

FUNCTIONAL MAGNETIC RESONANCE IMAGING 功能性磁振 造影

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fMRI

- ⦿ a type of specialized MRI scan.
- ⦿ measures the hemodynamic response
- ⦿ <http://www.youtube.com/watch?v=PYgO9mPA8fA>

History

- ◎ 1990 小川誠二 Blood-oxygen-level dependence (BOLD)
- ◎ 1991 use Gadolinium
- ◎ 1992, three papers were published using endogenous BOLD contrast MRI.

(Peter Bandettini, 鄺健民, Dr. Ogawa)

Principle

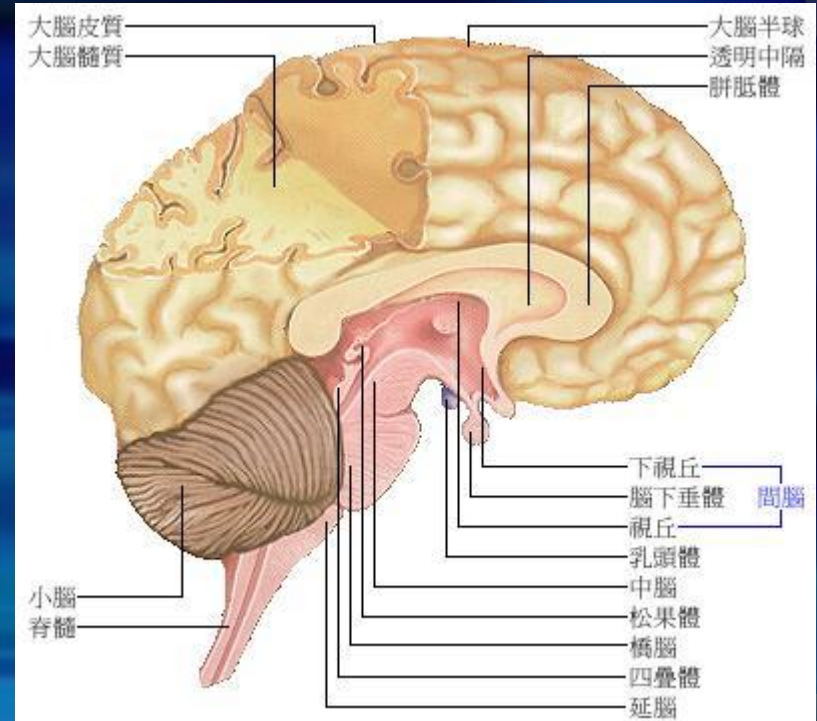
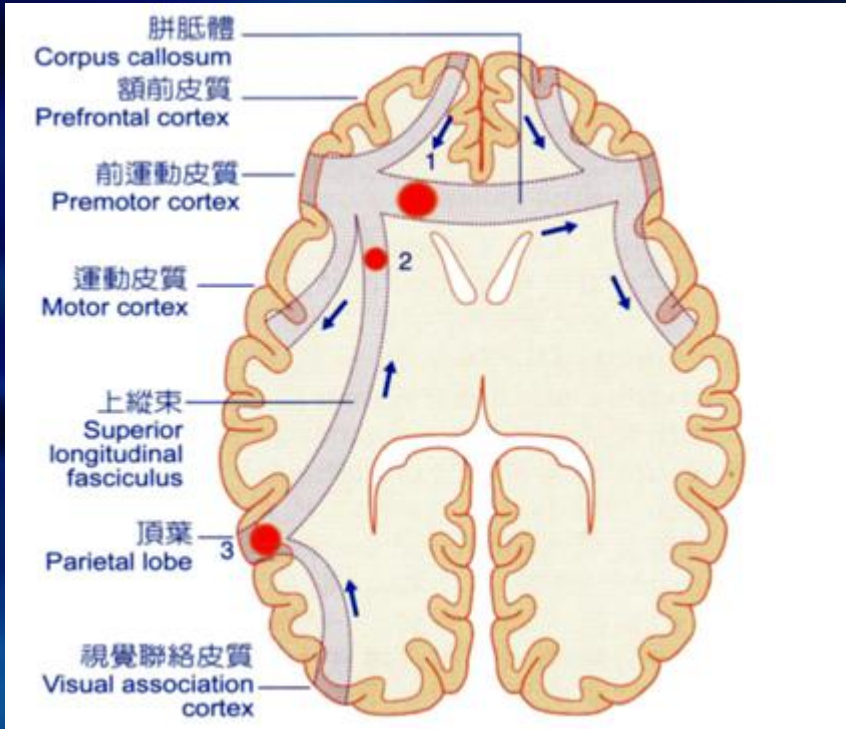
- ⦿ Hemodynamic response & Cranial nerves
- ⦿ BOLD fMRI signal
- ⦿ Deoxyhemoglobin
- ⦿ Oxyhemoglobin

Hemodynamic response

血液動力學反應

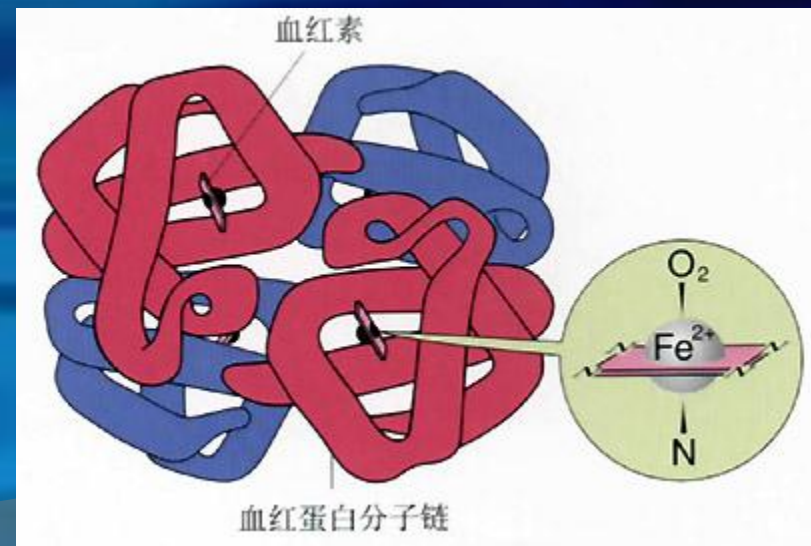
- ◎ Heart rate
- ◎ Heart pressure
- ◎ Stroke volume
- ◎ Cardiac output

Brain



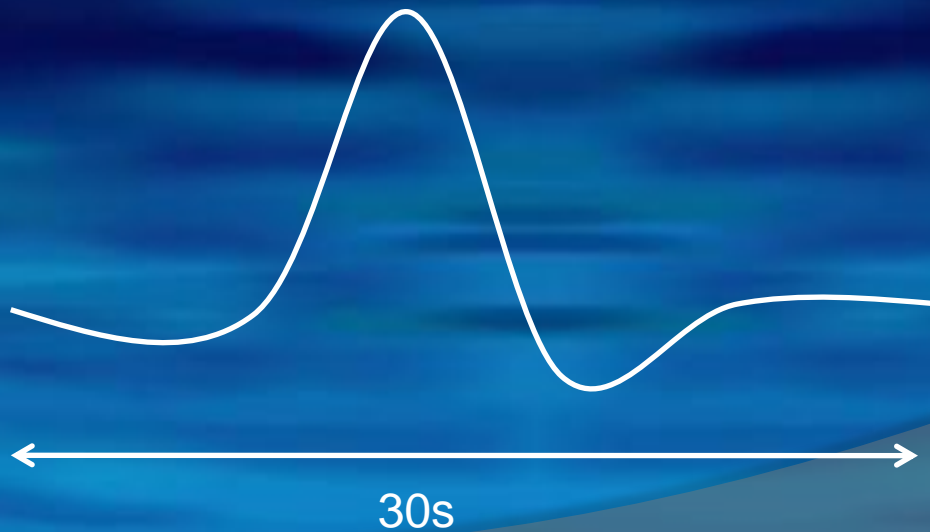
Principle(cont.)

- ◎ Deoxyhemoglobin: paramagnetic
- ◎ Theoretically, 訊號變弱
- ◎ Real: 血管擴張，血液補償，反而使訊號增強



BOLD SIGNAL

- ⦿ Initial dip
- ⦿ Peak
- ⦿ Undershoot



Resolution

- ◎ Spatial resolution

Few hundred microns (limited by capillaries distribution)

normally we use 1mm~4mm

- ◎ Temporal resolution

500~3000ms Activity based on slower change of vascular system.

Signal to Noise Ratio

- ⦿ MR signal
- ⦿ Thermal variability
- ⦿ Physiological variability
- ⦿ Raw SNR
- ⦿ Functional SNR

Application

- ◎ 1. 腦腫瘤診斷---確定腦瘤邊界
- ◎ 2. 腦功能研究
- ◎ 3. 新功能開發---測謊器

1. 腦腫瘤診斷---確定腦瘤邊界

- * 腫瘤強化區、瘤間區、正常區各區的信號值(DWI)有差異。
- * 盡可能準確的測得病灶範圍：
手術切除、放射治療---保護腦部功能
- * 預估精準度可高達97%以上。

2. 腦功能研究

*例子一：手術中主要運動區的監測

對腦腫瘤切除後主要運動區（M1）的功能能否恢復，以及運動功能是否能改善進行研究。

如轉移性腦瘤患者，腫瘤位於或鄰近M1區，經過“清醒”手術，手術過程中進行皮層映射和連續的任務監測，並同時以功能性MRI成像，觀察大腦行為的變化。即時觀察手術中M1功能異常的患者，在腫瘤的切除後M1功能的恢復和運動功能的改善。

* 例子二：認知行為

認知行為通常牽扯到心理問題，例如有些人看到熟悉的景象時會有欣喜之感。

但是，心理現象的形成畢竟來自大腦，而fMRI成像技術能夠觀察到在這些情況發生時，大腦「實際上產生的變化」，進一步瞭解大腦的運作原理，也就是直接探究這些認知、情緒反應的源頭。

3. 新功能開發——測謊器

- * 額葉內的神經會有明顯起伏
- * 偵測的是「腦神經反應」；
有別於傳統測謊器間接測量心跳、呼吸、血壓或汗液是否增多等生理變化。
- * 「號稱」準確率高達99%，但技術上依然有待克服。

腦功能研究 實驗設計

- ◎ Blocked design
- ◎ Event-related design

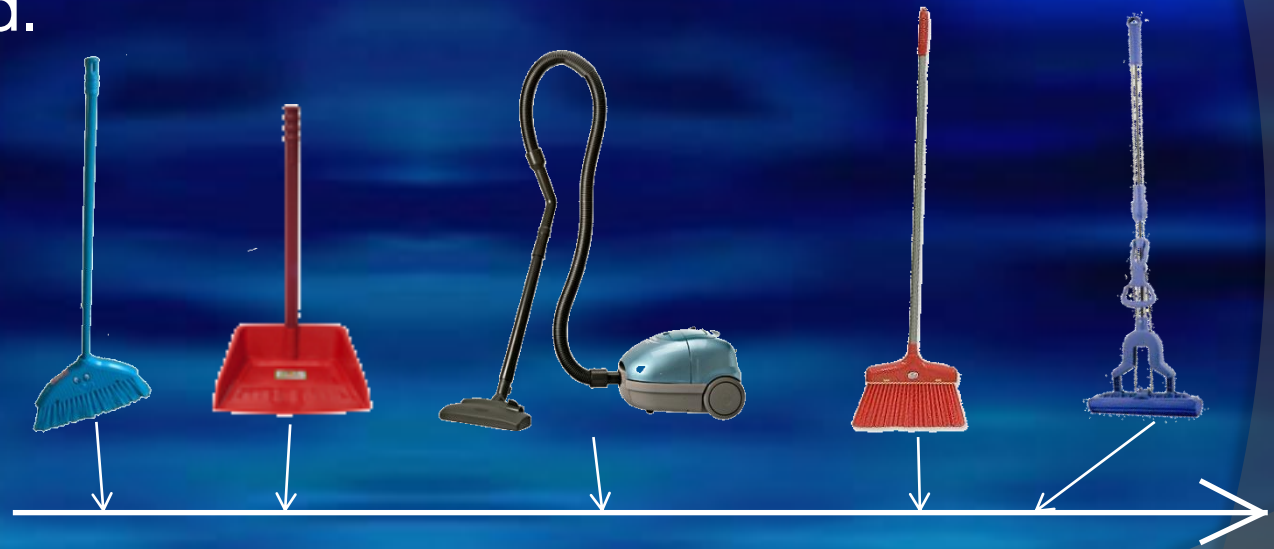
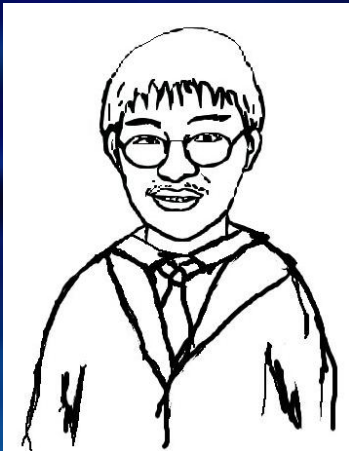
Blocked design:

- The separation of experimental condition into distinct blocks, so that each condition is presented for an extended period of time.



Event-related design:

- The presentation of discrete, short-duration events whose timing and order may be randomized.



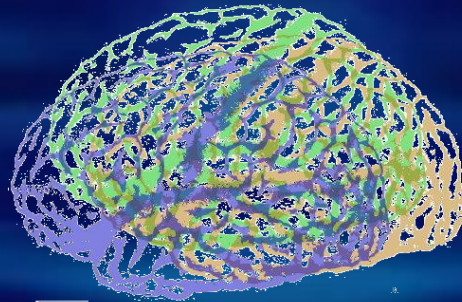
$$\text{[Gaussian Pulse]} * \text{[Dirac Delta]} = \text{[Gaussian Pulse]}$$

Preprocessing

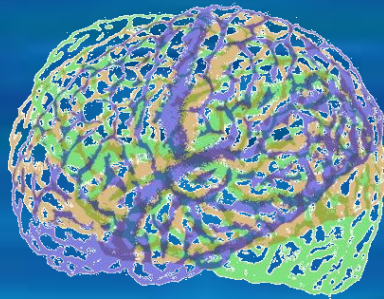
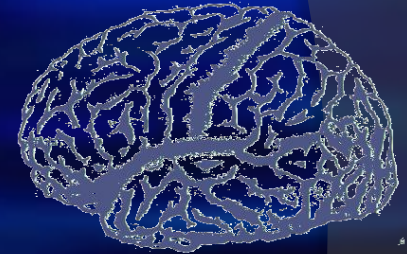
- ⦿ Realignment
- ⦿ Normalization
- ⦿ Filtering

Realignment:

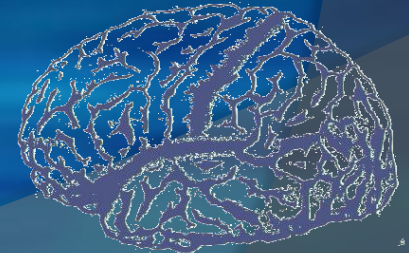
- Head motion prevention & correction



Translation

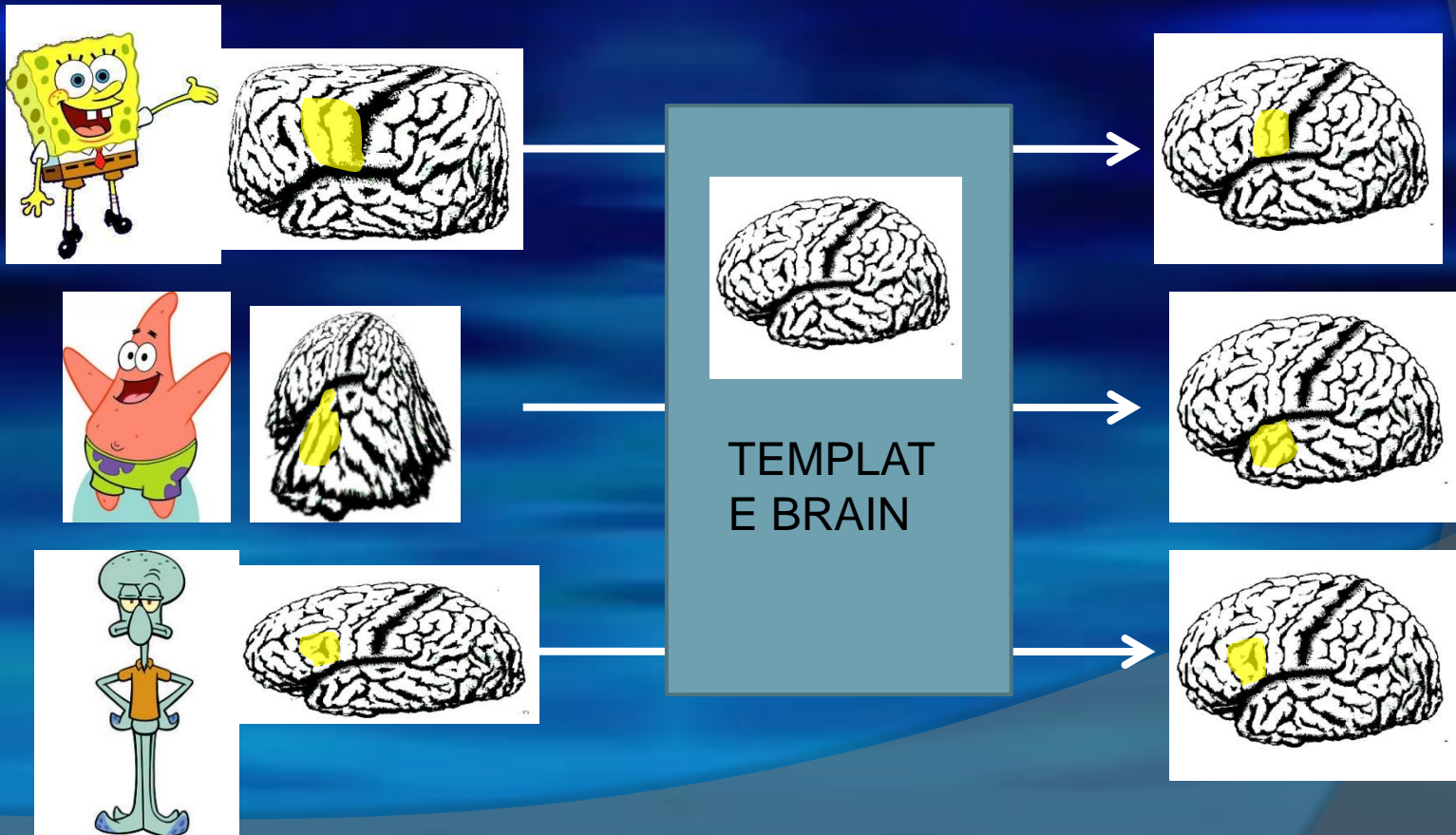


Rotation



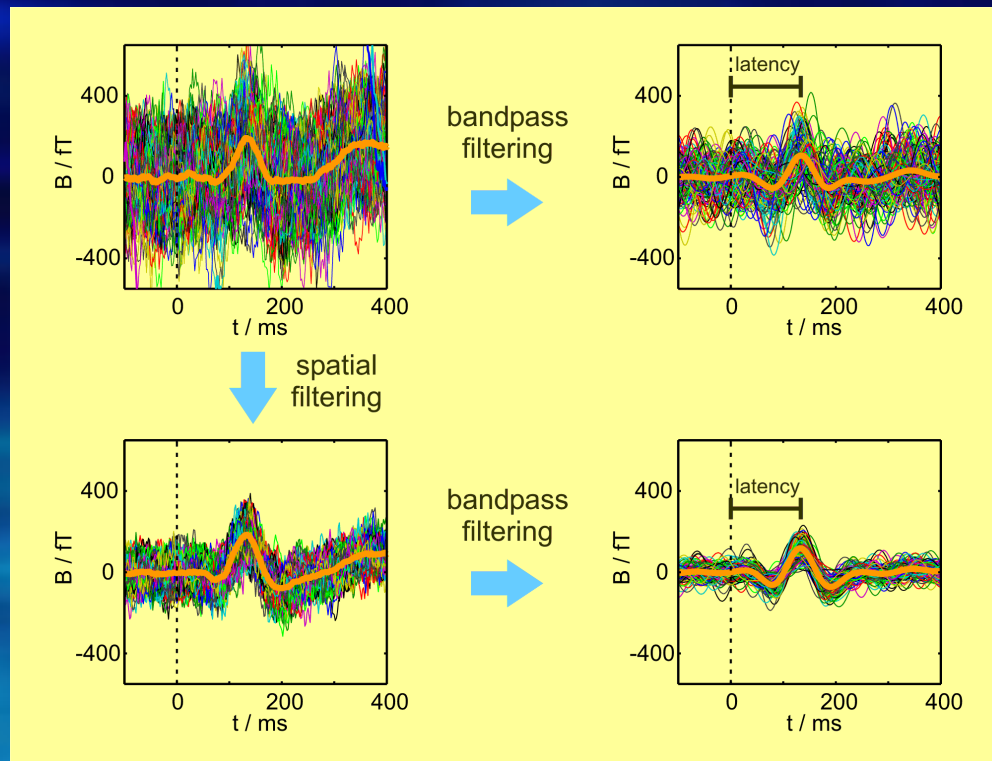
Normalization:

- to match the spatial properties of a standardized template brain.



Filtering:

⦿ Temporal & Spatial filtering



Ref

- ◎ 王君,劉嘉-功能性磁共振成像的應用和發展前景
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<http://www.pt.ntu.edu.tw/wu/exphysiol/ch2/1/6R1.htm>
- ◎ Wikipedia
- ◎ Scott A.Huttel, Allen W Song, Gregoruy McCarthy .Functional Magnetic Resonance Image 2nd