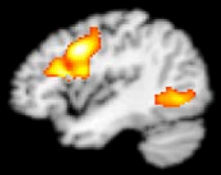
認知神經科學簡介

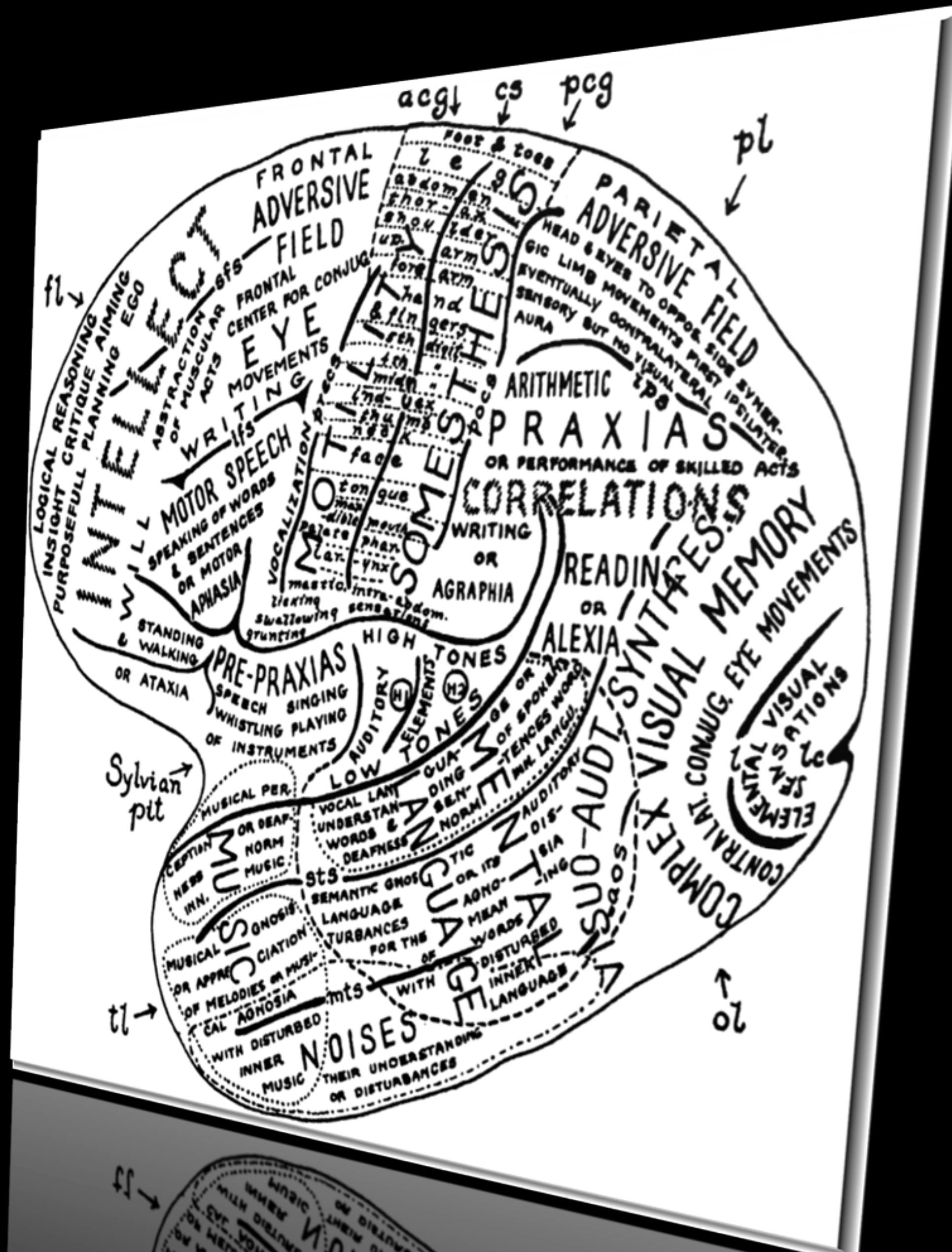
~以中文閱讀為例~



郭文瑞

陽明大學 神經科學研究所

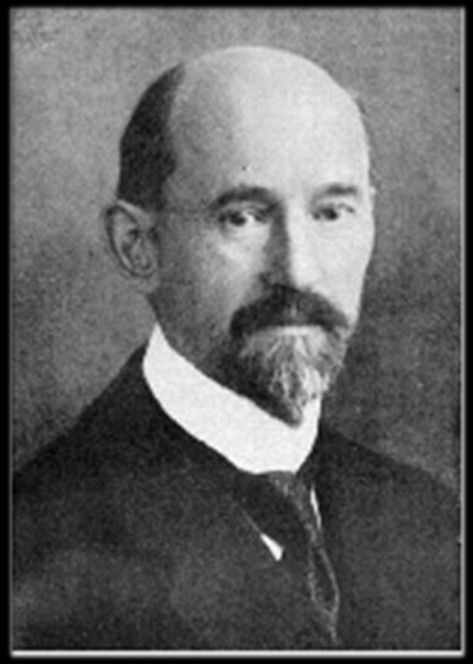
腦功能研究


acg
cs
pcg
pl
fl
FRONTAL ADVERSIVE FIELD
INTELLECT
LOGICAL REASONING
INSIGHT CRITIQUE AIMING
PURPOSEFULL PLANNING EGO
ABSTRACTION OF MUSCULAR ACTS
FRONTAL CENTER FOR CONJUG. EYE MOVEMENTS
WRITING
WILL
MOTOR SPEECH
SPEAKING OF WORDS & SENTENCES
OR MOTOR APHASIA
MOTILITY
SOMESTHESIS
face
tongue
swallowing
PARIETAL ADVERSIVE FIELD
ARITHMETIC
PRAXIAS
OR PERFORMANCE OF SKILLED ACTS
CORRELATIONS
WRITING OR AGRAPHIA
READING OR ALEXIA
SYNTHESES
VISUAL MEMORY
CONTRALAT. CONJUG. EYE MOVEMENTS
COMPLEX VISUAL
ELEMENTAL VISUAL SENSATIONS
STANDING & WALKING OR ATAXIA
PRE-PRAXIAS
SPEECH SINGING WHISTLING PLAYING OF INSTRUMENTS
HIGH TONES
LOW TONES
AUDITORY ELEMENTS
Sylvian pit
MUSIC
MENTAL LANGUAGE
VISUO-AUDIT.
sts
mts
NOISES
THEIR UNDERSTANDING OR DISTURBANCES
tl
ol
lc

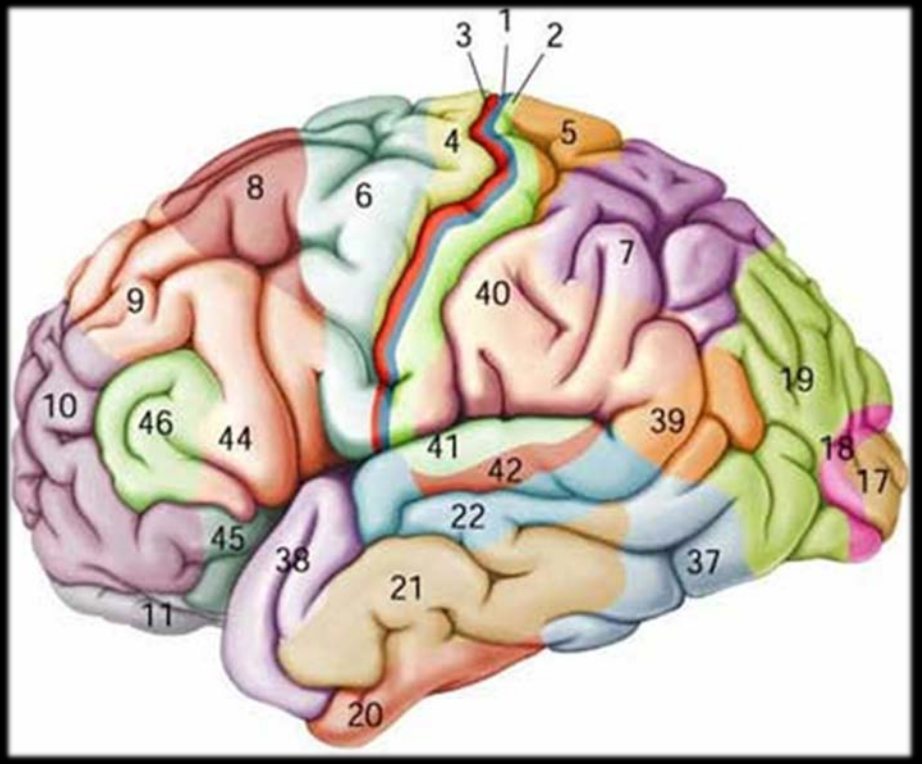
每個腦區都有其獨特的功能？

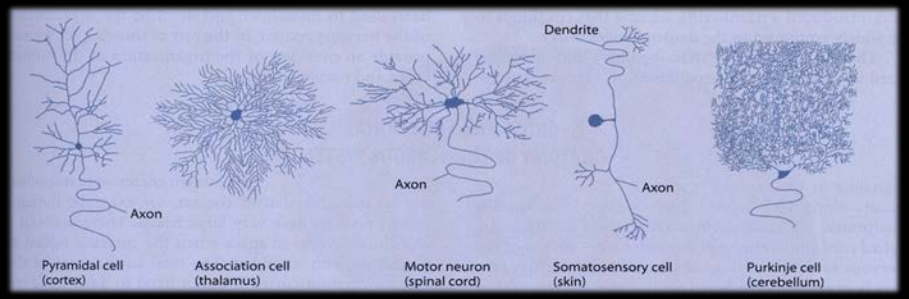
Paul Broca (1824-1880)

大腦分區地圖

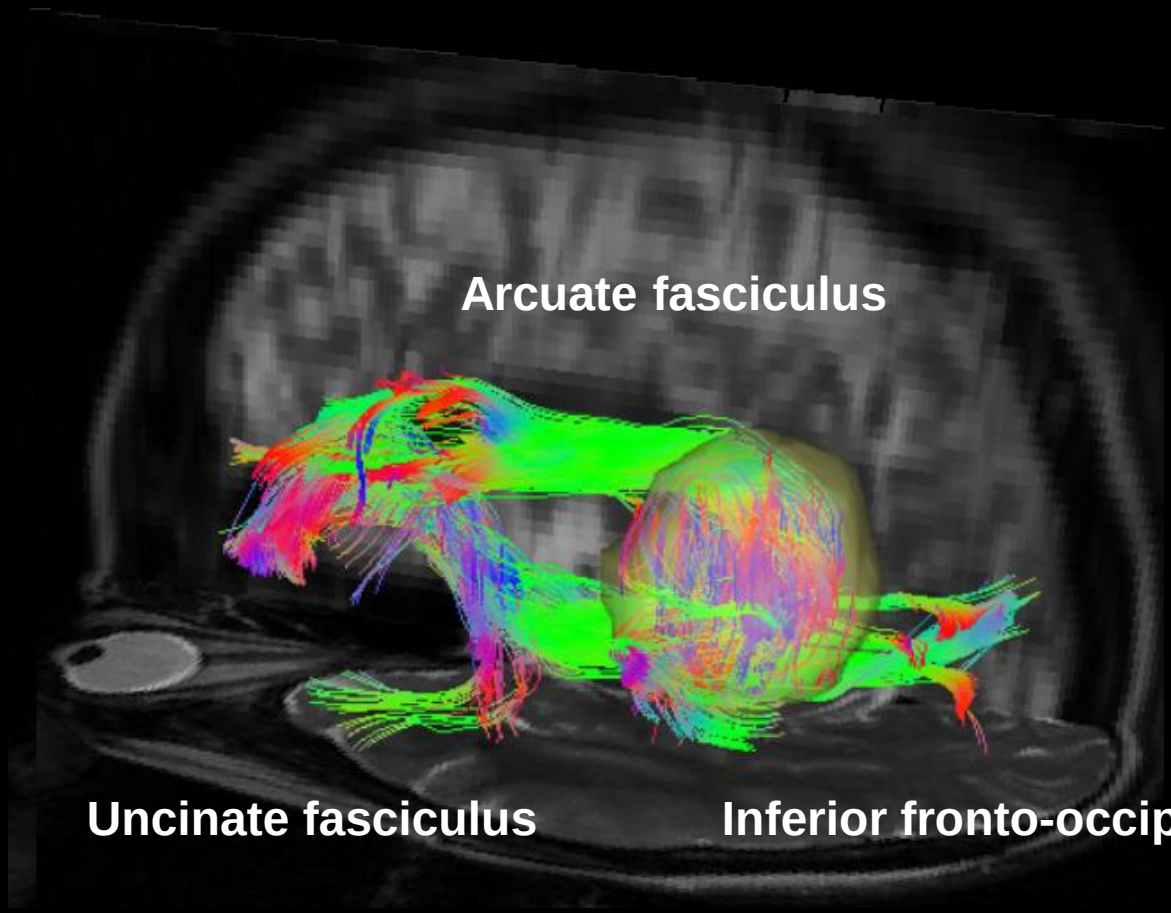


Korbinian Bordmann (1868-1918)

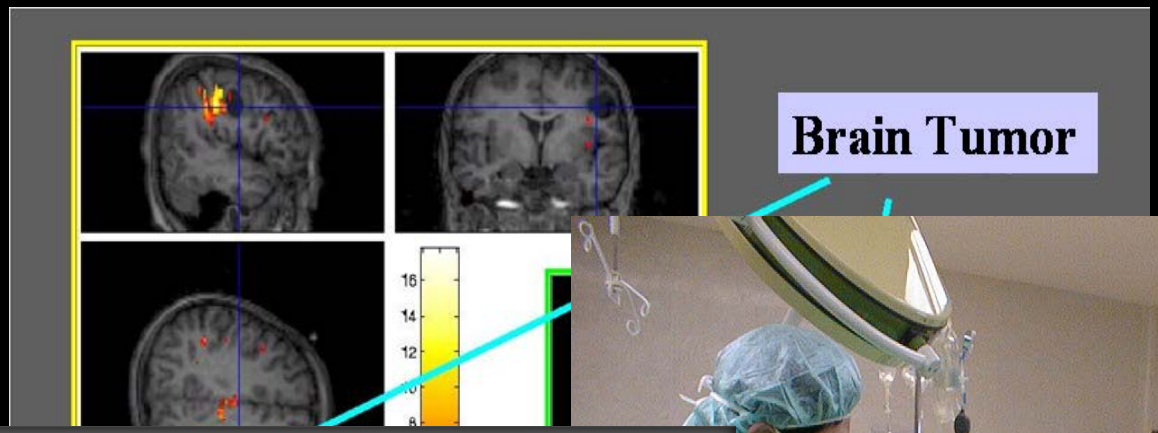


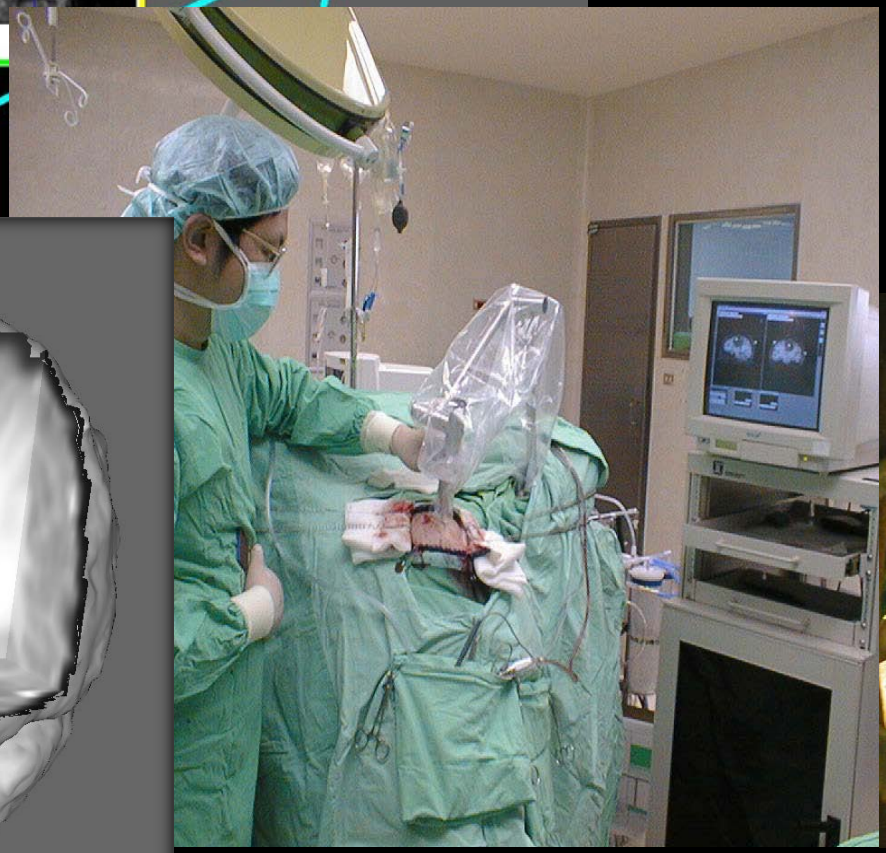


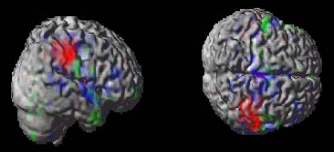
腦瘤的影響 *(1/2)*


Arcuate fasciculus
Uncinate fasciculus
Inferior fronto-occipital tract

腦瘤的影響 (2/2)

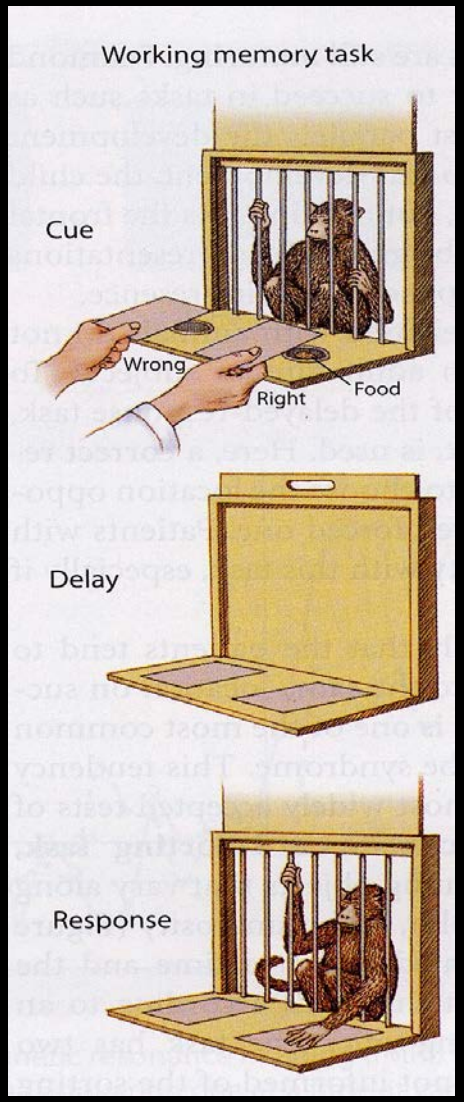




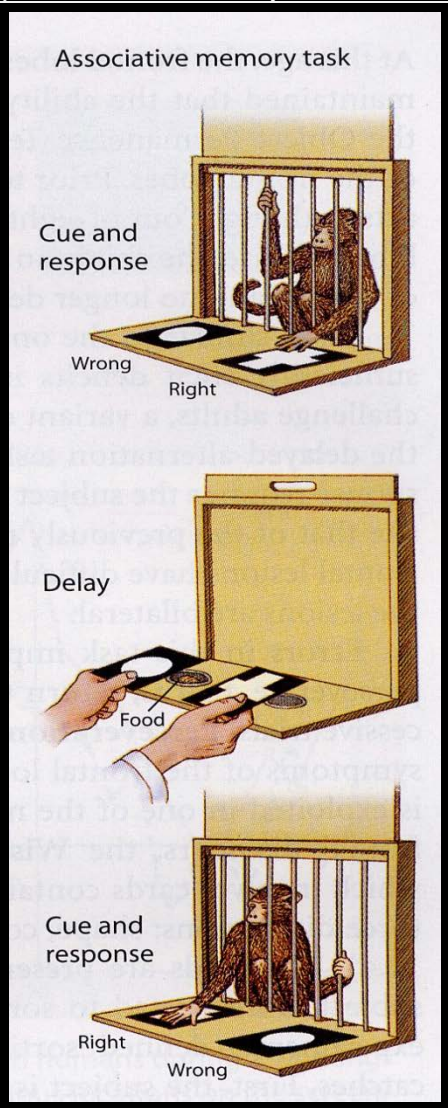


以*破壞腦結構*的方式探討工作記憶與大腦前額葉的關係

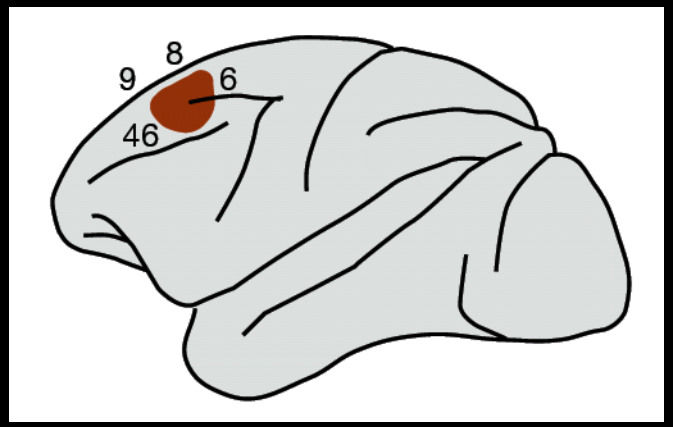
延遲反應作業
(Delayed response task)



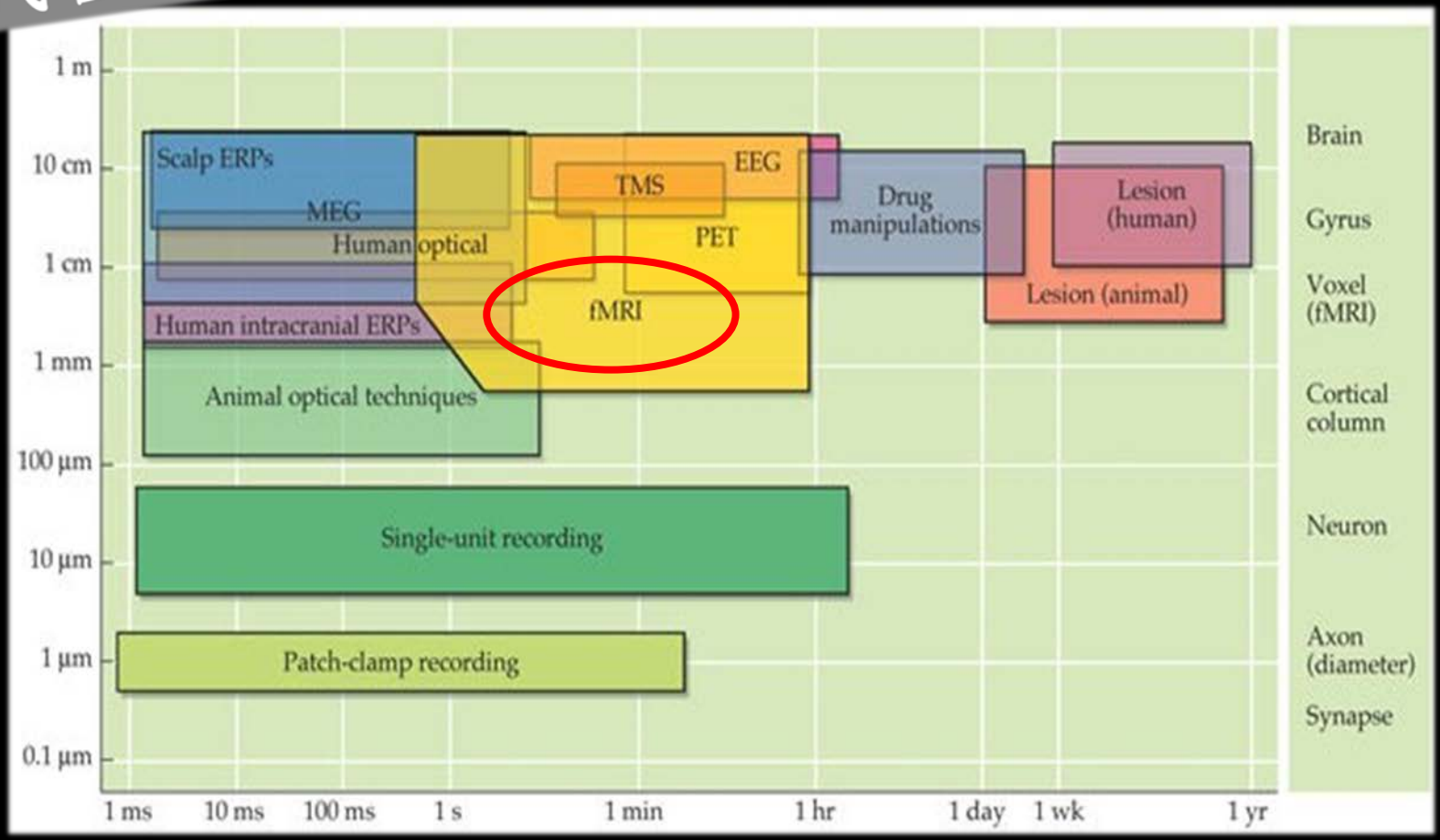
連結反應作業
(Associative response task)



➔*Damage to the lateral prefrontal cortex disrupts working memory, instead of recognition memory.*

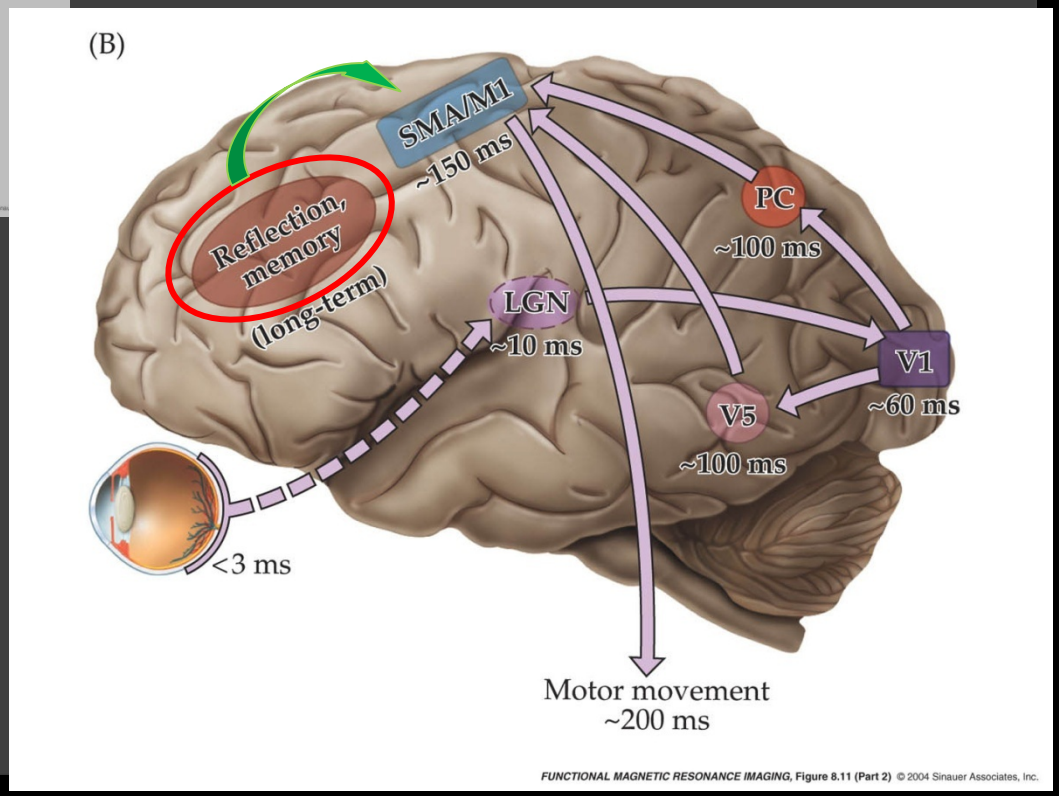


現代各式腦造影工具及特色

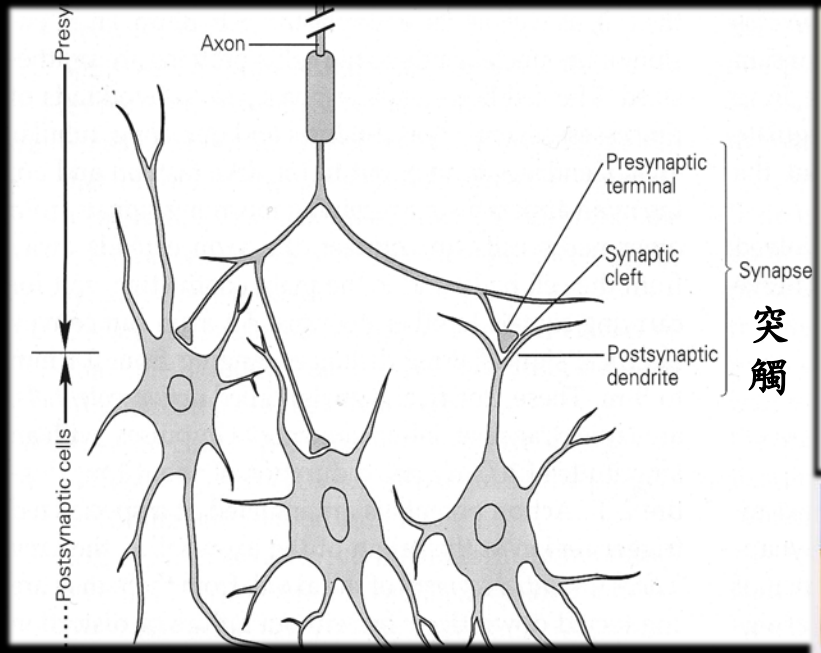


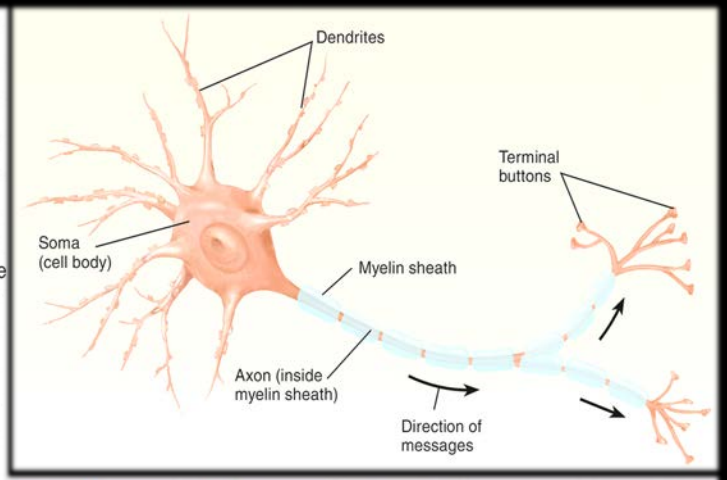
如何*啟動*和*觀察*腦神經系統運作?

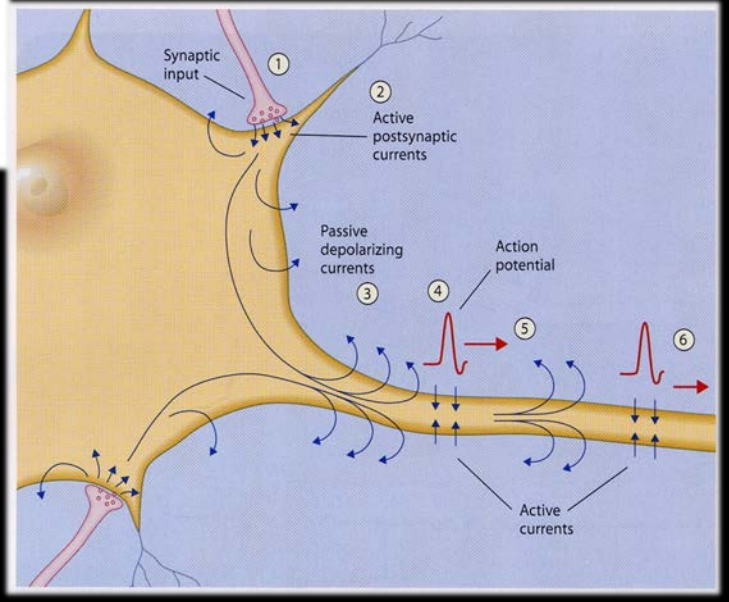
- *外在* 刺激所啟動, 例如視覺
- *內在* 運作所啟動, 例如記憶

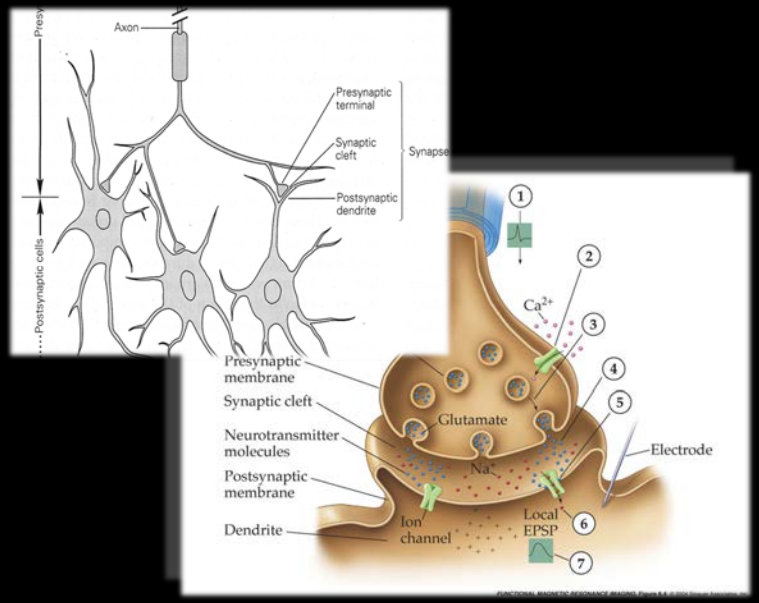


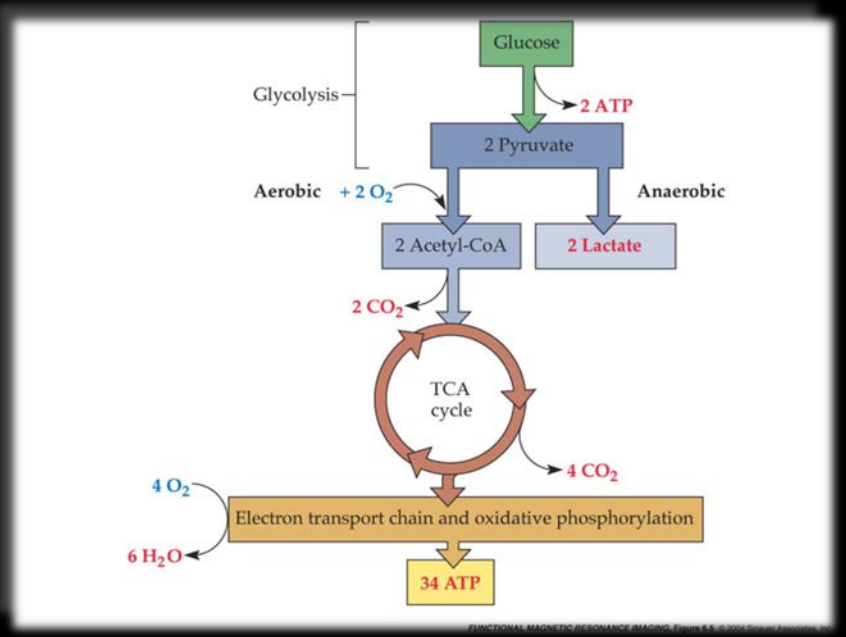
大腦神經元的訊息傳遞與溝通

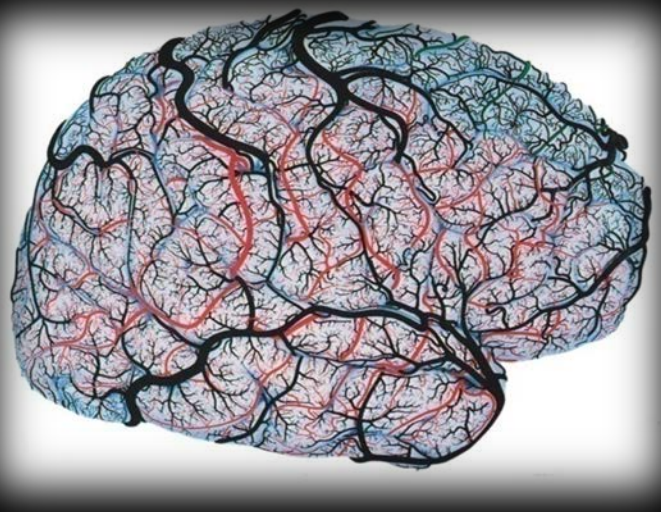


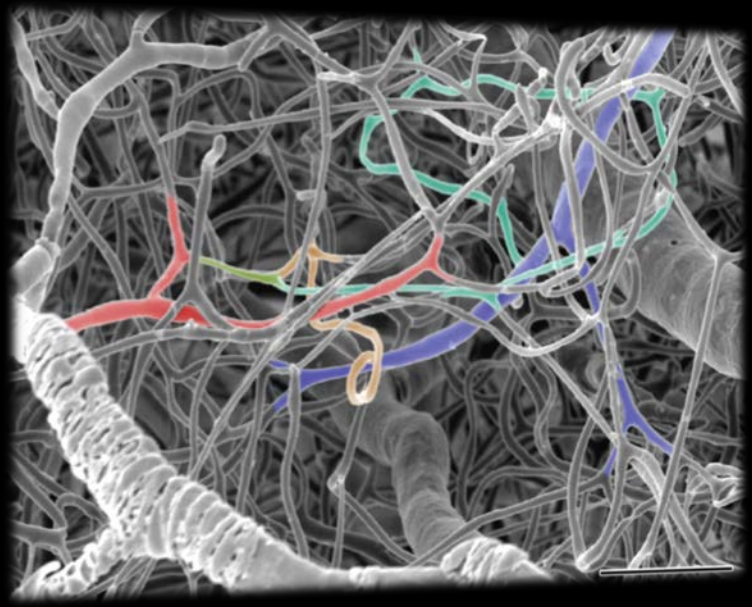





Axon
Presynaptic terminal
Synaptic cleft
Postsynaptic dendrite
Synapse
Presynaptic cells
Postsynaptic cells
Presynaptic membrane
Synaptic cleft
Neurotransmitter molecules
Postsynaptic membrane
Dendrite
Glutamate
Ion channel
Electrode
Local EPSP
Ca2+
Na+
1
2
3
4
5
6
7

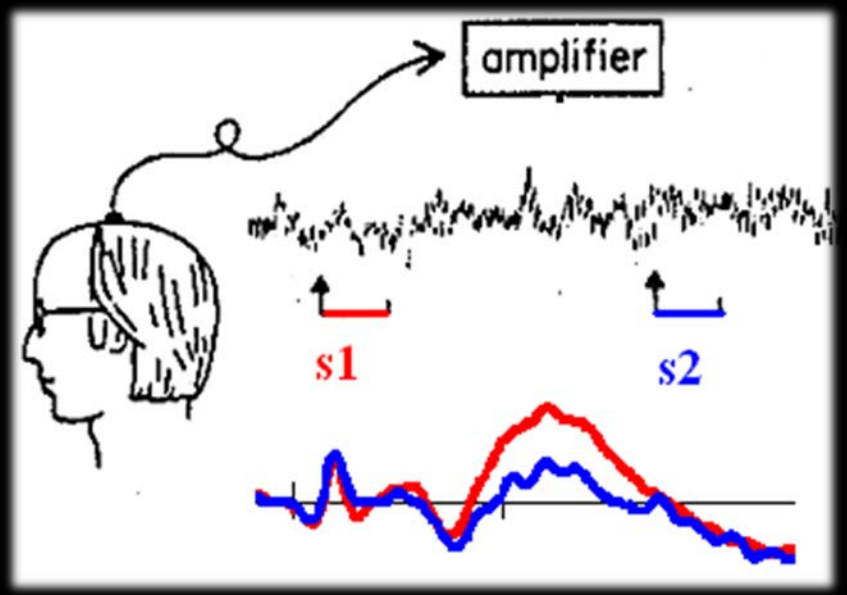

Glucose
Glycolysis
2 ATP
2 Pyruvate
Aerobic
+ 2 O2
Anaerobic
2 Acetyl-CoA
2 Lactate
2 CO2
TCA cycle
4 CO2
4 O2
Electron transport chain and oxidative phosphorylation
6 H2O
34 ATP

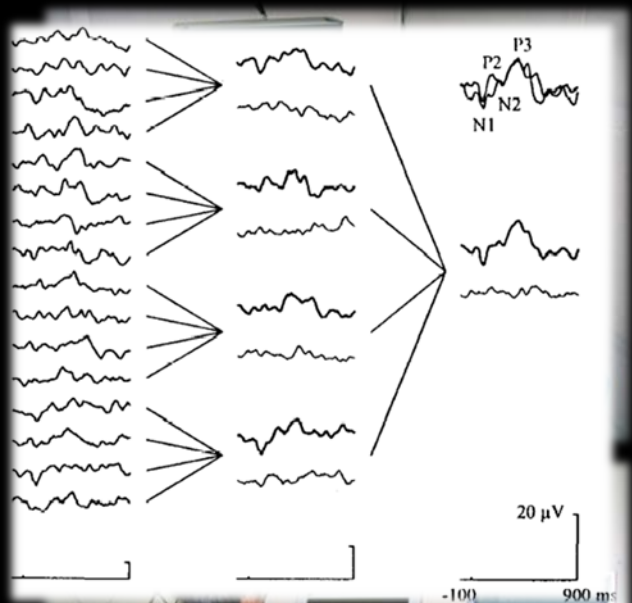


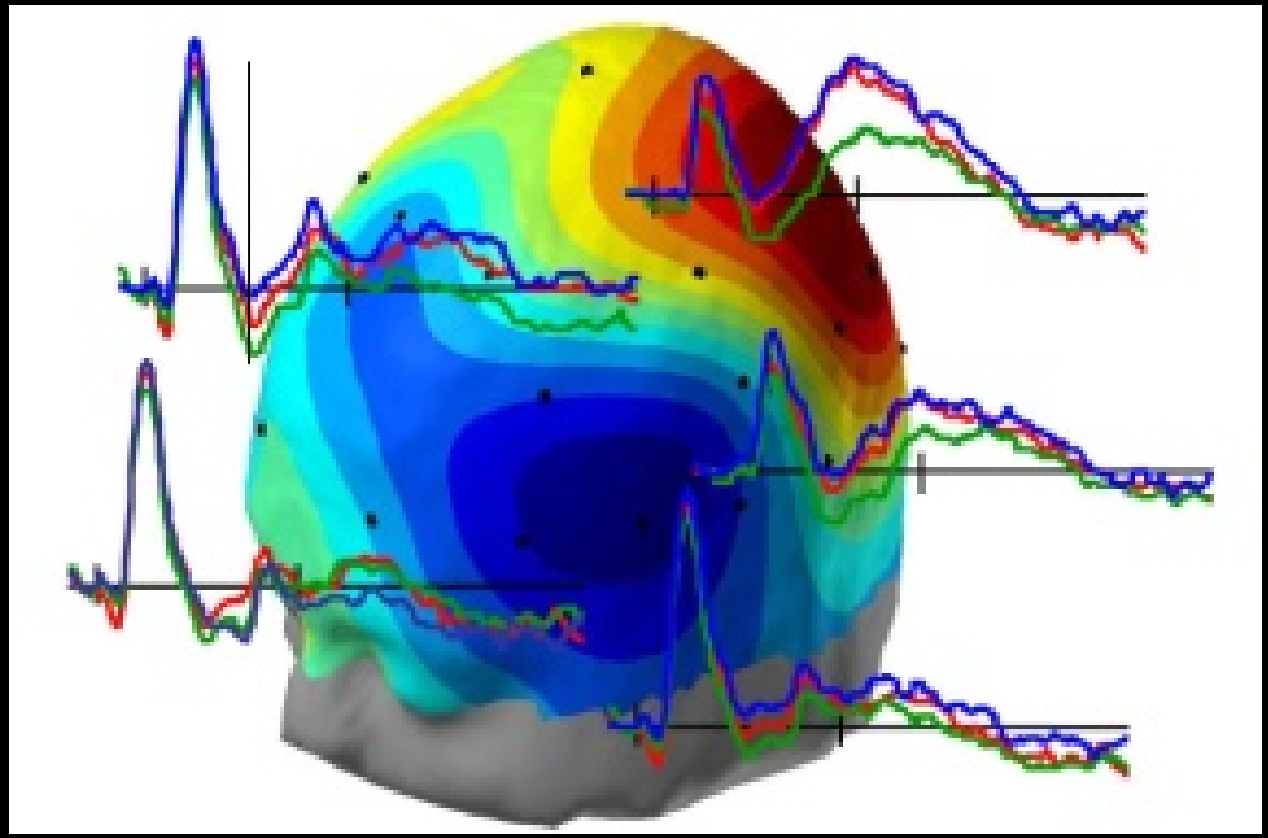


Event-Related Potentials (ERPs)

- ERPs are extracted from epochs of EEG associated with stimuli of the same category, and reflect the neural processing of experimental stimuli.

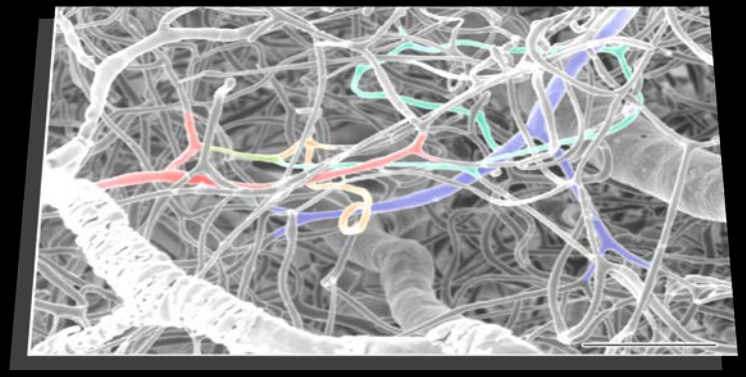






BOLD System

neuronal activity



fMRI signal

hemodynamic response

- Language processing
- Visual motor processing
- Memory processing
- Decision-making
- ……

Data transformations

Time-series data

Kernel

Design matrix

Statistical parametric map (SPM)

Realignment

Smoothing

General linear model

Normalisation

Template

Parameter estimates

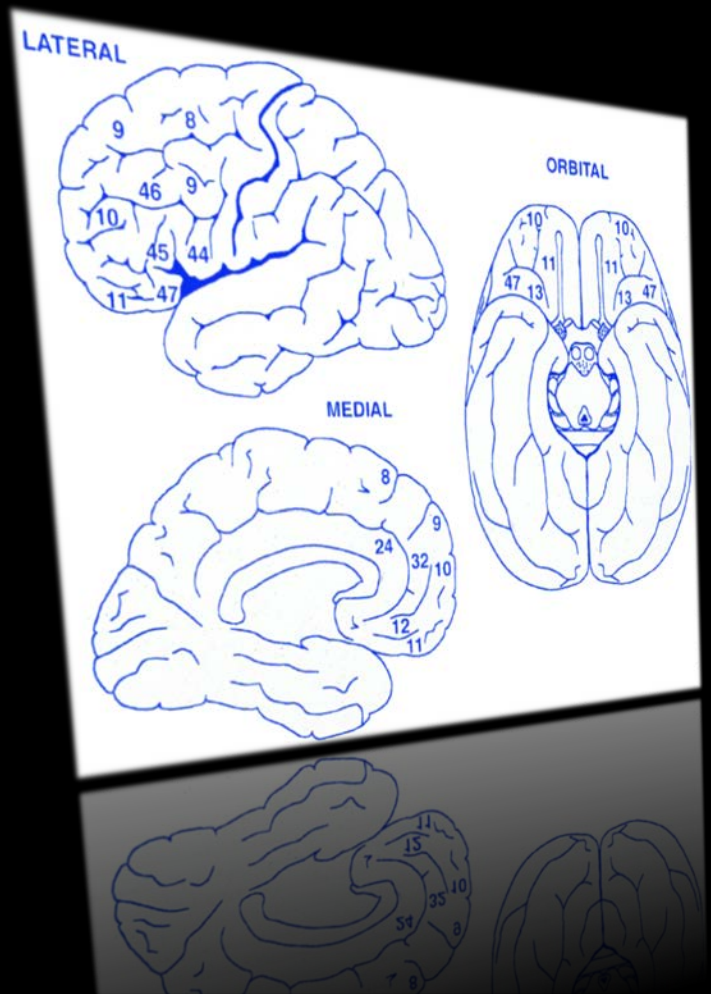
Statistical inference

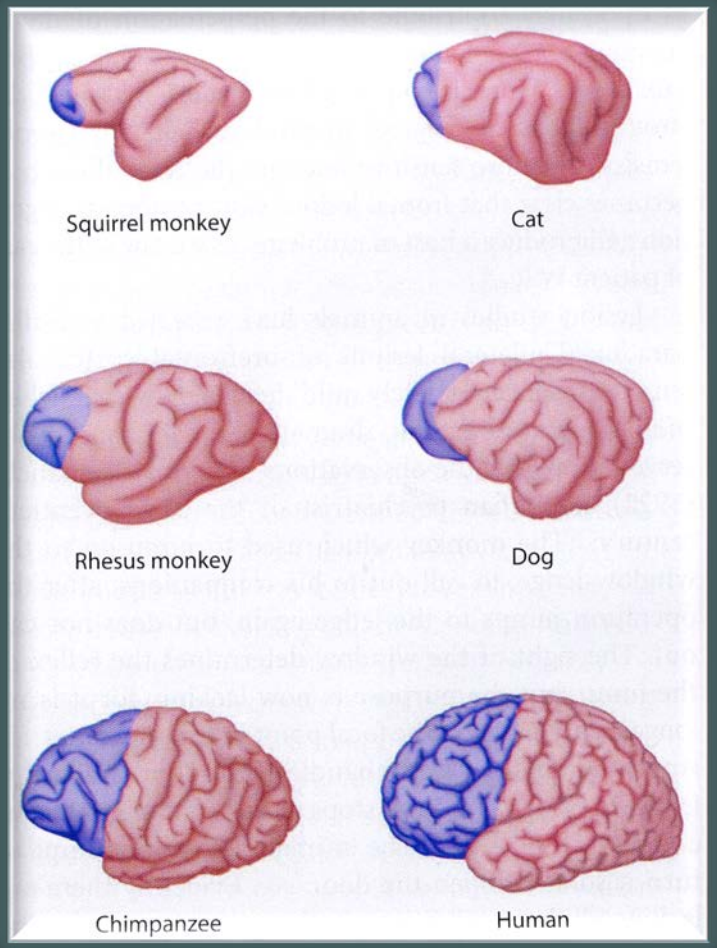
Gaussian field theory

p <0.05

大腦的發展與演化 --前額葉

The Human Prefrontal Cortex





隨著演化與發展，前額葉體積與神經連結逐漸增加

大腦前額葉的特性

- 演化上比較新

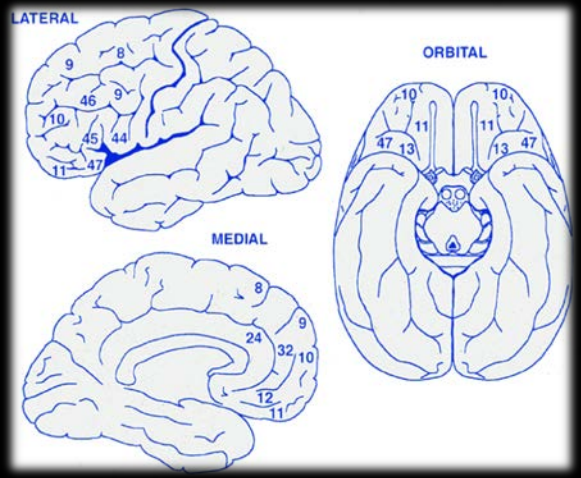
  Phylogenetically, it is one of the latest cortices to develop, having attained maximum relative growth in the brain.

- 發展上比較晚成熟

  The PFC undergoes late development in the course of ontogeny.

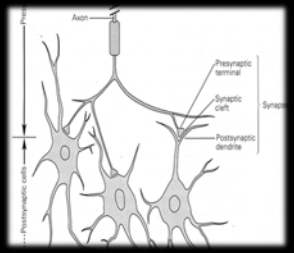
- 與高階認知功能比較相關

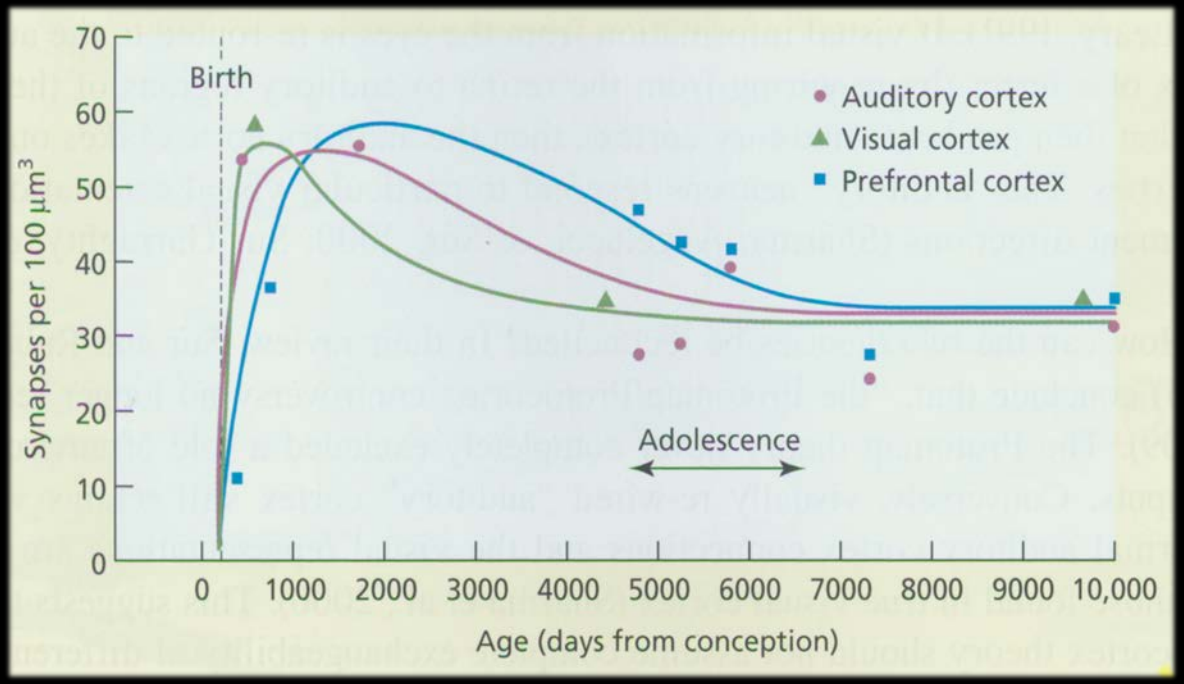
  Imaging studies, in the human, indicate that prefrontal areas do not attain full maturity until adolescence. This is consistent with the behavioral evidence that these areas are critical for those higher cortical functions that develop late.



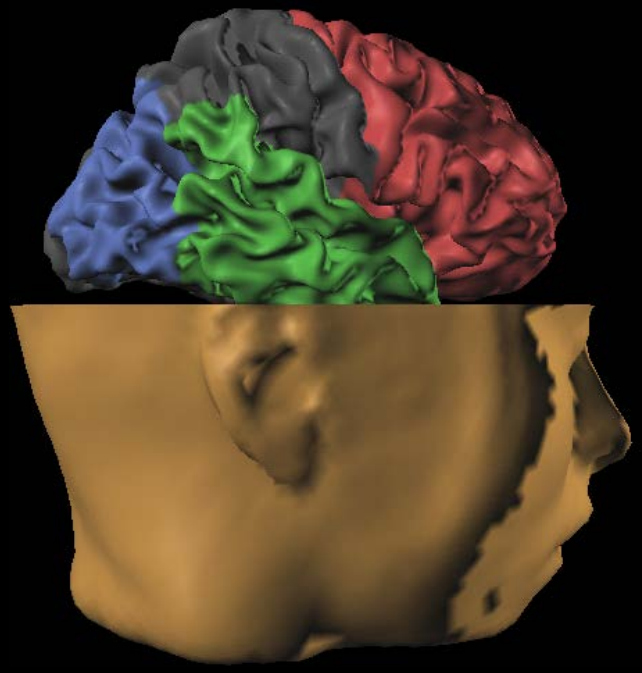
突觸密度 *Synaptic density* in human cortex

- Primary visual & auditory cortice (視覺、聽覺皮質)
  - peaks between 4-12months
  - falls to adult level between 2-4 years
- Prefrontal cortex (大腦前額葉皮質)
  - peak reaches after 12 months
  - return to adult level after 10 to 20 years





什麼是認知神經科學?



我們有哪些大腦認知功能 ？

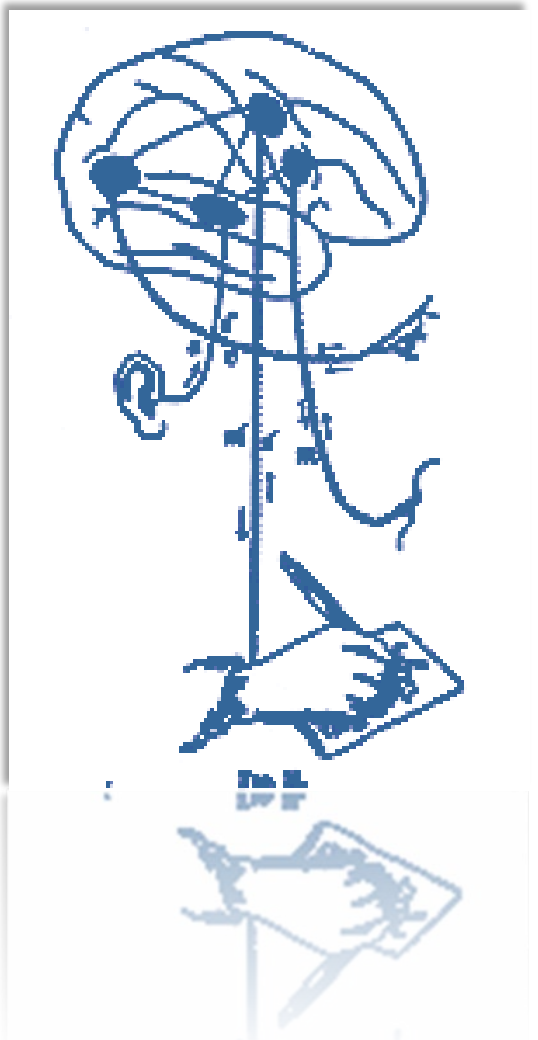
語言、閱讀、學習、記憶、注意力、

視覺認知、物體辨識、動作控制、

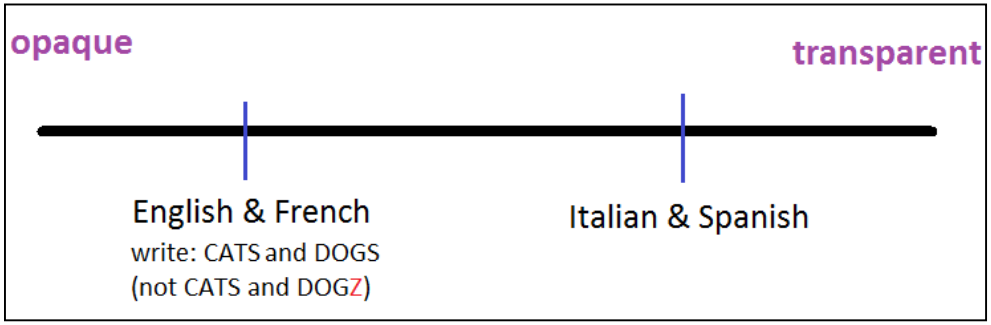
情緒、同理心 ……

意志力、計畫、決策、問題解決、
道德判斷、人際互動 ……

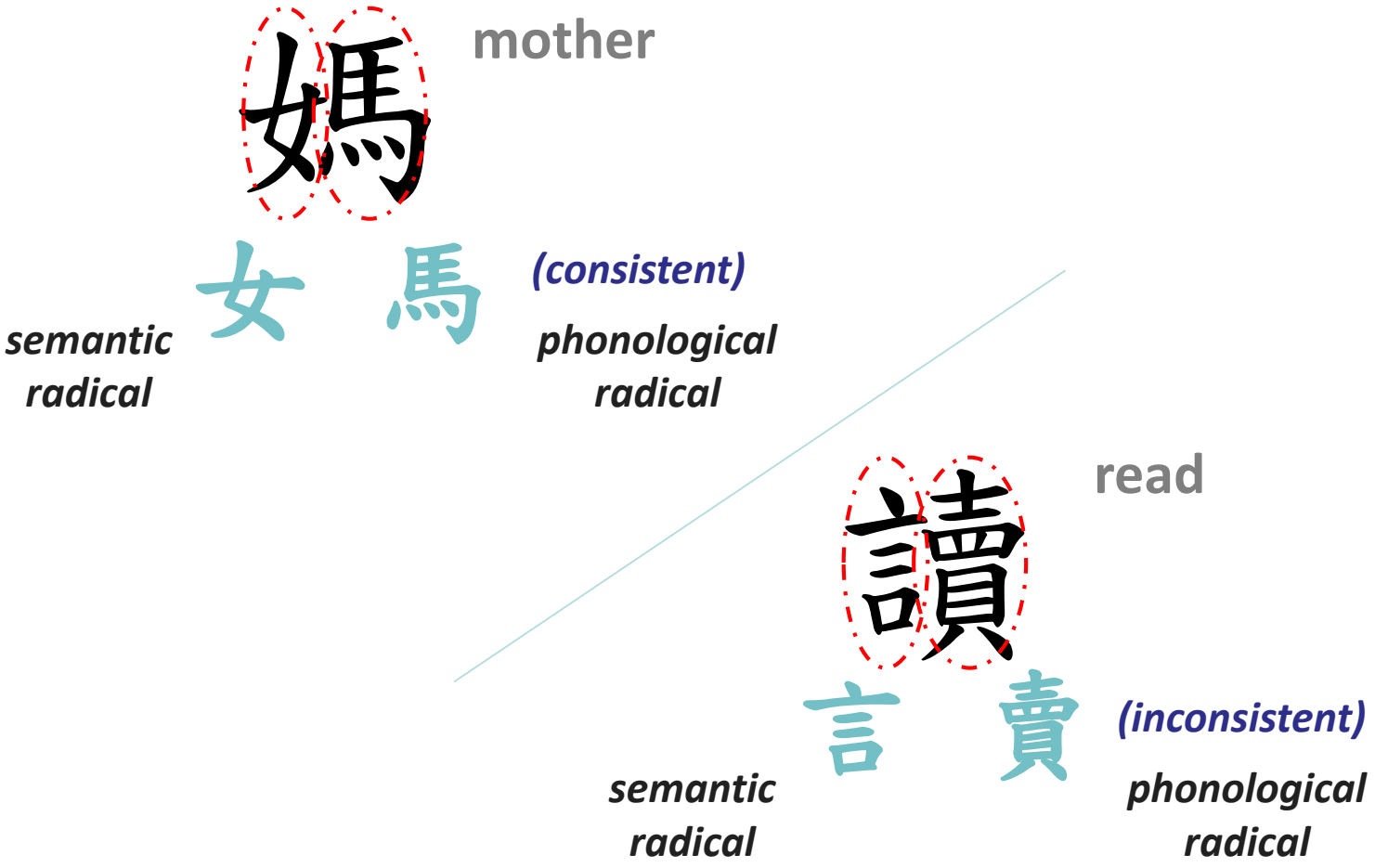
Chinese reading in the brain



- Writing systems are set to provide their readers with maximal phonological and semantic information using minimal orthographic units (Frost, 2012).
- Different writing systems carry different transparency levels of grapheme-to-phoneme mapping.

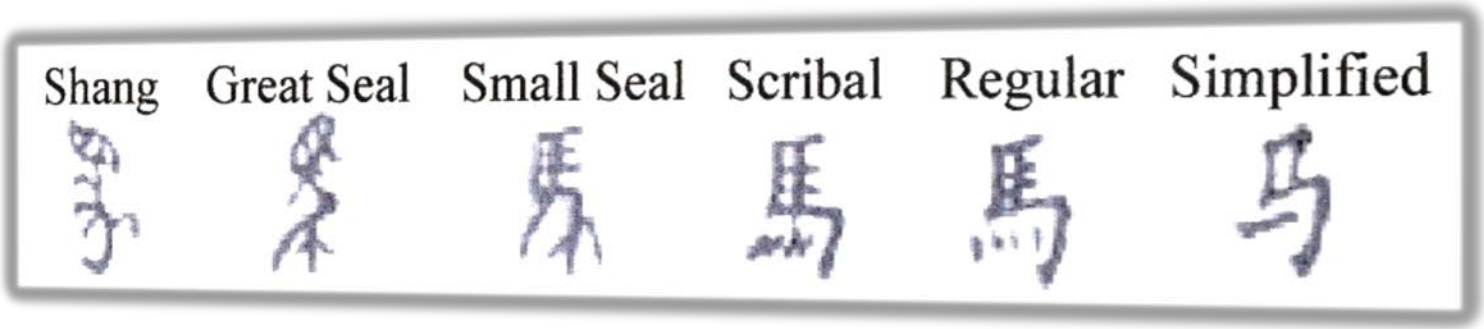


For English, YACHT, PINE, GAVE, *BRANE*, … *w*hich are irregular words.



Will properties of the components (radicals) of a character have systematic, psychological influence to its processing *?*

Are Chinese characters pictographic ?



No, not really.

Structural classification of Chinese characters

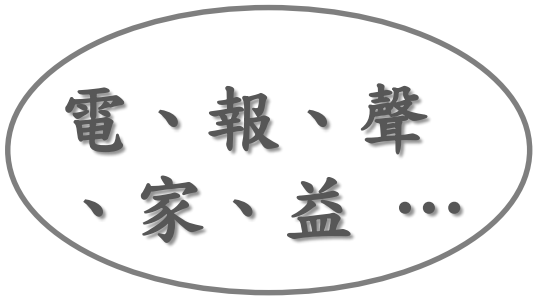
Principles	*Oracle Bones* (Shang dynasty, 1100-1400 BC)	*Xu Shen* (Han dynasty, 2nd century)	*Zheng Qiao* (Song dynasty, 12th century)	*Kang Xi* (Qing Dynasty, 18th century)
Pictographic	*227 (23%)*	*364 (4%)*	*608 (3%)*	
Simple indicative	*20 (2%)*	*125 (1%)*	*107 (1%)*	*~ 1500 (3%)*
Compound indicative	*396 (41%)*	*1167 (13%)*	*740 (3%)*	
Semantic-phonetic	*334 (34%)*	*7697 (82%)*	*21810 (93%)*	*47141 (97%)*
Total number	*977*	*9353*	*23265*	*48641*

形聲字

醋 錯 借 惜 …

(John DeFrancis, 1991)

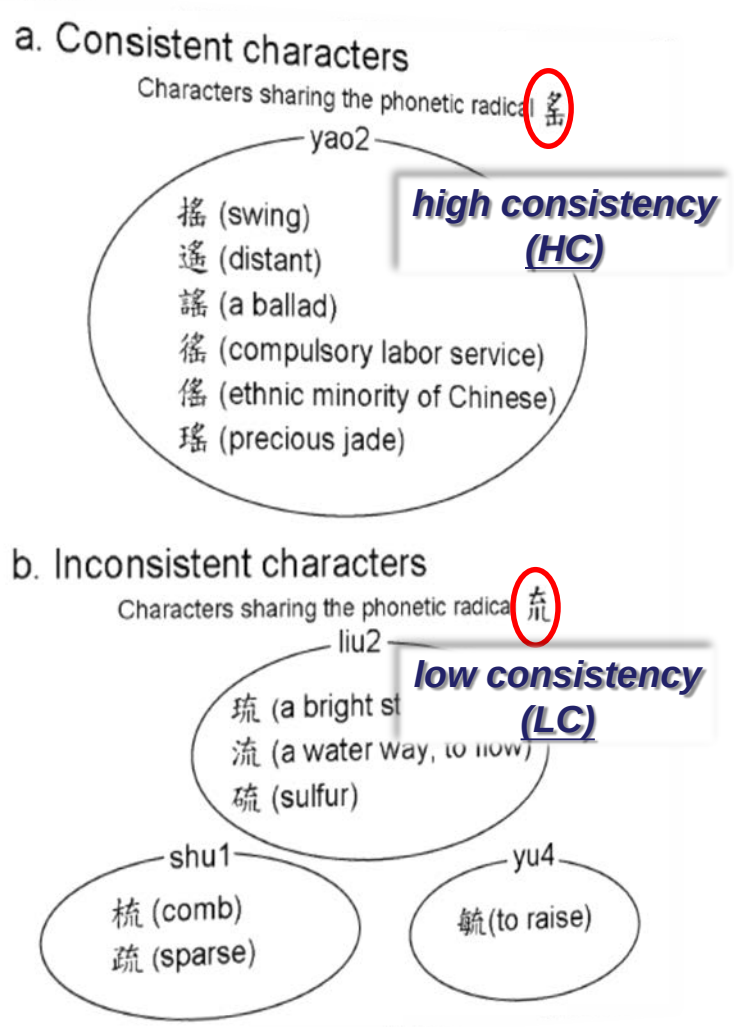
*書面頻率*效果

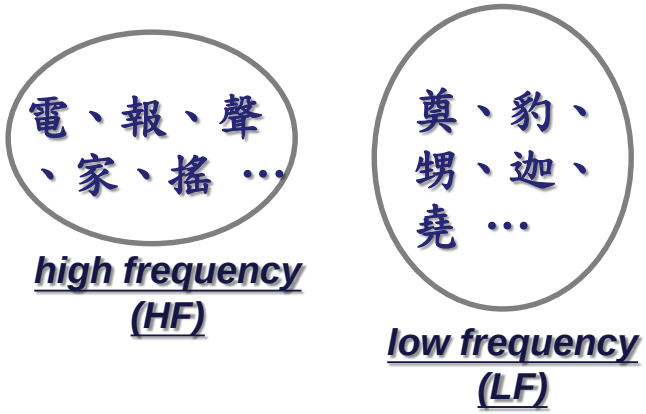


常看到的字
(高書面頻率)

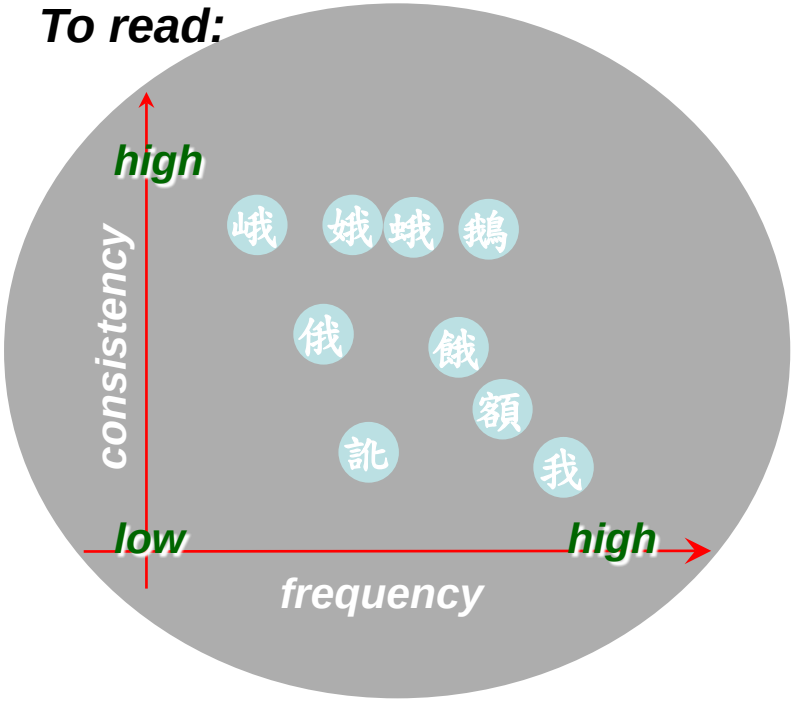
不常看到的字
(低書面頻率)

The processes



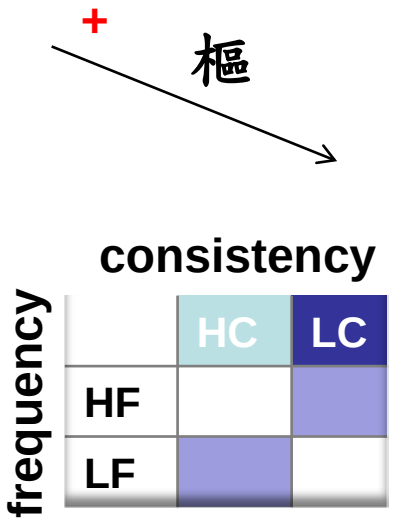


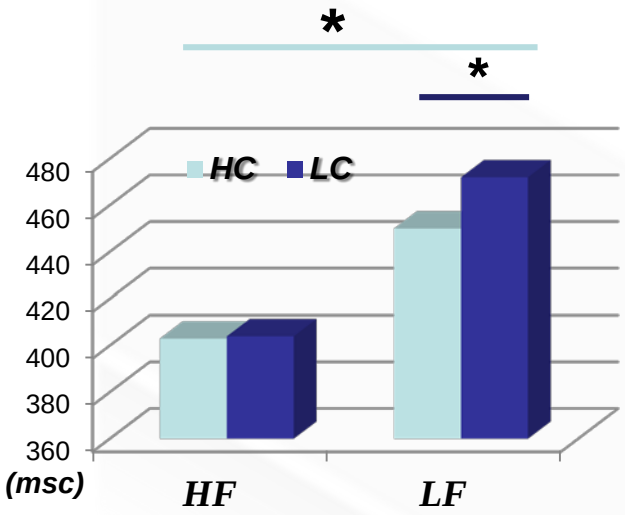
To read:



The task and findings

In a naming task, …





Yes, properties of a character component will affect its processing in a systematic way.

Neural substrates of reading processes revealed by frequency, consistency, and their interaction

- *3T event-related fMRI paradigm*
- *18 college students volunteered for subjects*
- *a naming task*
- *frequency and consistency for independent variables (2x2 within-subject design)*

frequency effect

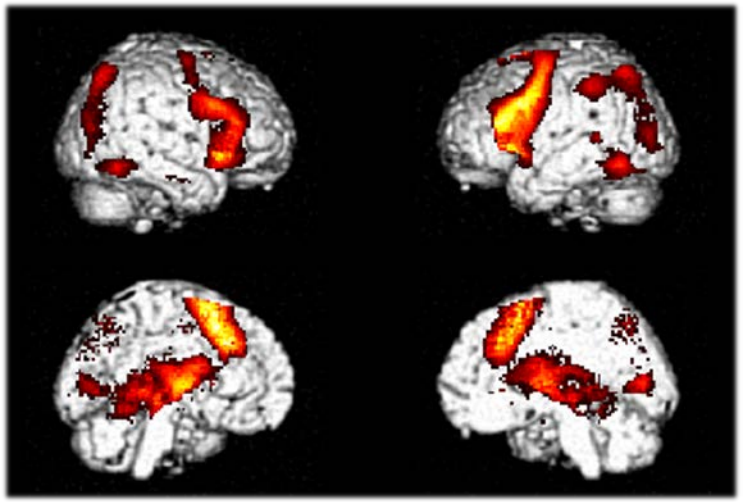
(low-vs.-high frequency)

電、報、聲、家、搖 …

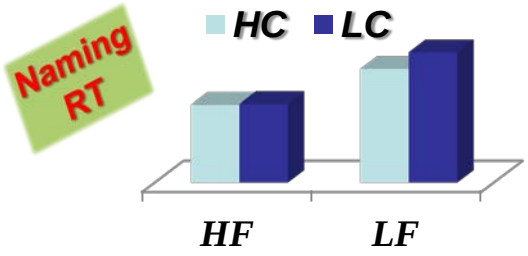
high frequency (HF)

奠、豹、甥、迦、毓 …

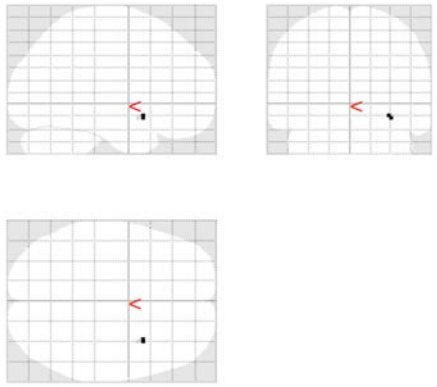
low frequency (LF)



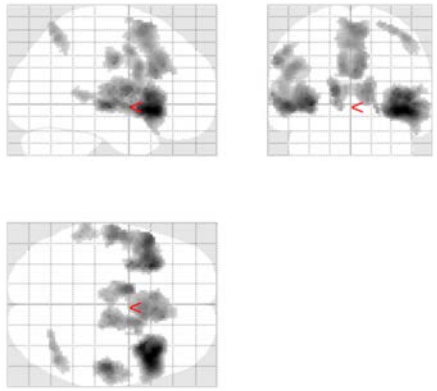
- The brain areas noted underpinned those processes adherent to frequency variation, including perceptual analysis, lexical access, …
- Both dorsal and ventral pathways …
  - ✓ The dorsal activation suggested ..
  - ✓ The ventral activation suggested …
- The inferior frontal, inferior parietal, and superior temporal activation …
- The sub-cortical activation also gave clues to …



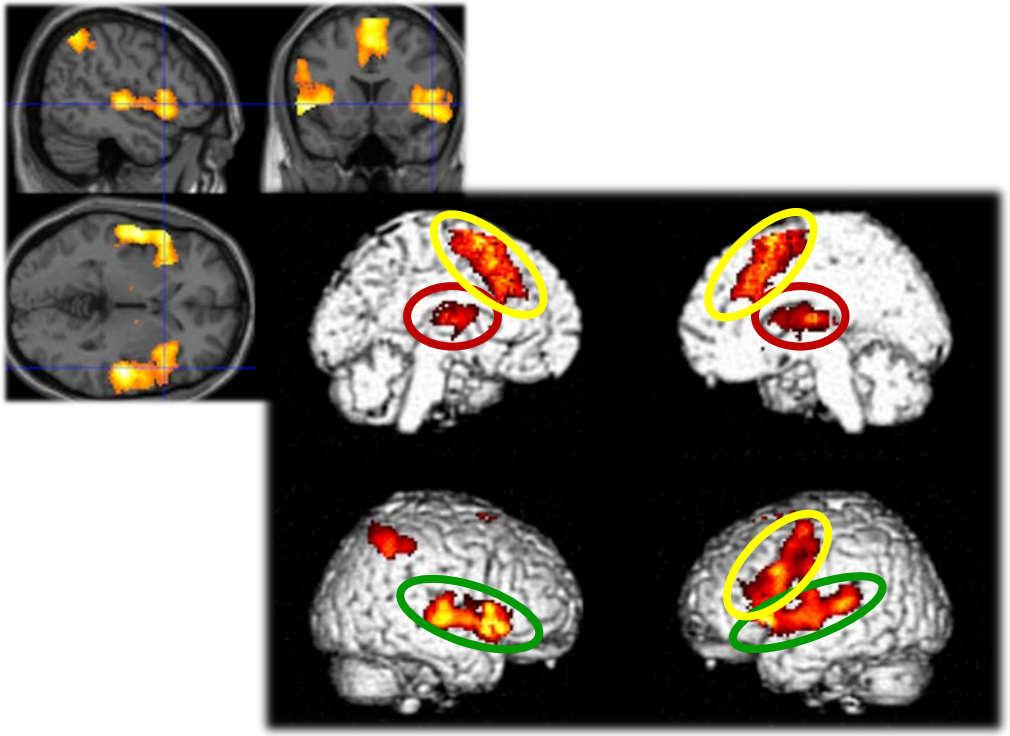
frequency-by-consistency interaction



(LC-HC) @ HF



(LC-HC) @ LF



*T*hose are brain areas constitute a network centrally to work for *transformation from orthography to phonology*.

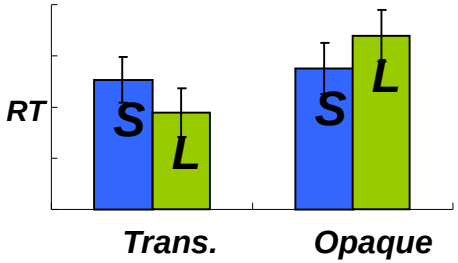
Search for a lexical control mechanism …

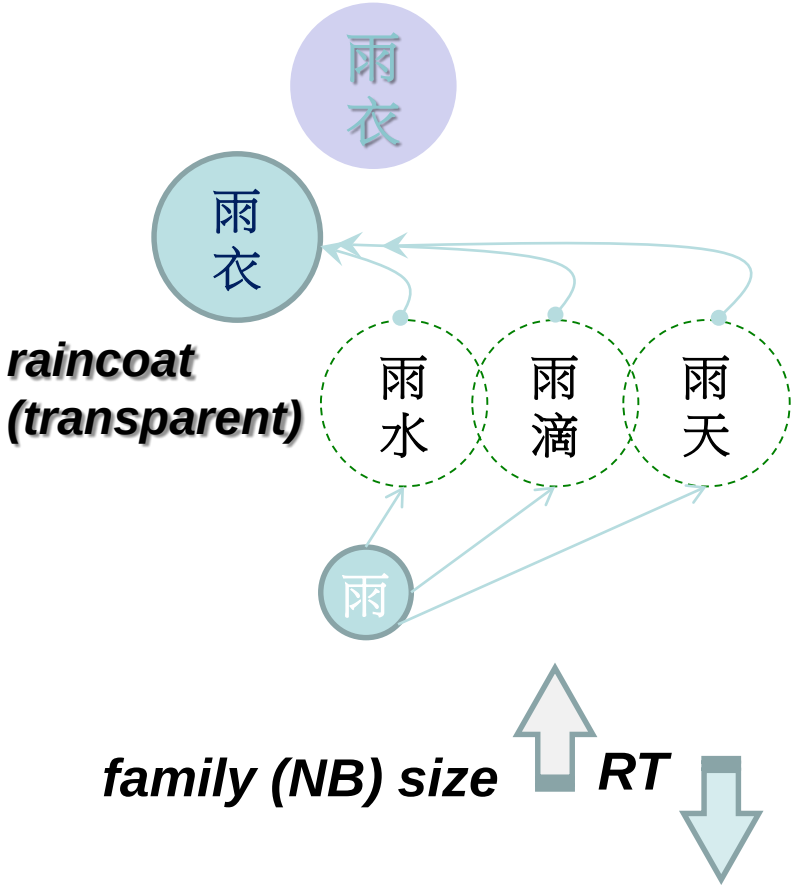
- In modern Chinese, 76% of the words are disyllabic compounds, e.g., *花園 (garden)*、*花生 (peanut)*、*騎士 (knight)*、*騎樓 (overhang)* ….
- Chinese words usually consist of characters that can be mapped onto syllables and morphemes.
- For a Chinese compound word,
  - it can come from a big or small family which shares one of the two constituent characters (sharing the first one has more impact).
  - it can be semantic transparent or opaque to its constituent characters.

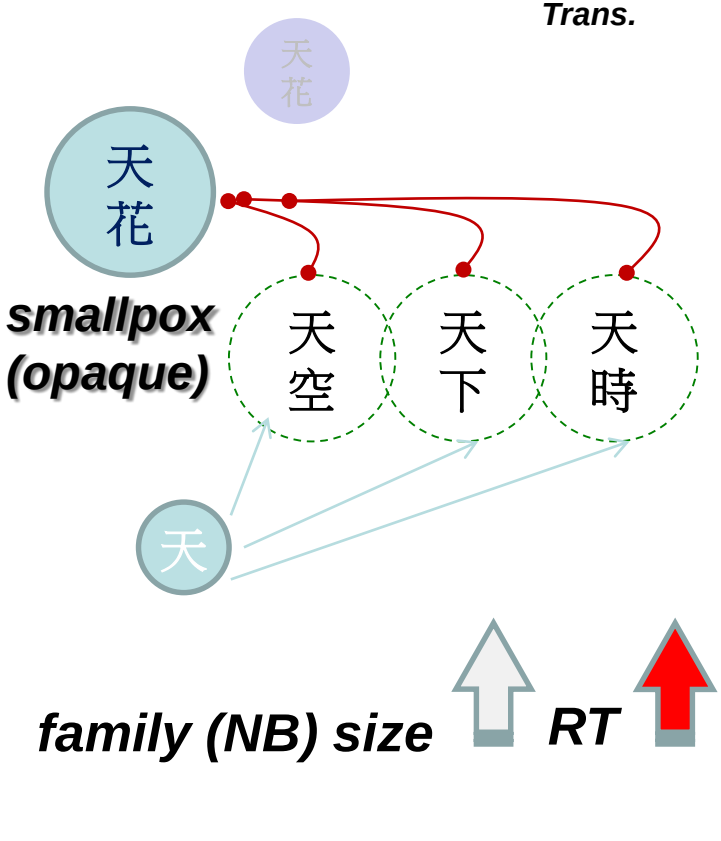
花園、花店、花草、
花束、花茶、花蕊、
花瓣、花蜜、花生…

騎士、騎樓…

The model





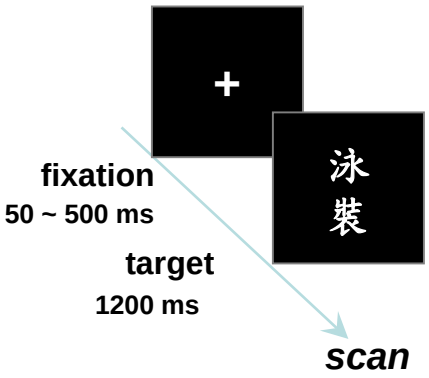


If so, a control mechanism for lexical *activation* and *inhibition* is expected.

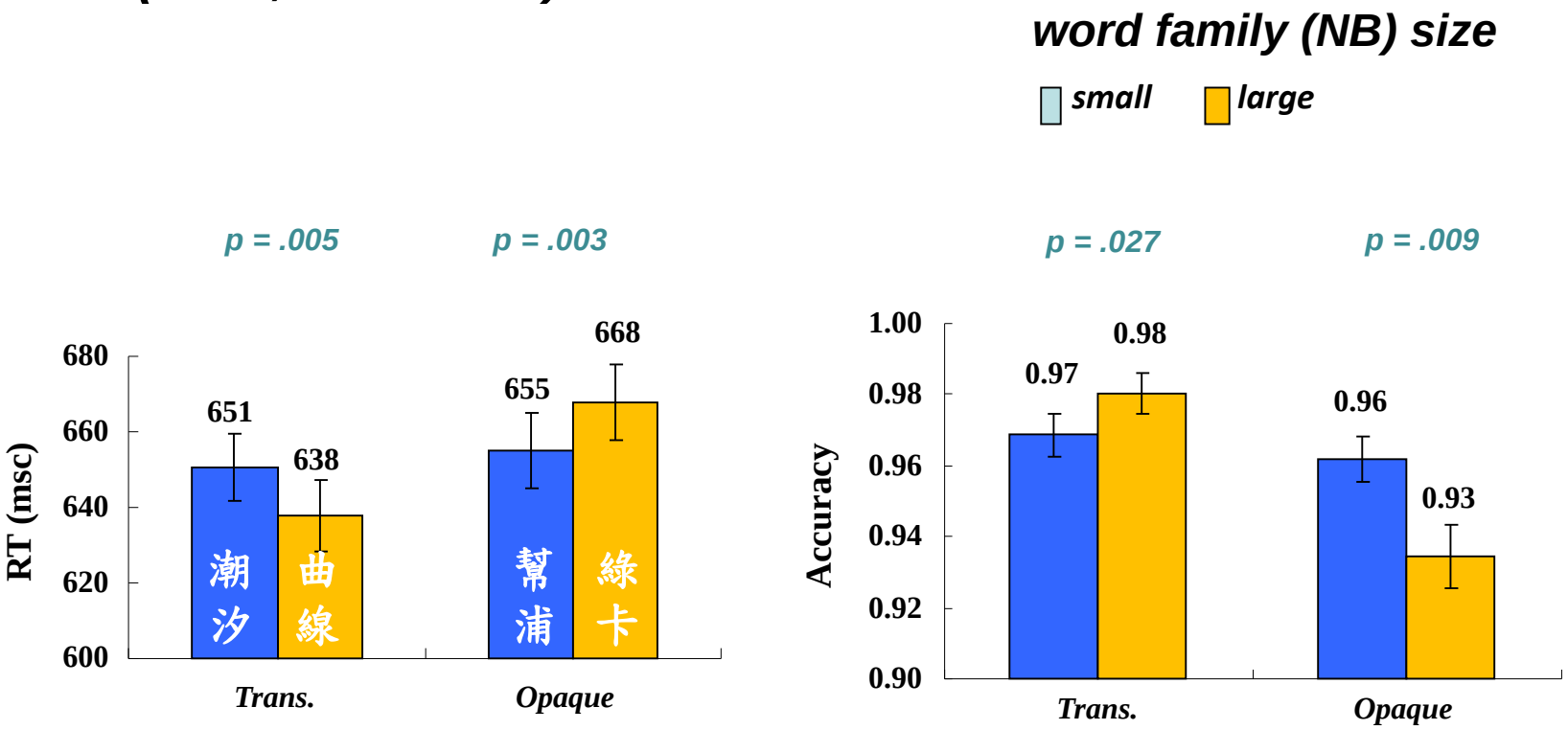
Neural effects of semantic transparency of Chinese reading

- *3T event-related fMRI paradigm*
- *28 college students volunteered for subjects*
- *Lexical decision task, reaction time and accuracy were recoded.*
- *transparency/opaqueness & family (NB) size for variables, word frequency balanced.*

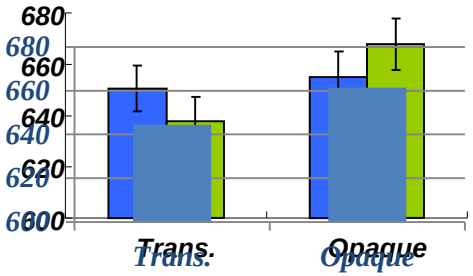
transparent words *(n=60)*	(S) 愚笨、潮汐、爬山、炊具 …. (L) 閃躲、鋼盔、曲線、皮箱 ….
opaque words *(n=60)*	(S) 蜘蛛、杜鵑、幫浦、摸魚 …. (L) 姑娘、綠卡、天花、把風 ….



Behavioral data
(n=28, 14 males)

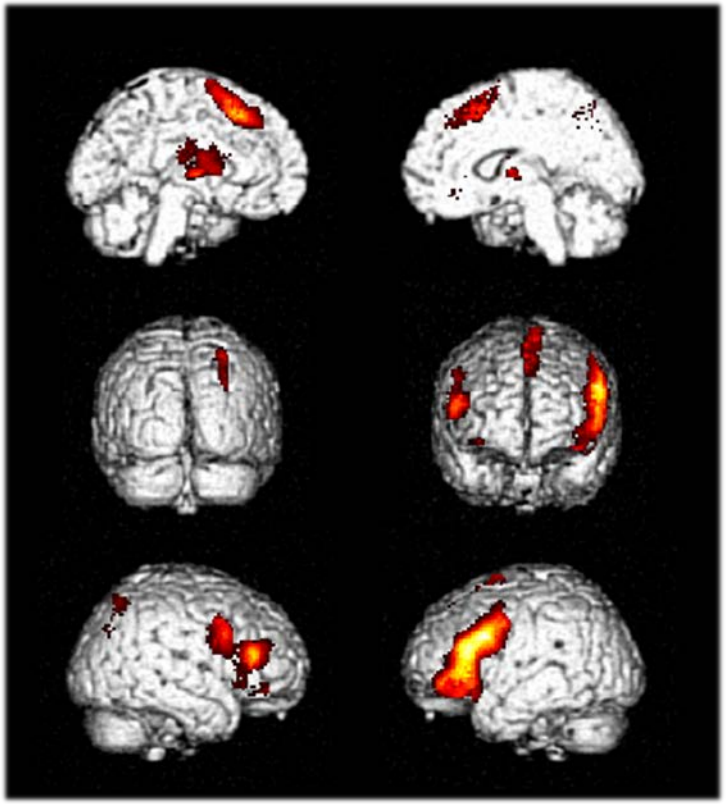


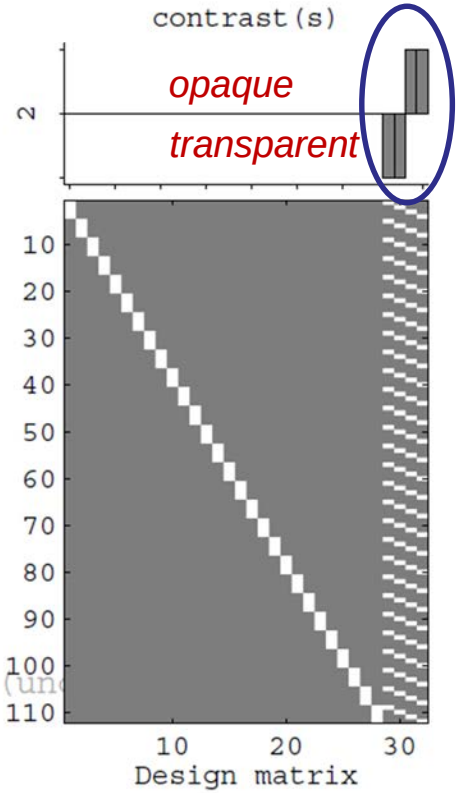
- ***RT transparent < RT opaque***
- ***Lexical activation and inhibition* was revealed.**



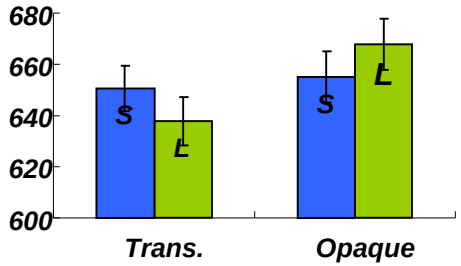
Main effects of semantic transparency

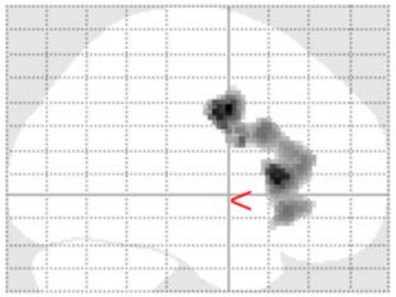
[revealed by the contrast of opaque-vs.-trans]

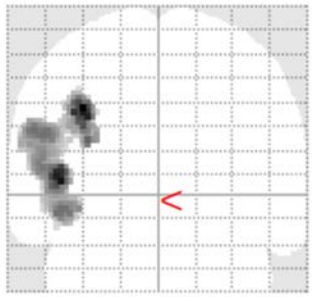




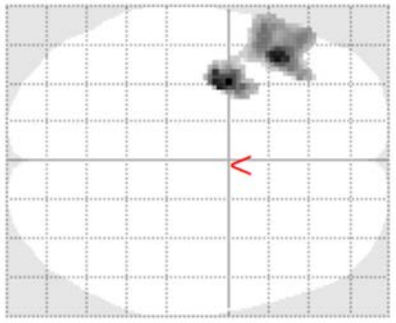
Interaction of word type and family (NB) size (1/2)

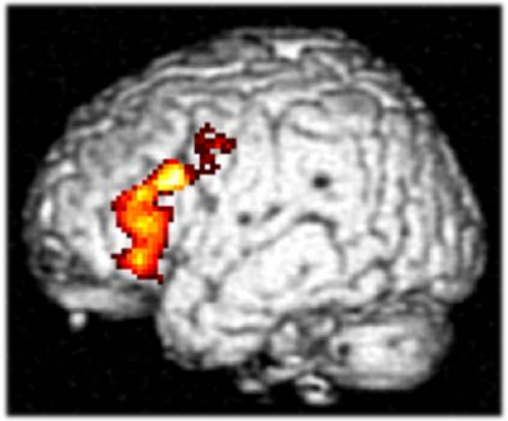


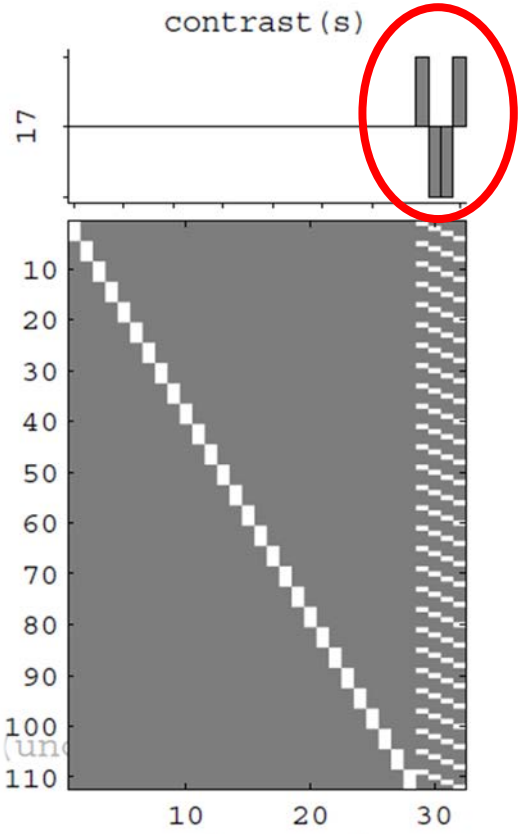




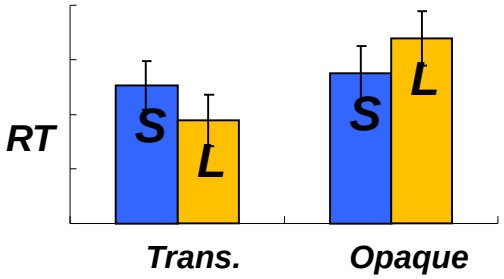
SPM(z)

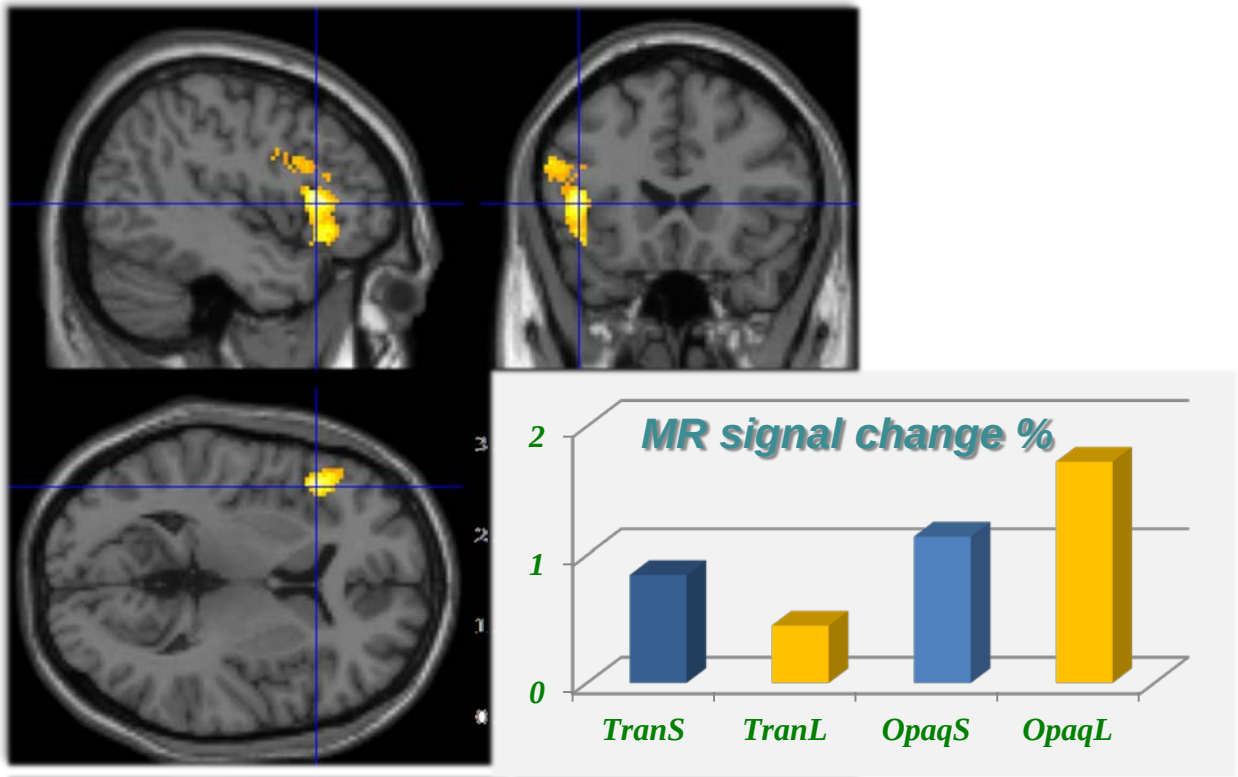






Interaction of word type and family (NB) size (2/2)





The most interesting part is the finding that there is a brain area to host interaction between different word types and family sizes, suggesting existence of a lexical control mechanism.