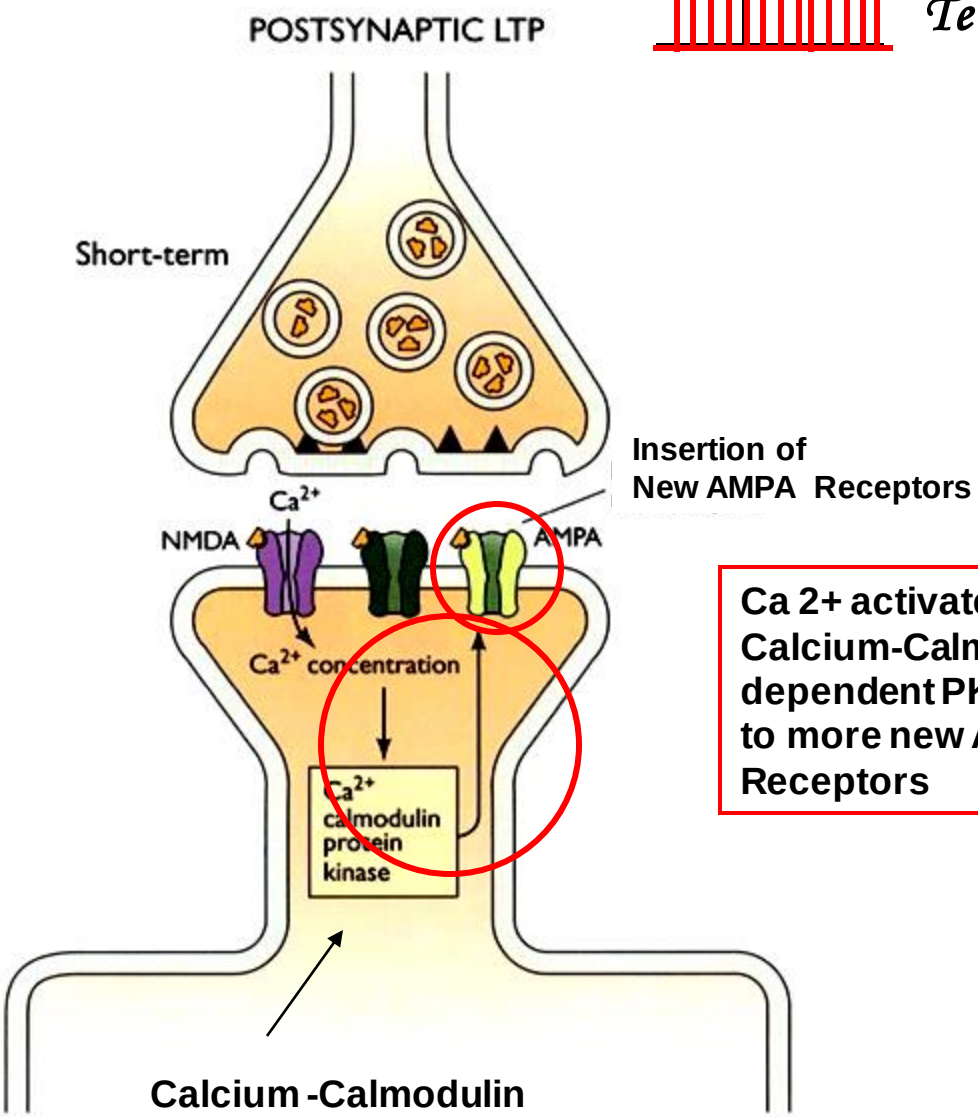
“ Engram “

Basics II

I

Maintenance of LTP – Short Term

Tetanus Stimulation



LTP – Short Term

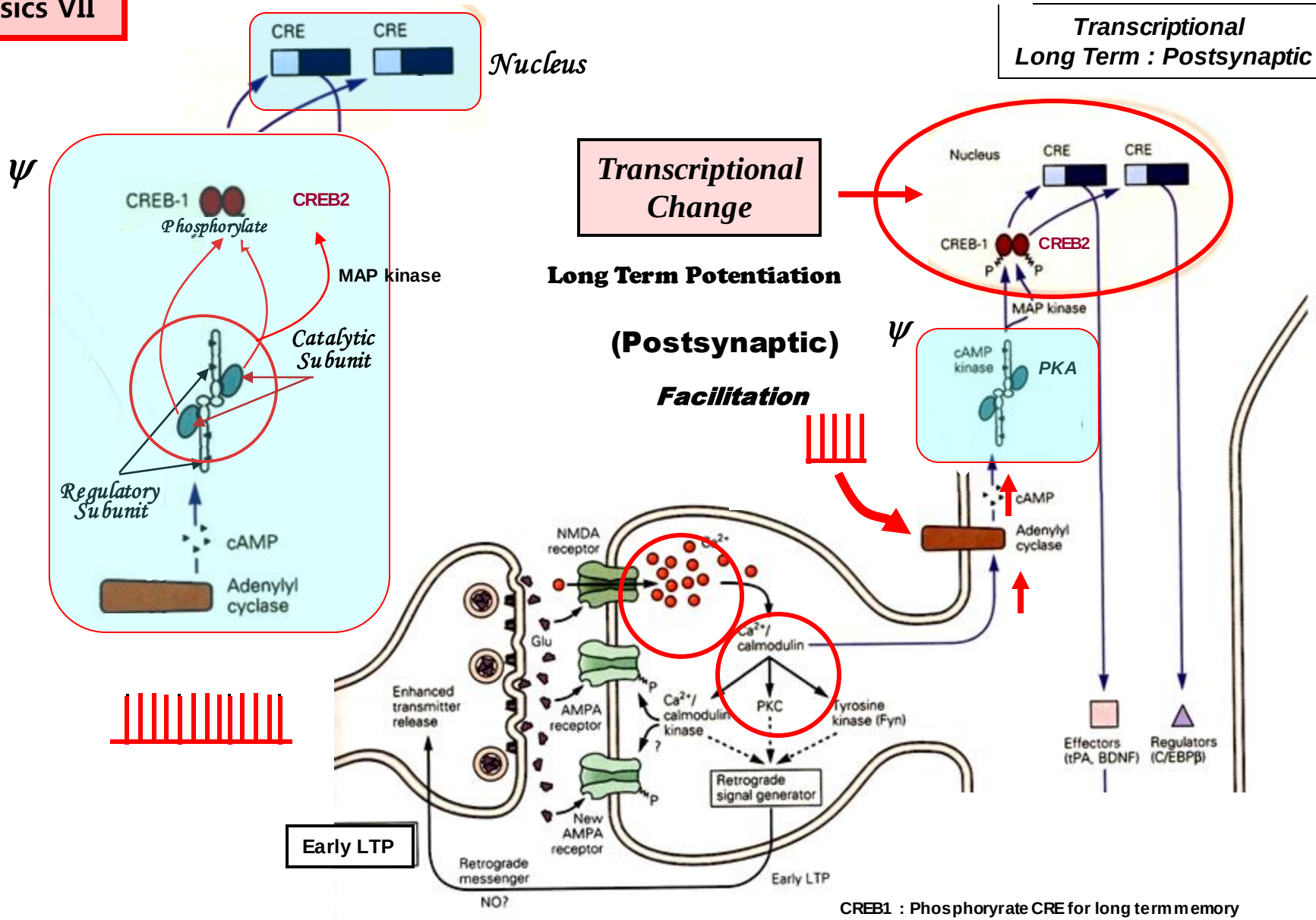
Ca 2+ activates Calcium-Calmodulin dependent PK leads to more new AMPA Receptors

Eric Kandel

Long Term - Transcriptional II

Basics VII

Transcriptional
Long Term : Postsynaptic



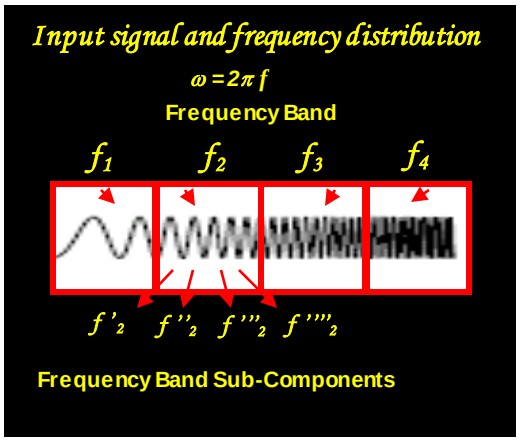
CREB1 : Phosphoryrate CRE for long term memory
CREB2 : Repressor for both CREB1 and CRE for longterm meory
MAPK: Mitogen Activated Protein Kinase ; repressor of CREB2

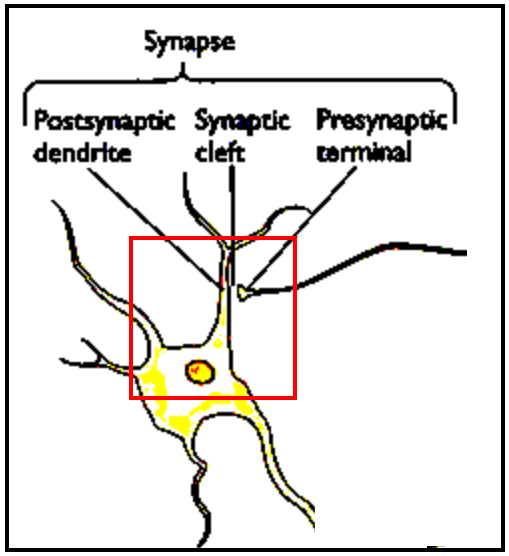
Principal of Neural Science. E. Kandel

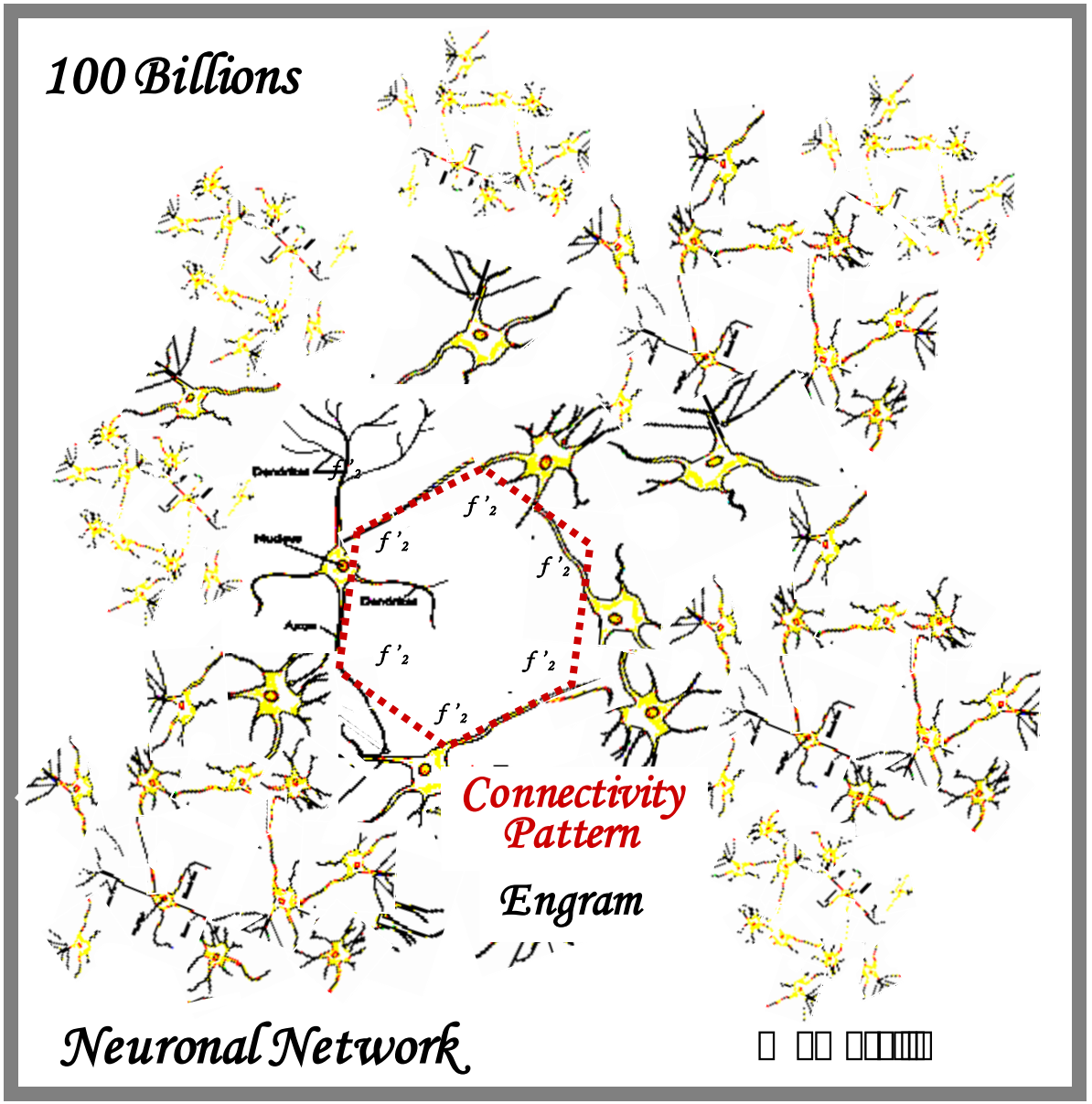
“ Engram “

A Neural Pattern

“Neurons” and “ Synaps “







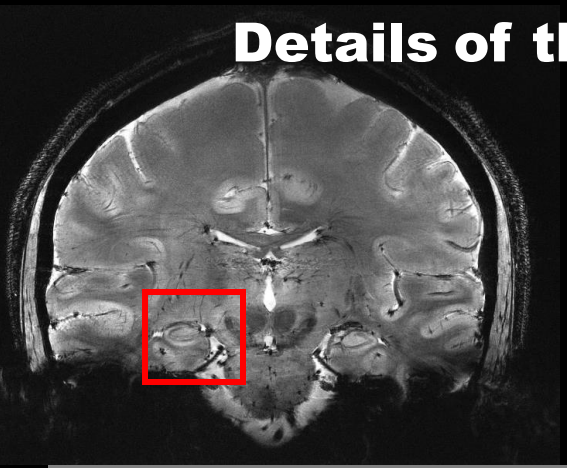
Semon R., Die mneme. Leipzig: Wilhelm Engelmann; 1904

Tonegawa S, M. Pignatelli, et al . Memory engram storage & retrieval. Current Opinion in Neurobiology, 35:101-109, 2015

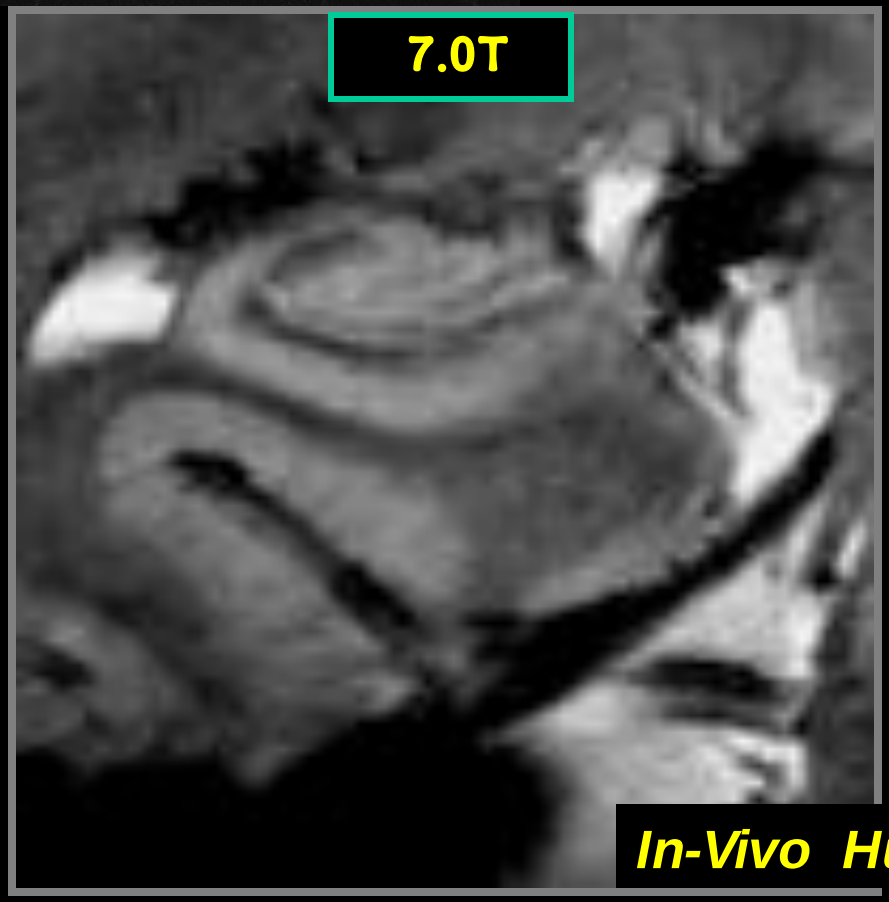
Hebb DO: The organization of behavior; a neuropsychological theory. New York: Wiley; 1949

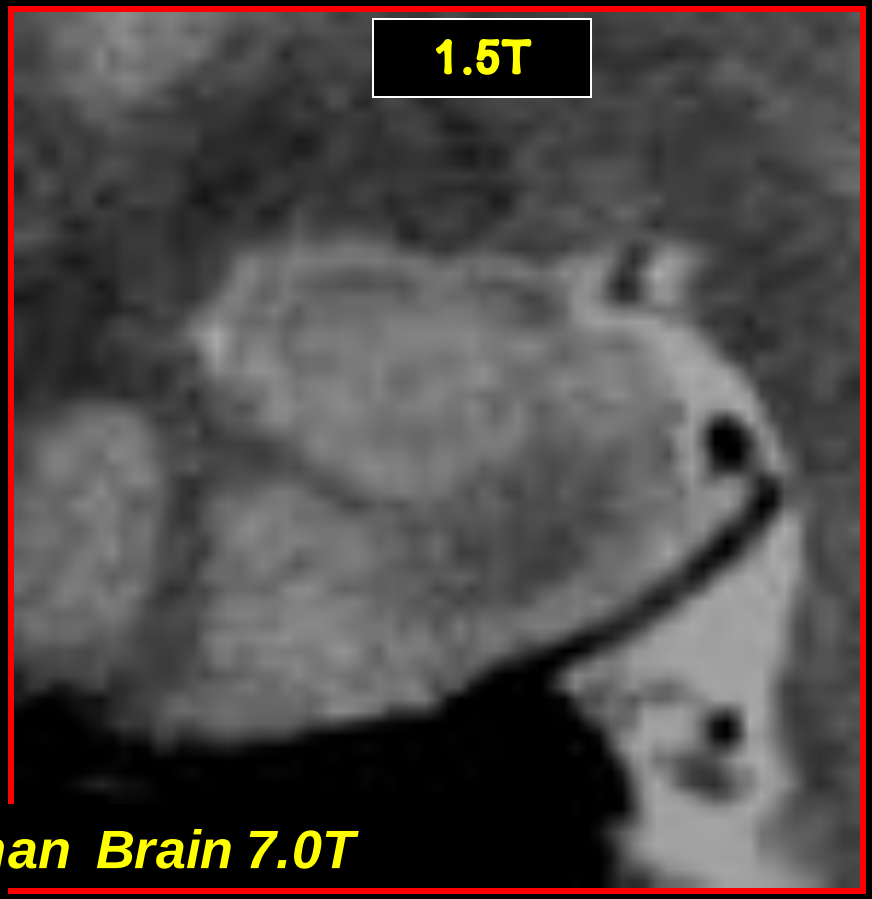
B. Hutcheon and Y. Yarom. Trends in Neuroscience, TINS Vol. 23, No. 5, 216-222, 2000

Details of the Hippocampal Areas Seen by 7T MRI



Coronal View

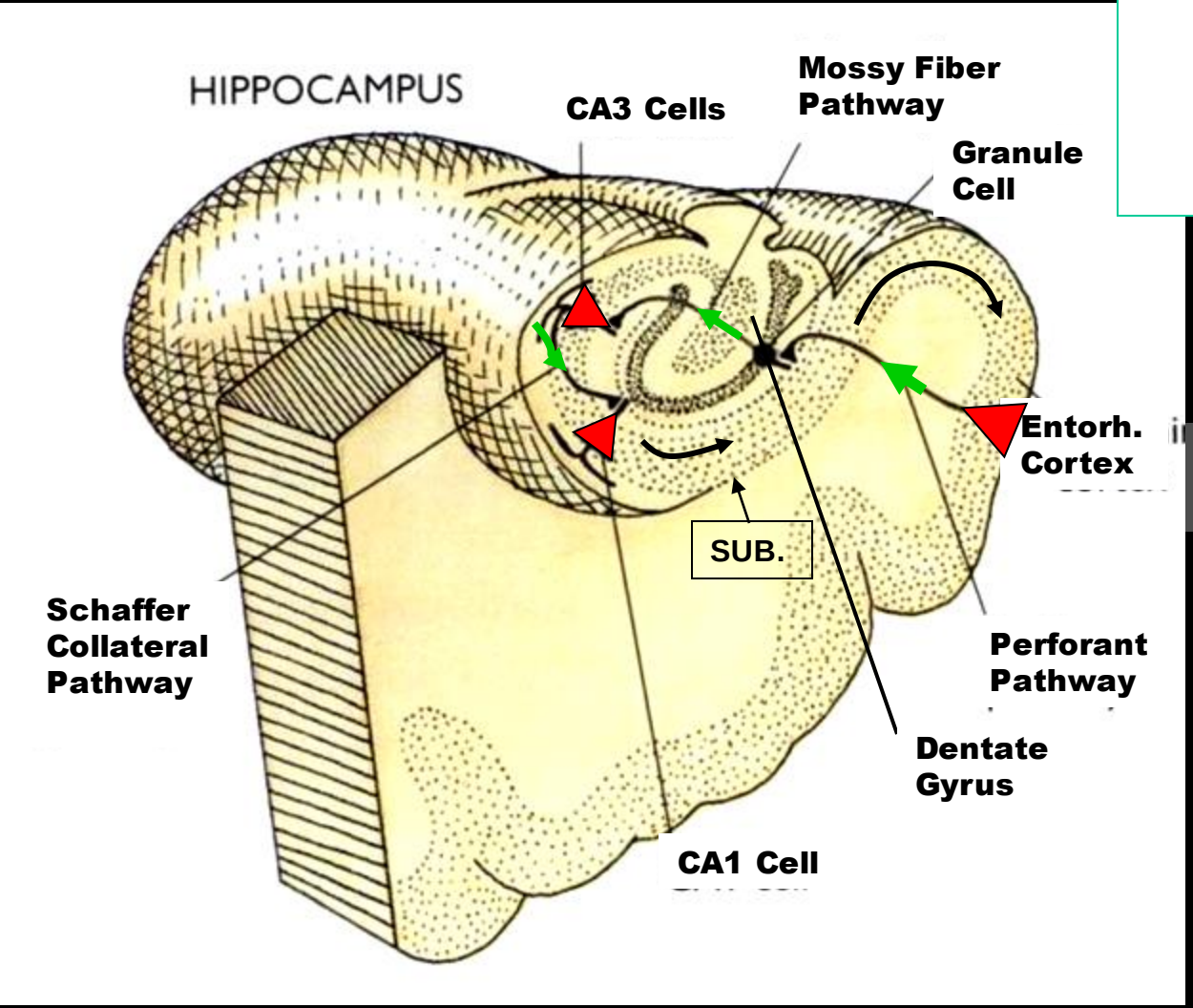


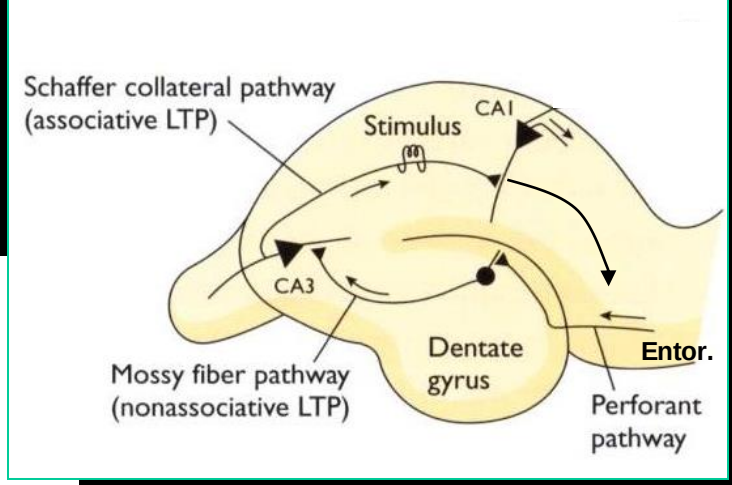


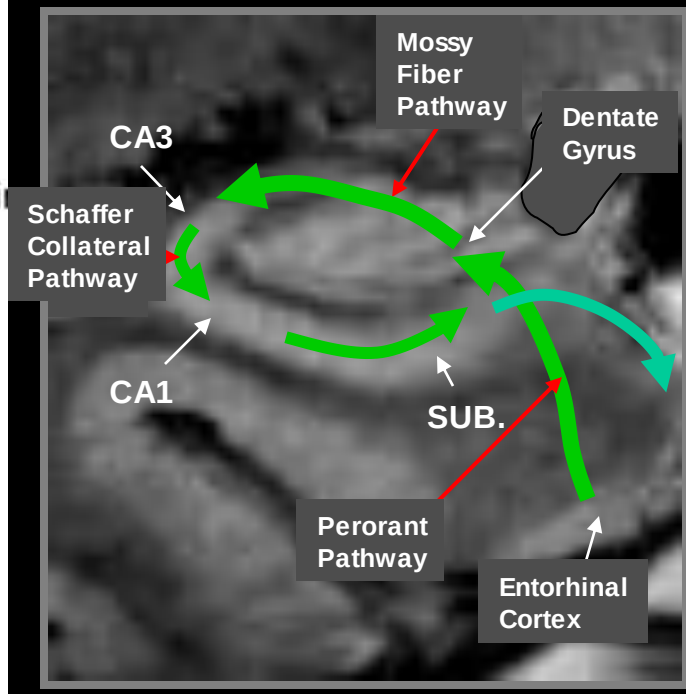
In-Vivo Human Brain 7.0T

Cho et al, in Neuroimage 49(3):2134-2140, 2010

Hippocampus







Sensory Assoc. Cortices - Entorhinal Cort - Perforant Path – Dentate Gyrus – Mossy fiber Path – CA3 – Schaffer Collateral Path – CA1 – Subiculum – Entorhinal Cortex – Sensory Assoc. Cortices

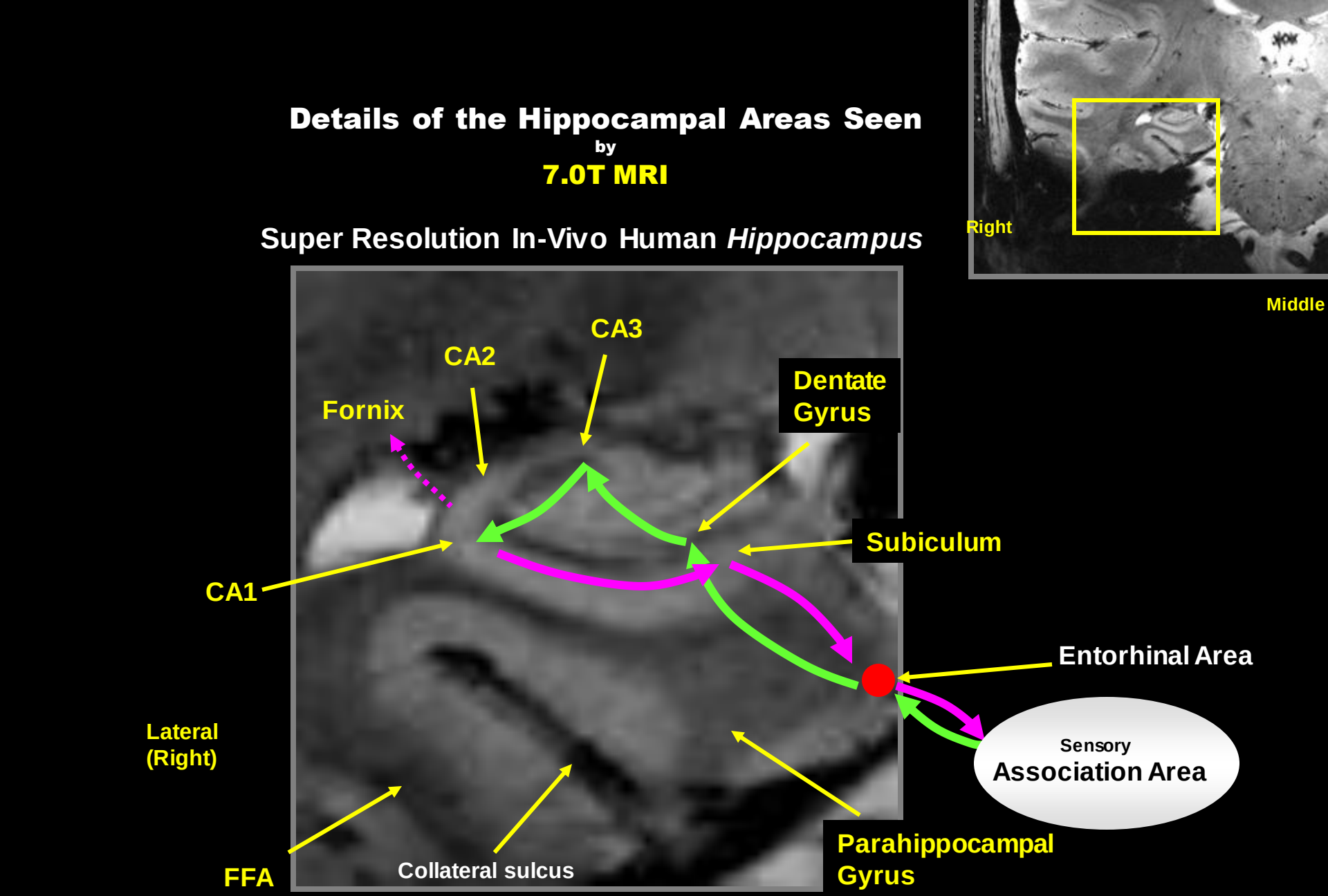
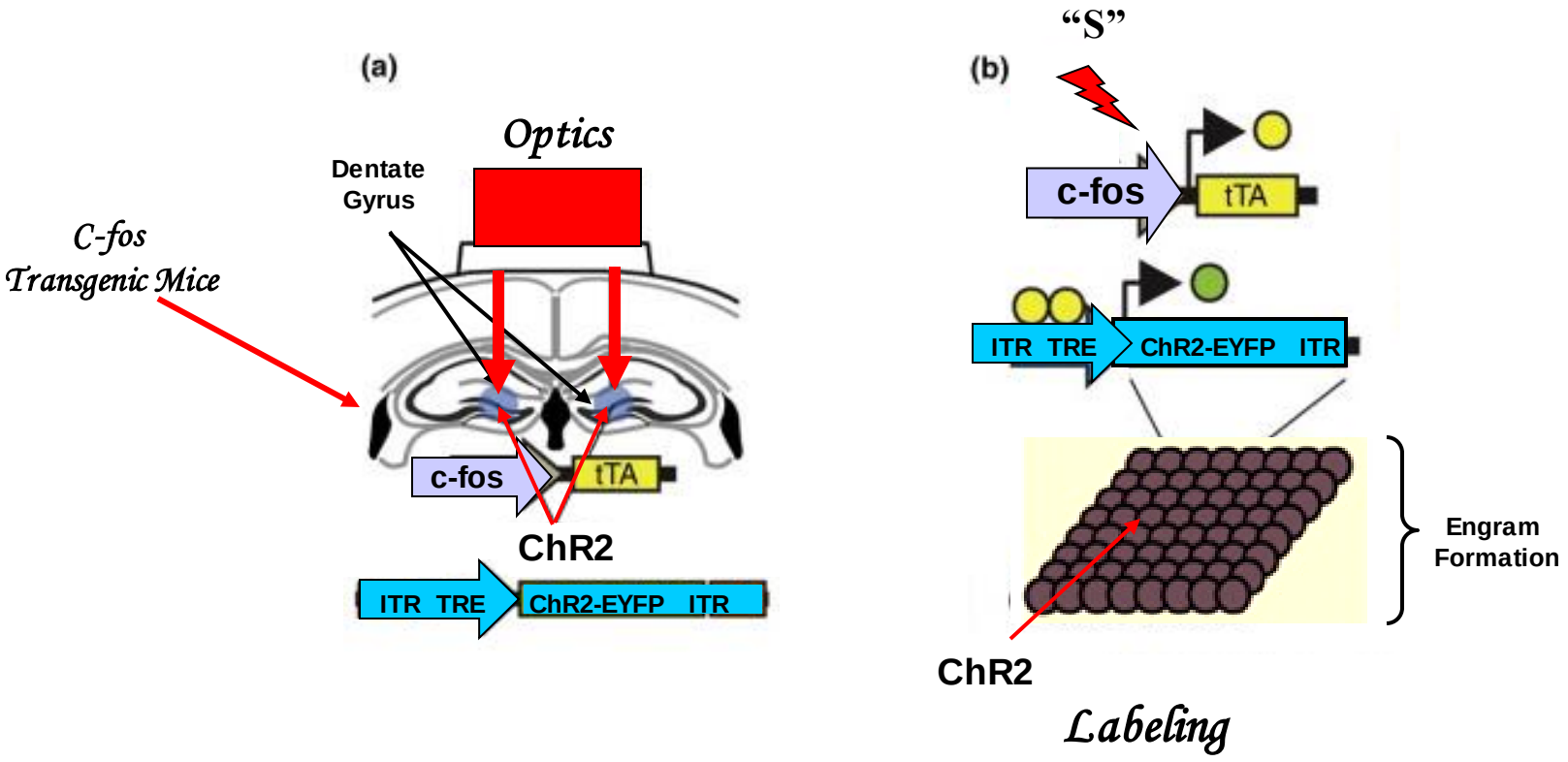


Fig. 3. An exemplary in-vivo human hippocampal head image of coronal view obtained from 7.0T MRI and the tentative signal pathway overlaid onto it. Note the input-output connection of the sensory association area or cortex.

Cho et al , in Neuroimage 49(3) :2134-2140, 2010

Tonegawa Model 2012 - 2015

In Hippocampus



"S" : Shock (Electric)

Labeling : Memory

c-fos : Immediate Early Gene (IEG)

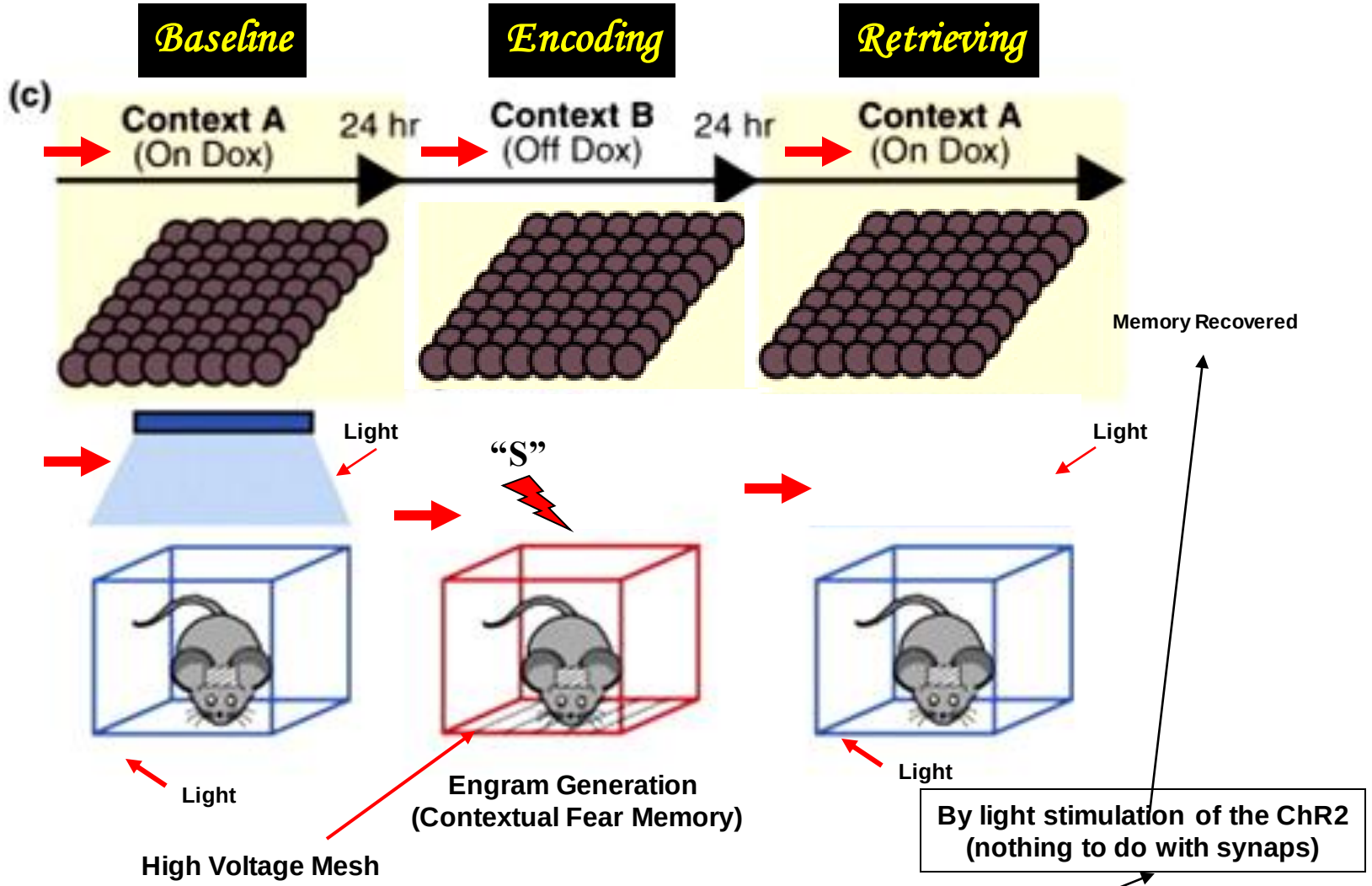
ChR2 : Channel Rhodopsin 2 (Light sensitive ion channel)

Protein synthesis

ChR2 labeling (Light sensitive)

Tonegawa Model 2015

In Hippocampus



By light stimulation of the ChR2
(nothing to do with synaps)

Hebb: Once fired together – wired together

Wiring is the memory

Dox : Doxycycline (synaptic inhibitor)

Anisomycine : Protein Synthesis Inhibitor

Saline Group
Anisomycin Group
Saline (No Shock) Group
Anisomycine (No Shock) Group

Saline/ Anisomycine

Context A (Habituation) 24 hr
Context B (Training) 24 hr

ON-OFF

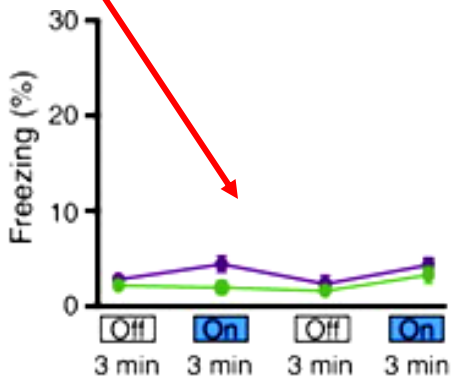
Engram Generation (Contextual Fear Memory)

"S"

"NS"

Habituation

Pre-Drug



Habituation & Engram Generation

Engram Generation under Drugs (Saline/Anisomycine) and Retrieve with Light Stimulation

Summary of Tonegawa Experiment :

Cells that fire together – wire together, Hebb

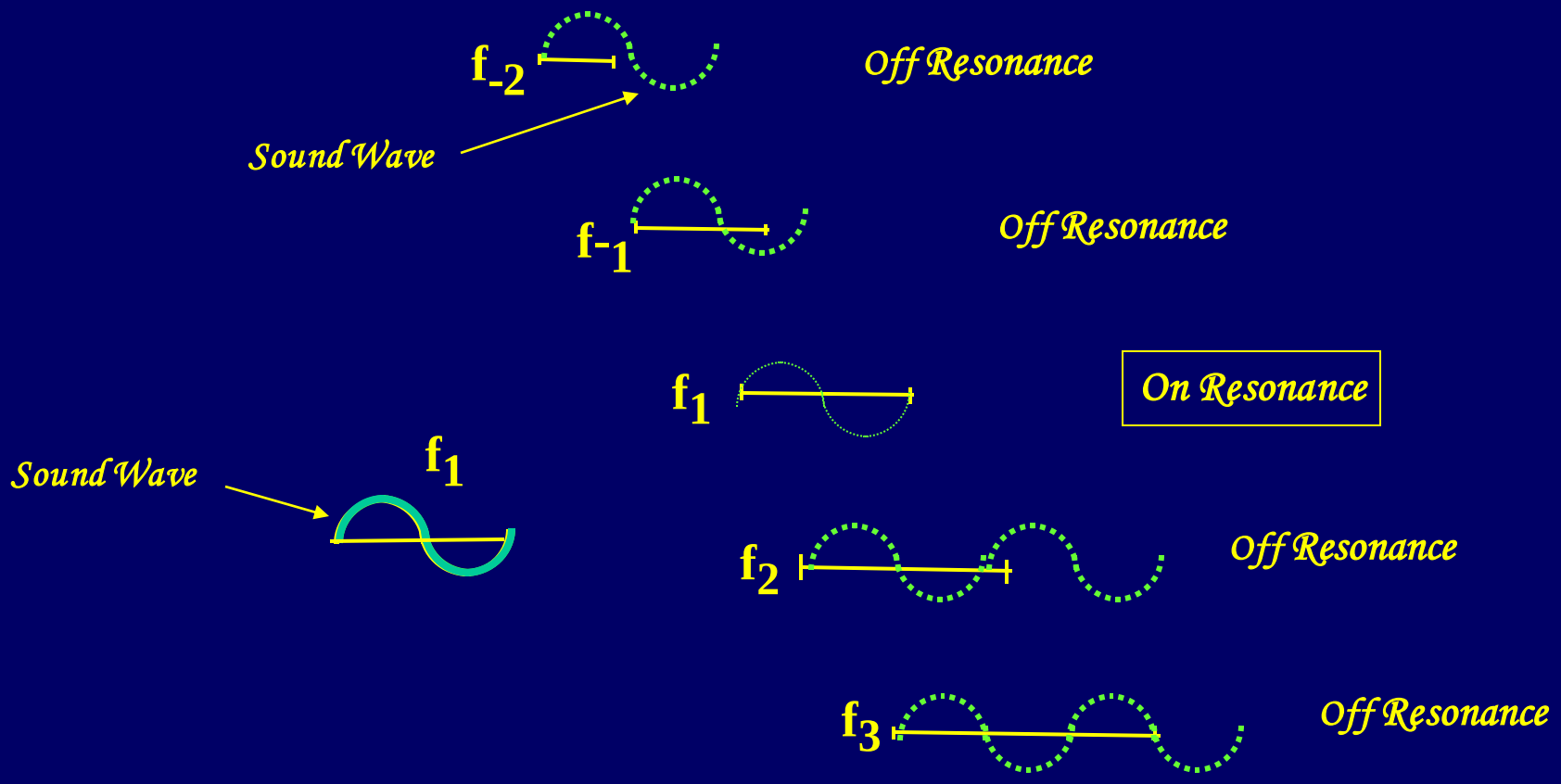
Wire together means, it forms a "pattern" or "Engram"

A formed pattern or the "Engram" is
the basic memory element that can be retrieved later

2. Resonance Excitation or Absorption :

" Resonance is nature's most efficient energy transfer mechanism".

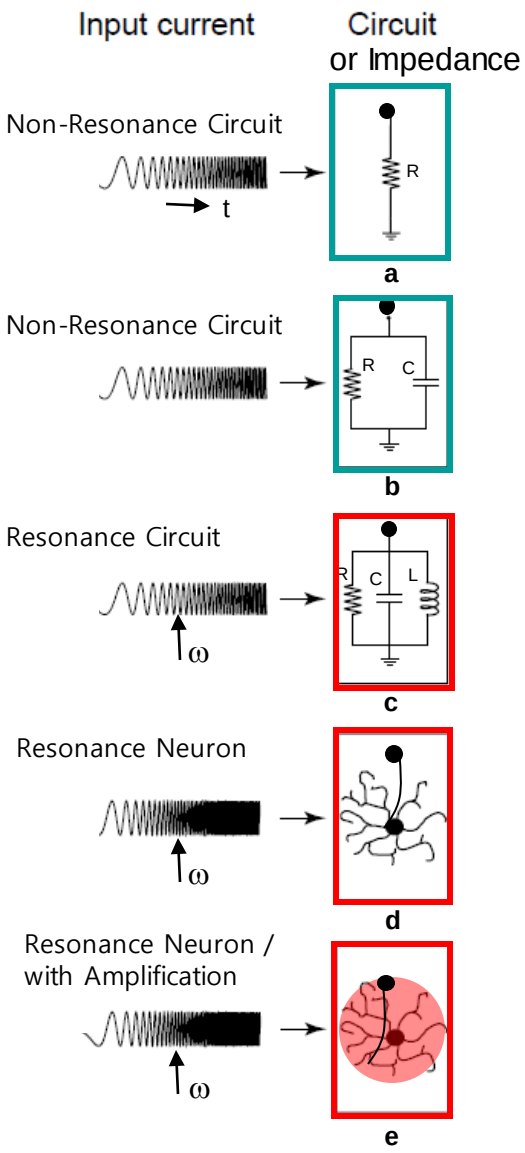
Resonance Excitation or Absorption :



" Resonance is nature's most efficient energy transfer mechnaism".

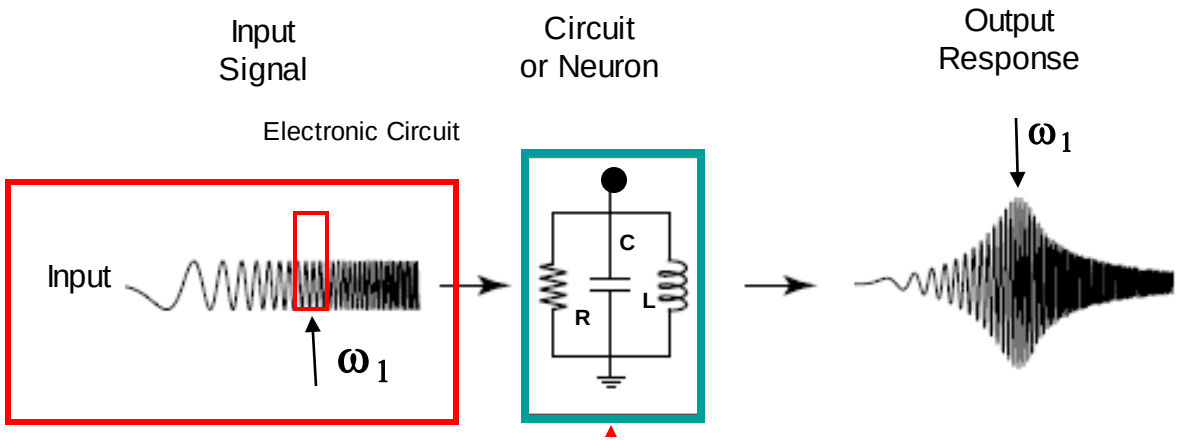
Resonance Excitation in Neurons and Electronic Circuits:

By B. Hutcheon and Y. Yarom, 2000.



Modified form from B. Hutcheon and Y. Yarom. Trends in Neuroscience, TINS Vol. 23, No. 5, 216-222, 2000

Resonance Excitation in Neurons and Electronic Circuits :

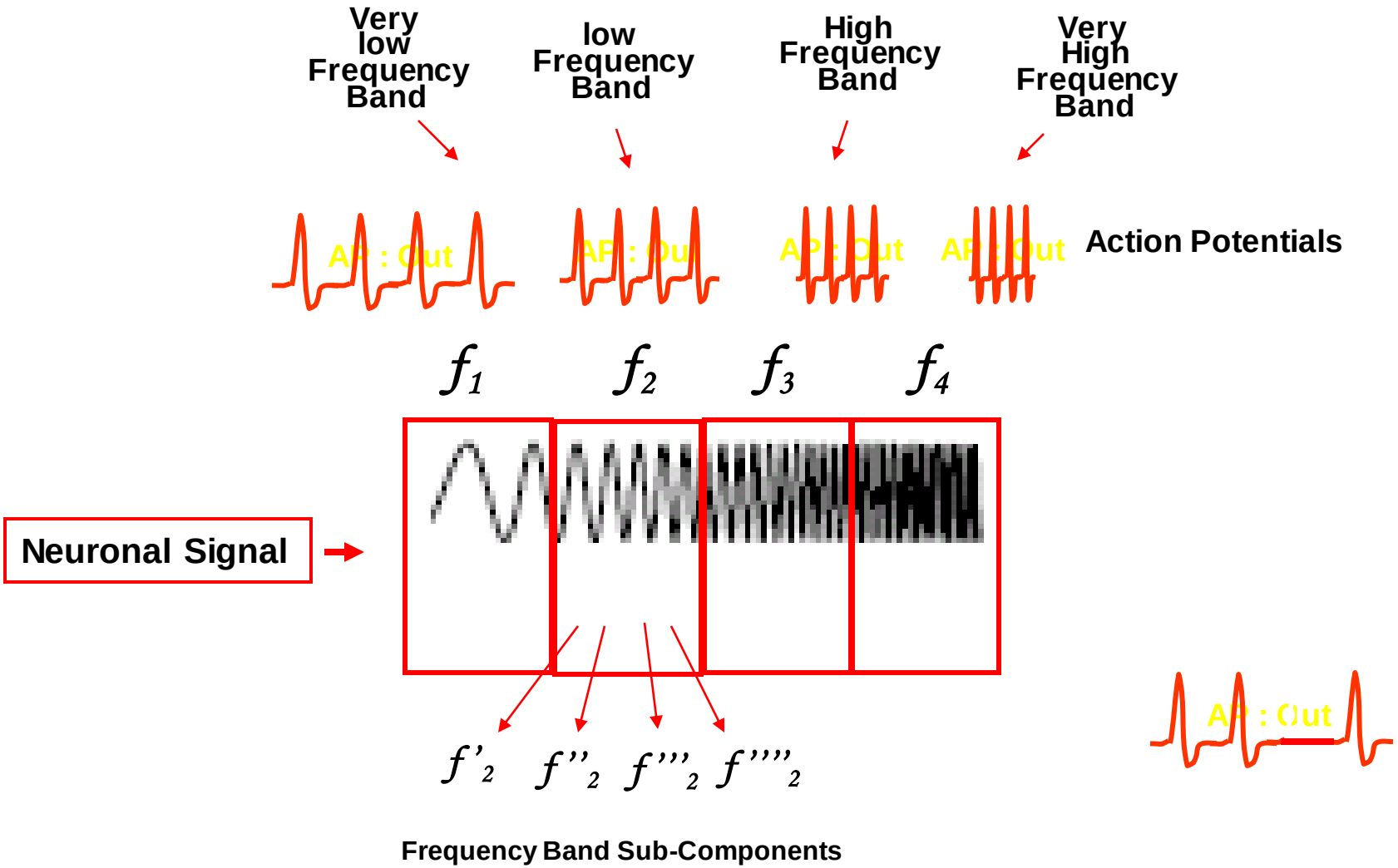


$$\begin{cases} 1/Z(\omega) = 1/R + 1/j\omega L + j(\omega c) \\ Z(\omega) = 1/\left(1/R + 1/j\omega L + j(\omega c)\right) = \text{Max} \quad \text{At reson} \\ 1/j\omega L + j(\omega c) = j(\omega c - 1/\omega L) = 0, \end{cases}$$

$\omega_1 = 1/\sqrt{LC}$: Resonance Frequency

Neuron resonates like Electronic Circuit !

Modified form from B. Hutcheon and Y. Yarom. Trends in Neuroscience, TINS Vol. 23, No. 5, 216-222, 2000

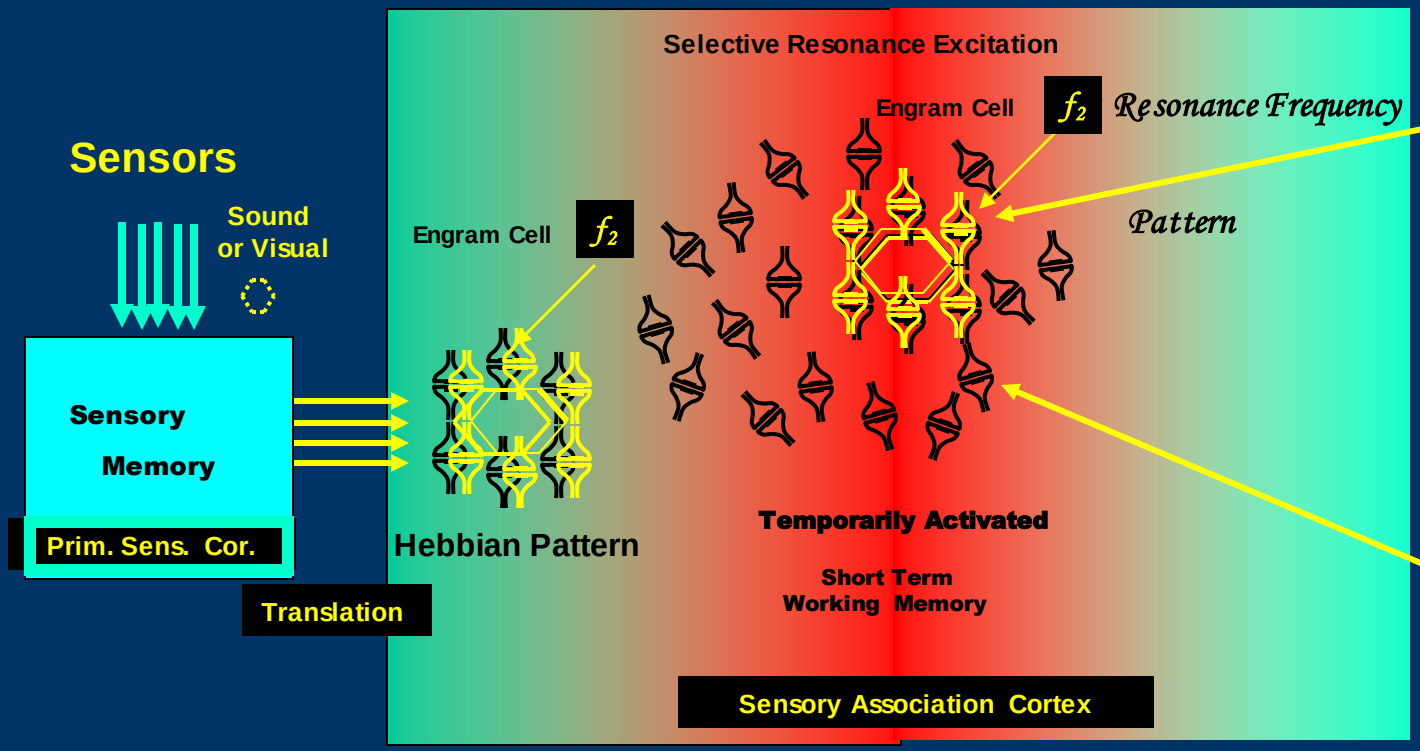


Modified form from B. Hutcheon and Y. Yarom. Trends in Neuroscience, TINS Vol. 23, No. 5, 216-222, 2000

Resonance Excitation Hypothesis

Hebb "Cells that fire together – wire together".

Encoding



First Clue of Memorization or Memory Formation !

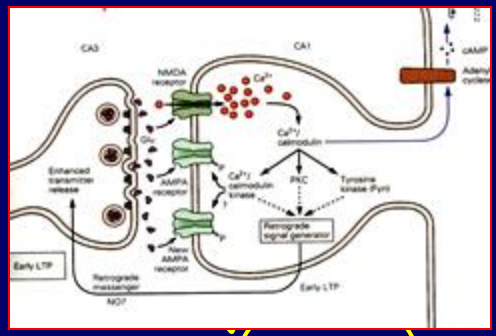
Memory Contents are All in the Sensory Association Areas
" Not Hippocampus "

Cho et al to be published 2016

Hippocampus

Resonance Excitation Hypotheis

Consolidation



Hippocampus

CA3 **CA1**

Mossy Fiber Path.
Dentate Gyrus
Perforant Path.

EPSP

Schaffer Collateral Path.

Entorhinal Cortex

Subiculum

Facilitation

No Output

Sensors

Resonance Excitation

Facilitation

Sensory Memory

Prim. Sens. Cor.

Intermediae or Long Term Memory

Sensory Association Cortex

Declarative Conscious Memory

Intermediate & Long Term Memory

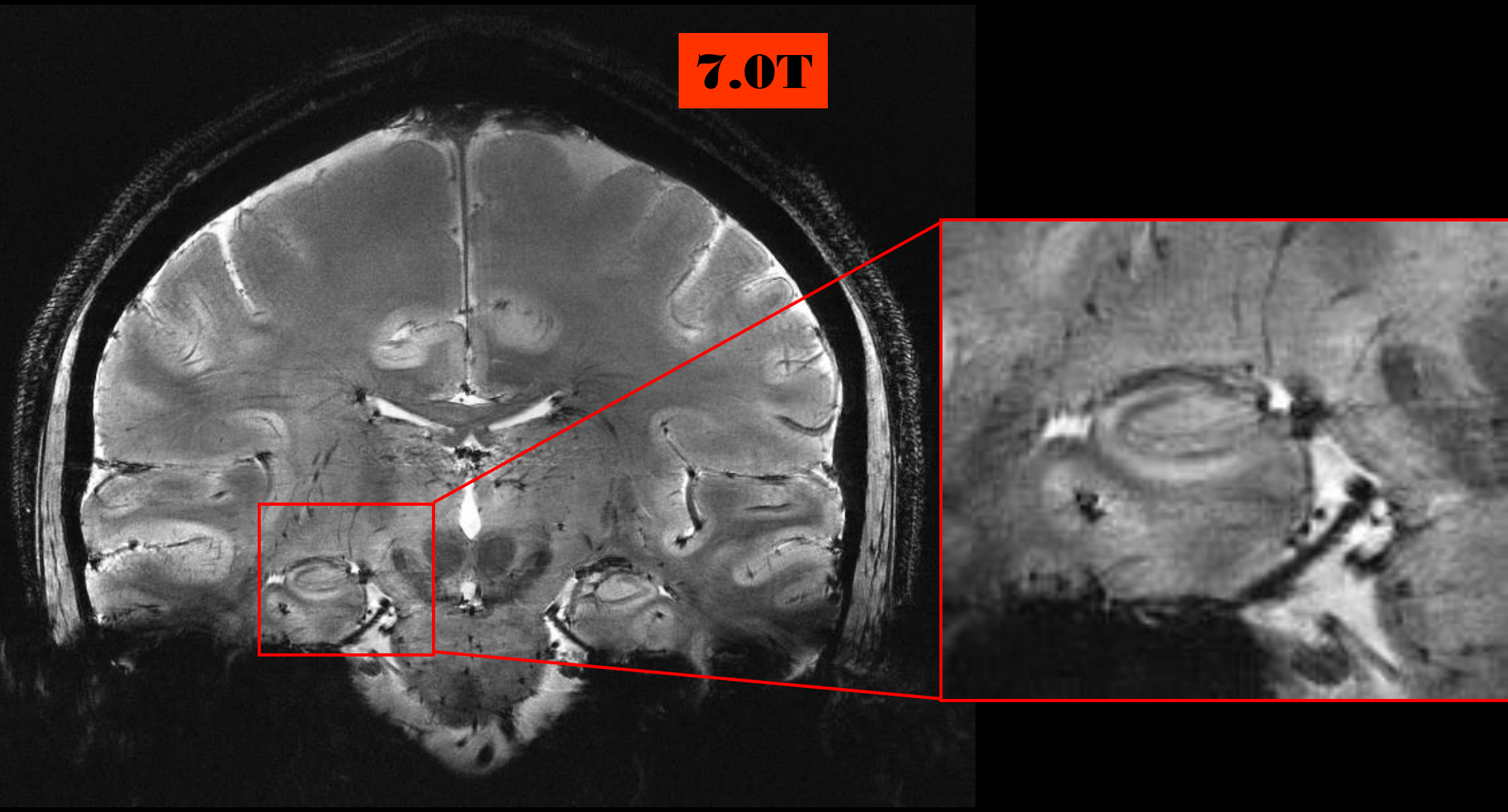
Where : x, y, z
When : t
What : α, β, γ

* ***Facilitation ~ Augmentation***

Fig. 10

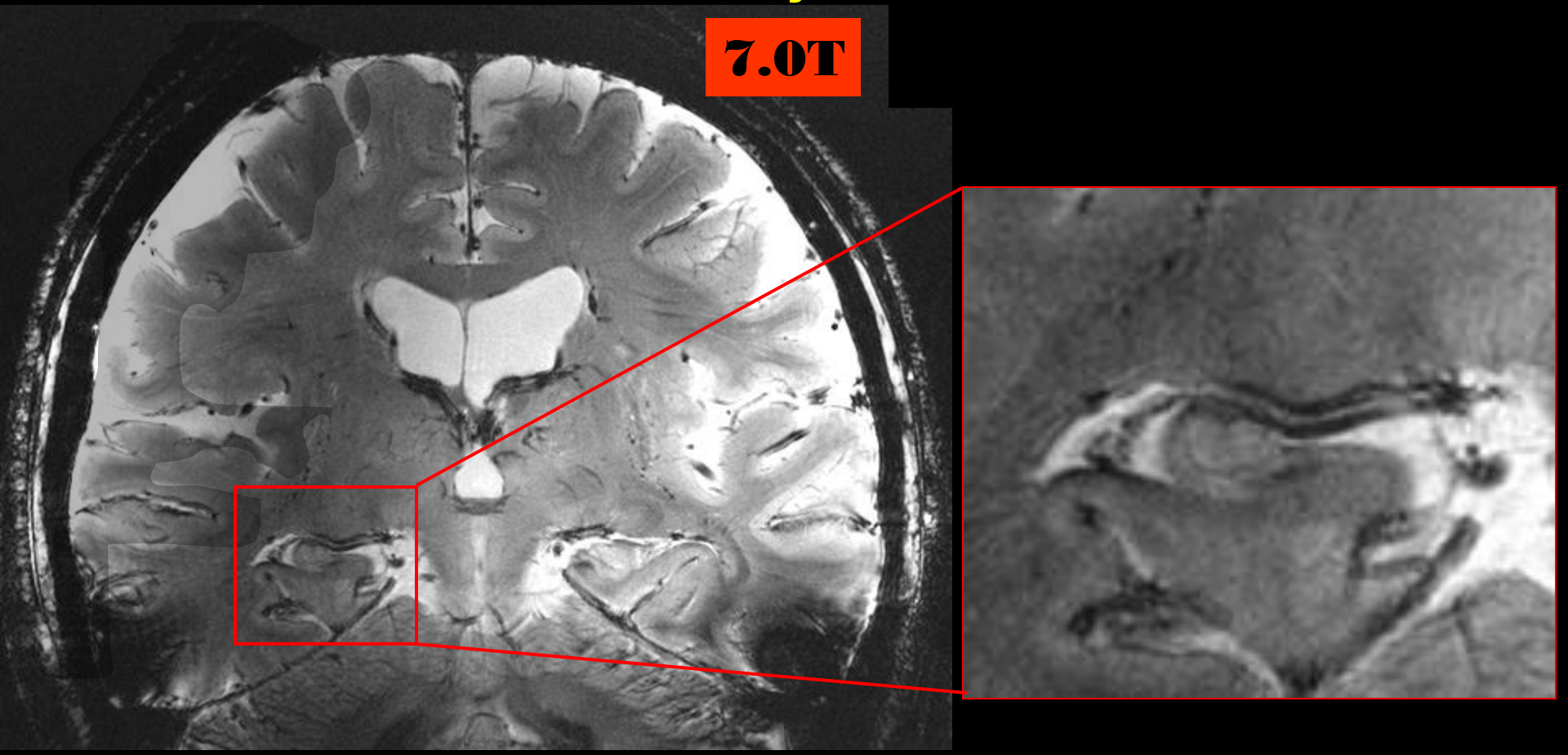
Cho et al to be published 2016

Healthy Normal Subject



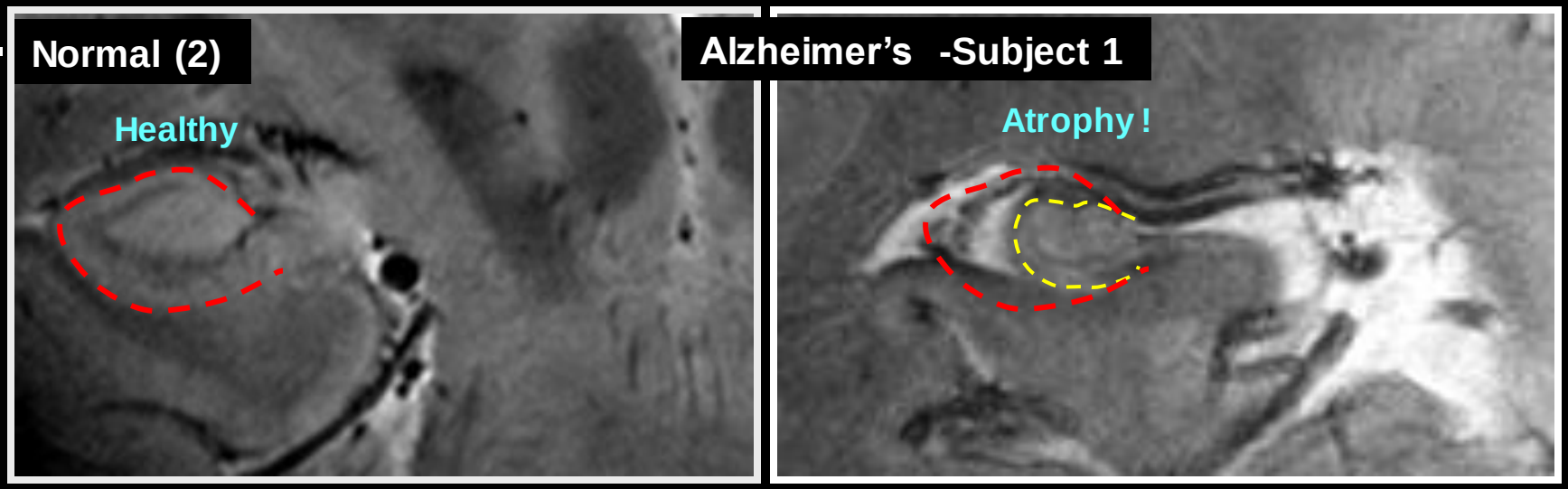
Alzheimer's

Subject 1



Normal & Alzheimer's
Subject 1

iii.



Hippocampus, obviously, play an important role,
but seems not the memory center itself !

What is

“Langram” and “Engram“ ?

**** Langram = Language Engram***

What is Language ?

Definition

Hierarchically Structured,
Classified, and
Categorized
Systematic and
Efficient "Learning Dependent Social Communication Tool"

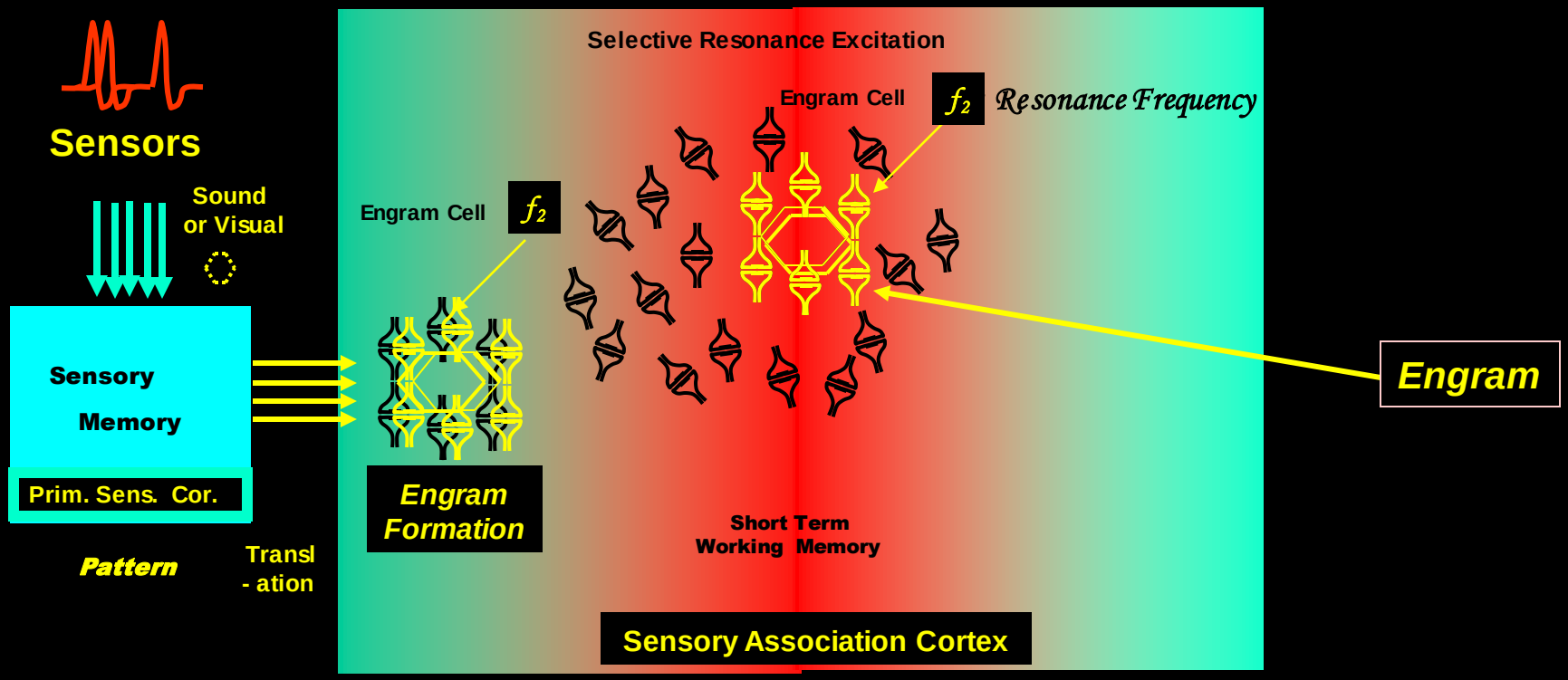
Learning Dependent

Is Unique Human Property !

"Engram"

Hebb "Cells that fire together – wire together".

Encoding – Resonance Absorption



First Memory Formation !

Each Input has Its own Pattern or "Engram"

Engram : Neural Pattern

Cho et al to be published 2016

“ Langram “

Engram is simply too inefficient to be used in the “Complex Neural Circuitry”

Neural Circuit requires better organized and efficient neural “Code”

Structured,
Classified, and
Systematic and
Efficient “Neural Communication Tool”

The “ Langram “

Cho et al to be published 2016

" Langram "

A Neural Correspondence of Social Language

Hierarchically Structured,
Classified, and
Categorized
Systematic and
Efficient "Neural Communication Tool"

Socially Adapted

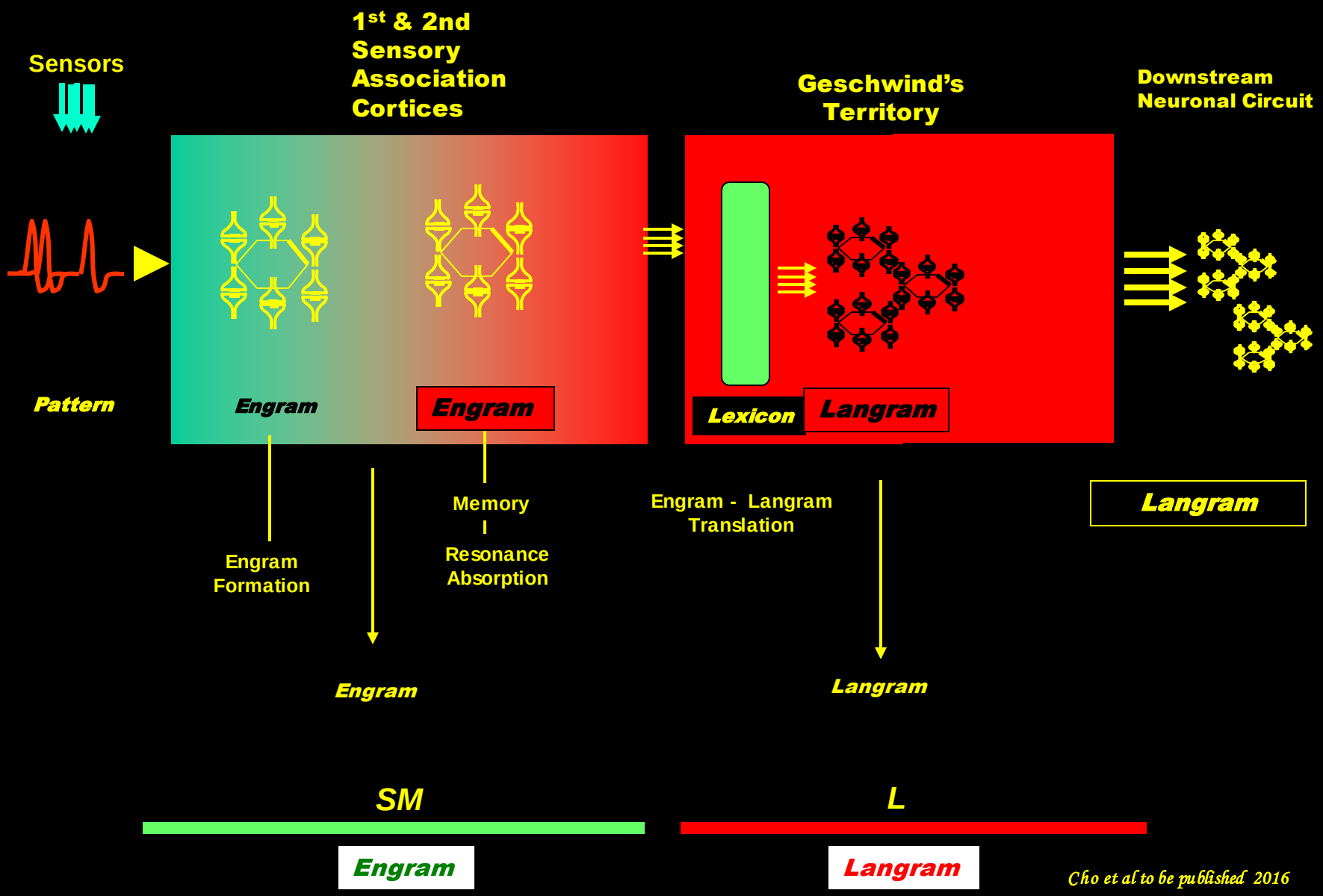
Learning Dependent

Langram is, therefore, the Product of SOCIETY !

Is Unique Human "Brain" Property !

Cho et al to be published 2016

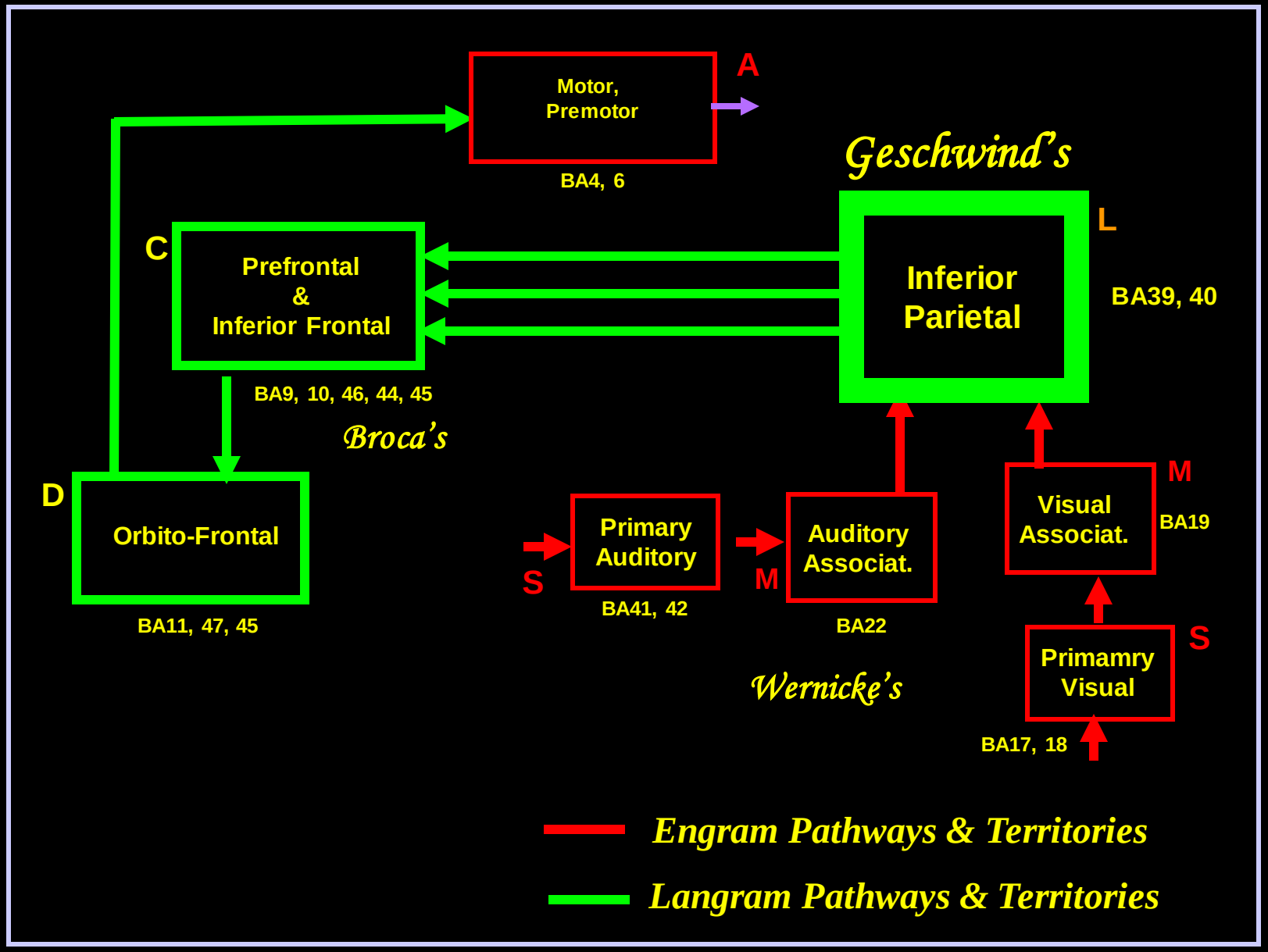
Sensory, Memory, Language, Cognition, Decision, and Action
Langram Formation



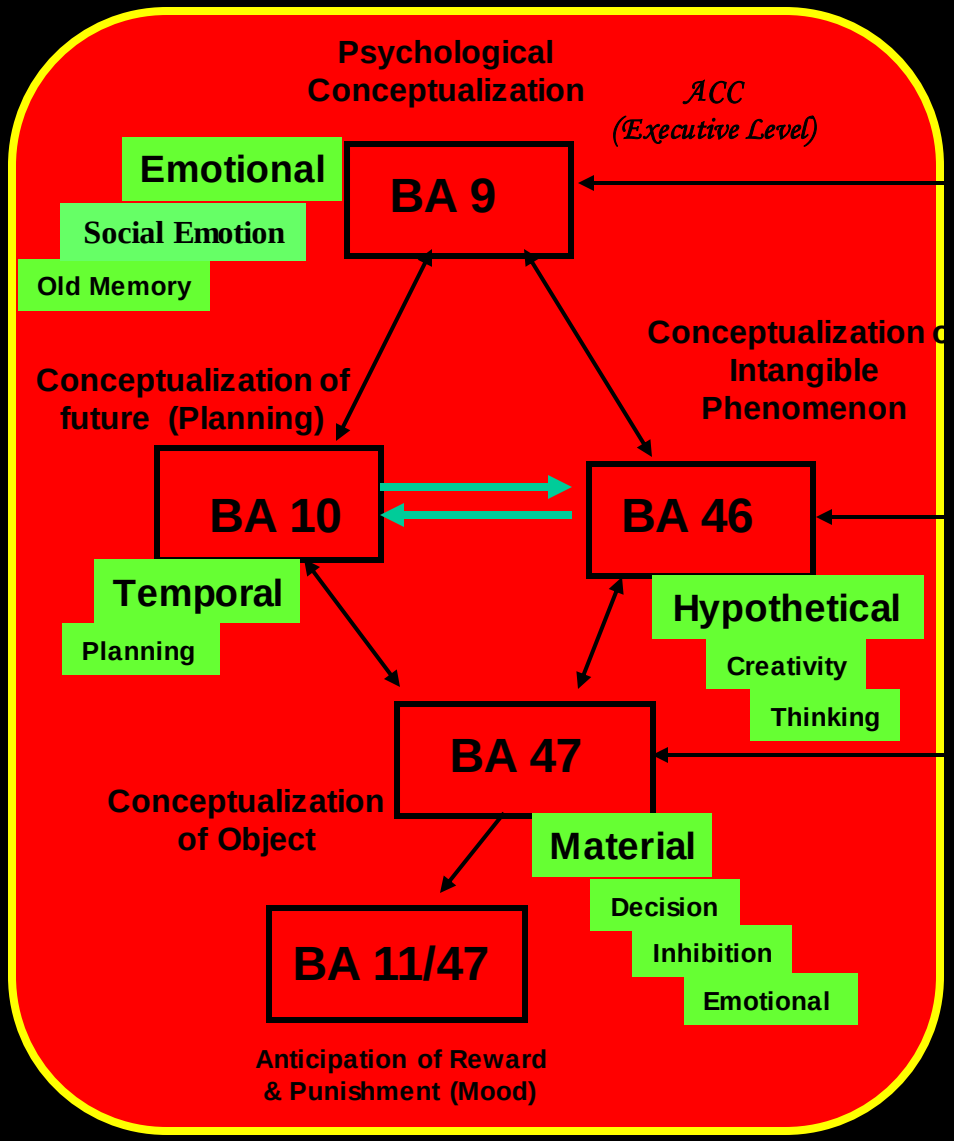
Cho et al to be published 2016

SM- LCDA Hypothesis

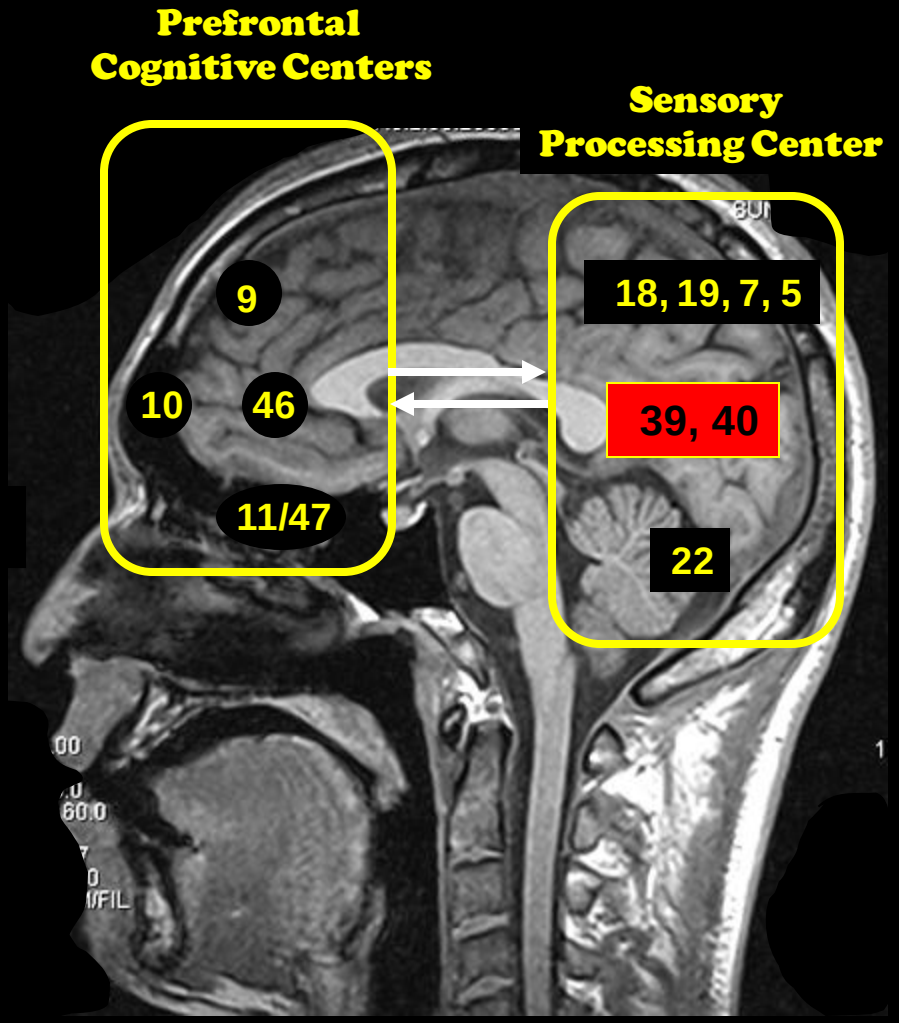
New Hypothesis of Human Language Circuitry Studied Based on the New MR Super-Resolution Tractography



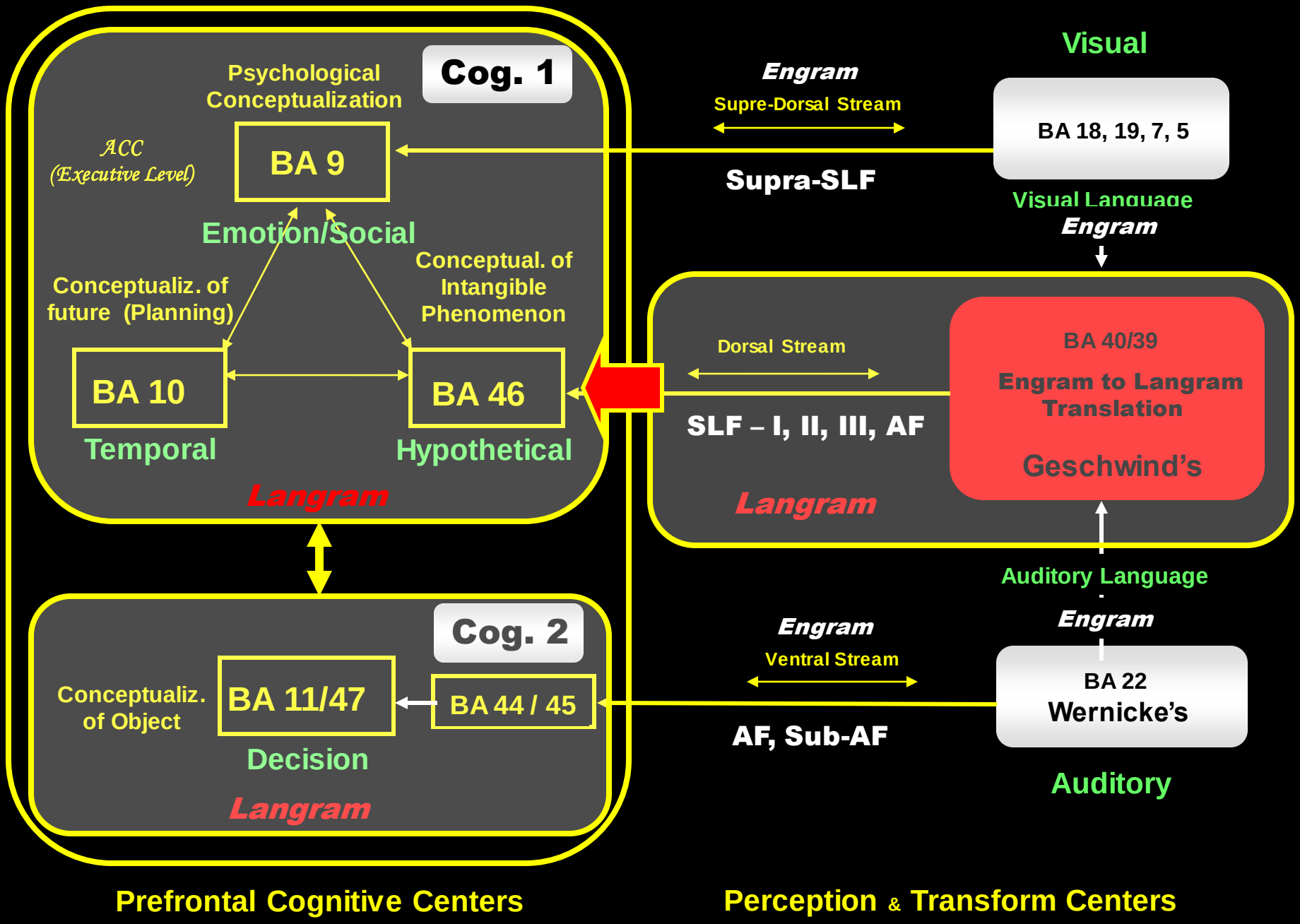
Cho et al to be published 2016



Prefrontal Cognitive Centers

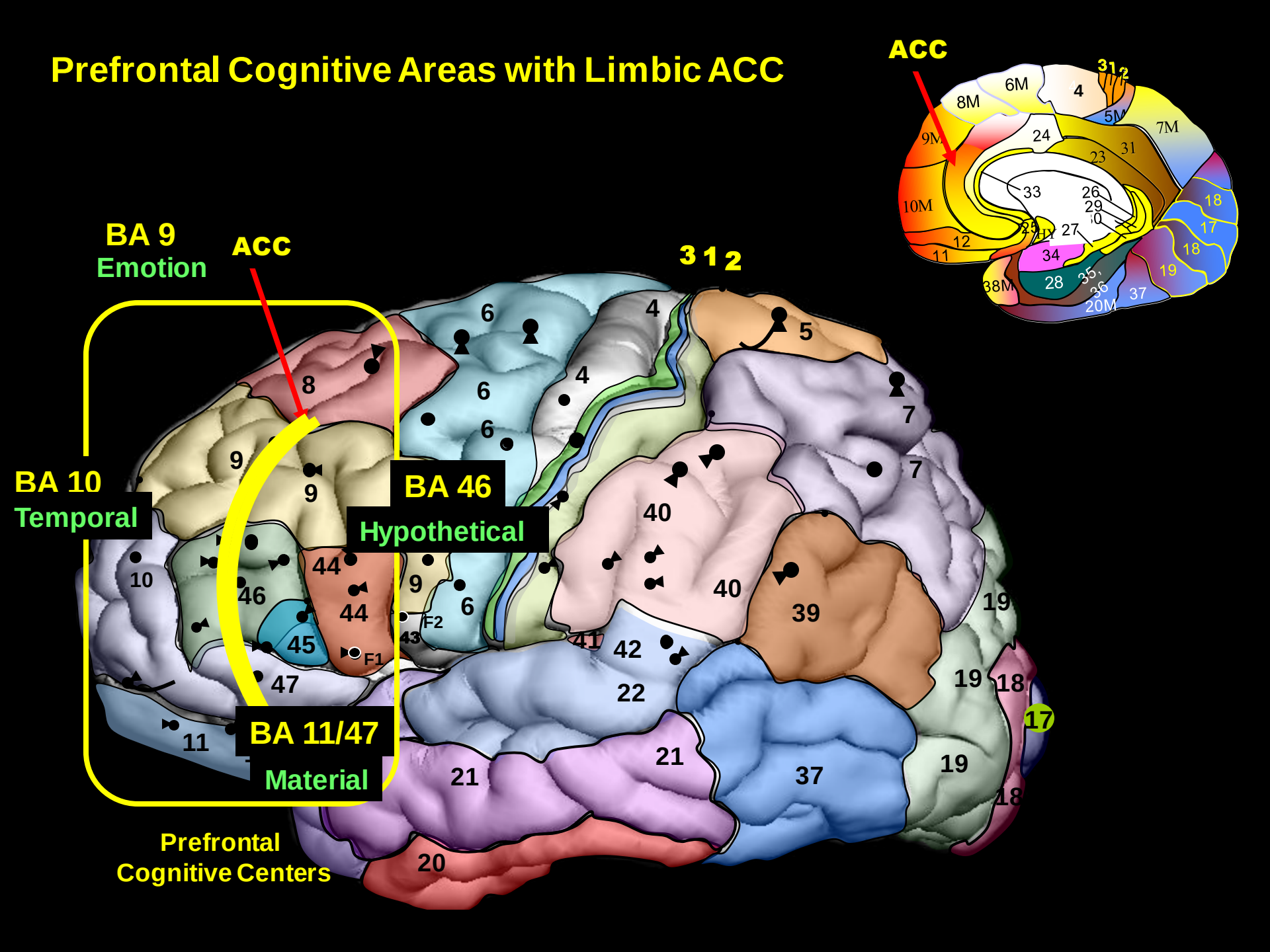


Peter J. Snow, Frontiers in Human Neuroscience, Oct. 2016



New Proposed Scheme 2017

Prefrontal Cognitive Areas with Limbic ACC



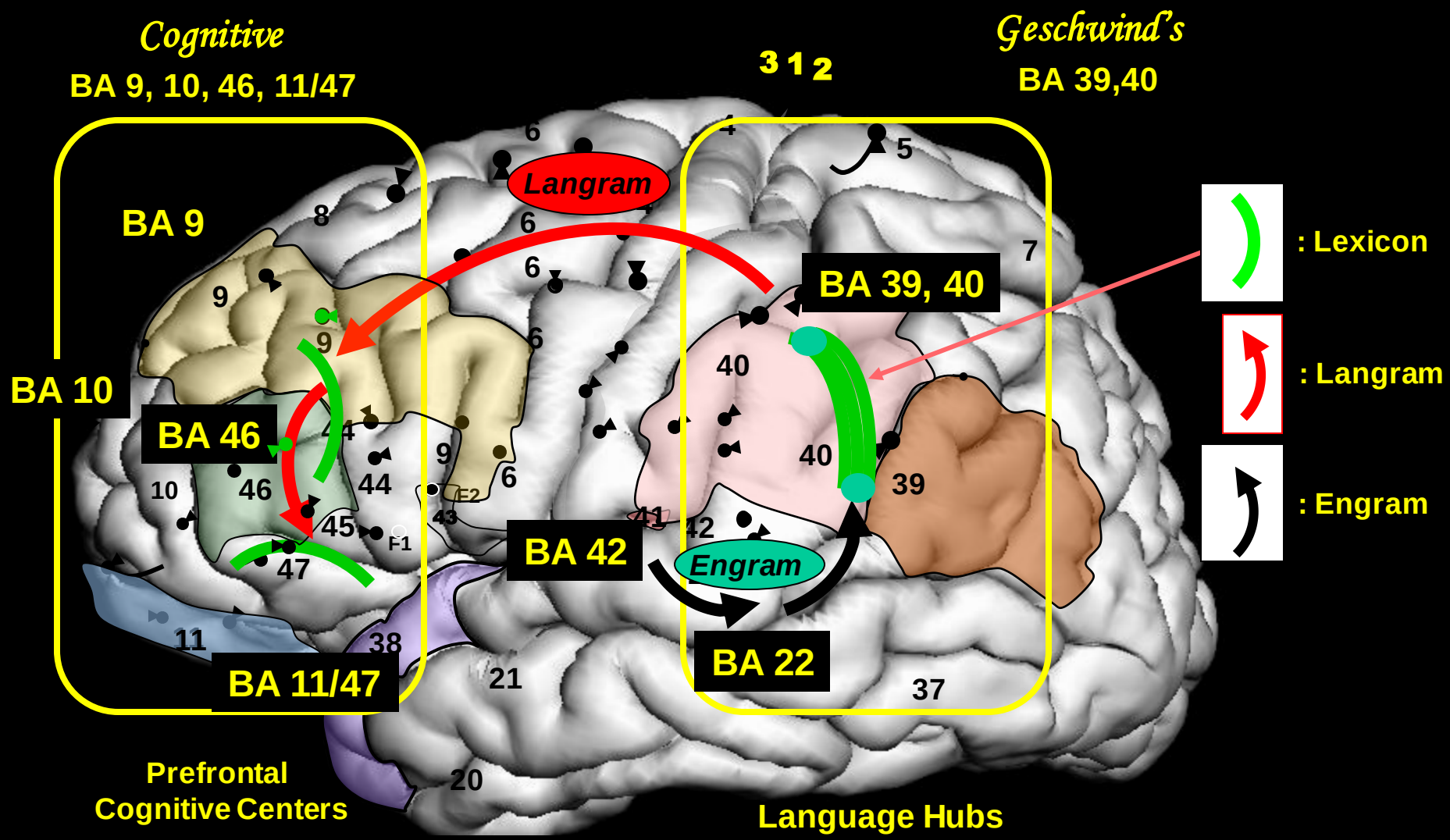
Back to Language

" Lexicon "

A learning dependent "Language Code Storage Unit"
believed to be In the Geschwind's Territory
with which the input data "Engram" can be translated to
"Langram" by help of classification, categorization, and
systematic organization

"Modern Deep Learning"
device

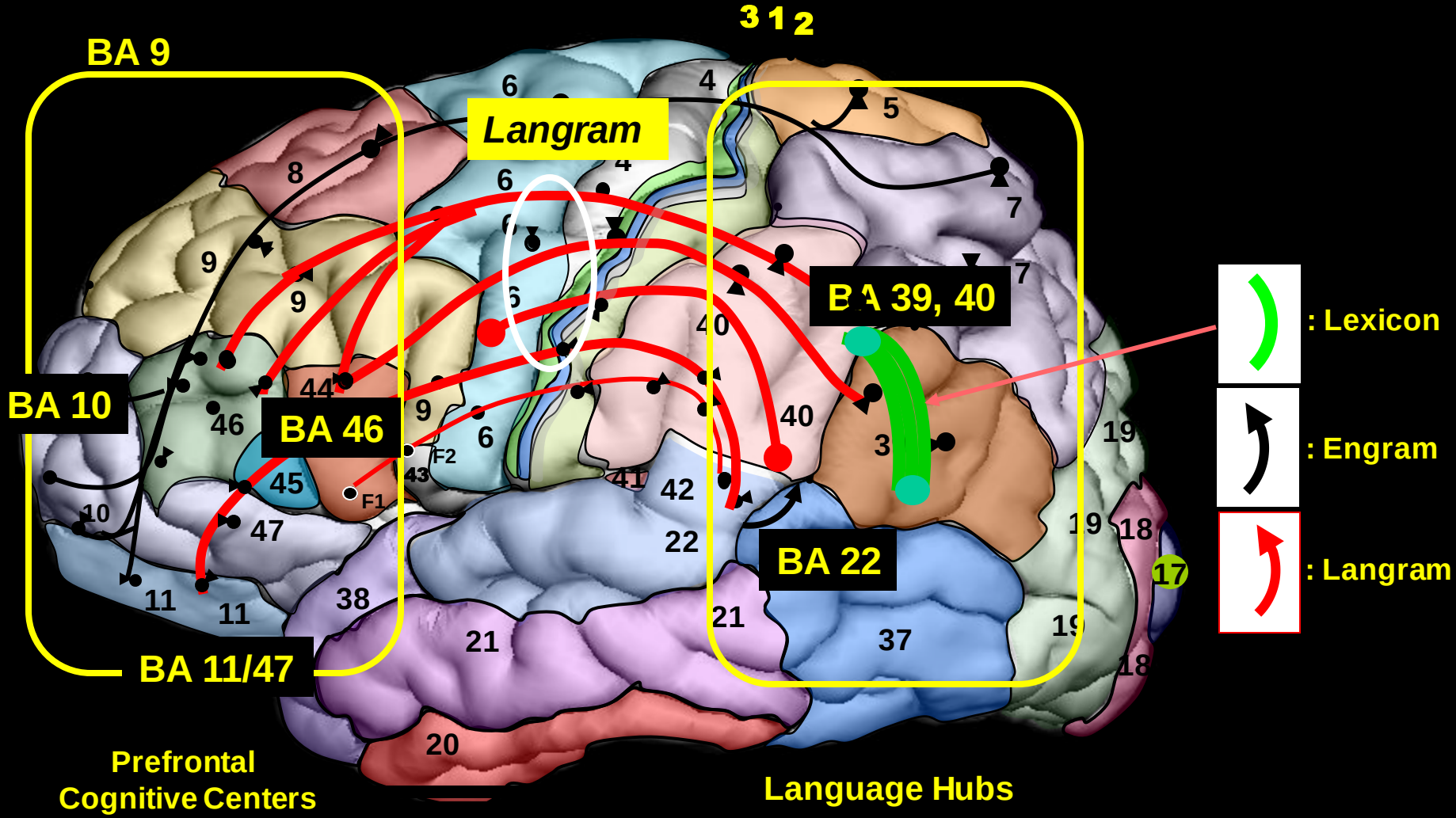
Geschwind's Territory and Hypothetical Connecting Pathways



Engram : Graphic type Neuronal Pattern .

Langram : Language based Neuronal Pattern, Language Engram

Lateral View of Brodmann's Area and Tractographic Fibers



Repeat

Pathway Tracing with Tractographic Data and Estimated Brodmann's Area

Real Pathways

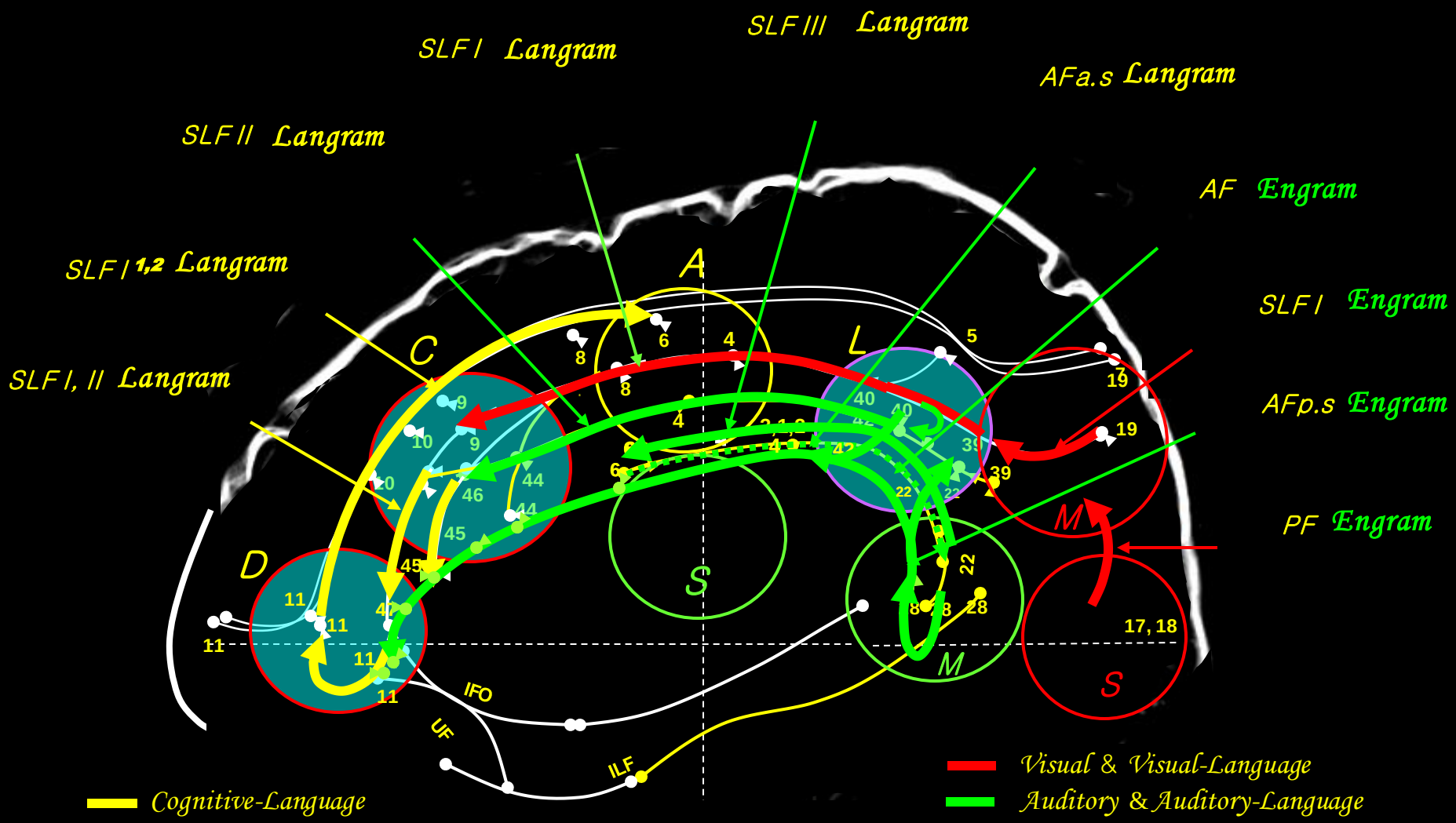


Fig. 3(a)

Repeat

Geschwind's Territory with All the Fine Pathways on the Real Tractography

C : Cognitive Center 1 D : Cognitive Center 2 L : Geschwind's Territory

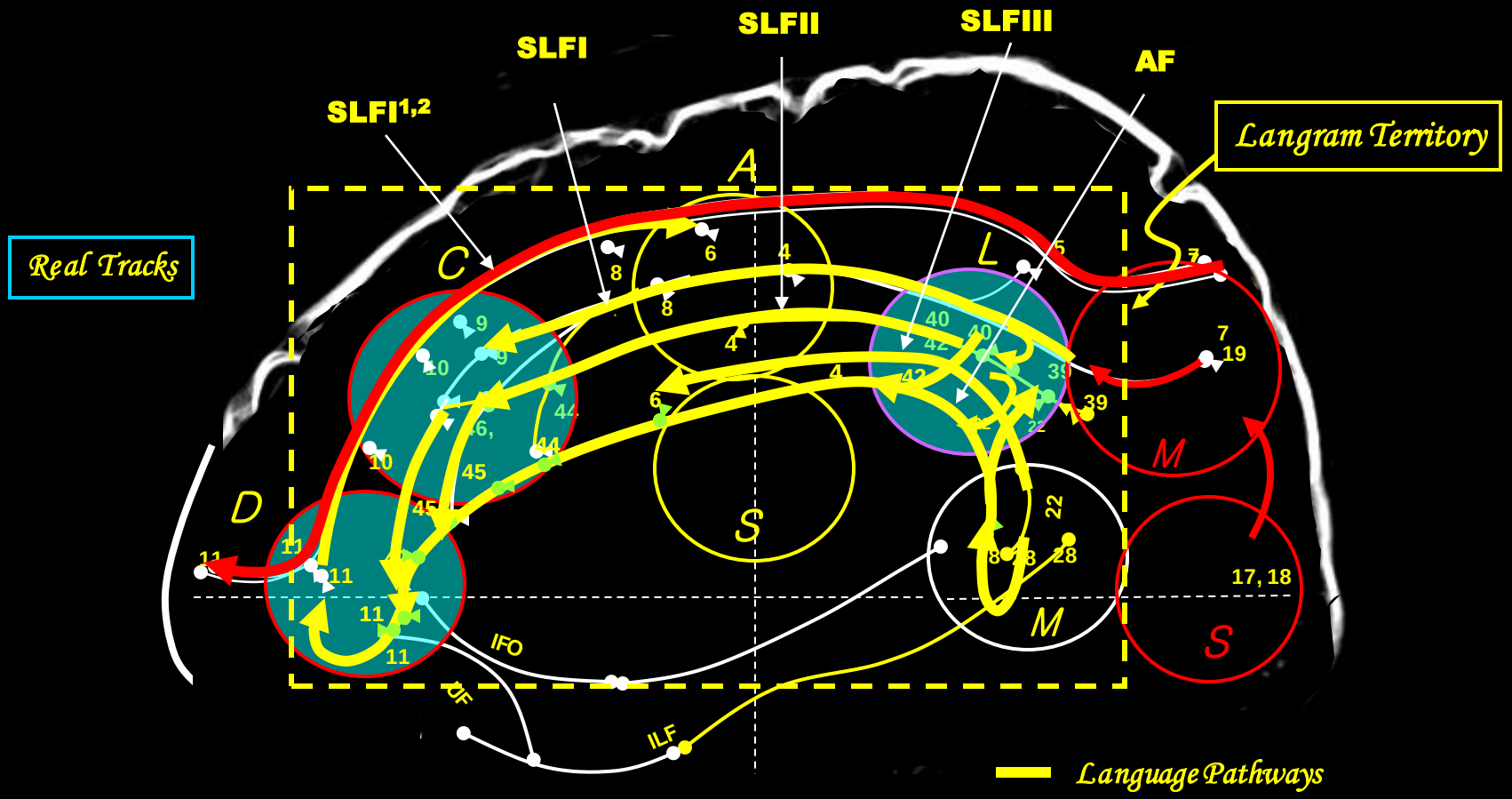
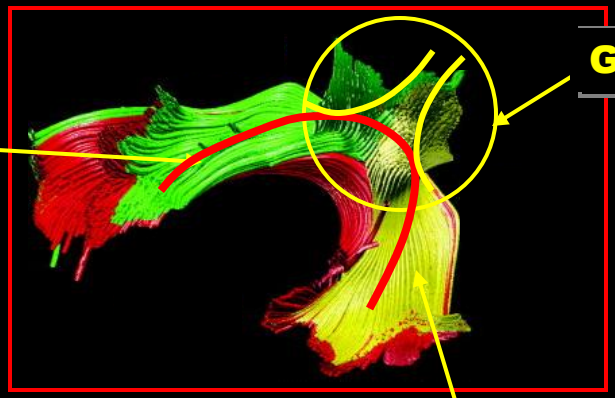


Fig. 3(b)

Catani's Ant. & Post. Segm. Hypothesis with Geschwind's Territory

Catani's AF & Geschwind's Territory

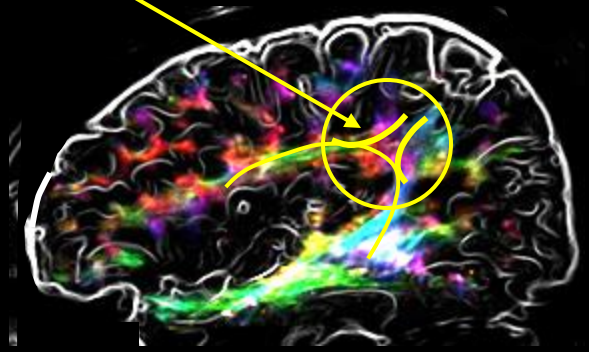


Geschwind's Territory

AF anterior segment

AF posterior segment

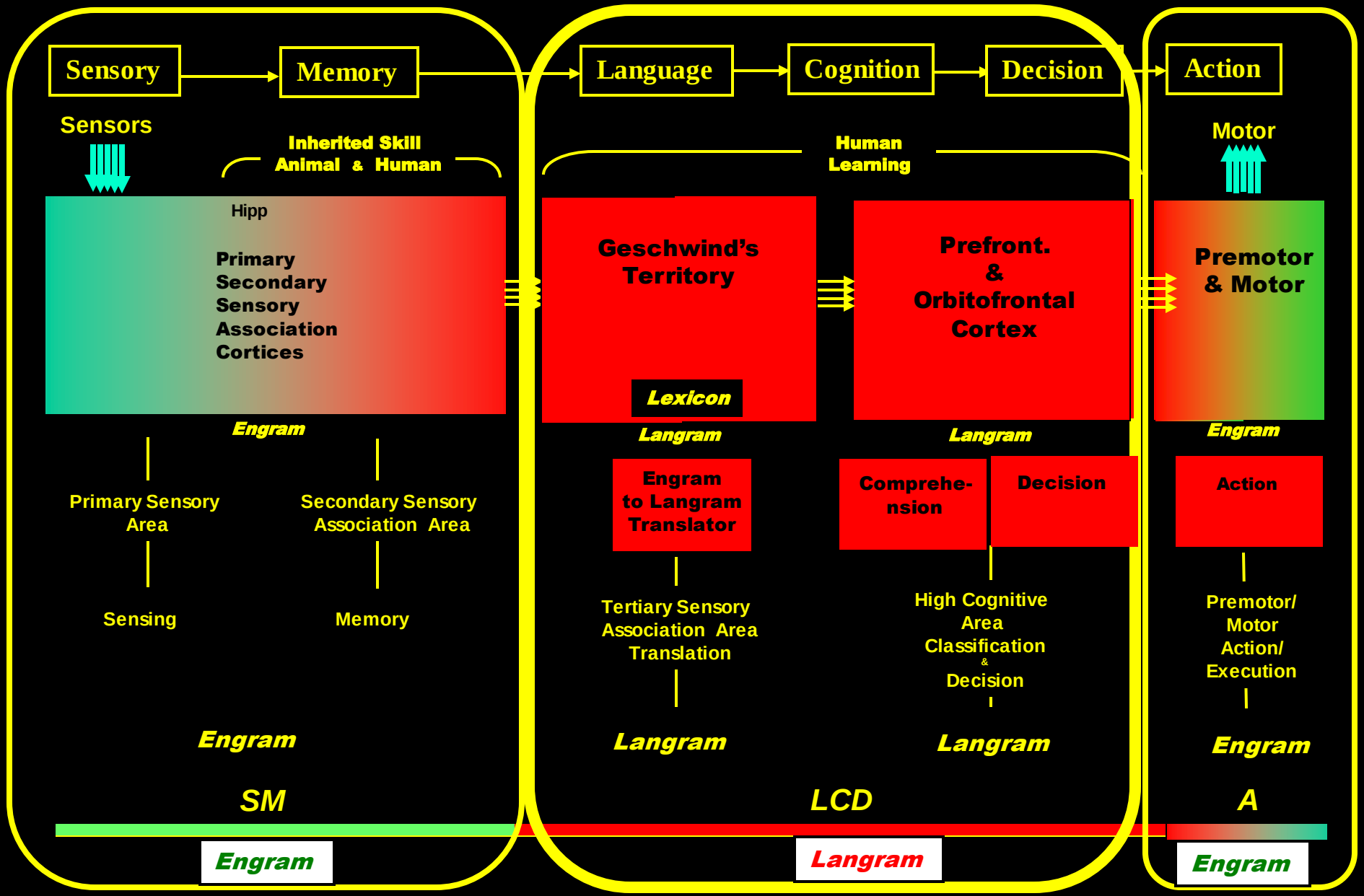
New Tractography !



TDI (- 44mm)

Engram - Langram - Geschwind's - Lexicon - Cognition - Ant.Post Segm. - SLFI, II, AF

Engram – Langram Hypothesis and Flow Diagram



Sensory, Memory, Language, Cognition, Decision, and Action

-

Engram - Langram Hypothesis and Its Pathway

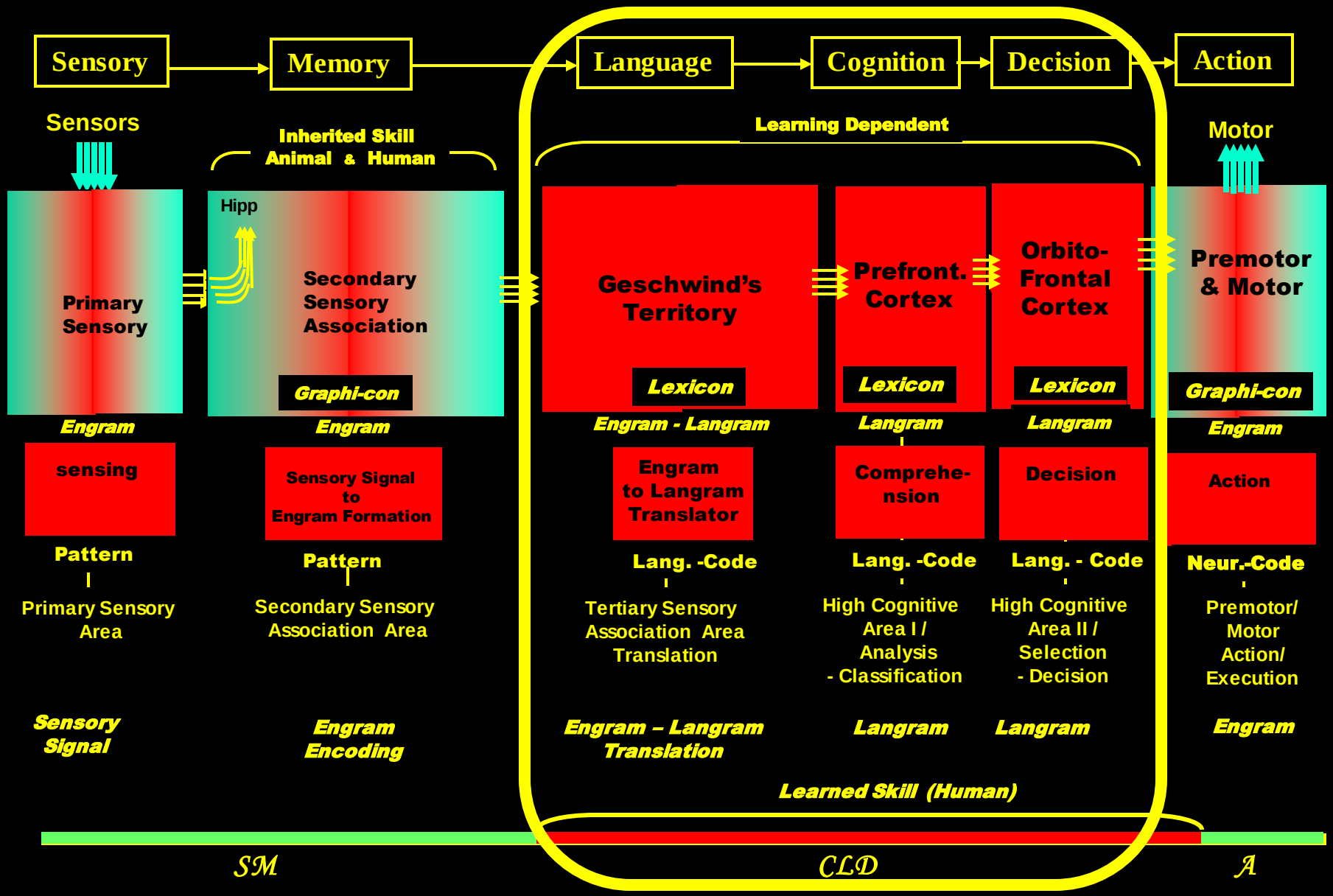
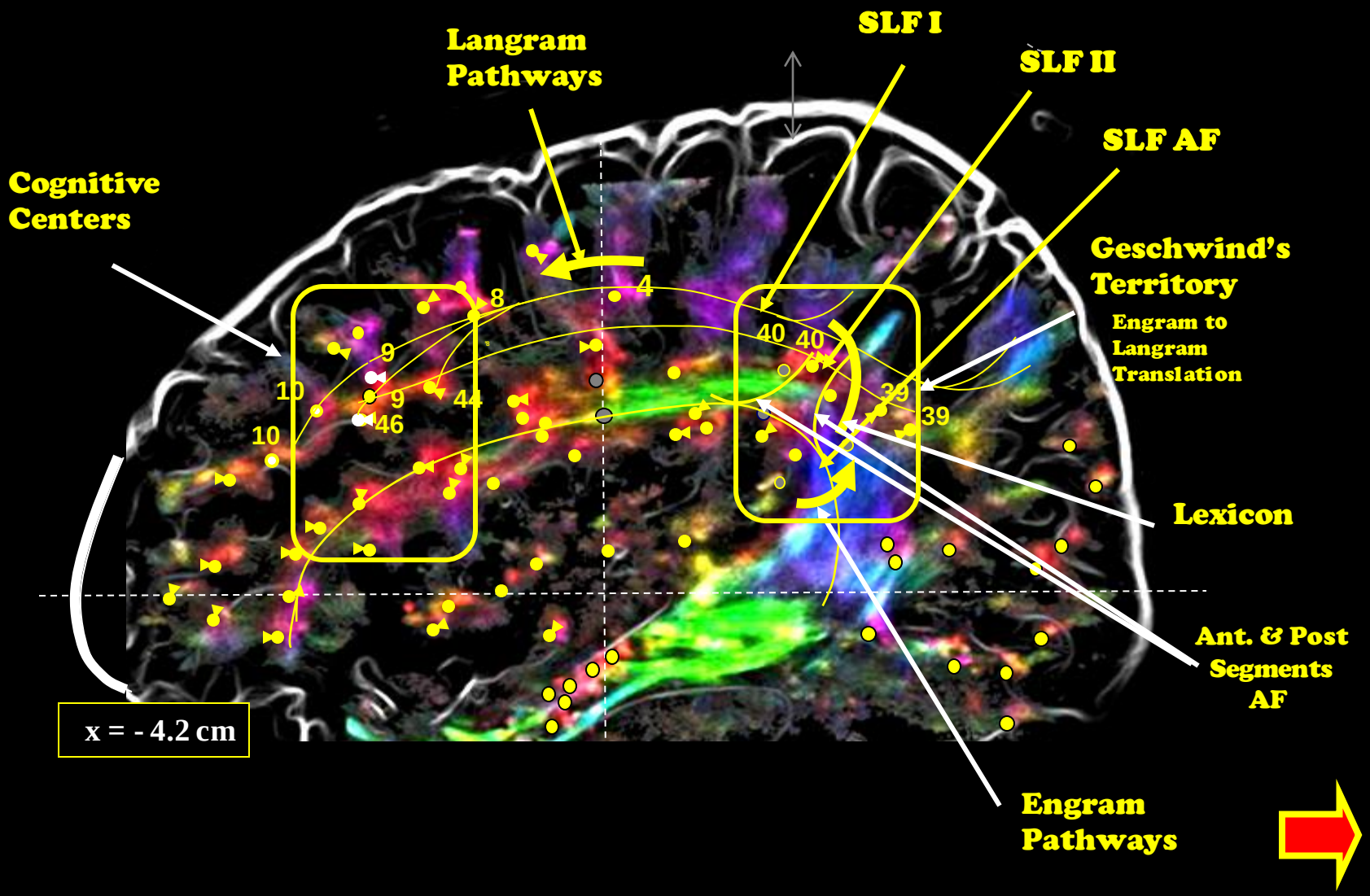


Fig. 5

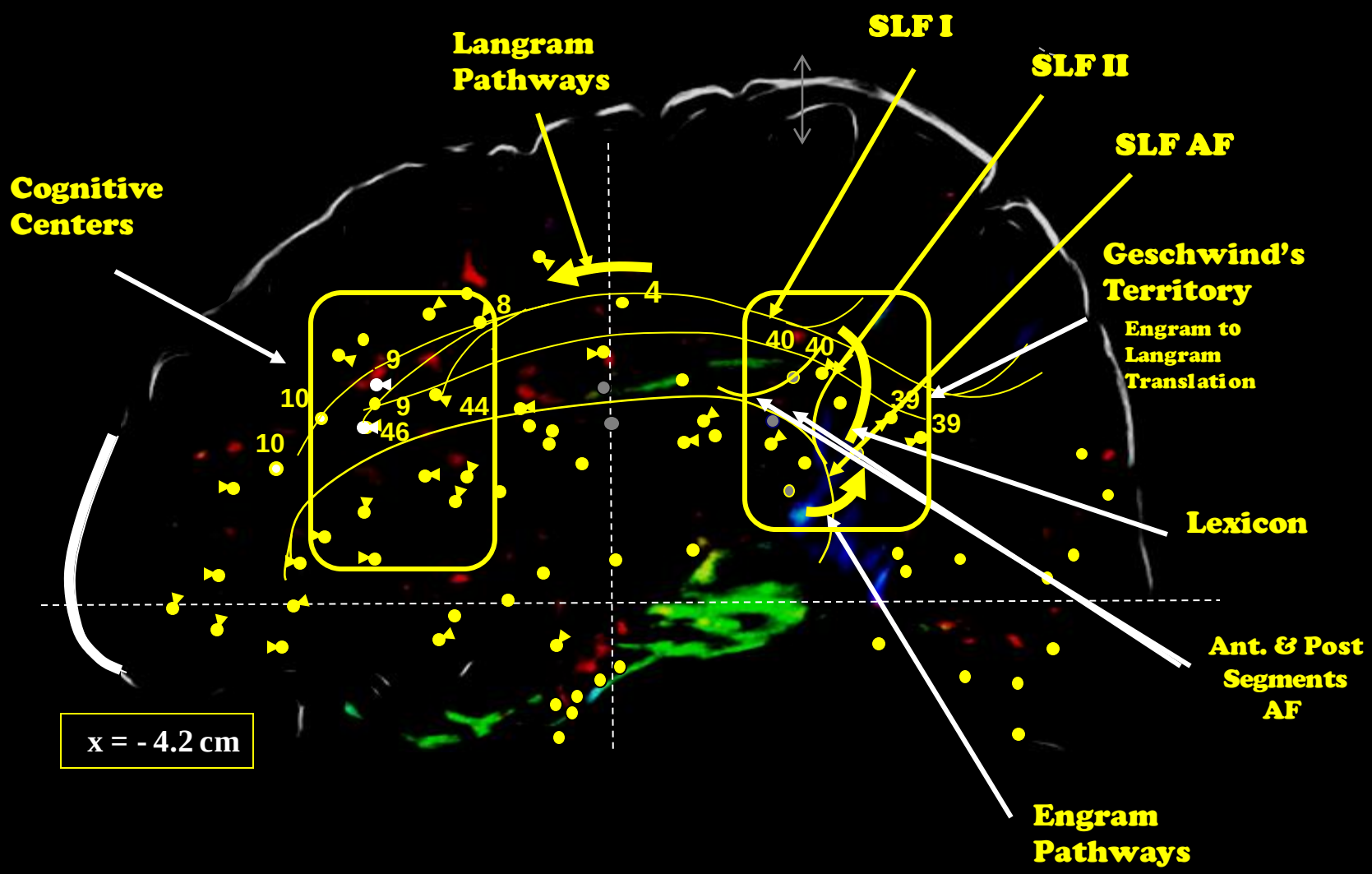
Langram – Engram and Connectivity

Engram - Langram - Geschwind's - Lexicon - Cognition - Ant.Post Segm. - SLFI, II, AF

Engram- Langram- Geschwind's- Lexicon- Cognition- Ant.Post Segm. - SLFI, II, AF



Engram - Langram - Geschwind's - Lexicon - Cognition - Ant.Post Segm. - SLFI, II, AF



Engram- Langram- Geschwind's- Lexicon- Cognition- Ant.Post Segm. - SLFI, II, AF — 1904, 2015

Engram- **Langram**- Geschwind's- Lexicon- Cognition- Ant.Post Segm. - SLFI, II, AF — 2016

Engram- Langram- **Geschwind's**- Lexicon- Cognition- Ant.Post Segm. - SLFI, II, AF — 1965, 2005

2000 — Engram- Langram- Geschwind's- **Lexicon**- Cognition- Ant.Post Segm. - SLFI, II, AF

1900 — Engram- Langram- Geschwind's- Lexicon- **Cognition**- Ant.Post Segm. - SLFI, II, AF

2005 — Engram- Langram- Geschwind's- Lexicon- Cognition- **Ant.Post Segm**. - SLFI, II, AF

2005, 2015 — Engram- Langram- Geschwind's- Lexicon- Cognition- Ant.Post Segm. - **SLFI, II, AF**

Semon R., Die mneme. Leipzig: Wilhelm Engelmann; 1904

Tonegawa S, M. Pignatelli, et al . Memory engram storage and retrieval. Current Opinion in Neurobiology, 35:101-109, 2015

Geschwind N. Disconnexion syndromes in animals and man. I. Brain 88:237-294, 1965a.

Catani M, Ffytche DH. The rises and falls of disconnection syndromes, Brain, 2005, 128:2224-39

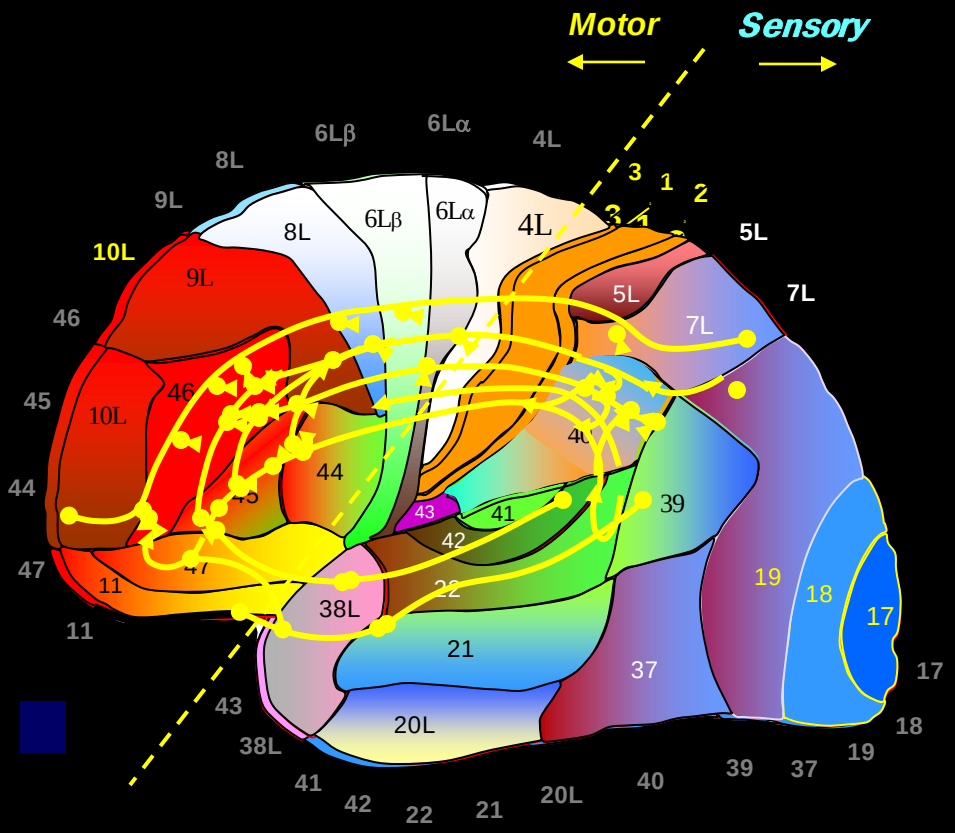
Catani M, Ffytche DH. The rises and falls of disconnection syndromes, Brain, 2005, 128:2224-39

Makris N, et al. Segmentation of subcomponents with in the superior longitudinal fascicle in humans: a quantitative in-vivo DT- MRI Study. Cereb. Cortex 15(6):854-869, 2005.

Cho Z. H et al. (Edit.) 7.0 T MRI Brain White Matter Atlas. Springer, 2015

On to the Color Coded Map

Multi-Color Coding based on the Proximity Rule & Geschwind's Territory



Lateral view

Fig. 9

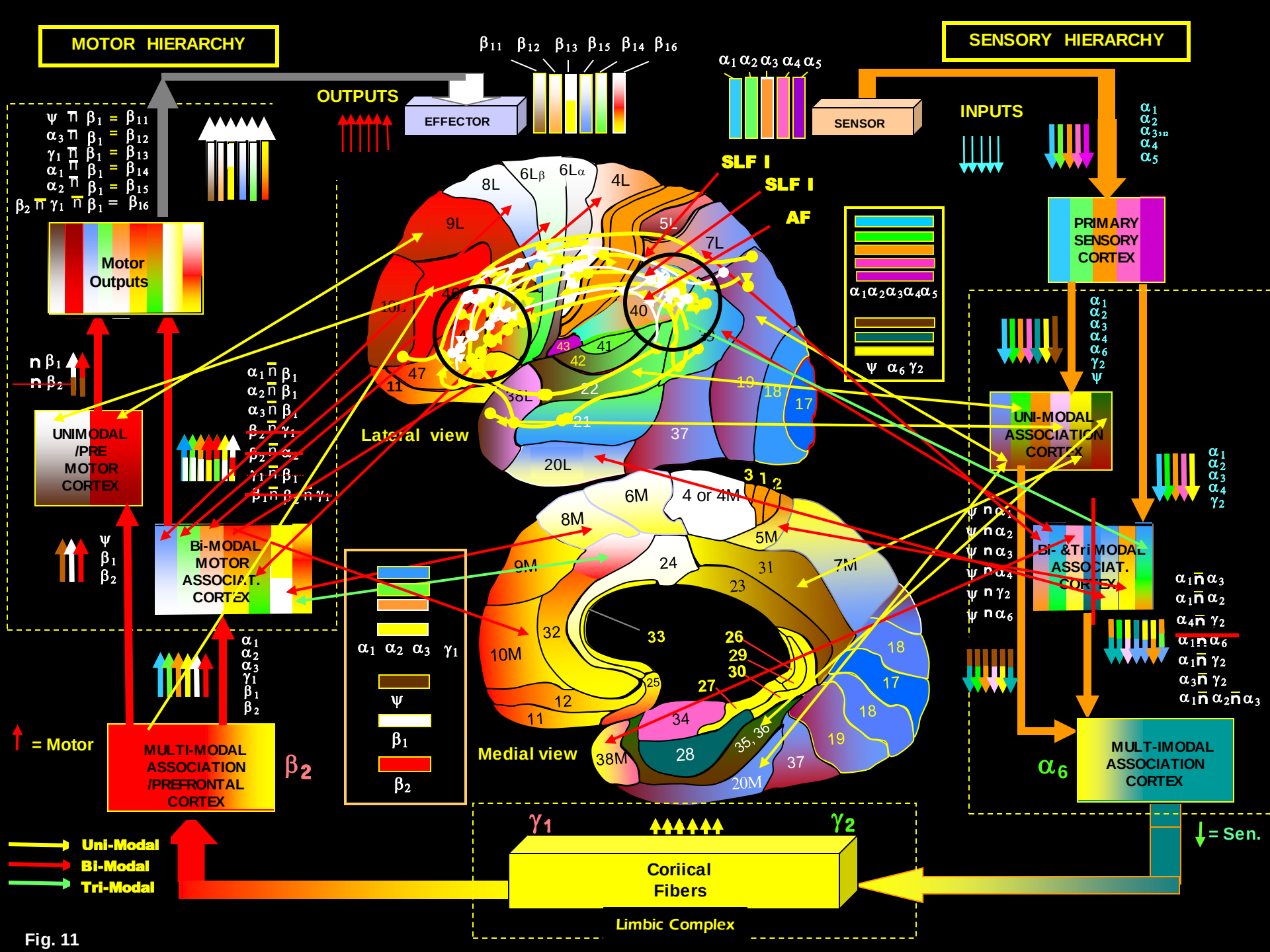

MOTOR HIERARCHY
SENSORY HIERARCHY
OUTPUTS
EFFECTOR
SENSOR
INPUTS
PRIMARY SENSORY CORTEX
Motor Outputs
UNIMODAL /PRE MOTOR CORTEX
Bi-MODAL MOTOR ASSOCIAT. CORTEX
UNI-MODAL ASSOCIATION CORTEX
Bi- &Tri MODAL ASSOCIAT. CORTEX
MULTI-MODAL ASSOCIATION /PREFRONTAL CORTEX
MULT-IMODAL ASSOCIATION CORTEX
SLF I
SLF I
AF
Lateral view
Medial view
= Motor
= Sen.
Uni-Modal
Bi-Modal
Tri-Modal
Coriical Fibers
Limbic Complex

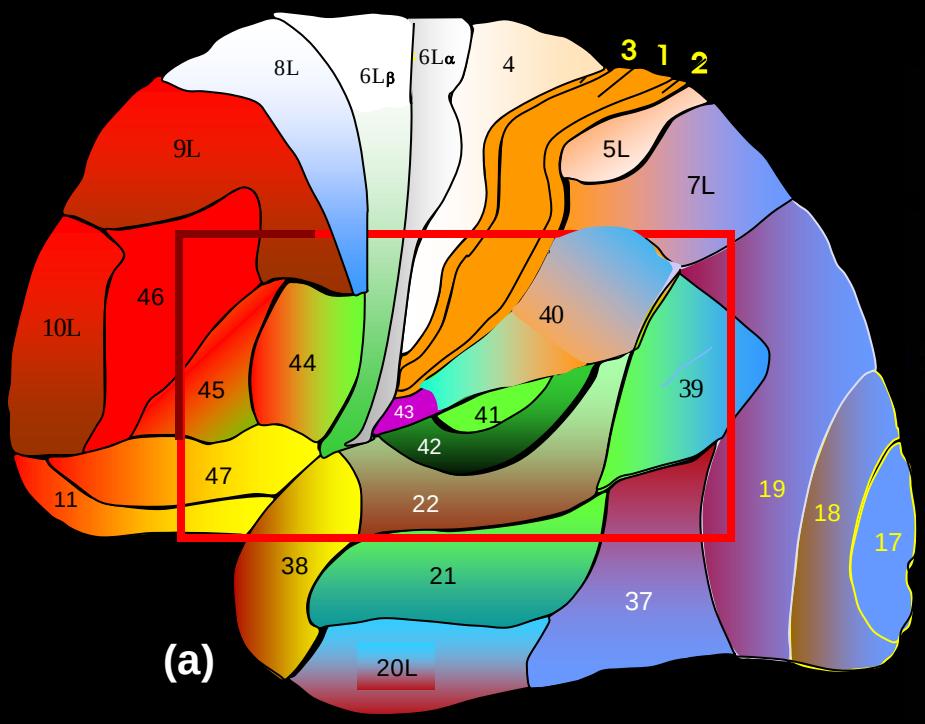
Fig. 11

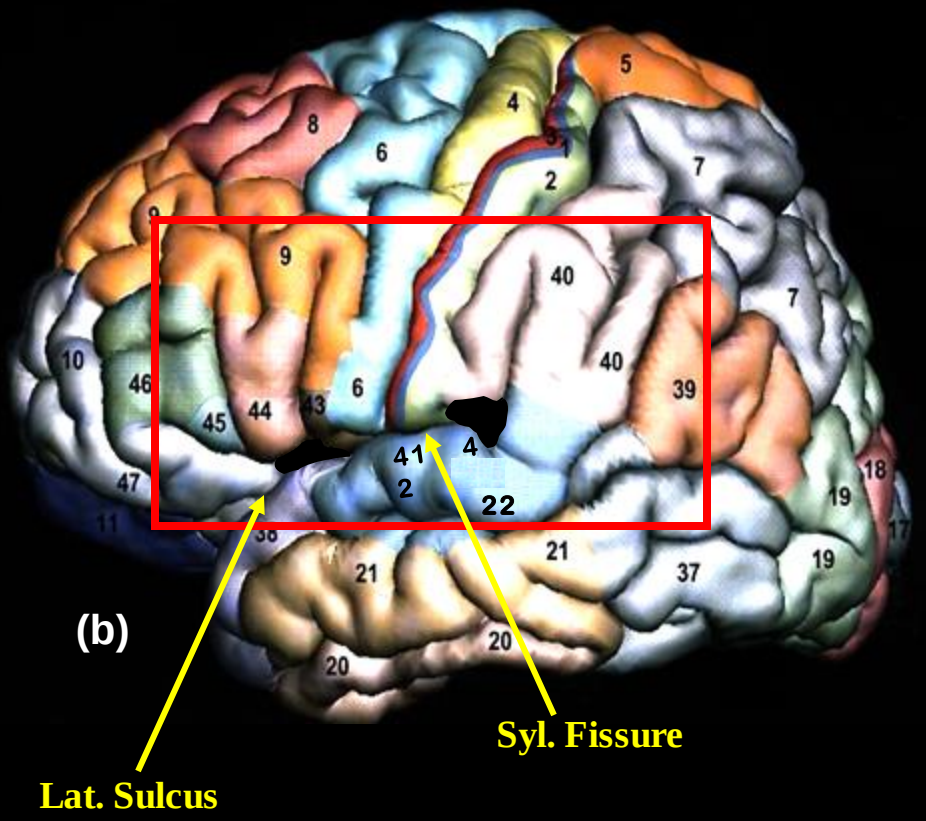
Back to Real World ！

Back to Real World !

The Language Area

Perisylvian Cortex





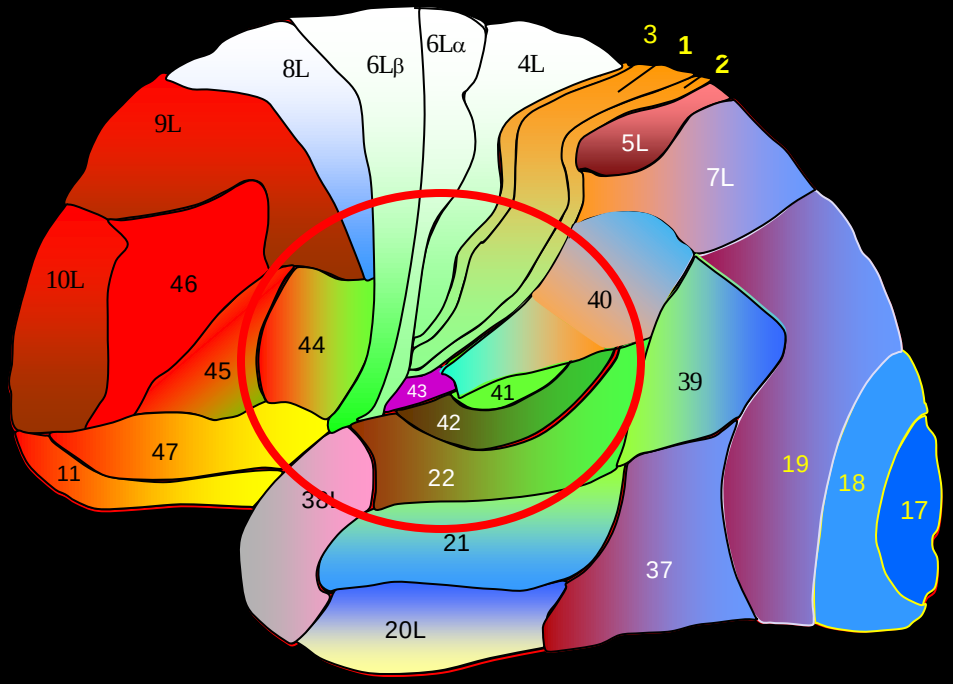
Function Specific
Dual & Triple Color Coding

Non-Function Specific
Single Color Coding

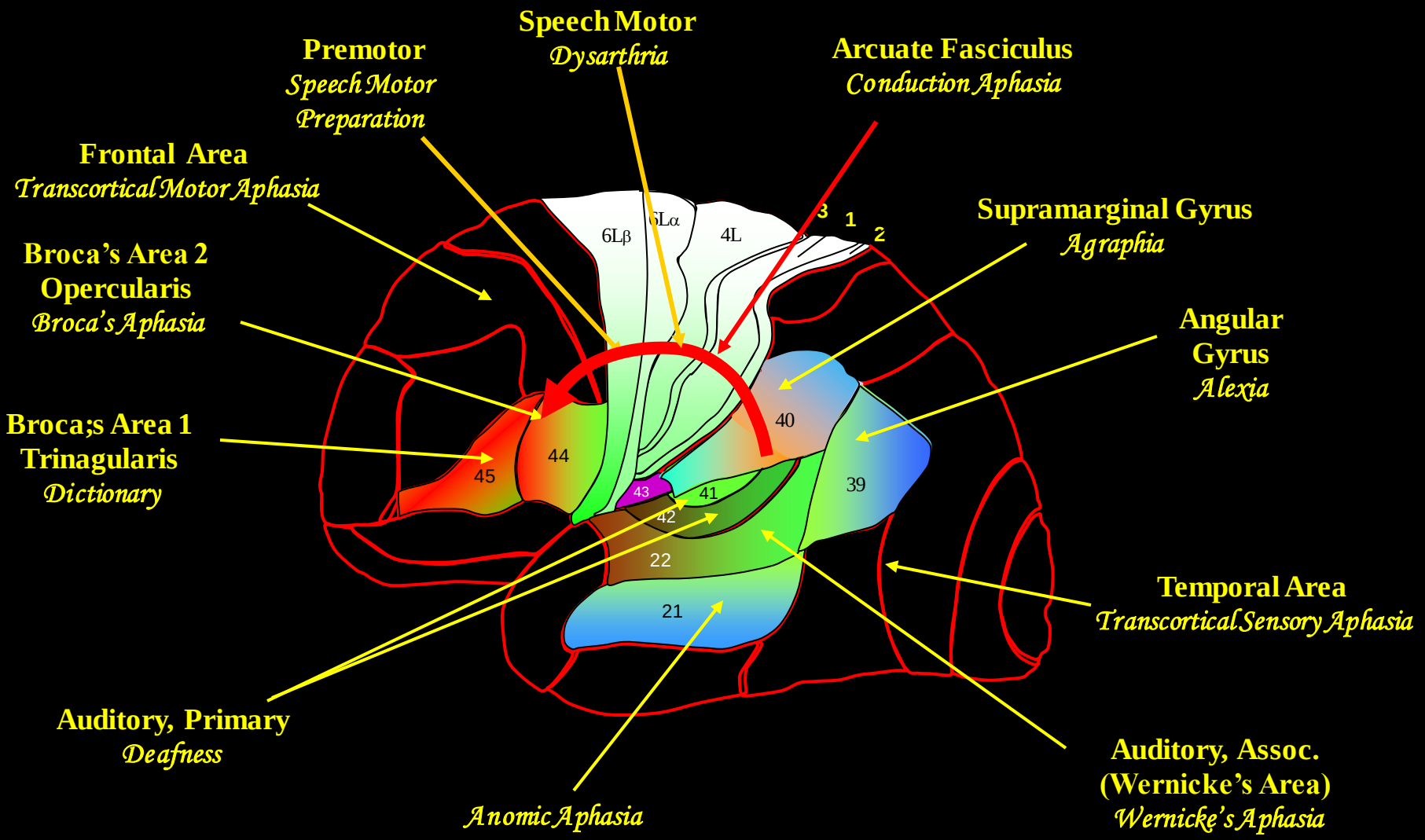
Fig. 32

The Language Area

Proximity Mapping



The Language Area



Application 6. - 4

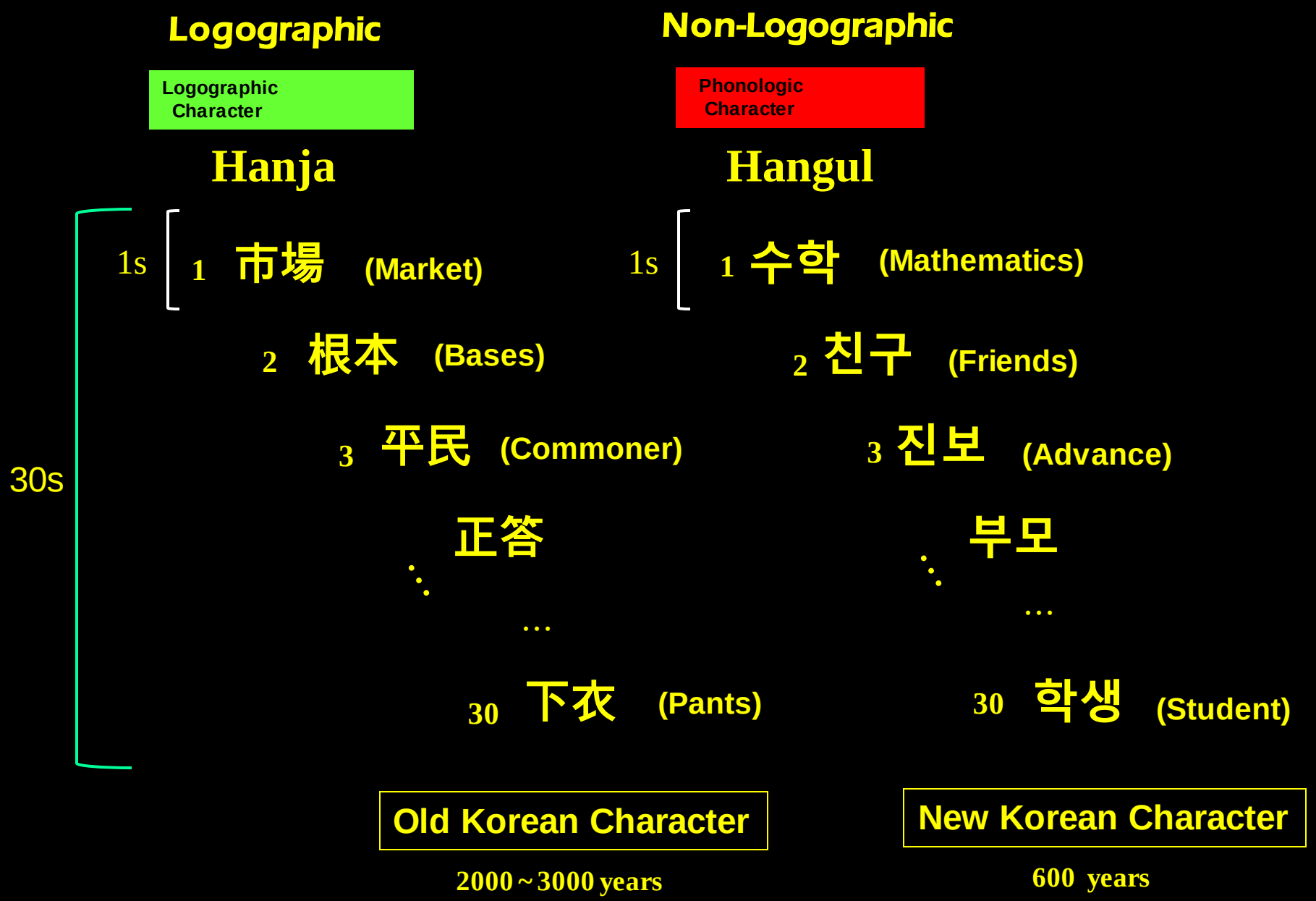
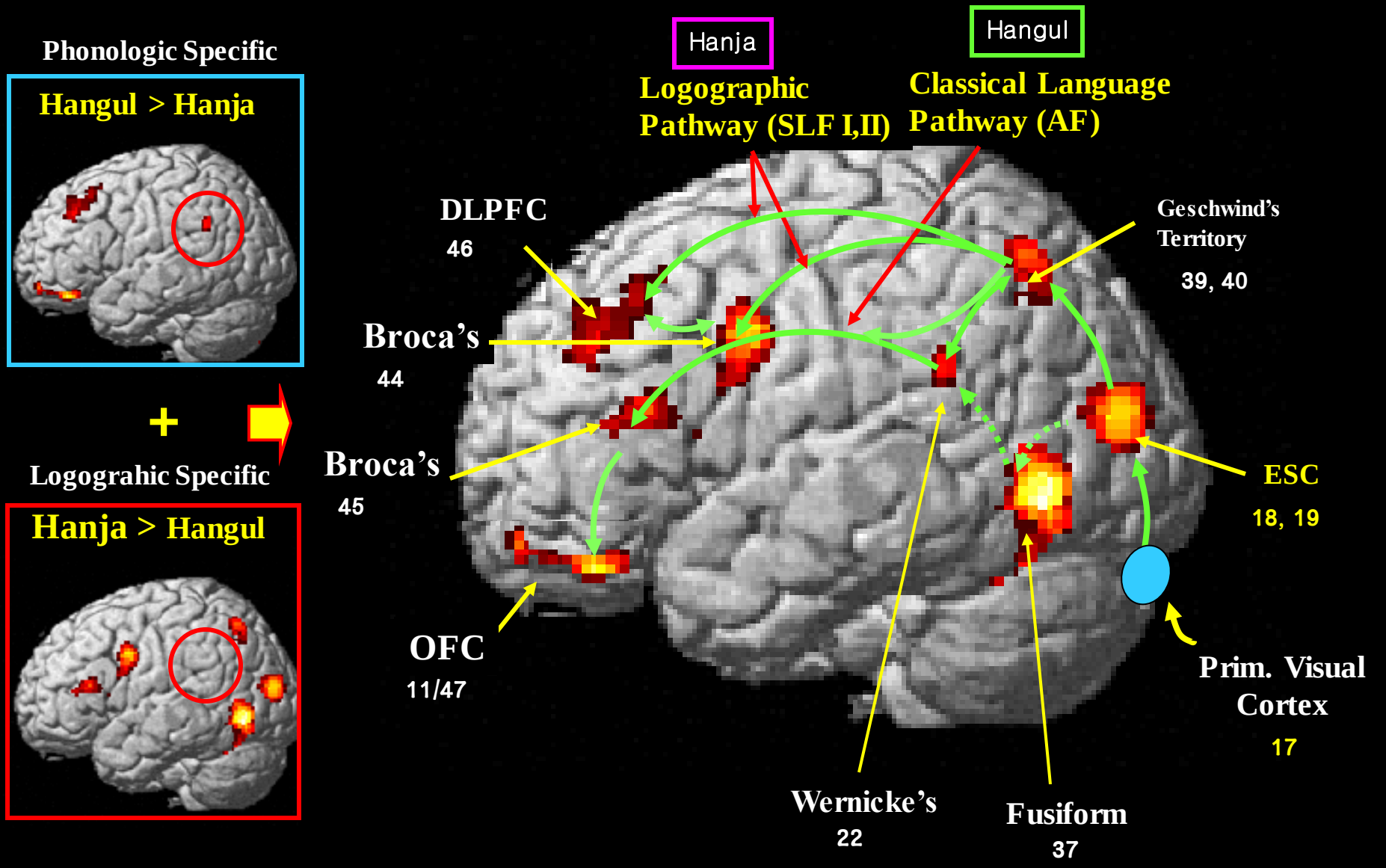


Fig. 41

Application 5. - 5

Experimentally observed New Language Pathways



AF : Arcuate Fasciculus
SFO : Superior Fronto-Occipital Fasciculus
HC : Hippocampus
IFO : Inferior Fronto-Occipital Fasciculus
ESC : Extrastriate Cortex
FFA : Fusi Form Area

Fig. 34

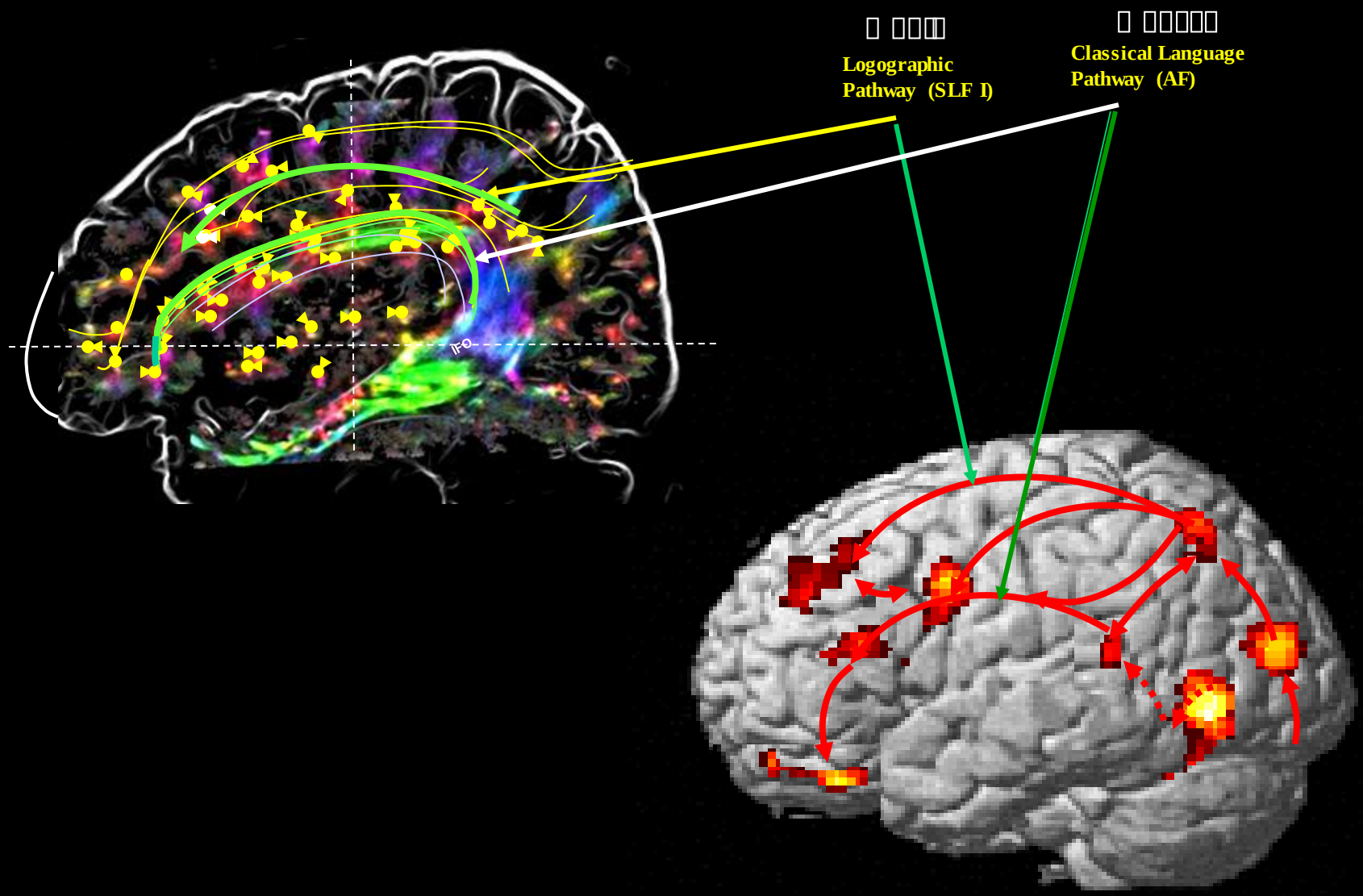
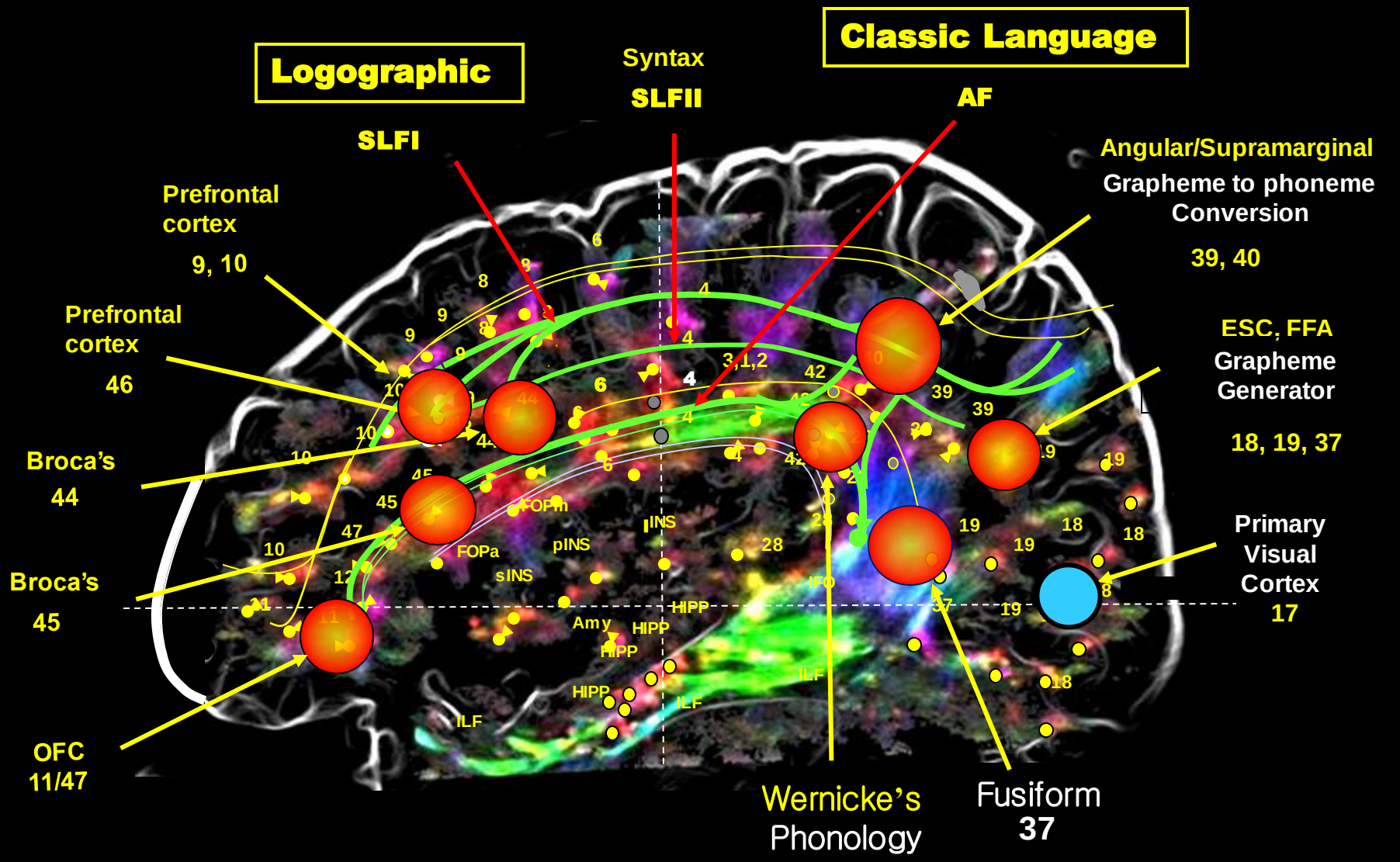


Fig. 34

Application 6. - 6

Revisit the Tractogram :



Legends : SLF I, II, III : Superior Longitudinal Fasciculus. SLF I ^{1,2} : Supra SLF I, 1, 2.

AF ^{1,2,3,4} : Sub – AF 1, 2, 3, 4. AF : Arcuate Fasciculus. ——— Replicated with scaling

Fig. 43

Application 5. - 7

New Language Pathways

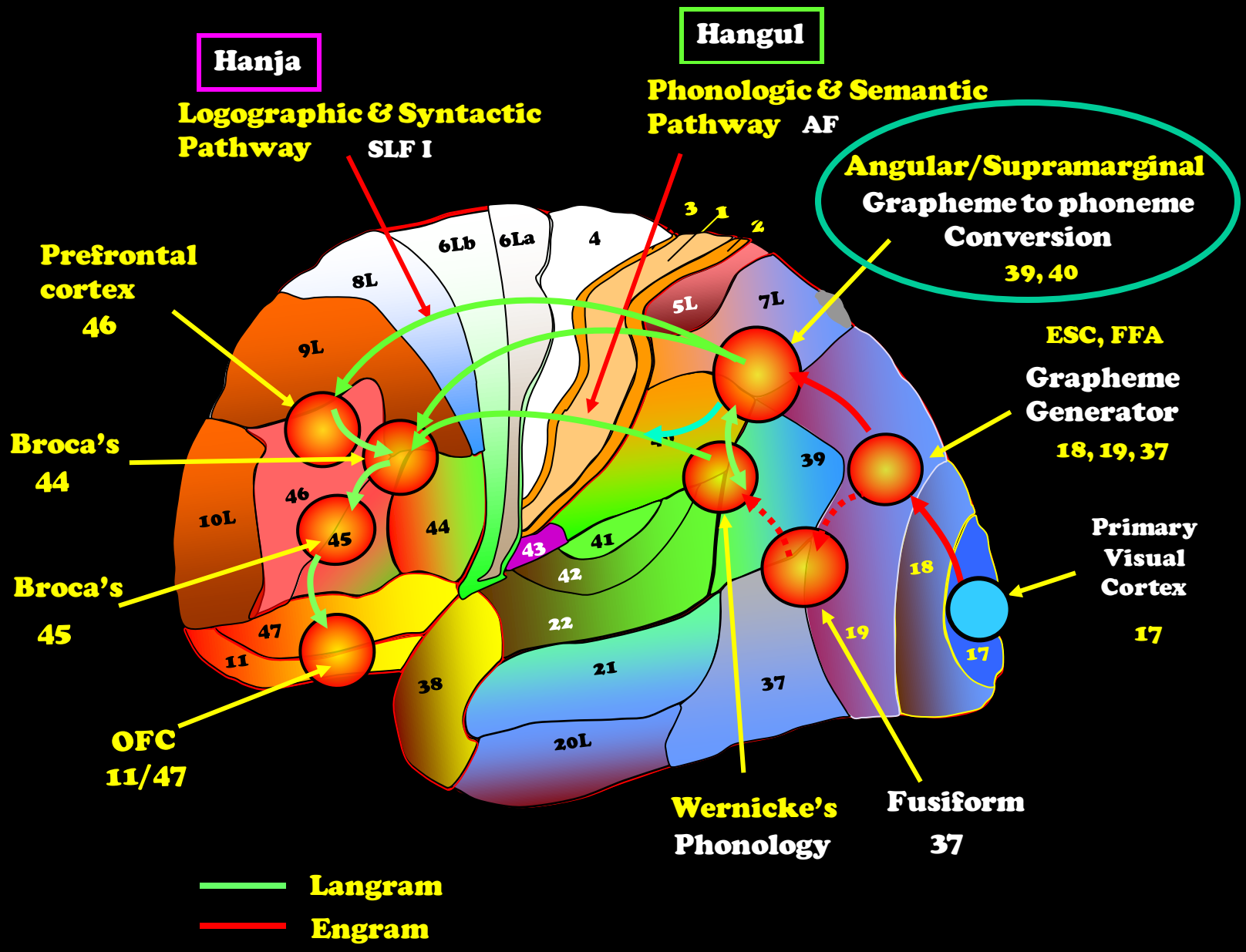


Fig. 35

Language & the Beyond

Language & the Beyond

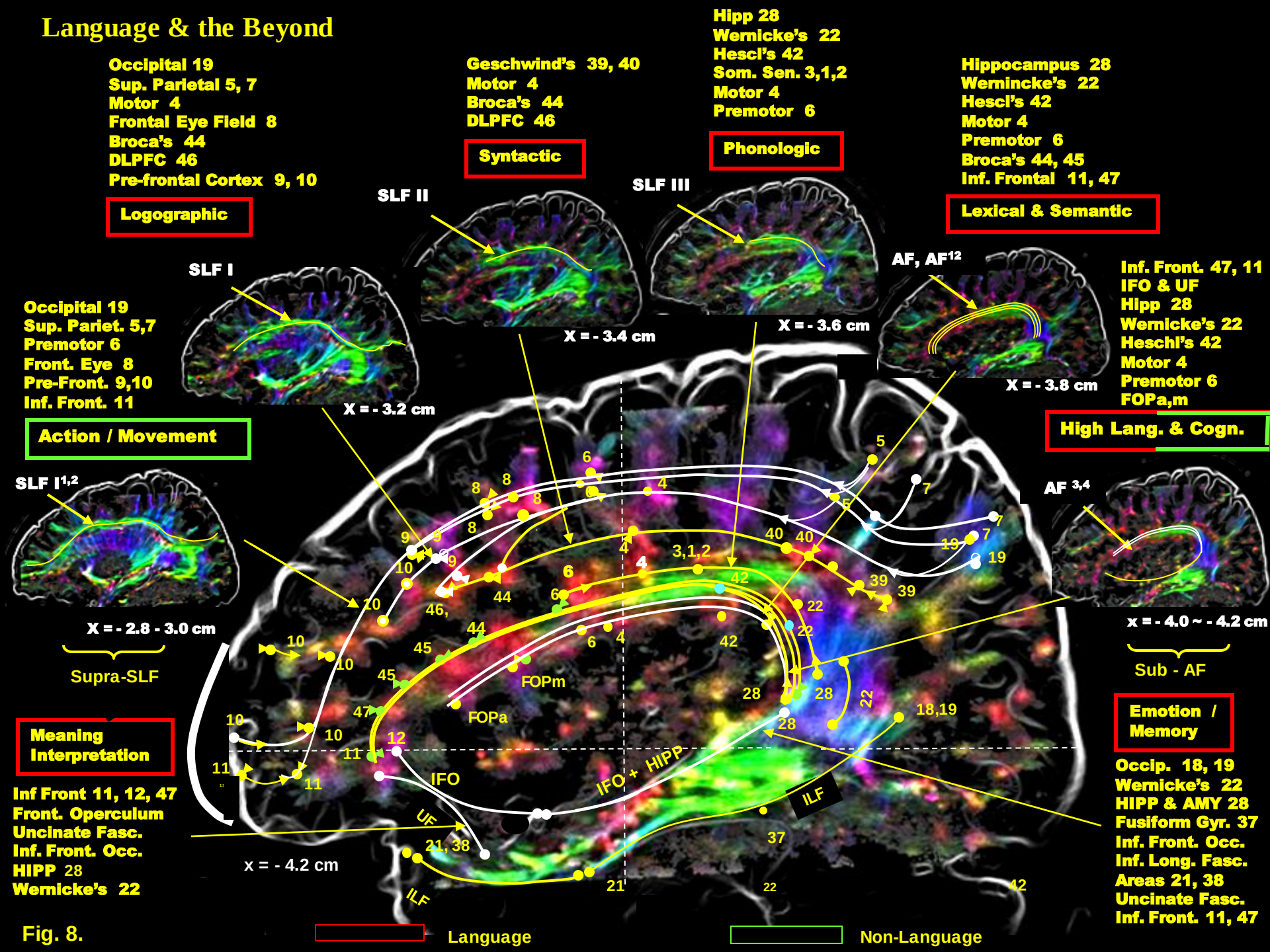


Fig. 8.

Language

Non-Language

What's Next ?

A True

Functional – Connectivity Map

I. Structural **Anatomy**

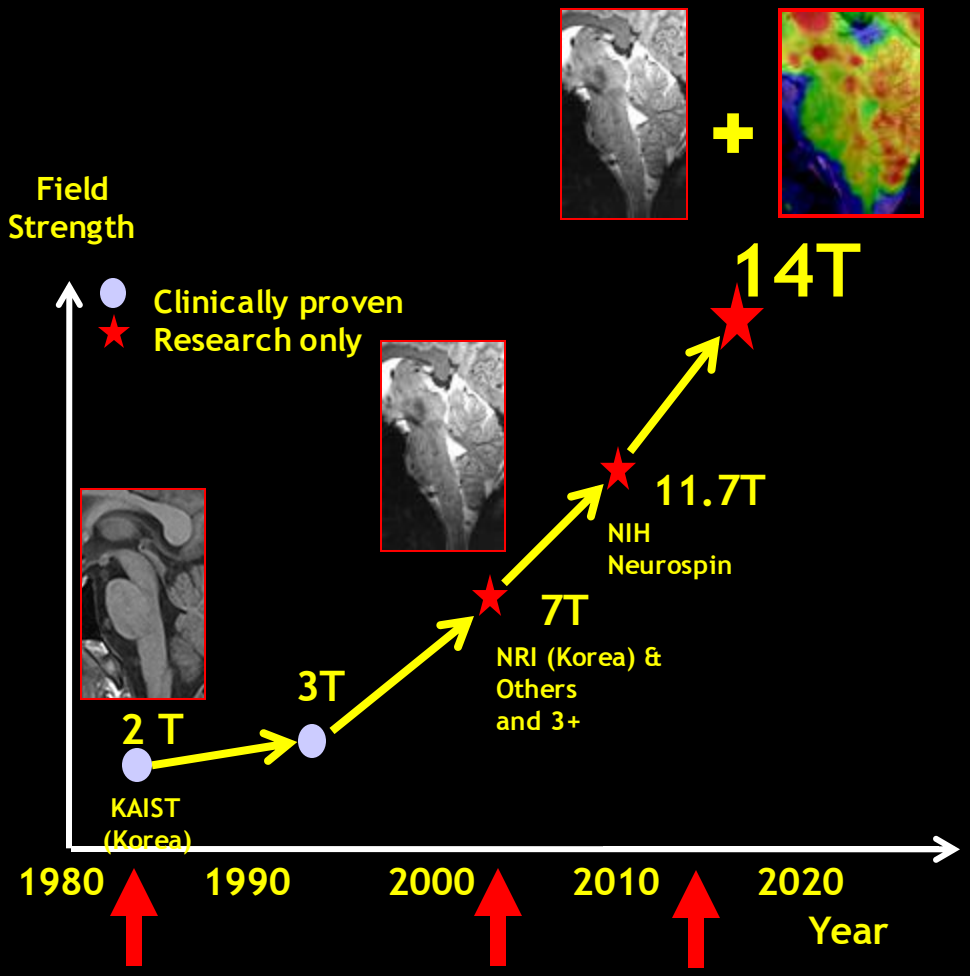
II. Functional **Anatomy**

III. Connectional **Anatomy**

Summary

Next Generation Super Resolution In-vivo Human Brain Imaging

DECA Tesla Era + New Gen. PET

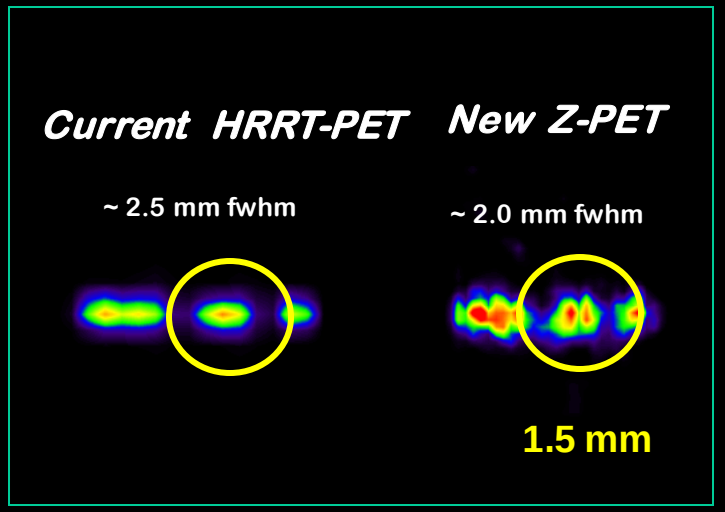


7.0T Superconducting Magnet Arrived in NRI on Aug. 9, 2005

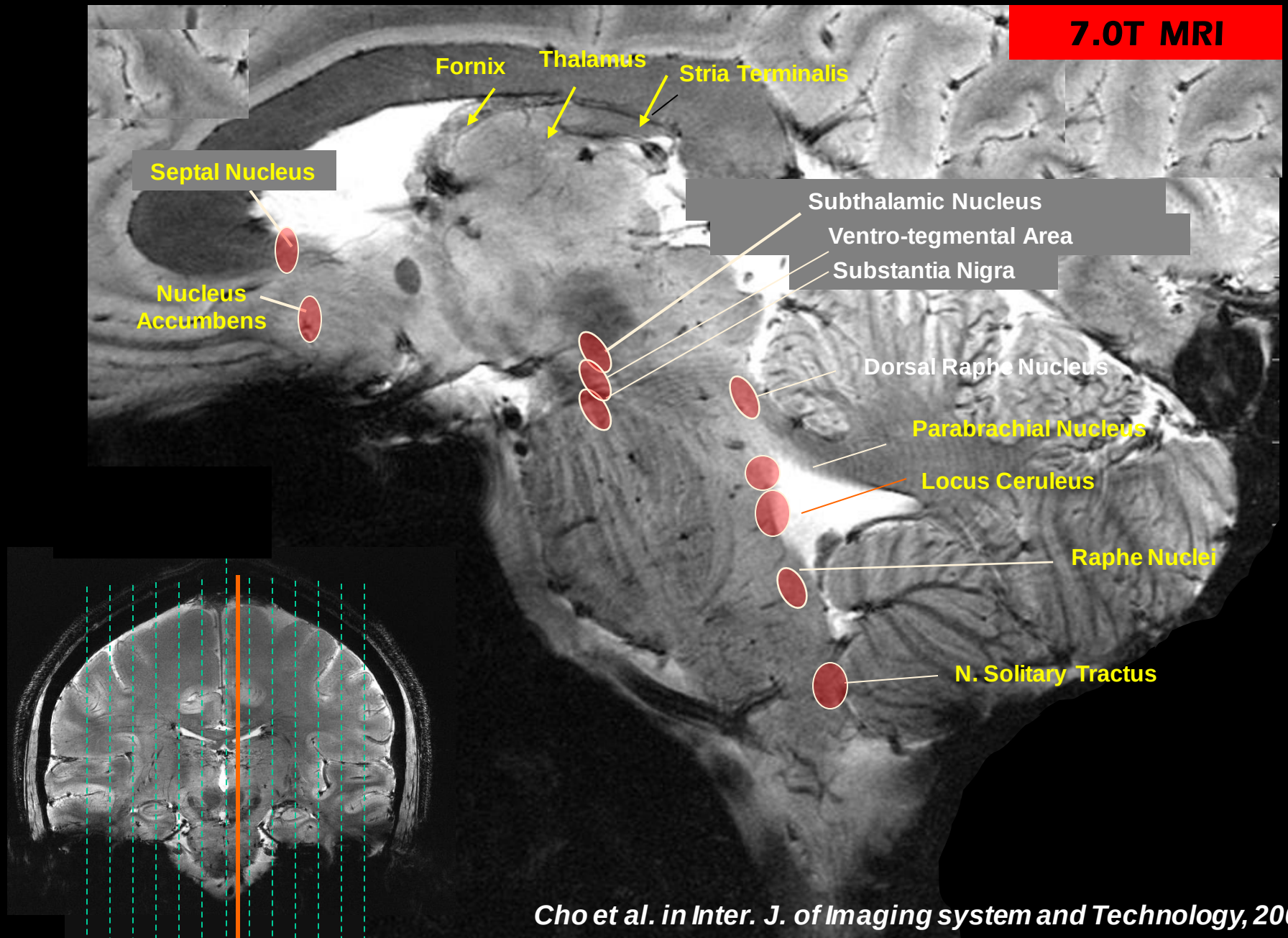
Next Generation Super Resolution In-vivo Human Brain Imaging

DECA Tesla Era + New Gen. PET

2015



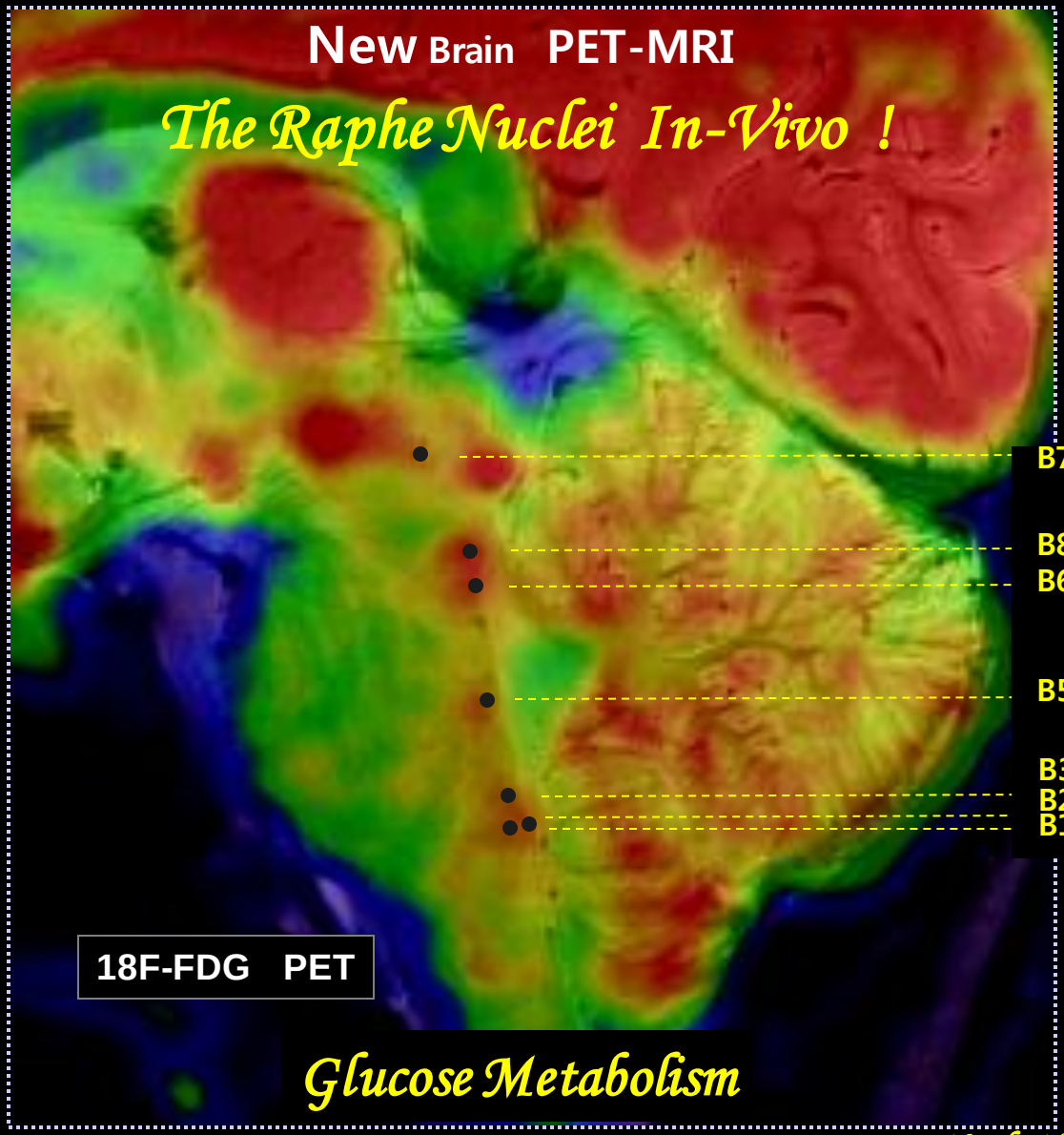
Brainstem



Cho et al. in Inter. J. of Imaging system and Technology, 2008

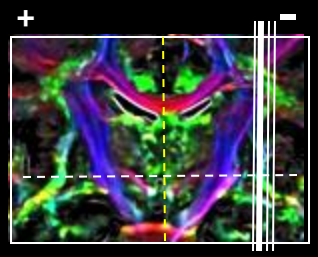
PET-MRI Molecular Fusion Imaging

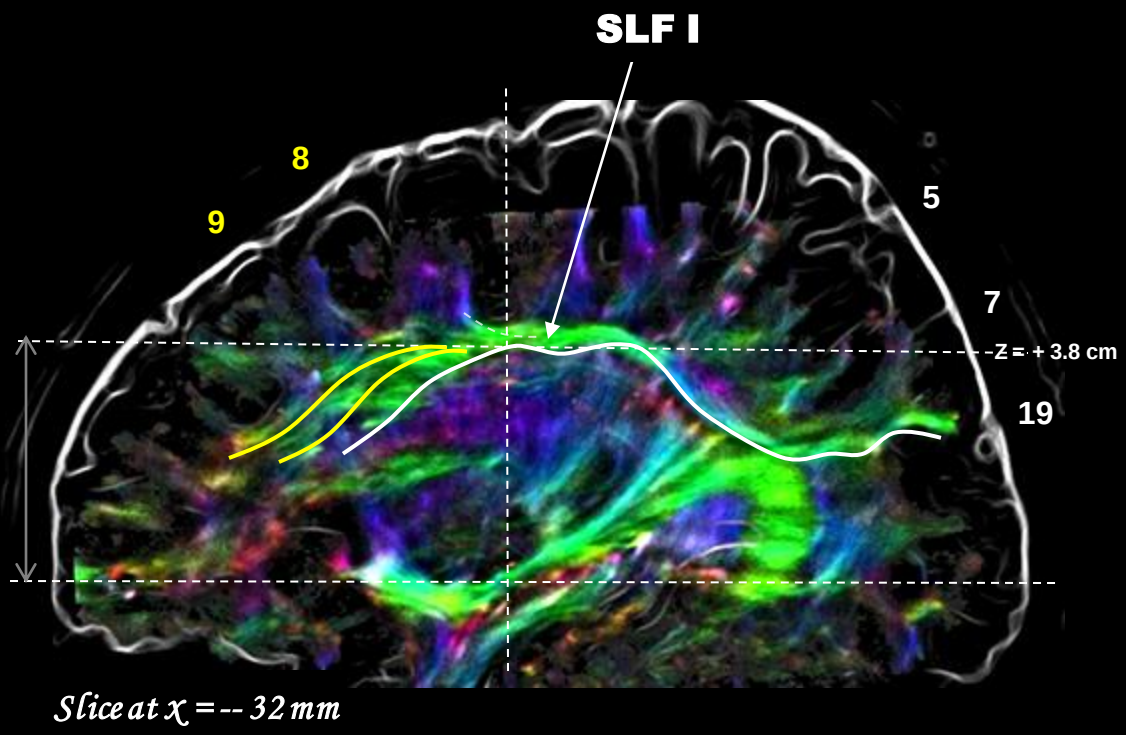
Metabolic Function in In-vivo Human Brainstem



J. Nucl. Med. 52(3):401-404, 2011

SLF I





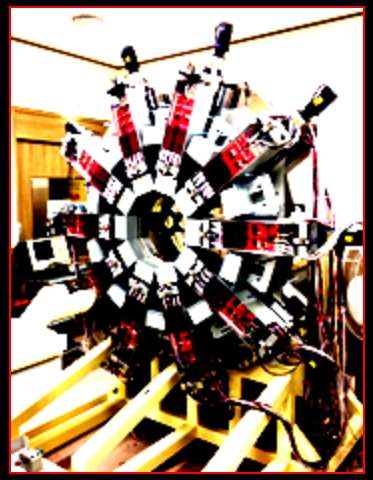
Enlarged tracks of SLF I

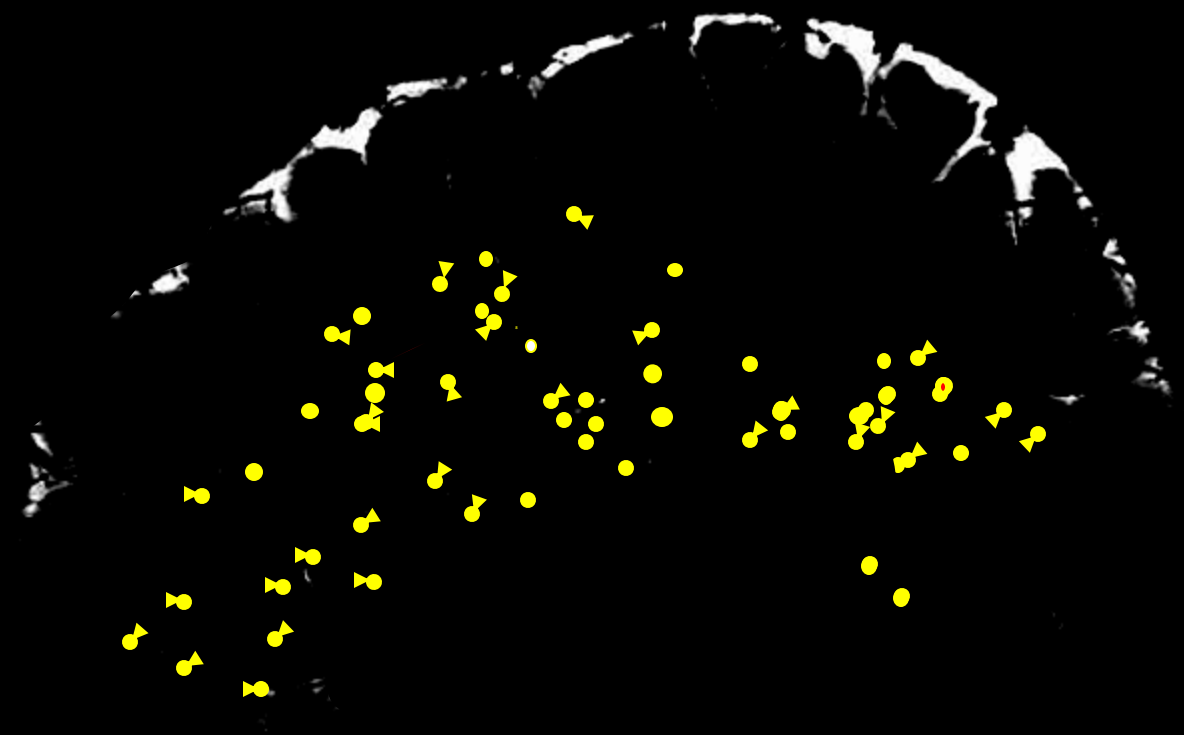
I. Structural Anatomy

Resolution 200 μm

Zoom-PET Functional Imaging Data

II. Functional Anatomy

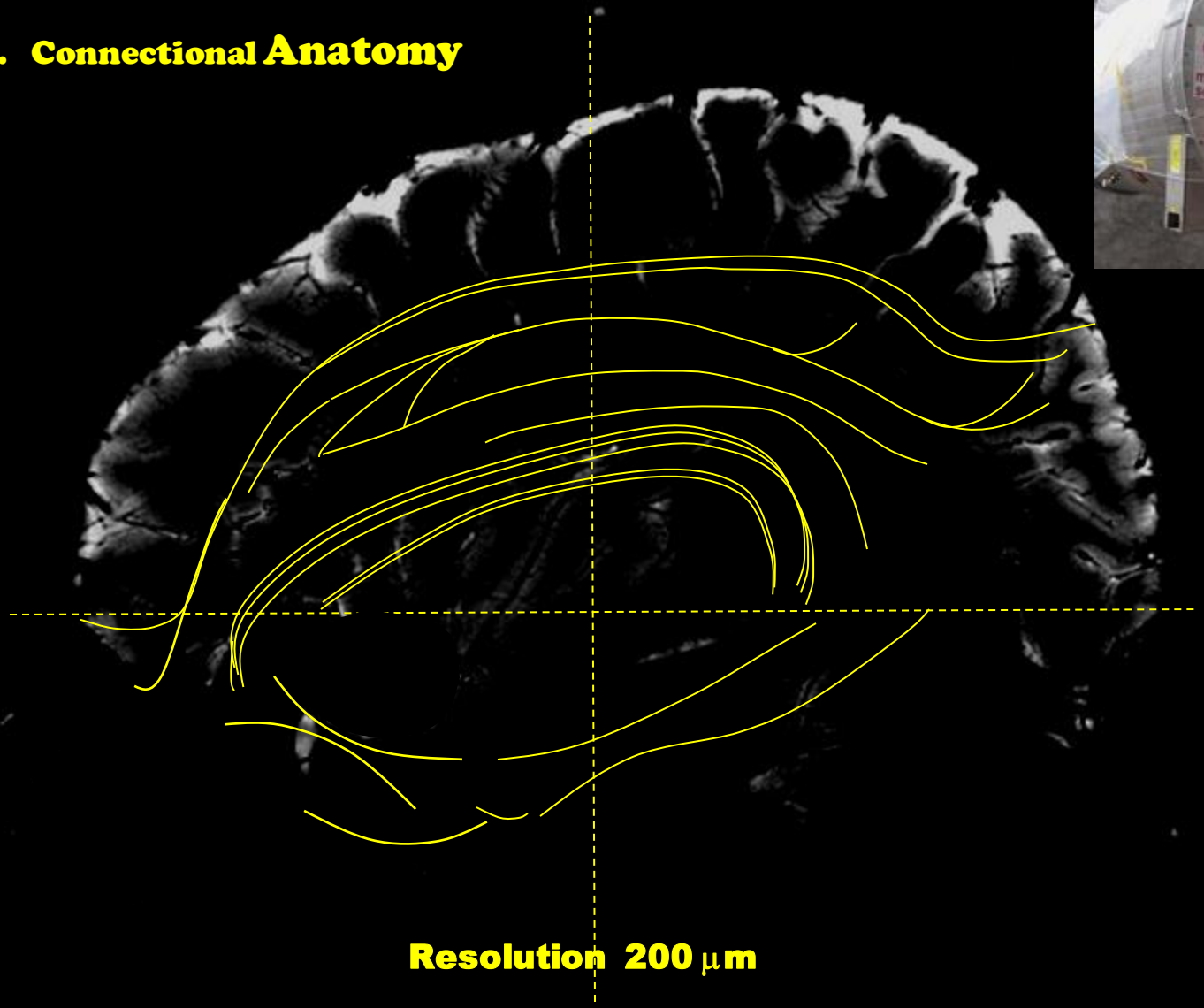




Resolution 1,5 mm

7T Super-Resolution MR Tractography

III. Connectional Anatomy

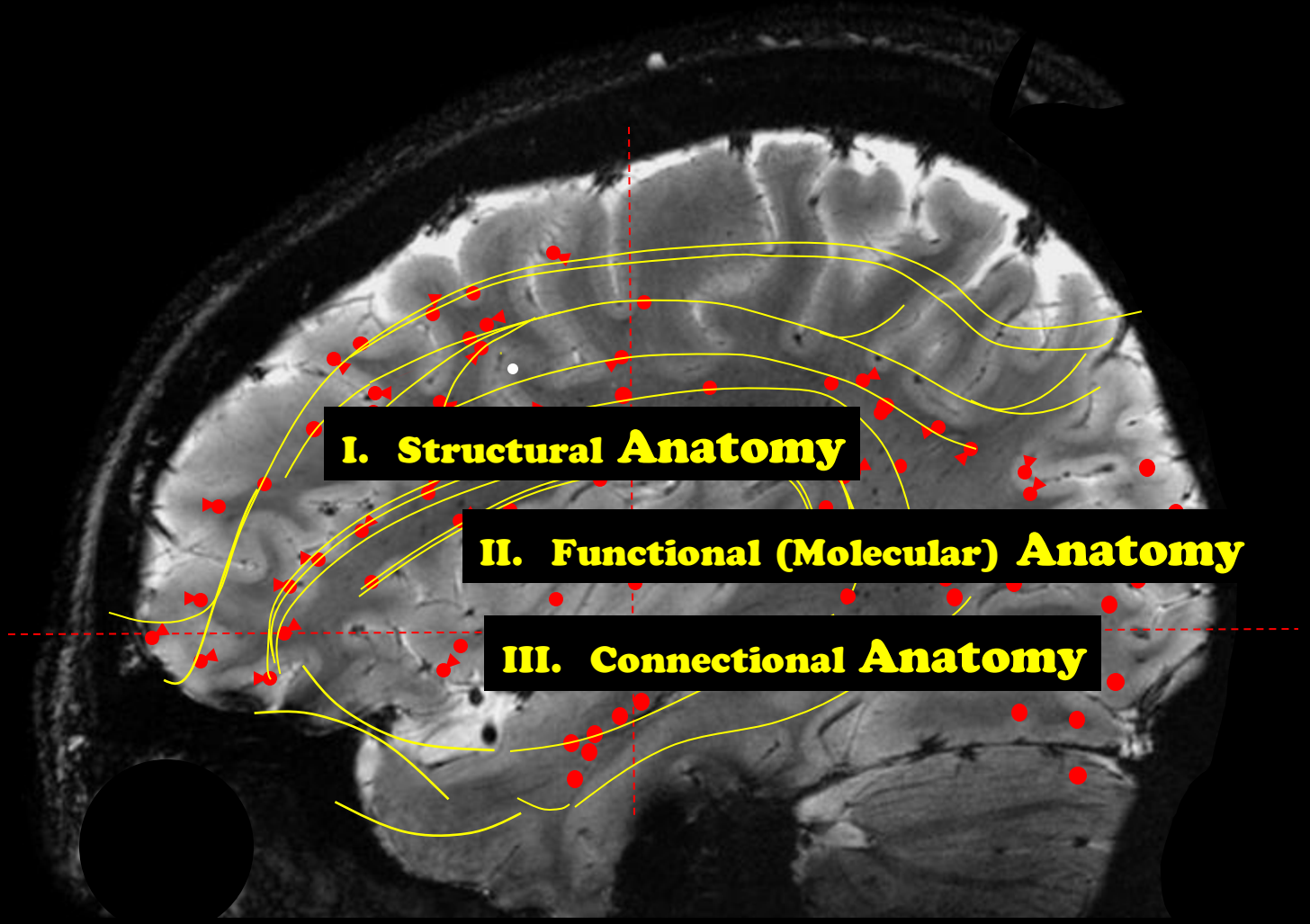


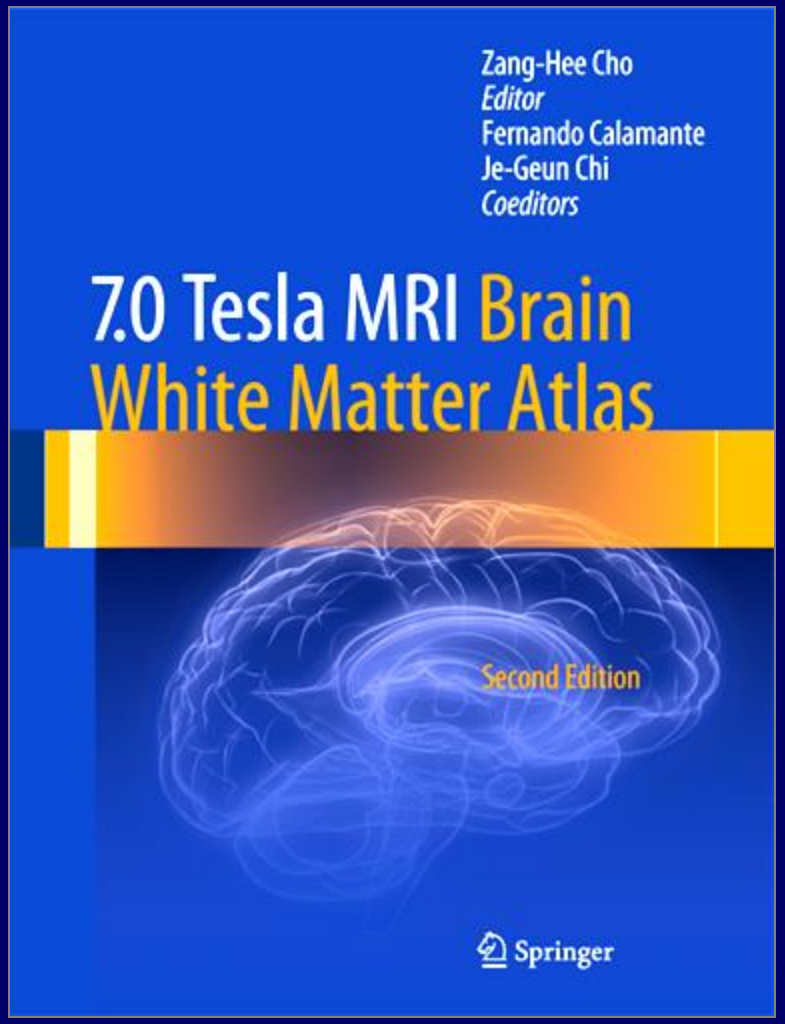
Resolution 200 μm

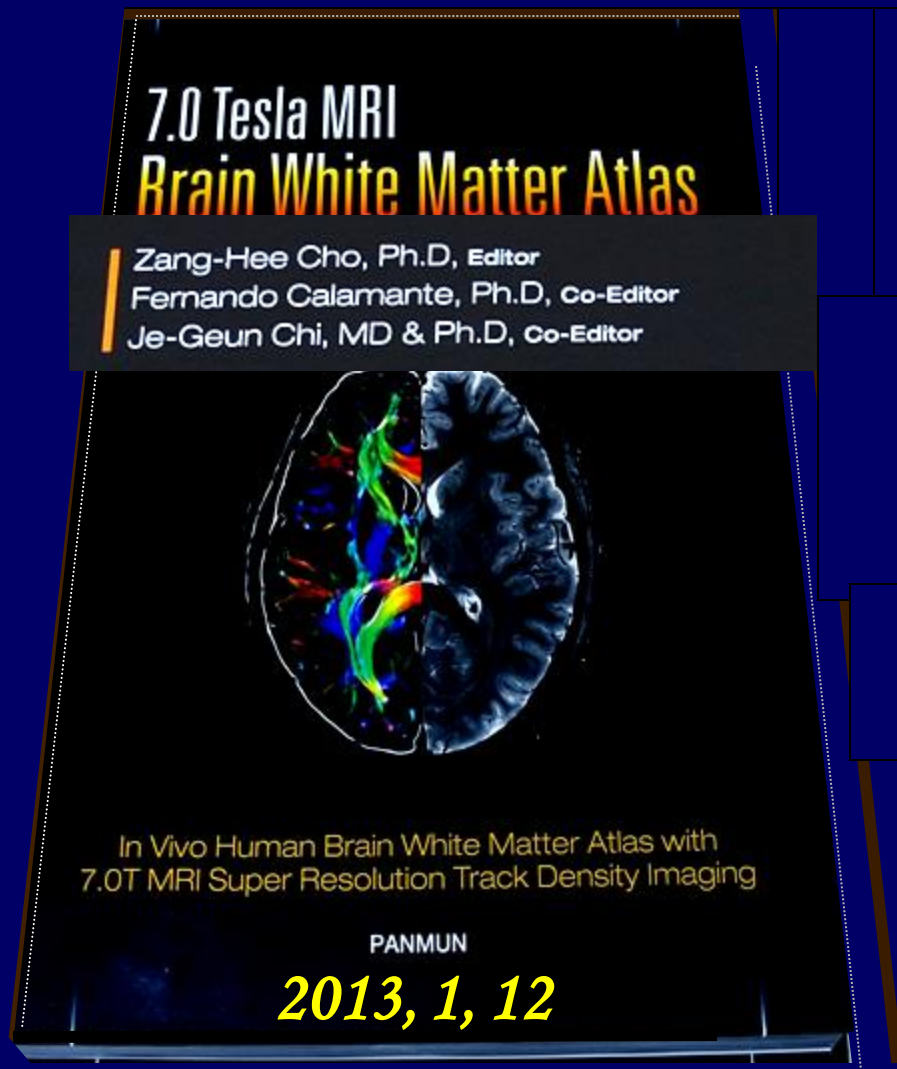
x = - 4.2 cm

In-vivo Human

Functional (Molecular) – Connectivity Map

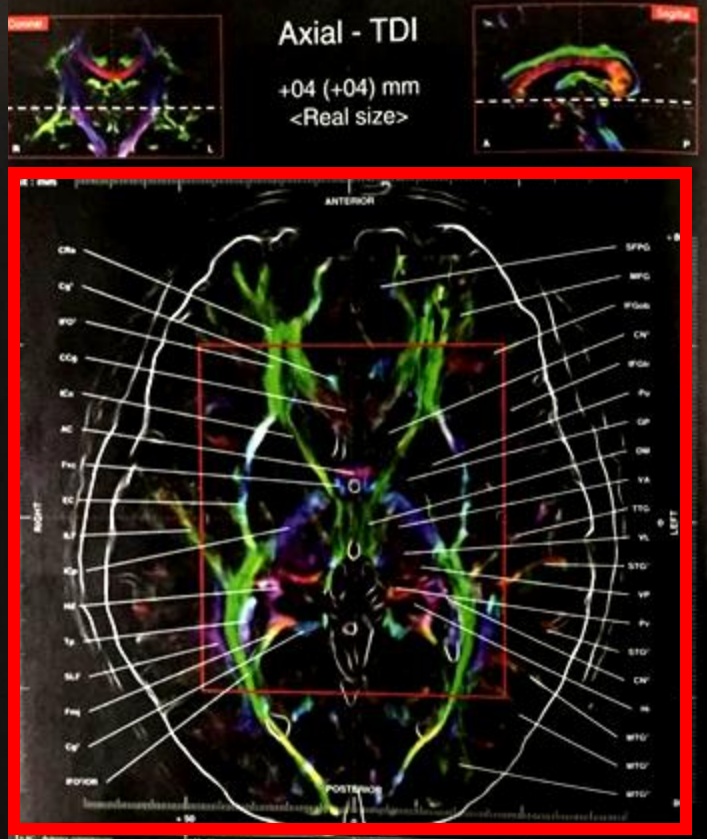






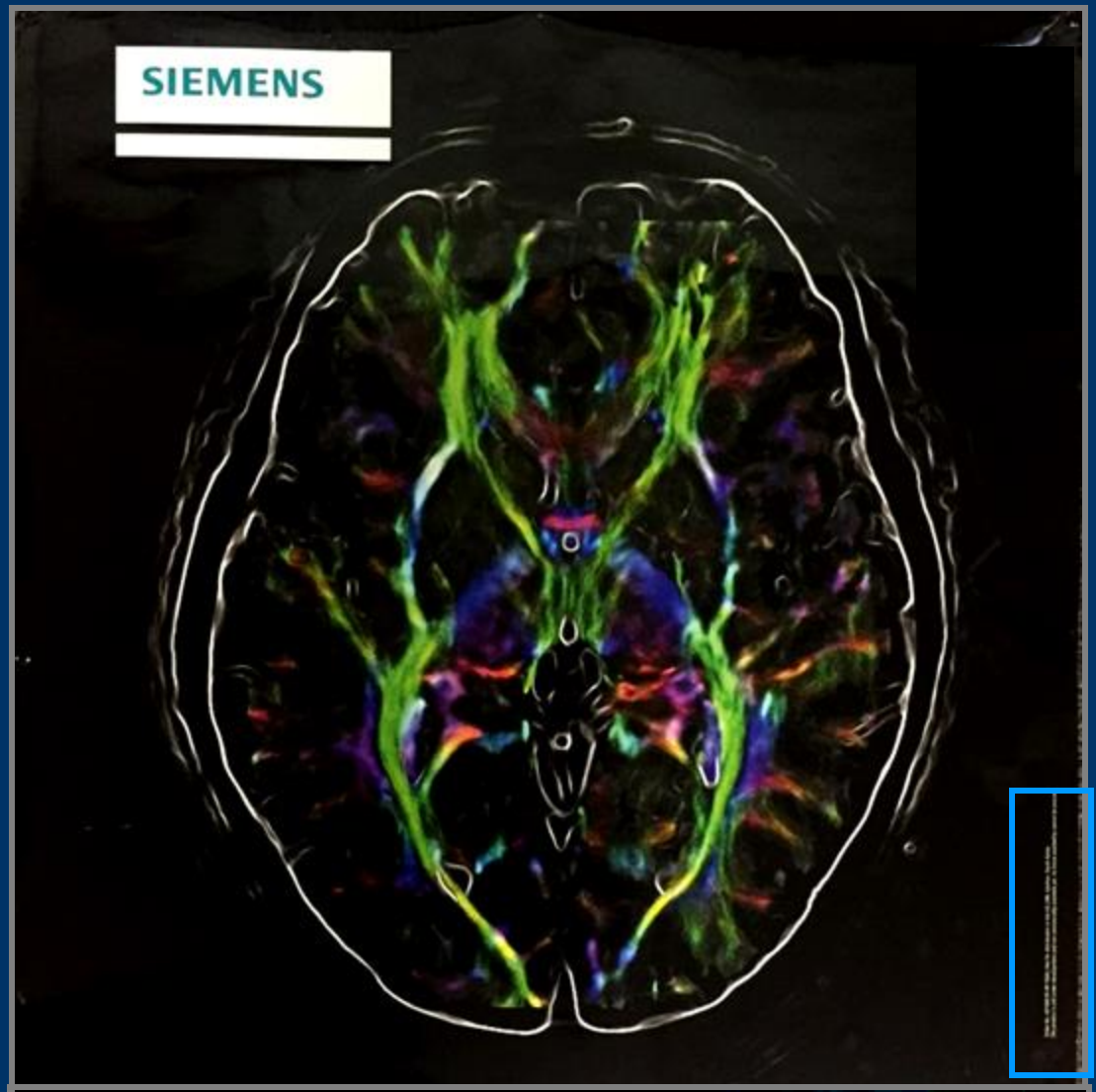
2013, 1. by Panmun, Seoul, Korea

2015, 1. by Springer Verlag, Heidelberg, New York, Dordrecht, London


Axial - TDI
+04 (+04) mm
<Real size>
ANTERIOR
POSTERIOR
RIGHT
LEFT


Axial - T2
+04 (+04) mm
<Real size>
ANTERIOR
RIGHT
LEFT

2015 Siemen's Brochure



Order No. A91MR-95-9P-7600 | Not for distribution in the US | NRI, Gachon, South Korea
The product is still under development and not commercially available yet. Its future availability

March. 26, 2017

감사합니다. 끝

Brain, Brain, ……

zcho1@snu.ac.kr

Feb. 26, 2017

END

Summary of Tonegawa Experiment

1. **Once it is fired, therefore, wired, it remains (ChR2), the Engram remains.**

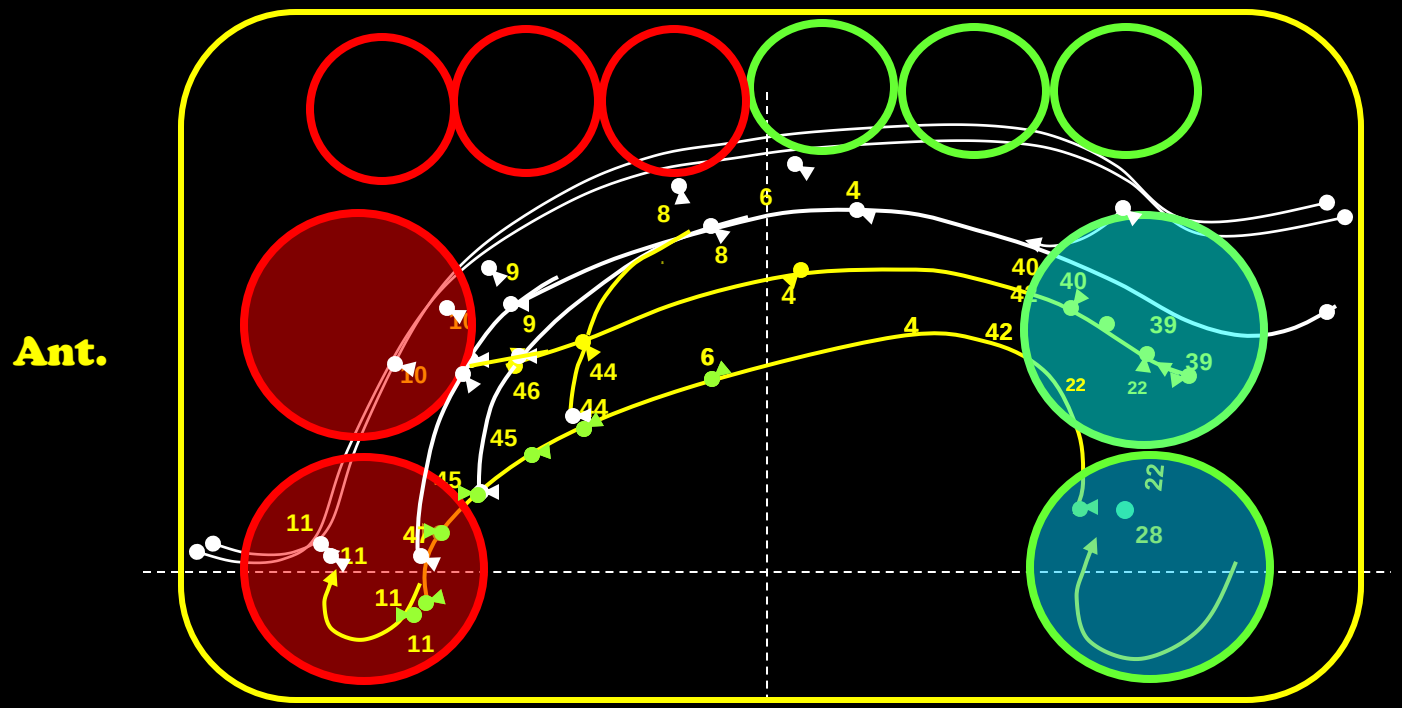
2. **Contex change from B to A, erase the memory of B, the Engram synaps dependent states.**

3. **Once the Engram is formed, it can be activated if condition is right, like ChR2 with light stimulation. Thus the Engram is permanent memory.**

System Symmetry of Human Brain

Real Pathways

Pathway Tracing with Tractographic Data and Estimated Brodmann's Area



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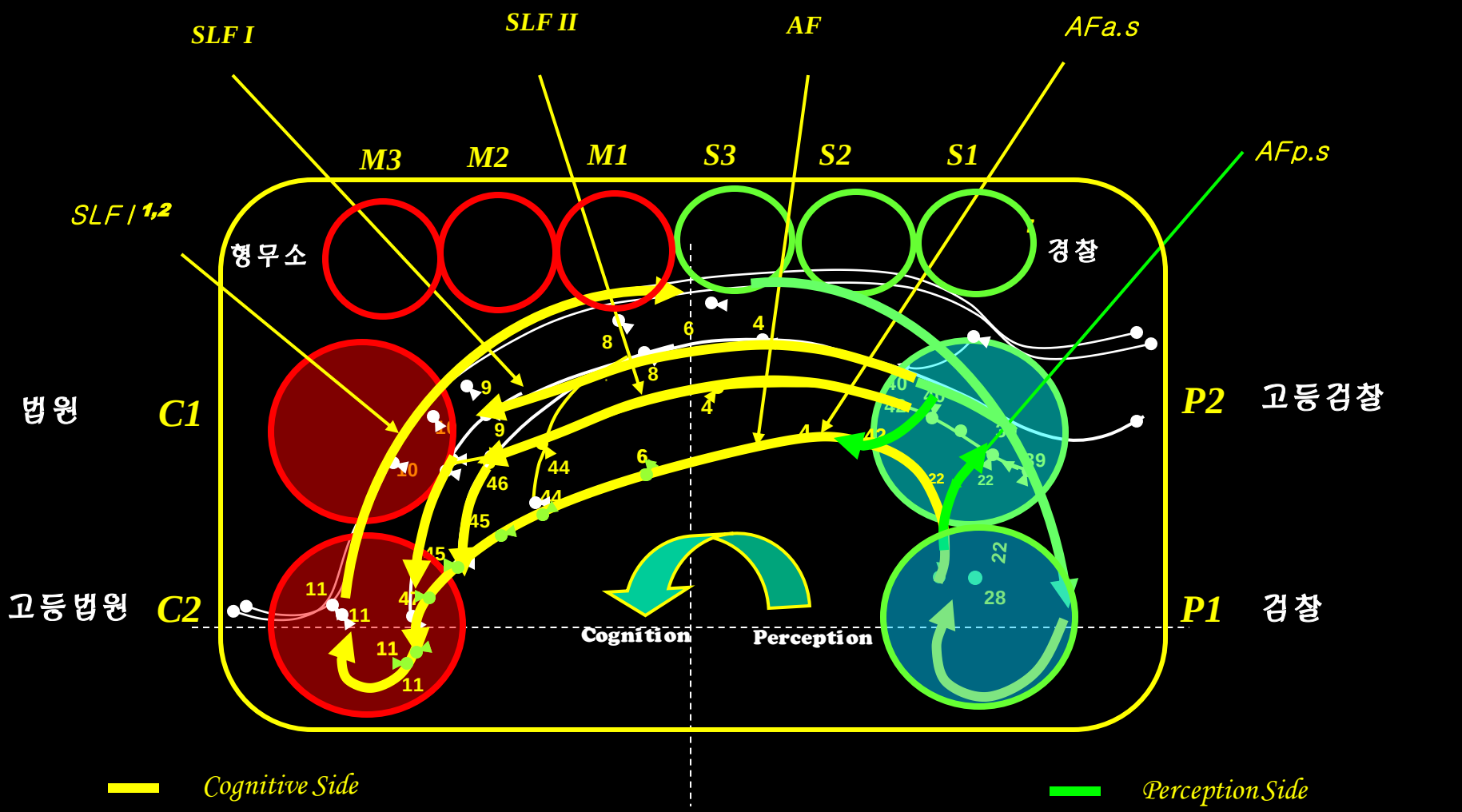
Pathway Tracing with Tractographic Data and Estimated Brodmann's Area



Cognitive Centers :

C2 : Orbitofrontal Cognitive

C1 : Prefrontal Cognitive

Motor Areas :

M3 : Frontal Eyefield

M2 : Premotor

M1 : Primary Motor

Perceptive Centers :

P2 : High Perceptive Center

P1 : Perceptive Center

Sensory Areas :

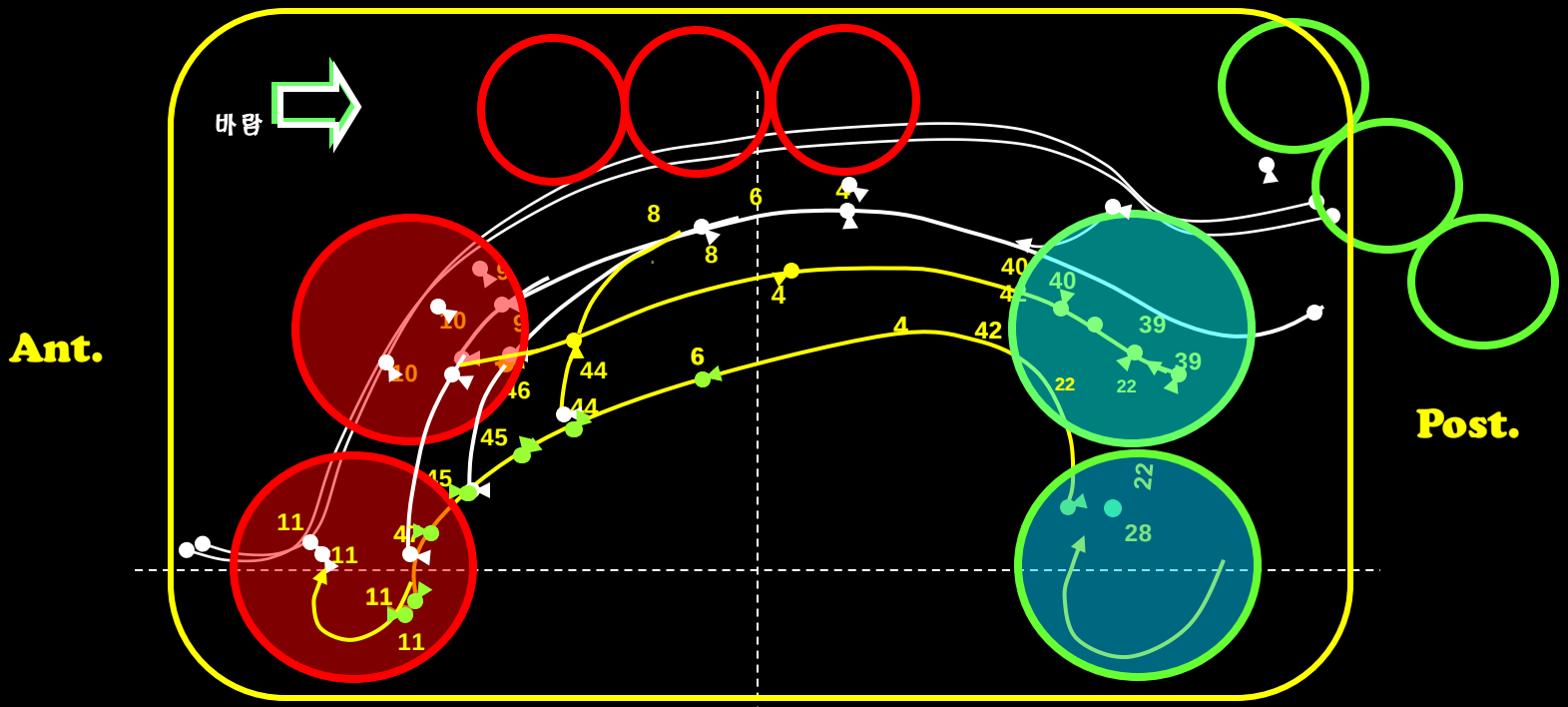
S3 : Somatic Sensory

S2 : Auditory Sensory

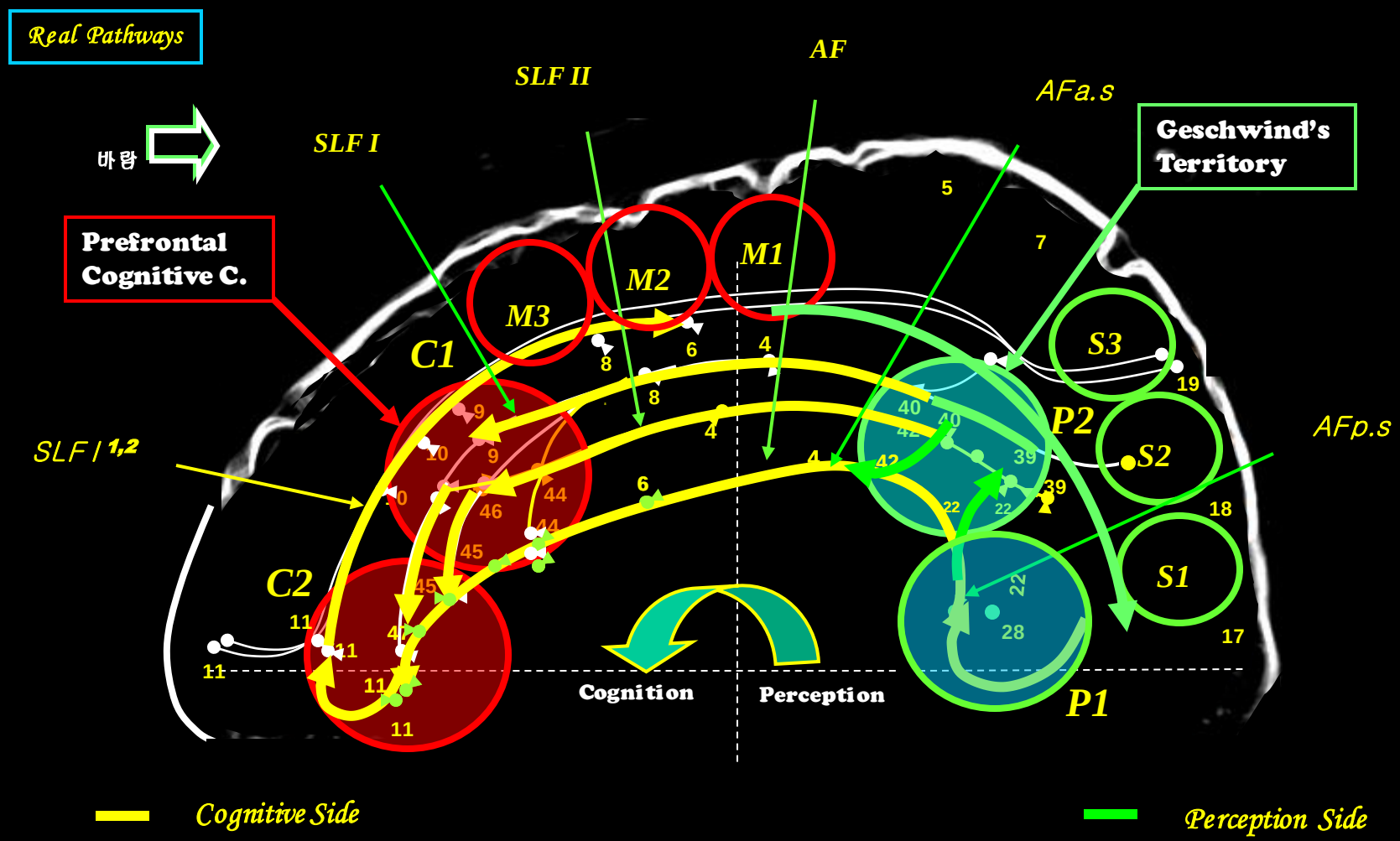
S1 : Visual Sensory

Real Pathways

Pathway Tracing with Tractographic Data and Estimated Brodmann's Area



Pathway Tracing with Tractographic Data and Estimated Brodmann's Area



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