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探索人腦的奧秘 — 介紹功能磁力共振技術

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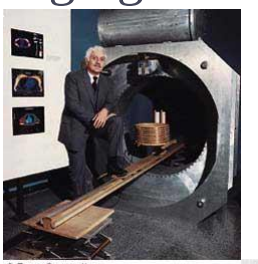
Outline

- What is MRI?磁力共振成像
- What is fMRI? 功能磁力共振成像
  - Brain activity
  - How does fMRI work?
  - What can it tell us?
  - Types of fMRI
- Uses of fMRI
  - Clinical
  - Research

Magnetic Resonance Imaging

Paul Lauterbaur

Sir Peter Mansfield



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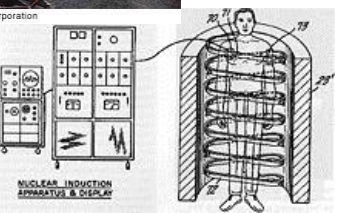
zeugmatography



What is MRI? 磁力共振成像

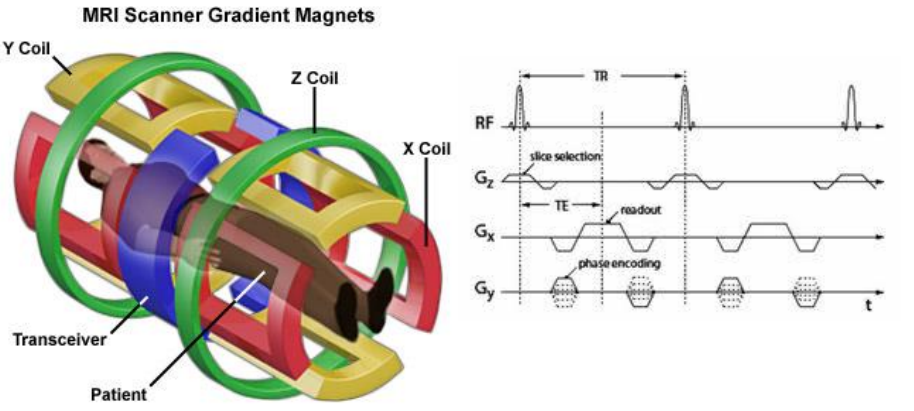
- **M**agnetic **R**esonance **I**maging，簡稱**MRI**

3T-MRI Unit
HKU

磁力共振成像

- 當把物體放置在磁場中，用適當的電磁波照射它，原子核在進動中，吸收與原子核進動頻率相同的射頻脈衝，即發生共振吸收；
- 去掉射頻脈衝之後，原子核磁矩又把所吸收的能量中的一部分以電磁波的形式發射出來，稱為共振發射。
- 由於不同的組織會產生不同的電磁波訊號，經電腦分析處理，就可以得知構成這一物體的原子核的位置和種類，據此可以繪製成物體內部的精確立體圖像

MRI Scanner



磁力共振成像

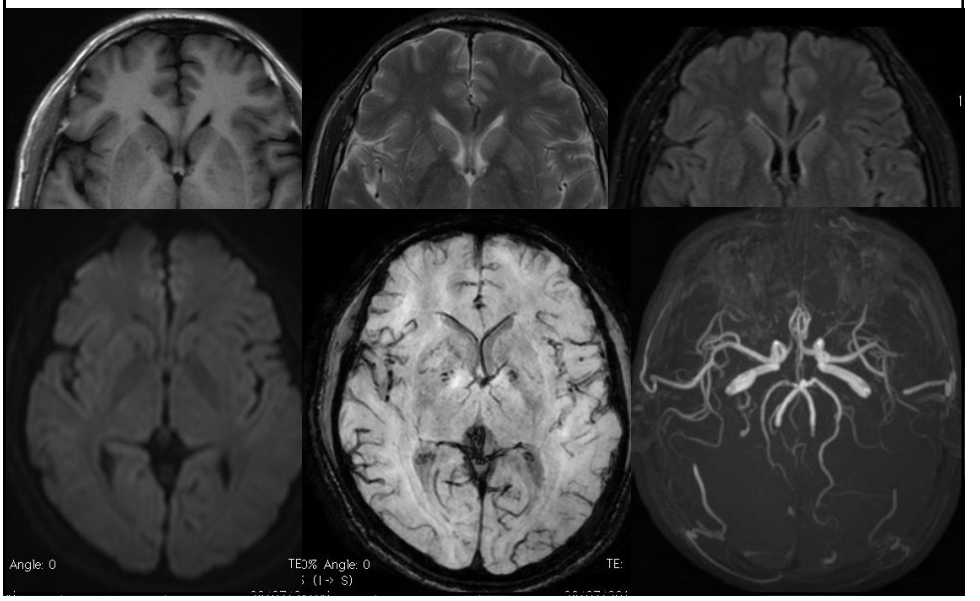
- 可對人體各部位多角度、多平面成像，其分辨力高，圖像非常清晰精細，能更客觀更具體地顯示人體內的解剖組織及相鄰關係，對病灶能更好地進行定位定性。
- 不使用 X 射線，因此對人體沒有輻射損害。

The following items can be hazardous to your safety and may also interfere with MR imaging. Please complete the following checklist by marking the appropriate box.

如體內懷有以下物體即可能不適宜進行磁力共振檢查，請小心填報下列表格：

		有/是	無/否
Cardiac pacemaker	心臟起搏器/ 除顫器	☐	☐
Brain clips/ Vascular clips	腦動脈/ 血管夾子	☐	☐
Neurostimulators	神經激動器	☐	☐
Heart valve	人工心瓣膜	☐	☐
Implanted pumps	內植胰島素泵/ 灌注泵	☐	☐
Electrodes	體內電極	☐	☐
Hearing aids/devices/implants	助聽器/ 耳內移植物	☐	☐
Shunts	體內分流器	☐	☐
Joint replacements/prosthesis	人工關節/ 義肢	☐	☐
Claustrophobia	密室恐懼症	☐	☐
History of fractured bone with metal rods, pins, screws, nails, clips	骨折金屬固定物：金屬棒螺絲、釘子、夾子	☐	☐
Metal mesh/wire sutures	金屬篩網/ 縫線	☐	☐
Permanent eyeliner tattoos	永久性紋眉	☐	☐
Dentures	假牙	☐	☐
I.U.C.D.	金屬宮內避孕器	☐	☐
Metal workers ?	工作會否接觸金屬碎片 ？	☐	☐
Any intra-corporeal metallic F.B. ?	體內有否金屬異物 ？	☐	☐

(Location of metallic F.B. if any : 如有，請說明所在部位 ：) _____

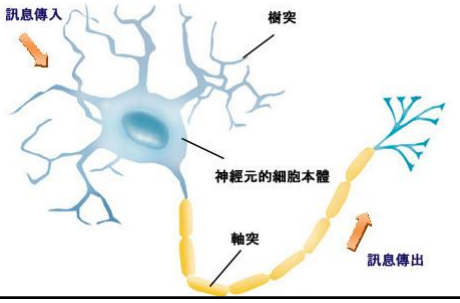


What is fMRI? 功能磁力共振成像

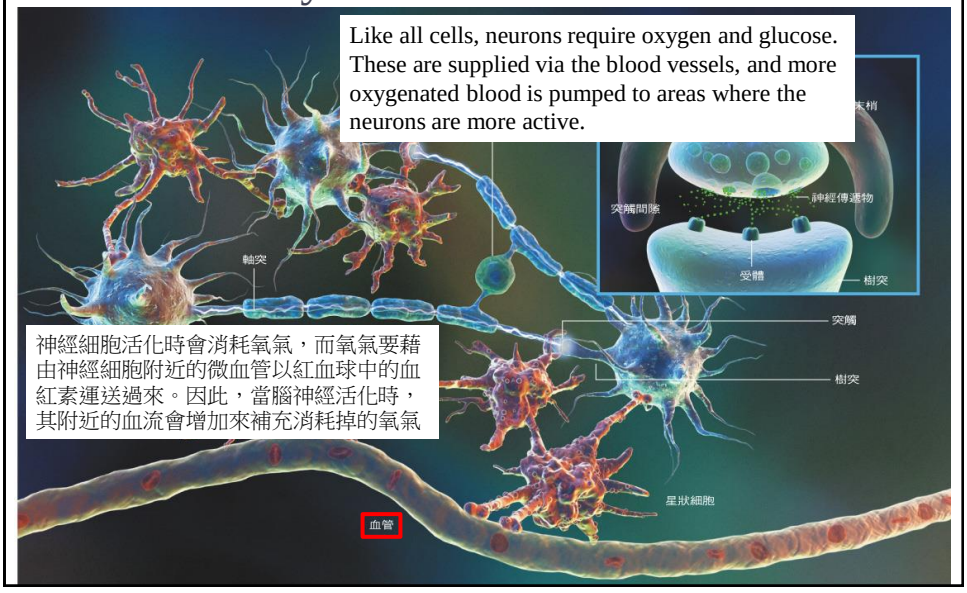
- Functional **M**agnetic **R**esonance **I**maging，簡稱fMRI
- fMRI is a neuroimaging method that can measure brain activity. 檢測人在進行各種腦神經活動時（包括運動、語言、記憶、認知、情感、聽覺、視覺和觸覺等）腦部皮層的磁力共振訊號變化，配合在人腦皮層中樞功能區定位，研究人腦思維進行的軌跡，揭示人腦奧秘。
- 其基本原理是利用MRI來測量神經元活動所引發之血液動力的改變。

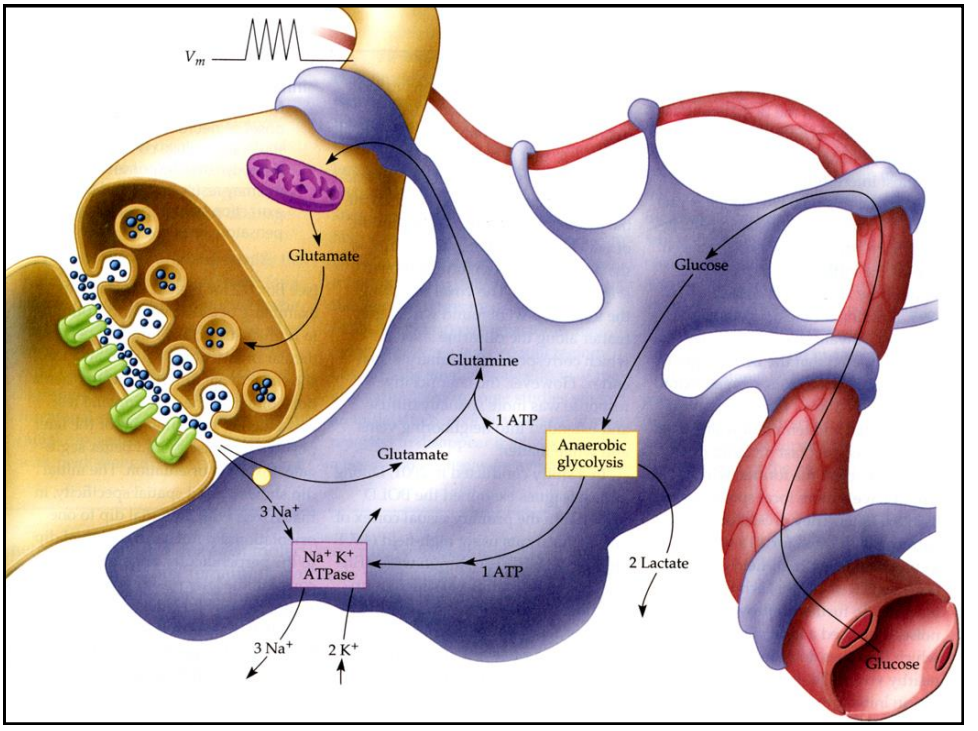
Brain activity

- There are approximately 86 billion neurons in the brain. 人的大腦大約有860億神經元
- Neurons communicate with each other by sending electrochemical signals. 神經元間以電化學信號聯繫
  - Information transferred from neuron to neuron is what allows perception, thinking, learning, and memory.

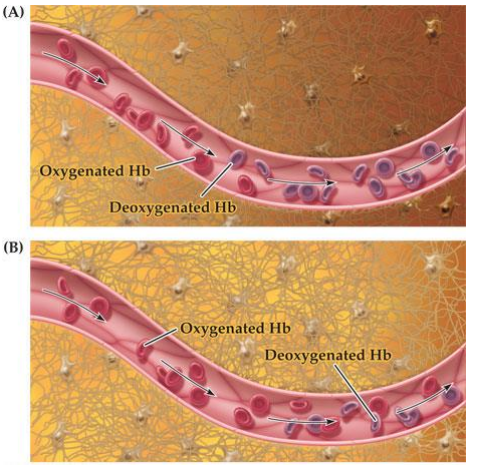


Brain activity





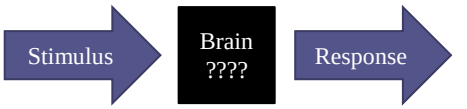
How does fMRI work?



- Inside an MRI machine, oxygenated blood appears brighter than deoxygenated blood. 帶氧血紅素比缺氧血紅素的信號亮
  - This difference is known as the blood-oxygenation-level-dependent (BOLD) contrast. （血氧濃度相依對比）
- Areas that are more active are supplied more oxygenated blood, therefore they appear brighter on fMRI scans. 活化部位的帶氧血紅素的濃度上升，在fMRI圖像上顯示高亮

What can fMRI tell us?

- In the early days of psychology and neuroscience, the brain was regarded as a "black box"; we couldn't see what was happening inside the brain, just the response to stimuli. 在早期的心理學和神經科學研究中，大腦被認為是一個"黑匣子"，我們不知道大腦裡是怎樣運作，只能看到它對外加刺激的反應

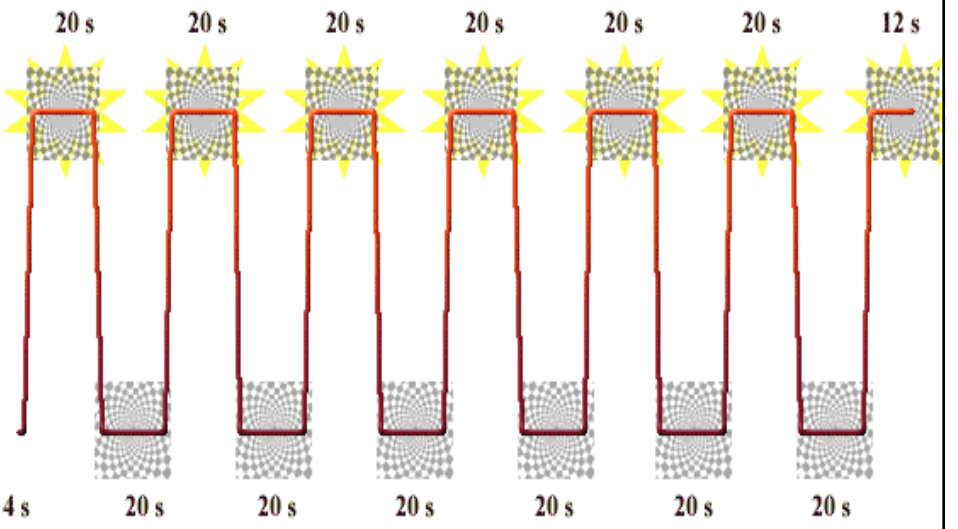


- With fMRI, we can see which areas are actually activated by different stimuli, giving us a better understanding of how the brain works. 利用fMRI，我們可以看到針對不同刺激，究竟是大腦的那個部位被激活，這使我們對大腦如何運作有了更深的瞭解

Types of fMRI

- Task-based fMRI (基於任務的fMRI)
  - Participants are asked to do tasks while in the MRI scanner and the changes in activity are used to determine which areas are responsible for each process.
  - Perceptual or cognitive task (paradigm) to perform
- Task-free (resting state) fMRI (靜息fMRI)
  - Participants are asked to lie in scanner with eyes open or closed, not thinking about anything particular. Regions of the brain that activate with the same pattern are considered to be connected to each other.

Block design



Block Design

Types of paradigm(tasks)

1. Simple:
   - Motor cortex運動皮層 (finger-thumb tapping)
   - Sensory cortex感覺皮層 (touch)
   - Broca's area布洛卡區 (picture naming)
   - Wernicke's area韋尼克氏區 (listening to spoken words)
   - Visual cortex視覺皮層 (checkerborad)

2. Complex:
   - Working memory工作記憶 (N-Black)
   - Selective attention選擇性注意 (Stroop)
   - Executive processes執行過程 (Go No-Go)

Task-based fMRI

- Task-based fMRI can be used to study:基於任務的fMRI常用於研究
  - Presurgical planning 術前計劃
  - Abnormal activity in diseased patients 病患者的反常表現
  - Memory 記憶力
  - Attention 注意力
  - Perception of faces 面部識別
  - Inhibition 抑制力
- Task-free fMRI can be used to study:靜息fMRI常用於研究
  - Connected brain networks during rest 靜息狀態下大腦的神經網絡連接

Uses of fMRI

Clinical

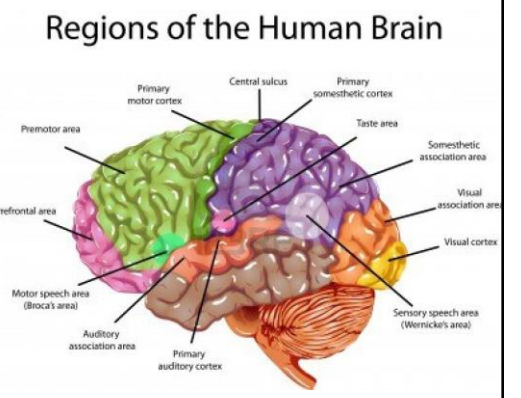
- Presurgical planning 術前計劃
  - 如腦腫瘤的患者，於手術前進行此檢查，可較準確得知腫瘤的位置，避免手術時觸及其他正常的組織，有助減低手術的風險。

Sensori-motor or Language fMRI tasks

1. Motor
2. Sensory
3. Language

Broca's area - 表達性語言

Wernicke's area - 接受性語言

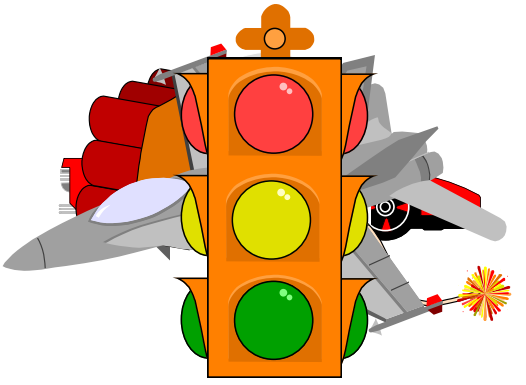


fMRI– Chinese Reading

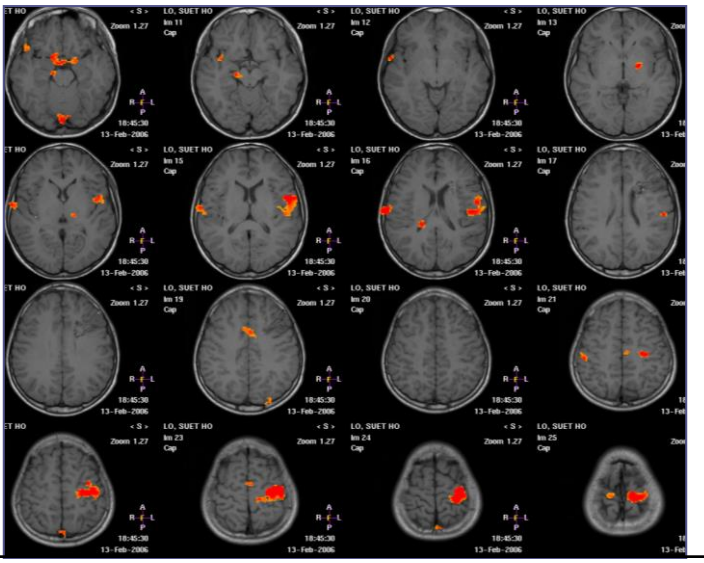
-

報紙

fMRI– Picture Naming圖片命名



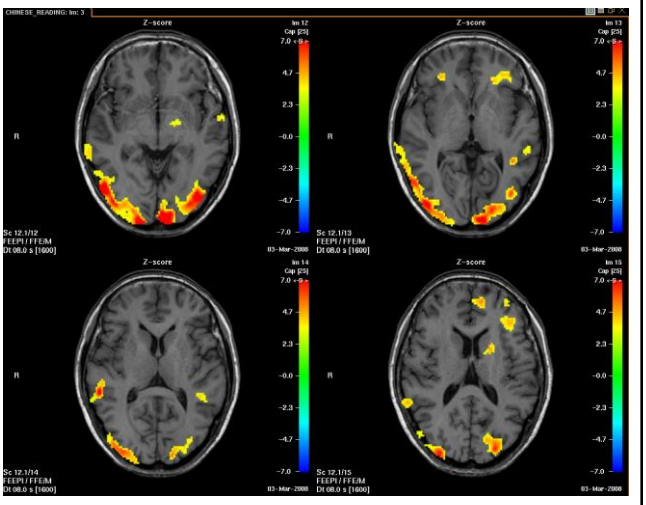
Motor Task Hand- tennis ball squeezing



Chinese reading

Bilateral superior Temporal, bilateral inferior frontal, left medial frontal gyri

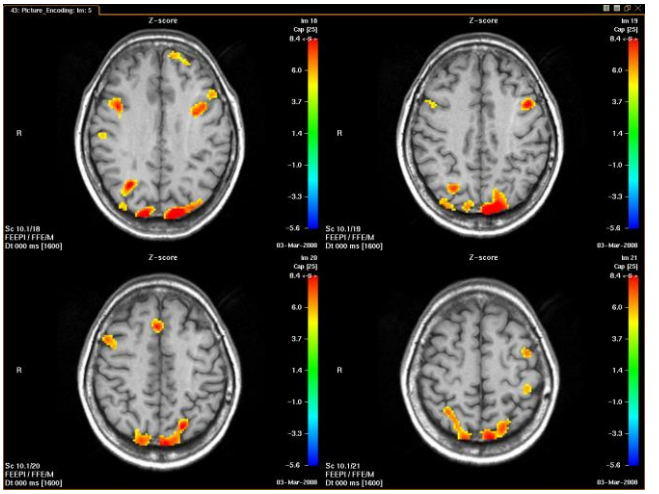
Primary visual and visual associative Cortices (視覺聯想皮層)



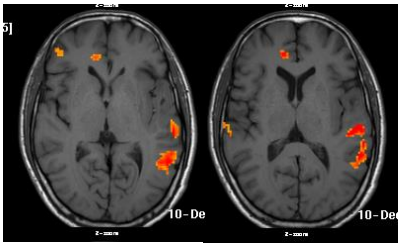
Picture naming

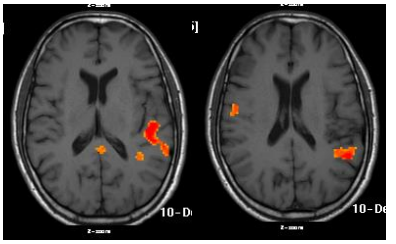
Bilateral inferior frontal, left superior frontal gyri, superior parietal lobule

Visual associative cortex



A right-handed patient with left temporal lobe tumour





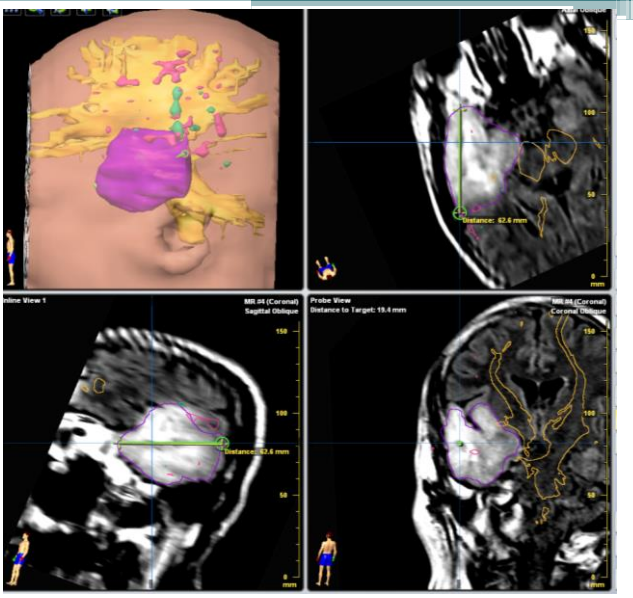
speech functional activation just posterior to the tumour

Comparison of fMRI and intra-operative cortical stimulation for speech function mapping

•Speech areas

.Tumour (腫瘤)

.Corticospinal tract
(皮質脊髓束)



Neuronavigation plan
(神經導航計劃)
- preoperative

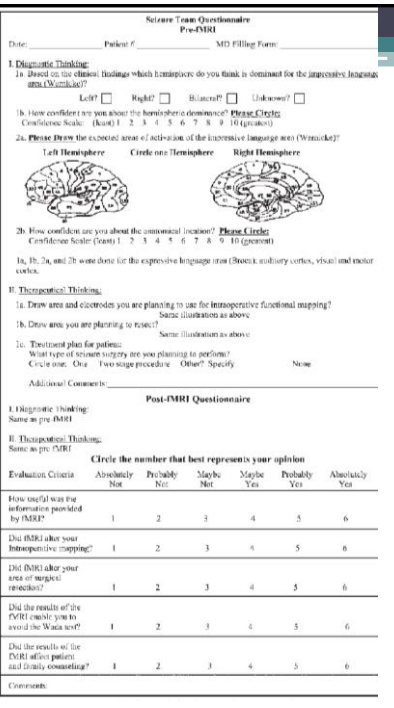
Seizure Disorders: Functional MR Imaging for Diagnostic Evaluation and Surgical Treatment—Prospective Study

TABLE 2
Study Population Demographics

Parameter	Value
Total	60
Sex*	
M	33 (55)
F	27 (45)
Age (y)†	15.8 ± 8.7
Disorder	
Seizure disorder	20
Neoplasm	14
Cortical dysplasia	12
Encephalomalacia	9
Developmental delay	2
Rasmussen encephalitis	2
Sturge-Weber disease	1

Note.—Data are numbers of patients unless otherwise indicated.
* Numbers in parentheses are percentages.
† Numbers are the mean ± standard deviation.

Medina Radiology 2005



Seizure Team Questionnaire
Pre-fMRI

Date: _____ Patient #: _____ MD Filling Form: _____

I. Diagnostic Thinking:

1a. Based on the clinical findings which hemisphere do you think is dominant for the impressive language area (Wernicke)?

Left? ☐ Right? ☐ Bilateral? ☐ Unknown? ☐

1b. How confident are you about the hemispheric dominance? Please Circle:
Confidence Scale: (least) 1 2 3 4 5 6 7 8 9 10 (greatest)

2a. Please Draw the expected areas of activation of the impressive language area (Wernicke)?

Left Hemisphere Circle one Hemisphere Right Hemisphere

2b. How confident are you about the anatomical location? Please Circle:
Confidence Scale: (least) 1 2 3 4 5 6 7 8 9 10 (greatest)

1a, 1b, 2a, and 2b were done for the expressive language area (Broca's), auditory cortex, visual and motor cortex.

II. Therapeutic Thinking:

1a. Draw area and electrodes you are planning to use for intraoperative functional mapping?
Same illustration as above

1b. Draw area you are planning to resect?
Same illustration as above

1c. Treatment plan for patient:
What type of seizure surgery are you planning to perform?
Circle one. One Two stage procedure Other? Specify None

Additional Comments: _____

Post-fMRI Questionnaire

I. Diagnostic Thinking:
Same as pre fMRI

II. Therapeutic Thinking:
Same as pre fMRI

Circle the number that best represents your opinion

Evaluation Criteria	Absolutely Not	Probably Not	Maybe Not	Maybe Yes	Probably Yes	Absolutely Yes
How useful was the information provided by fMRI?	1	2	3	4	5	6
Did fMRI alter your Intraoperative mapping?	1	2	3	4	5	6
Did fMRI alter your area of surgical resection?	1	2	3	4	5	6
Did the results of the fMRI enable you to avoid the Wada test?	1	2	3	4	5	6
Did the results of the fMRI affect patient and family counseling?	1	2	3	4	5	6

Comments: _____

TABLE 3
Changes in Functional Location or Lateralization of Language

Language Lateralization Area	Did Not Change	Did Change
Receptive (Wernicke)	38 (72)	15 (28)
Expressive (Broca)	42 (79)	11 (21)

Note.—Data are numbers of patients. Numbers in parentheses are percentages calculated on the basis of 53 patients in whom language mapping was performed.

TABLE 4
Change in Confidence Level for Prediction of Critical Brain Function

Critical Cortex	Before Imaging*	After Imaging*	*P* Value
Visual cortex	6.4 (4.4, 8.5)	9.6 (9.1, 10)	.012
Motor cortex	7.8 (7.3, 8.4)	9.3 (9.0, 9.6)	<.001
Wernicke area	7.8 (7.4, 8.3)	9.2 (8.9, 9.4)	<.001
Broca area	7.9 (7.5, 8.4)	8.9 (8.6, 9.3)	<.001

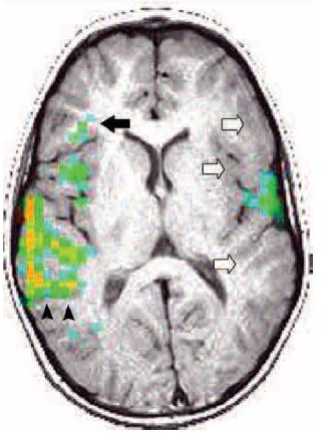
Note.—Confidence in prediction was based on the 10-point Likert scale, with 1 as the low score and 10 as the high score.
* Values are the mean Likert scores, and numbers in parentheses signify the 95% confidence interval. Imaging refers to functional MR imaging.

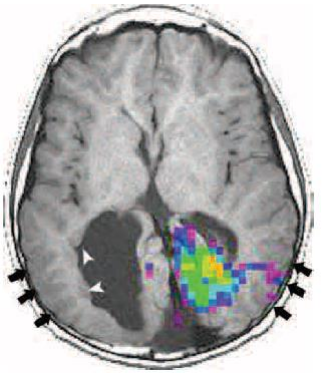
TABLE 5
Influence of Functional MR Imaging Results on Diagnostic and Therapeutic Strategies

Parameter	Did Influence*	Did Not Influence*
Altered counseling	35 (58)	25 (42)
Helped to avoid further tests	38 (63)	22 (37)
Altered intraoperative mapping†	31 (52)	29 (48)
Altered surgical plans‡	25 (42)	35 (58)

* Data are numbers of patients. Numbers in parentheses are percentages calculated on the basis of the total of 60 patients.
† Altered from stage 2 to stage 1 surgery in five patients.
‡ Altered extent of resection in four patients.

Medina Radiology 2005





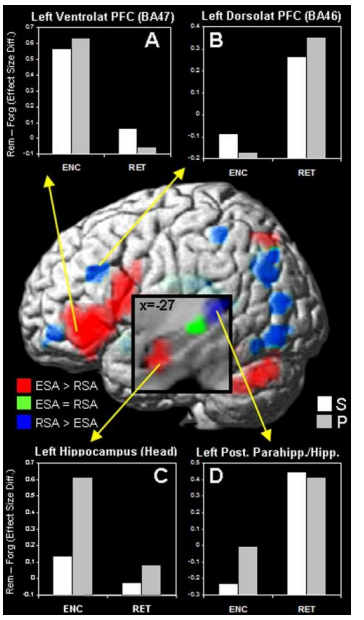
CASE 1

CASE 2

Medina Radiology 2005

Research

- Memory 記憶力
  - Working memory, memory encoding vs. retrieval – important for understanding how memory works
    記憶的編碼與喚回

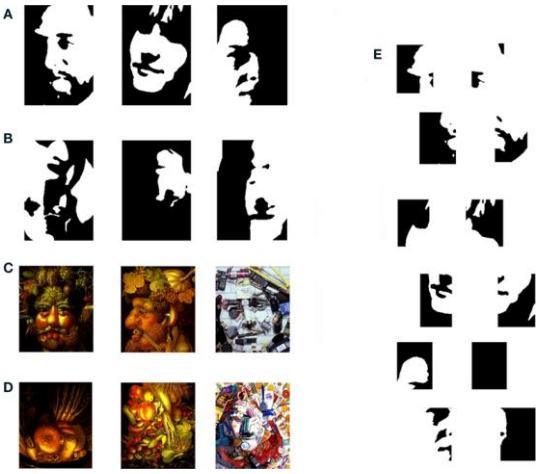


Brain regions showing differences between successful relational memory activity during encoding (ESA) and during retrieval (RSA). The bar graphs display differences in the effect size of activations for remembered versus forgotten items during encoding (ENC) (i.e., subsequently remembered(Rem) vs forgotten (Forg)) and during retrieval (RET) (i.e., hits vs misses).P, perceptual; S, semantic.

-- S. Prince, Neural Correlates of Relational Memory: Successful Encoding and Retrieval of Semantic and Perceptual Associations, The Journal of Neuroscience, 2005

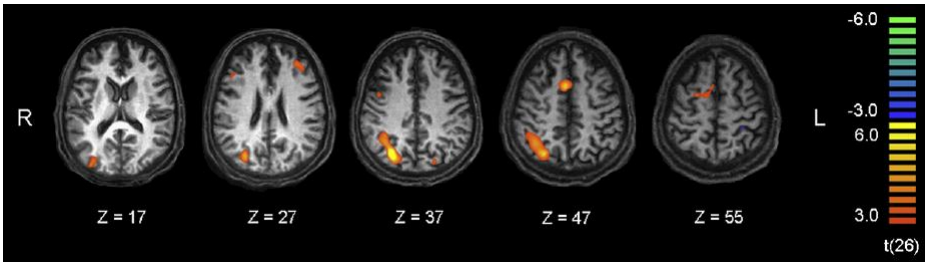
Research

- Facial recognition 面部識別



Research

- Attention 注意力
  - Attentional changes over age 隨著年齡的增長，注意力的變化

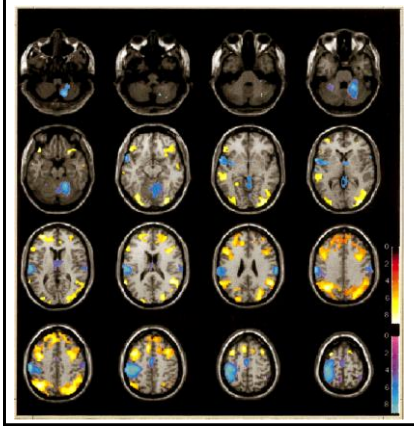


A summary of the main effect contrast of switch blocks and repeat blocks. Panels show ***activation*** in parietal cortex bilaterally, dorsolateral prefrontal cortex bilaterally, right inferior frontal junction, pre-supplementary motor area and right superior frontal sulcus, and ***deactivation*** in left post-central sulcus.

-- B. Morton, et, al,. Age-related changes in brain activation associated with dimensional shifts of attention: An fMRI study, NeuroImage, 2009

Research

- Inhibition 抑制力
  - Go/No-go task, regions engaged in making and monitoring of decisions, or in response inhibition

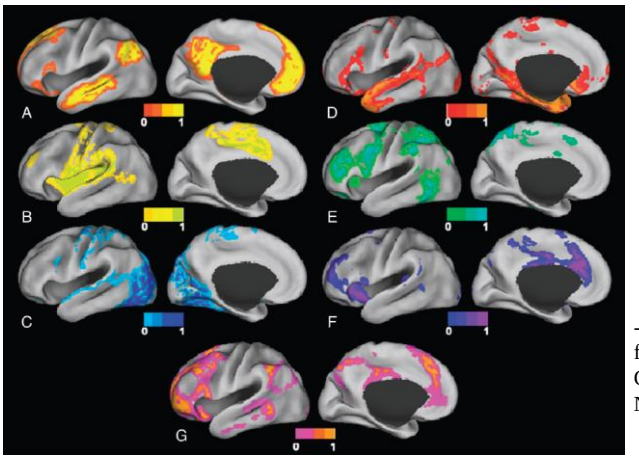


Comparison of cerebral activity during No-go trials with that during Go trials. Sites of significantly greater activation during No-go trials compared with Go trials are shown in shades of orange. Sites of significantly greater activation during Go trials compared with No-go trials are shown in shades of blue.

-- P. Liddle, et. al,. Event-Related fMRI Study of Response Inhibition, Human Brain Mapping, 2001

Research

- Neural networks 神經網絡



Surface plots of resting-state networks:
A, Default mode network.
B, Somatomotor network.
C, Visual network.
D, Language network.
E, Dorsal attention network.
F, ventral attention network.
G, Frontoparietal control network.

-- M.H. Lee, et, al,. Resting-State fMRI: A Review of Methods and Clinical Applications, AJNR Am J Neuroradiol, 2013

Summary

- What is MRI?磁力共振成像
- What is fMRI? 功能磁力共振成像
  - Brain activity
  - How does fMRI work?
  - What can it tell us?
  - Types of fMRI
- Uses of fMRI
  - Clinical
  - Research

無「病」呻吟？
症狀從何而生？

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病因不明的症狀

- 功能性疾病 **(Functional disorder)**
- 身心症/心身症 **(Psychosomatic disorder)**
- 軀體化疾患 **(Somatoform disorder)**
- 醫學上未能解釋之症狀 **MUPS/MUS (Medically unexplained symptoms)**
- **?身體症狀疾患 (DSM 5) (Somatic symptom and related disorders)**

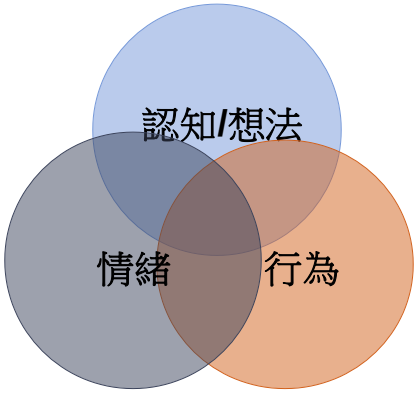
其他…

症狀多面睇－病人的反應

影響因素

- 個人經驗
- 別人經驗
- 有其他疾患
  - 性格
  - 傳媒

症狀多面睇－病人的反應



症狀多面睇－病人的反應

想法: (視乎症狀)

- 沒有大問題
- 可能因為.....(如：睡眠不足，食錯嘢等等)
- 不知有沒有問題，是否大病的初期病徵？
- 如果有大病，早醫早着
- 如果有大病我就..... (災難化)

症狀多面睇－病人的反應

情緒

- 平靜
- 疑惑
- 擔心
- 焦慮
- 不忿

症狀多面睇－病人的反應

行為

- 順其自然
- 與親人/朋友傾訴 → 支持/改變想法
- 自行服藥/其他治療
- 看醫生

看醫生後的結果

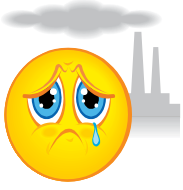
- 有XX病 → 醫治，心境平靜
- 未能確診， 針對徵狀觀察
- 未能確診，建議做其他檢查如驗血、X-光、超聲波等等
- 結論:
  1. 確診XX病 → 醫治
  2. 沒有發現任何病症 → 安心/更焦慮

症狀持續而又未能解釋原因

？？？

有沒有隱疾?
醫生有無睇漏?

Cancer!



迷思

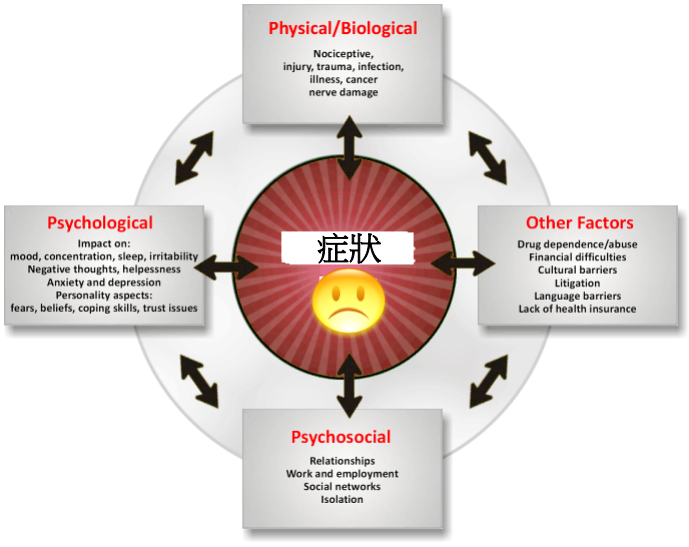
1. 單一因果關係
2. 沒有症狀我才可以工作
3. 未能解釋是因為未檢驗清楚
4. 未完全復原是因為未遇到一個適合的醫生
5. 身體不舒服便一定要休息

行為

- 繼續尋求解釋
- 尋求不同種類的治療

→ ±標籤 (視乎症狀及反應而定)

→ 安心/更迷惘

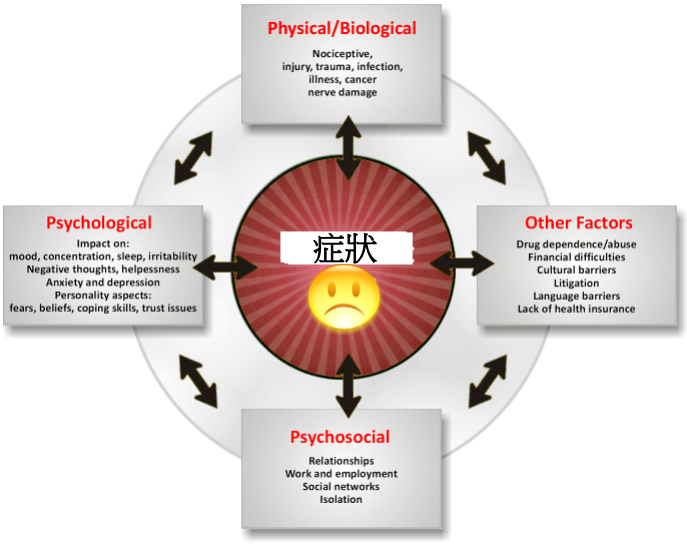


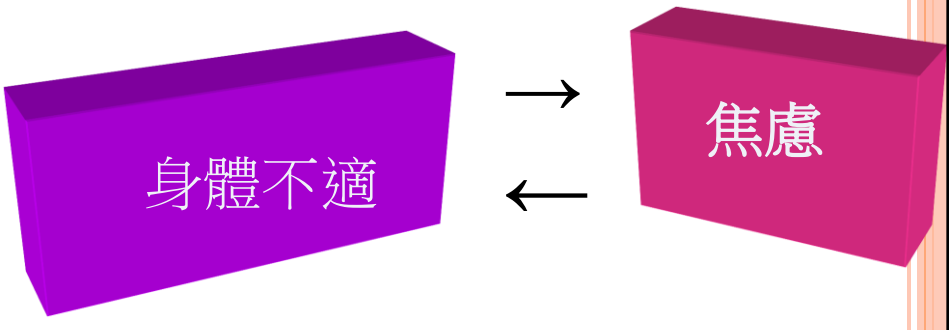
文獻的研究結果

1. 每個病人不同－非單一因素
2. 成為醫療架構的「孤兒」
3. 與壓力、焦慮、抑鬱有關聯
4. 有部份求診者合乎焦慮症/抑鬱症
5. 病者與醫生都可能覺得困擾
6. 病患者與非患者面對問題/困難有不同應對方法

學術上有不同的解釋

1. 患者太專注身體的不適
2. 因以往的經驗而增加不適的敏感度
3. 常懷負面思想－可能與成長經歷有關
4. 免疫系統失調
5. 訊息篩選理論
6. 病者對不適的信念及反應
7. 自主神經系統失調
8. 誘發因素、引發因素、持續因素


Physical/Biological
Nociceptive,
injury, trauma, infection,
illness, cancer
nerve damage
Psychological
Impact on:
mood, concentration, sleep, irritability
Negative thoughts, helpessness
Anxiety and depression
Personality aspects:
fears, beliefs, coping skills, trust issues
症狀
Other Factors
Drug dependence/abuse
Financial difficulties
Cultural barriers
Litigation
Language barriers
Lack of health insurance
Psychosocial
Relationships
Work and employment
Social networks
Isolation

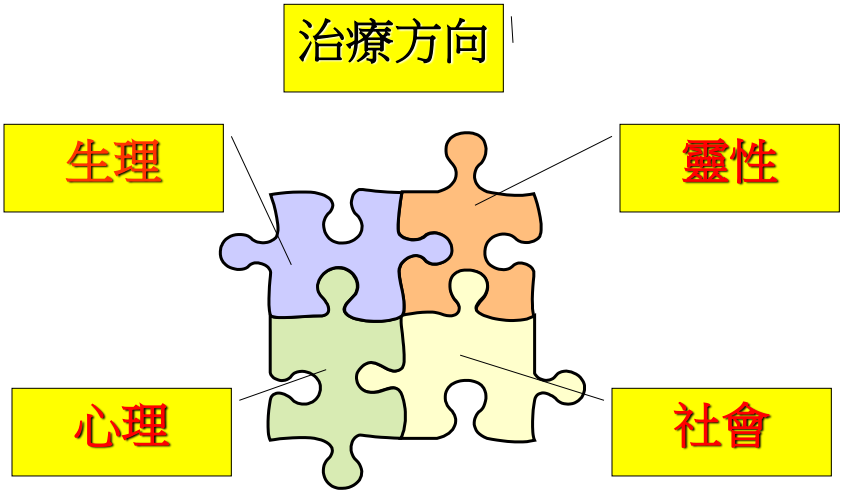

身體不適
焦慮

焦慮 →

- ↑腎上腺素－心跳、血壓上升、出汗..
- ↓CO_2－血管收縮→暈眩、麻痺..
- 呼吸困難

有以上症狀→加倍緊張→增加症狀→.....

惡性循環



治療方法－因人而異

1. 接受現況/限制
2. 盡量保持正常生活
3. 避免向不同醫生求診/反覆體檢
4. 提升面對問題的智慧
5. 藥物如鎮靜劑/抗抑鬱藥(如醫生建議)
6. 心理輔導
7. 其他
8. **依醫生指示定期觀察**

案例

1. 差不多每天晚飯後肚痛的小孩
2. 常常頭痛的青少年
3. 腰部劇痛的女士
4. 腸胃不適的男士
5. 吞嚥困難的六十多歲女士
6. 耳鳴的男士

祝大家

有一顆平靜安穩的心
做一個健康快活人

謝謝!