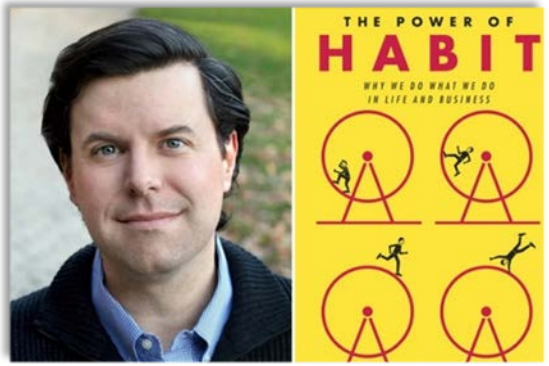


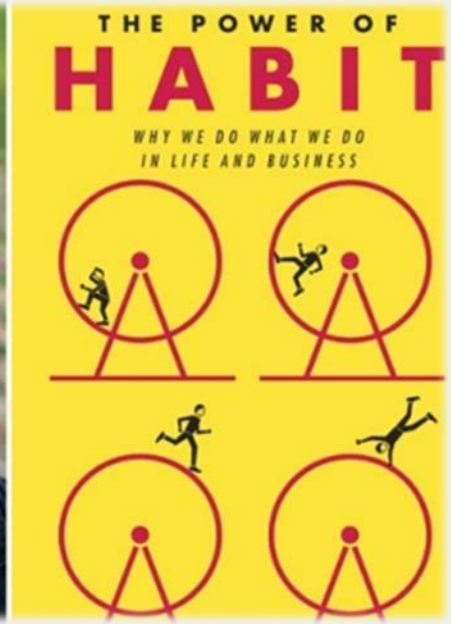
為什麼我們這樣生活，那樣工作?

人類習慣學習的神經機制

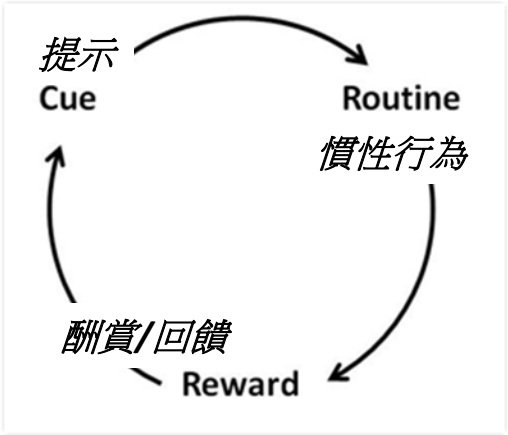
Habit Learning System in Humans

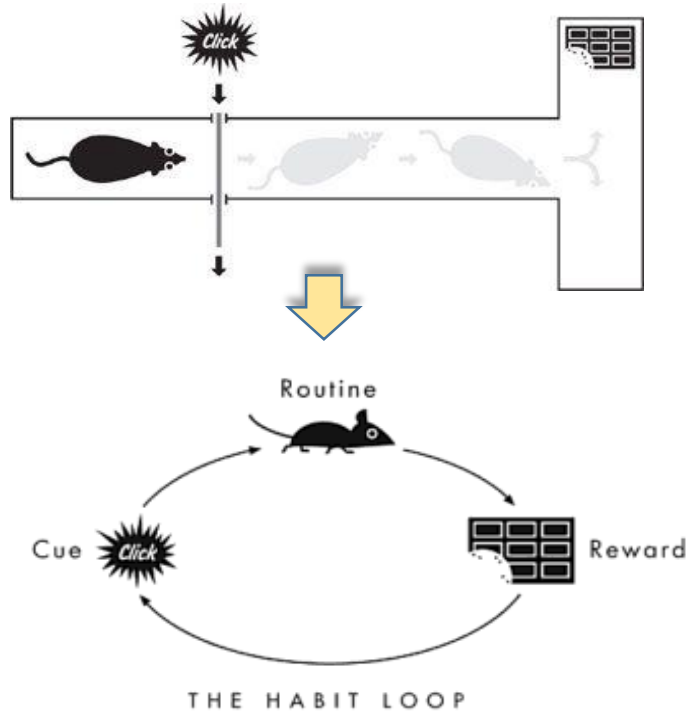
郭文瑞 副教授

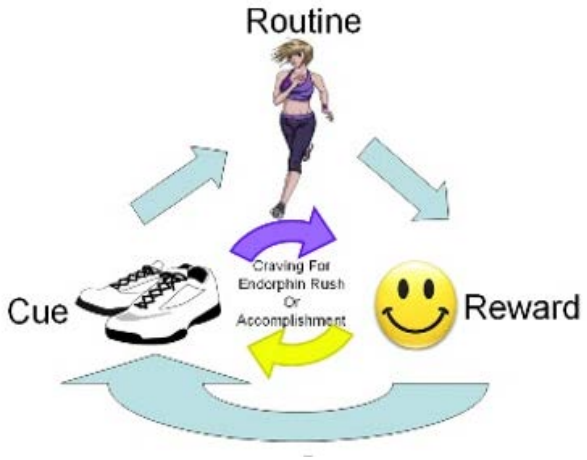
國立陽明大學神經科學研究所

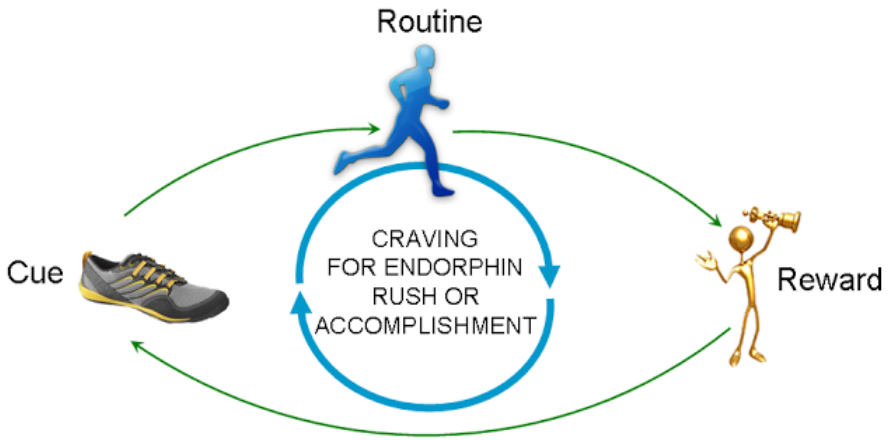


為什麼我們這樣生活，那樣工作?





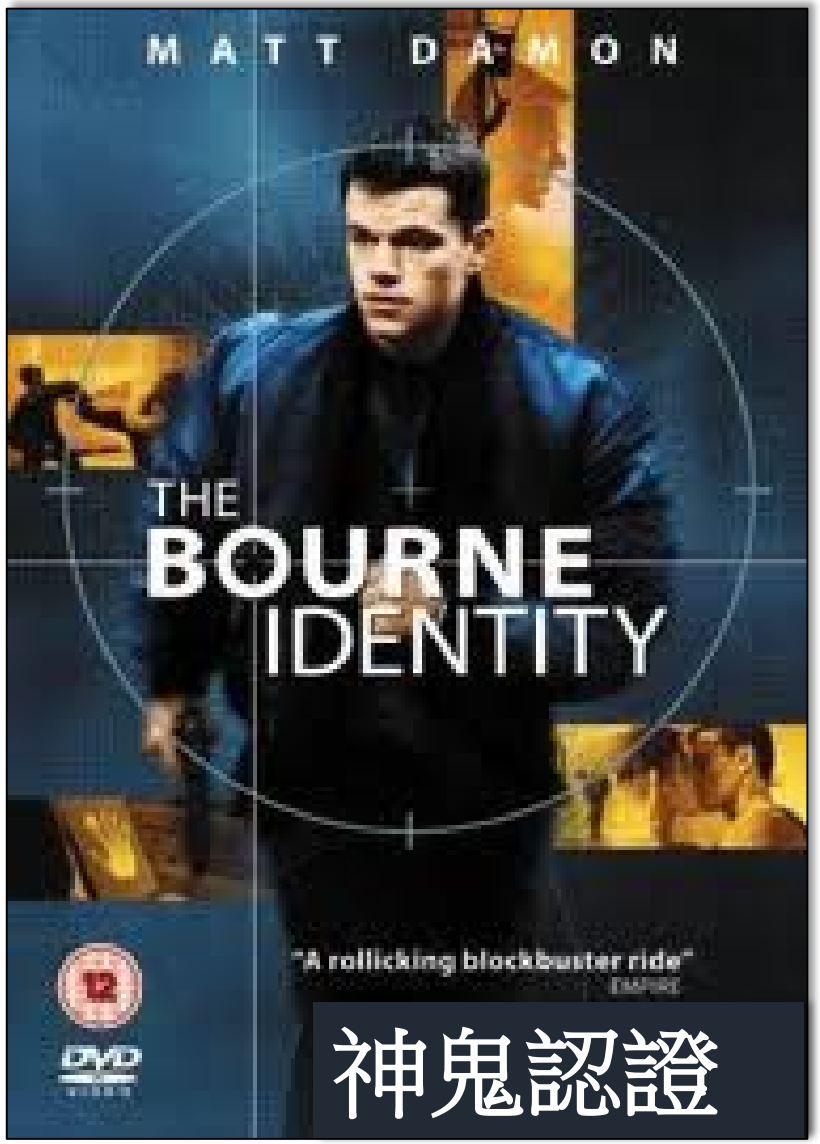




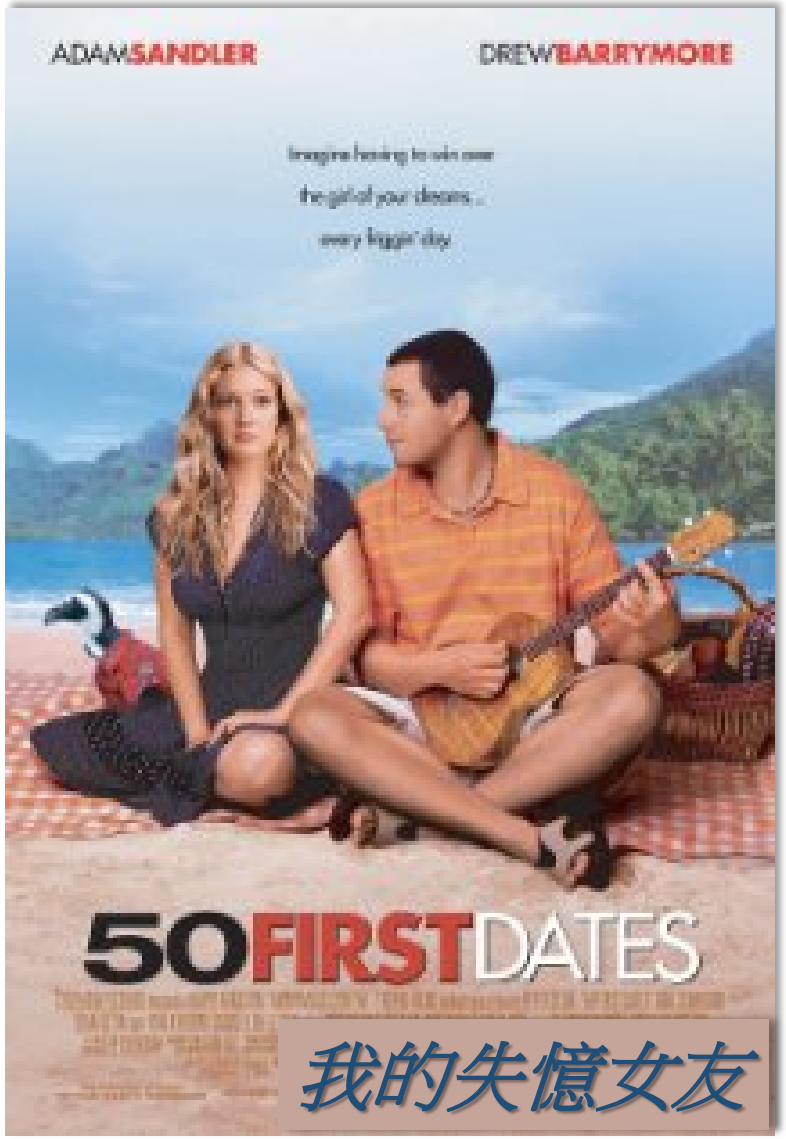
本日菜單

- 人類記憶
- 人腦結構
- 腦傷病人**H.M.** 與 **E.P.**
- 習慣學習的神經機制 **(**動物研究**)**
- 結語

人類記憶



神鬼認證



我的失憶女友

人類記憶

學習與記憶

- 什麼是學習？ 什麼是記憶？
- 很難給予簡單的定義。
- 但，確定的是，今天談的記憶不是下面這幾種：

- 雖然這些記憶體或是記憶裝置常被拿來與人類記憶作類比，人類的學習與記憶要比這些東西複雜許多。

人類記憶

- **學習** 是由經驗所產生，使行為潛在地、持續地改變
- **記憶** 則是由於學習所產生的經驗記錄

WIKIPEDIA
The Free Encyclopedia

Learning (學習)

Contents [hide]

Memory (記憶)

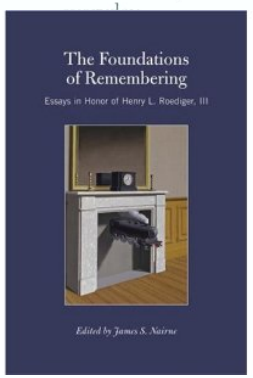
Contents [hide]

256 種記憶 (by Tulving)

APPENDIX: ALPHABETICAL LISTING OF KINDS OF MEMORY

(In most cases only the term modifying "memory" is printed.)

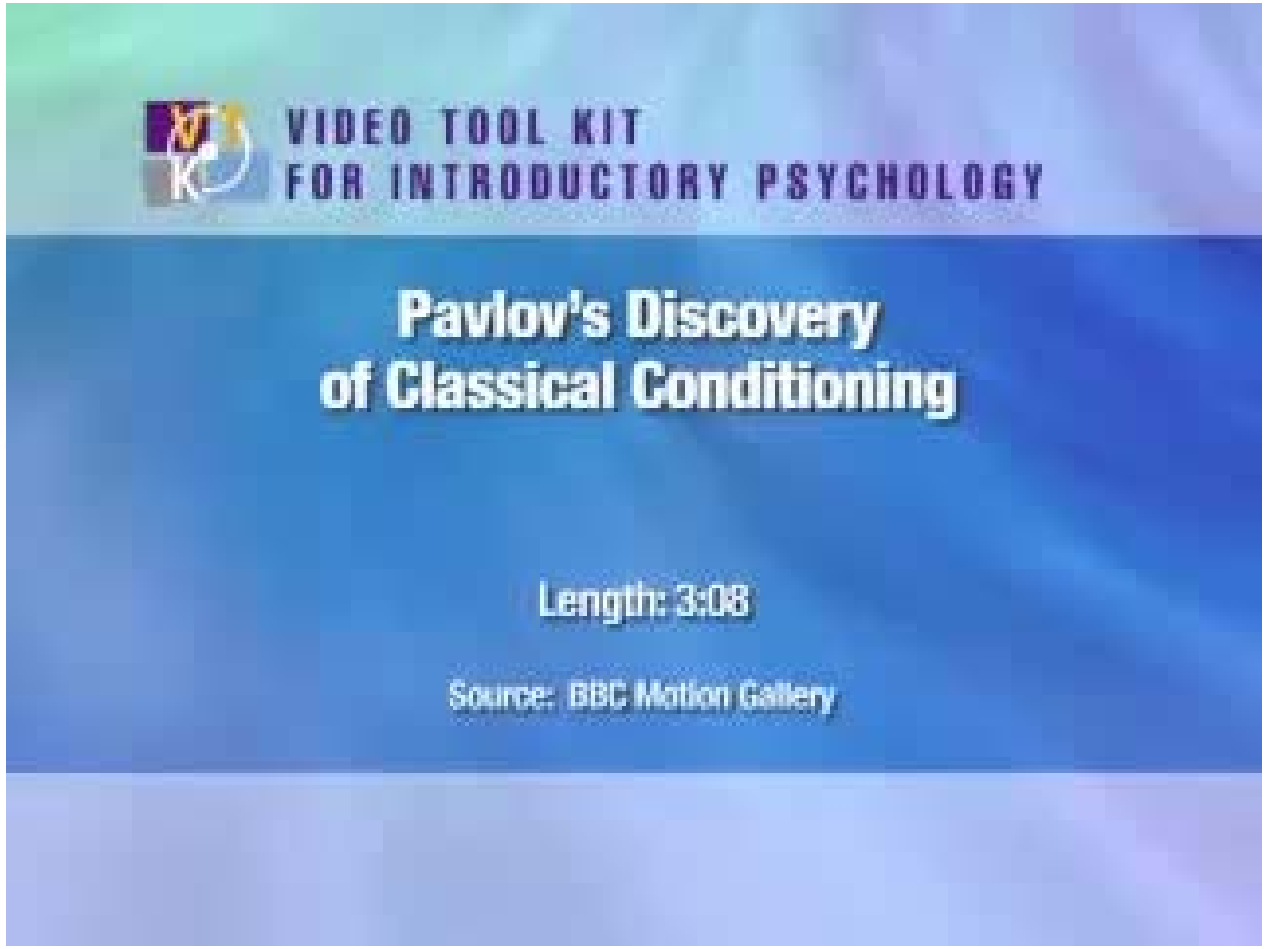
abnormal
abstract
accessible
acoustic
acquisition
active
active cultural
affective
age-related
age-related relational
allocentric
allocentric spatial
animal memory
anterograde
archival cultural
arousal-mediated
articulated
associative
auditory
autobiographical
bodily
brain-stem
cache memory
categorical
cellular
cerebellar
chemical
childhood
cognitive
collective
color memory
concrete
configural
conscious
constructive
context
context-dependen
cortical
cultural
declarative
diencephalic
direct
discovered
disembodied
distinct
distributed
dream memory
dynamic
early
echoic
elementary
emotional
enhanced
episodic
episodic-like
ERP (event-related potentials)
evaluative
event memory



人類記憶

舉一個簡單的例子說明學習機制

古典制約 (classical conditioning)



狗狗最後學會了鈴聲與食物的連結，流口水是為吃食物做準備的。所以，狗狗已經學會、也記得鈴聲的另一層意義。
另一個明顯的例子是”望梅止渴”。

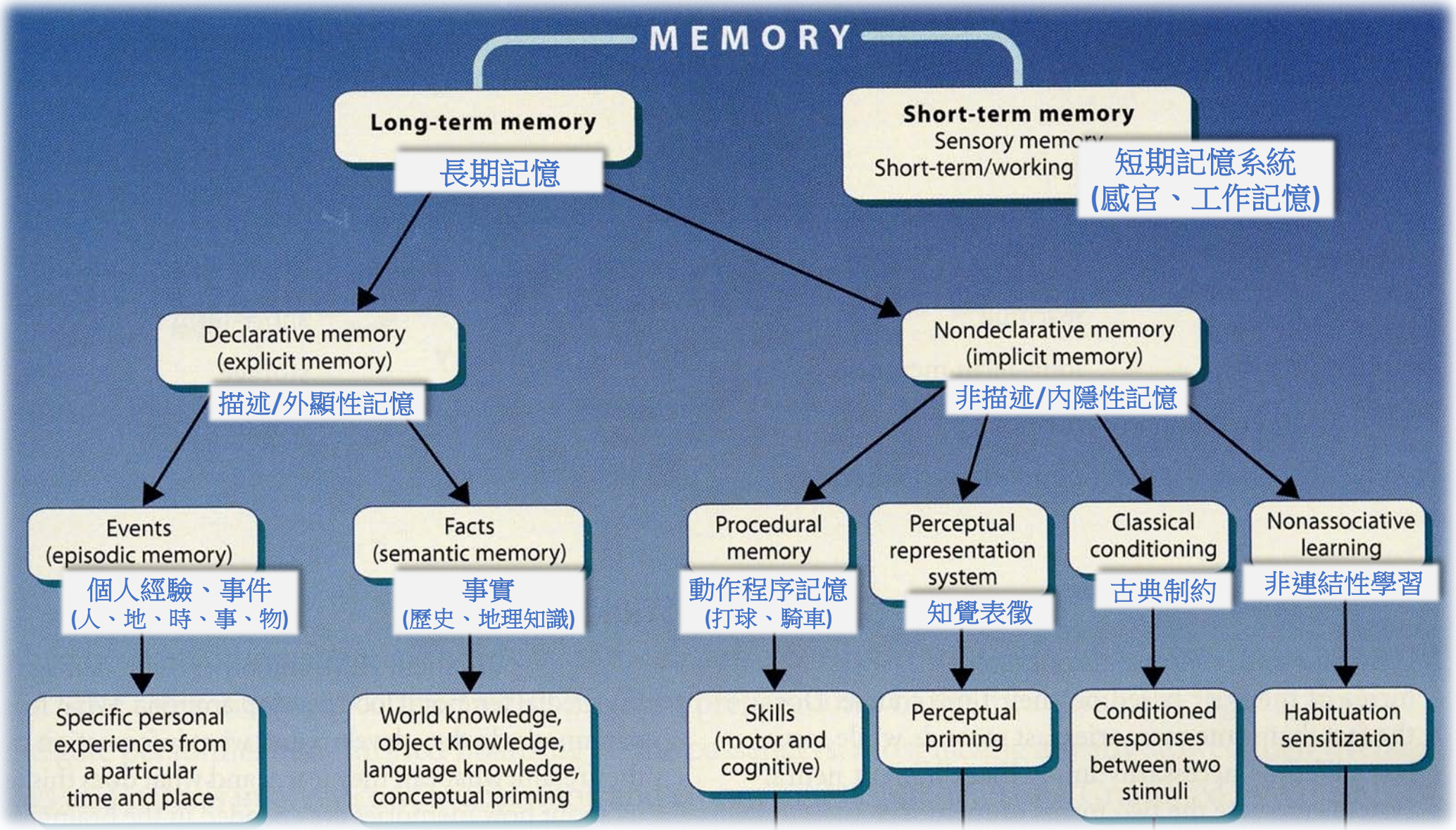
人類記憶

另一個學習機制的例子

操作制約 **(operant conditioning)**

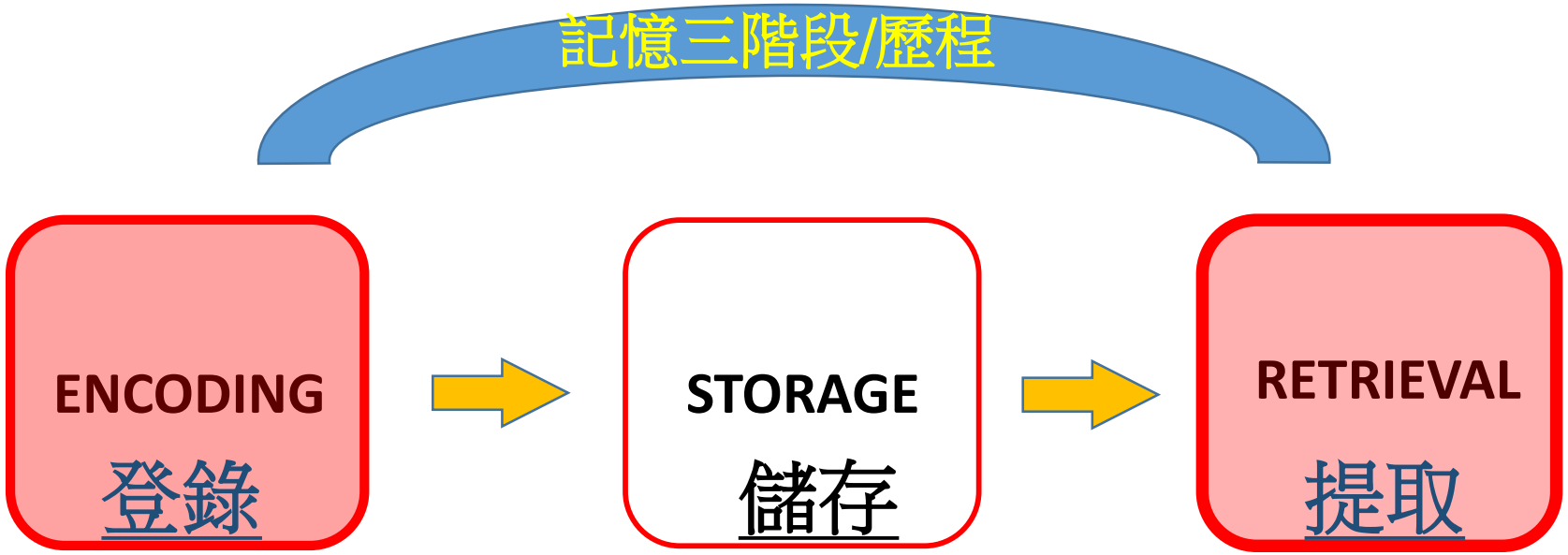
透過增強物(食物)的強化，狗狗會學會將行為與不相關的東西做連結，進而增加目標行為出現的可能性。最後，狗狗學會如何開啟柵欄，重獲自由。

人類記憶

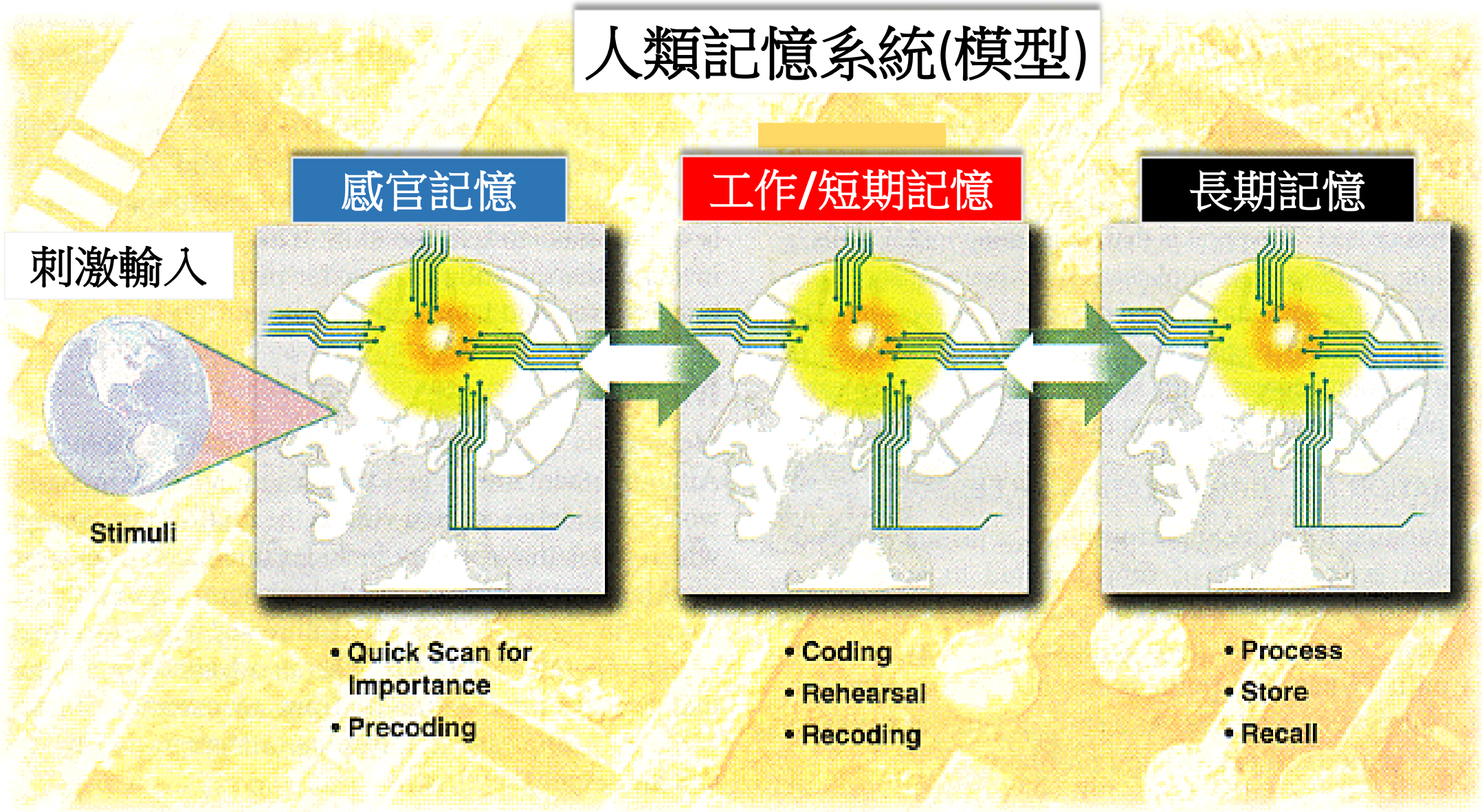

MEMORY
Long-term memory
長期記憶
Short-term memory
Sensory memory
Short-term/working
短期記憶系統
(感官、工作記憶)
Declarative memory
(explicit memory)
描述/外顯性記憶
Nondeclarative memory
(implicit memory)
非描述/內隱性記憶
Events
(episodic memory)
個人經驗、事件
(人、地、時、事、物)
Facts
(semantic memory)
事實
(歷史、地理知識)
Procedural
memory
動作程序記憶
(打球、騎車)
Perceptual
representation
system
知覺表徵
Classical
conditioning
古典制約
Nonassociative
learning
非連結性學習
Specific personal
experiences from
a particular
time and place
World knowledge,
object knowledge,
language knowledge,
conceptual priming
Skills
(motor and
cognitive)
Perceptual
priming
Conditioned
responses
between two
stimuli
Habituation
sensitization

人類記憶

實驗室中的記憶研究



人類記憶

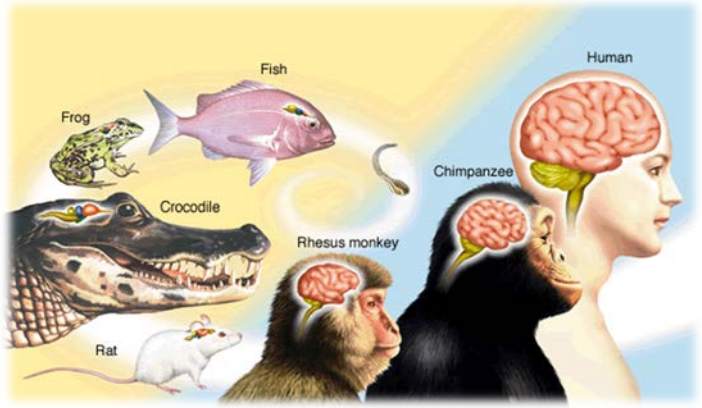

人類記憶系統(模型)
感官記憶
工作/短期記憶
長期記憶
刺激輸入
Stimuli
• Quick Scan for Importance
• Precoding
• Coding
• Rehearsal
• Recoding
• Process
• Store
• Recall

人類記憶

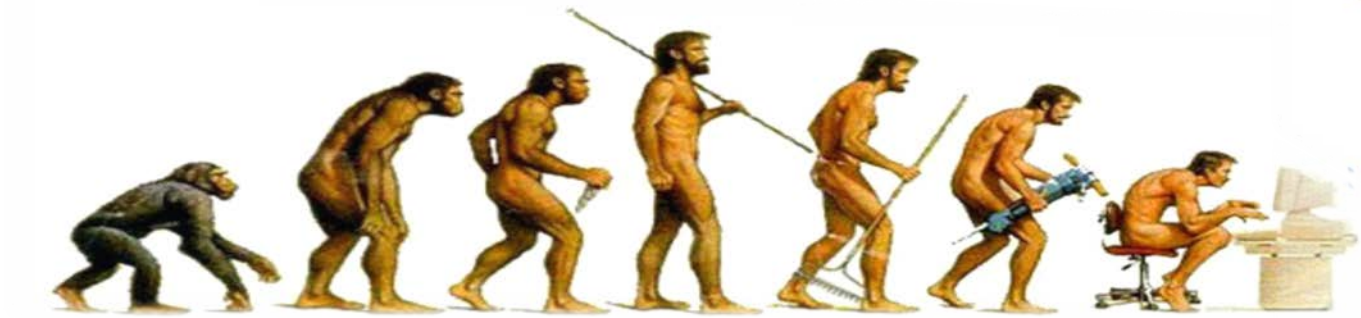
***幾個延伸的問題*:**

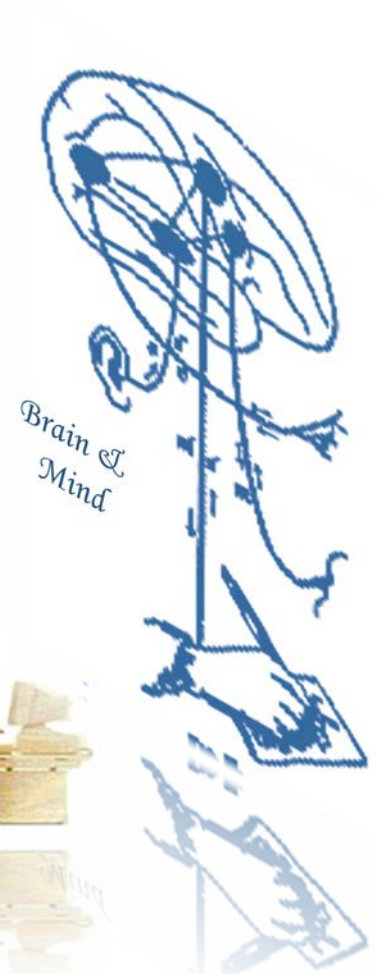
1. 日常生活中，哪些訊息可以被我們處理，經由感官記憶進到短期記憶，再進到長期記憶？
2. 記憶有容量限制嗎？
3. 有假的記憶嗎？
4. 記憶可以被竄改嗎？
5. 遺忘是如何造成？

人腦結構



生活中面臨越多挑戰的動物，大腦也越來越大、複雜!

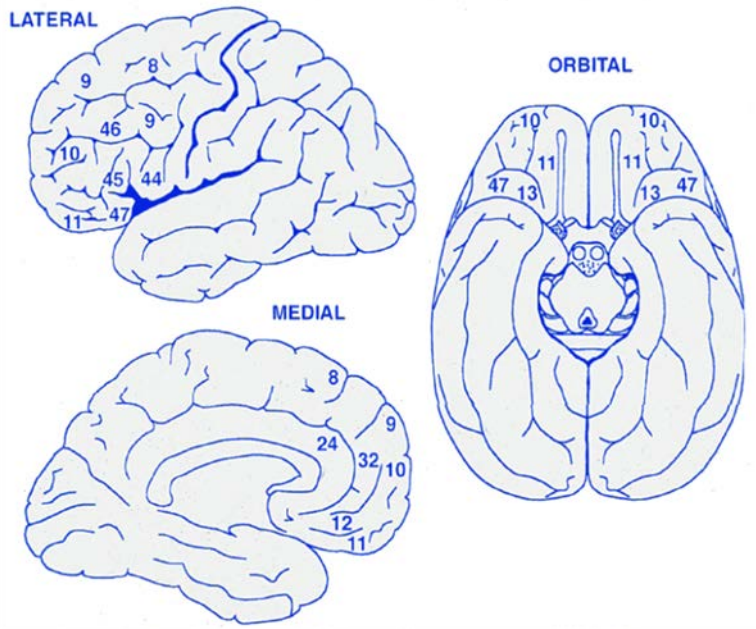


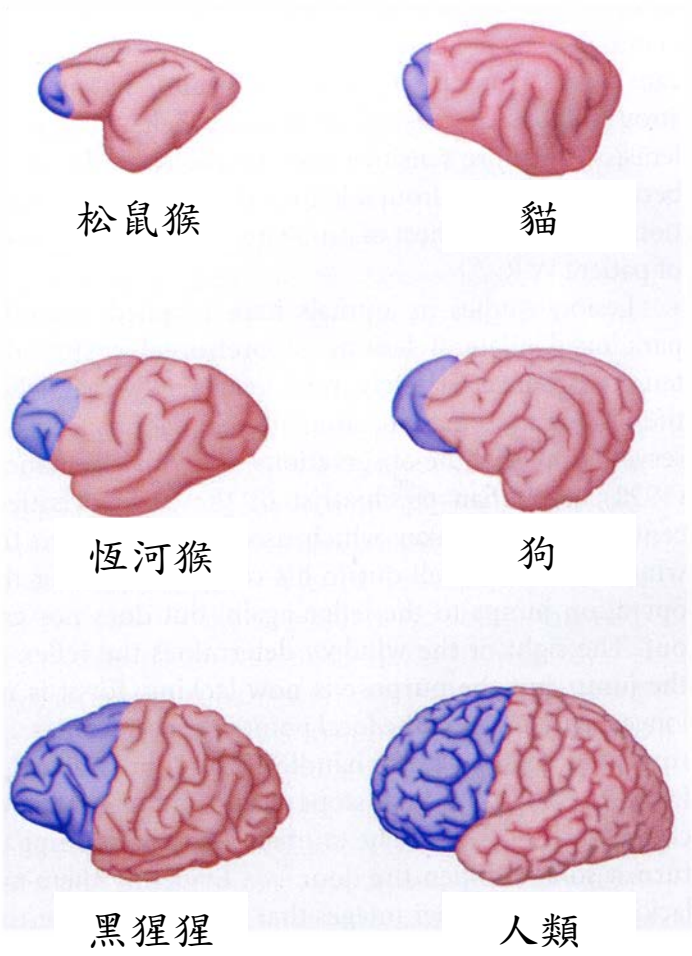


人腦結構

大腦前額葉的發展與演化

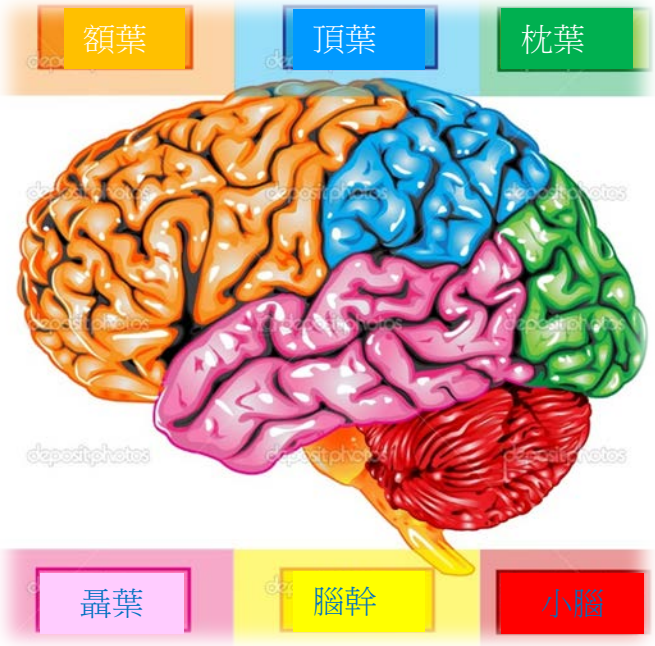
The Human Prefrontal Cortex



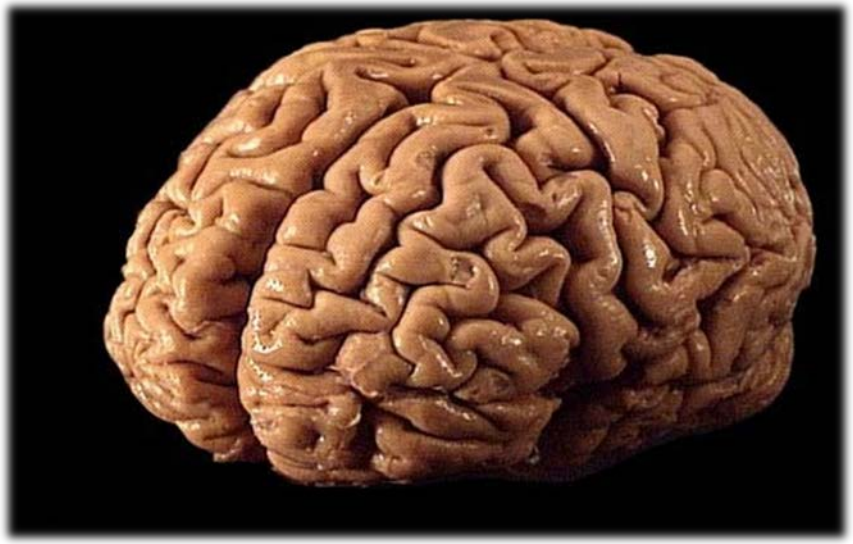


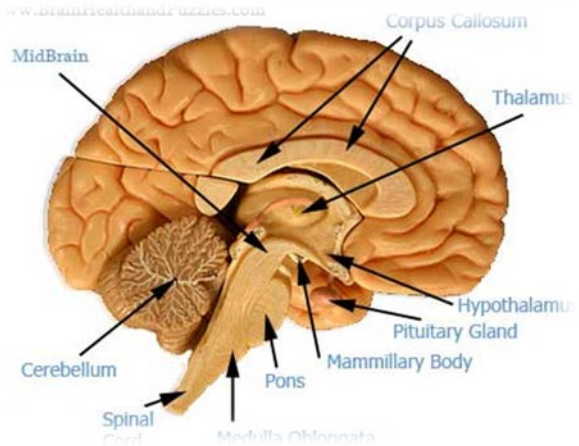
隨著演化與發展，前額葉體積與神經連結逐漸增加。

人腦結構



人腦分為左右兩個腦半球





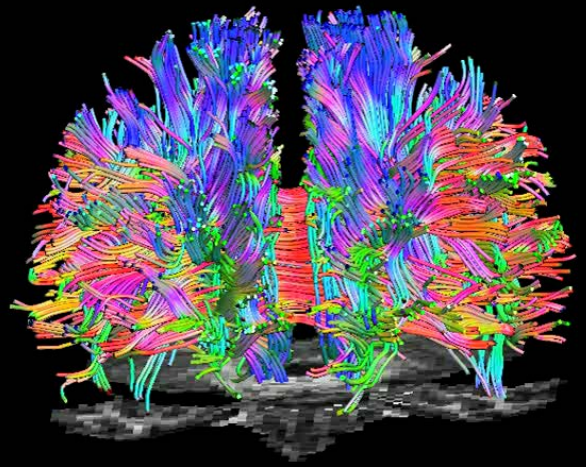
人腦結構

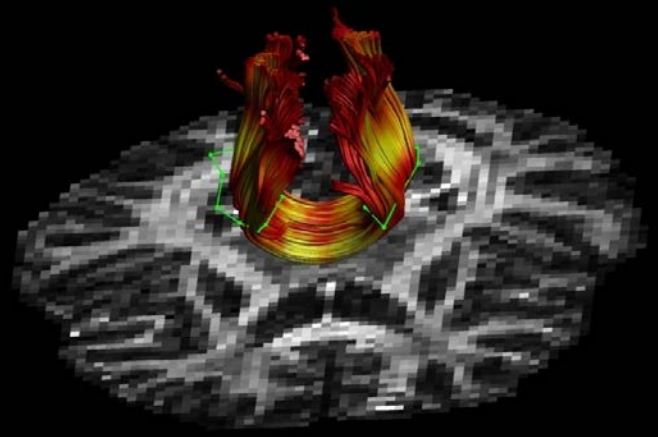
T1 image

灰質

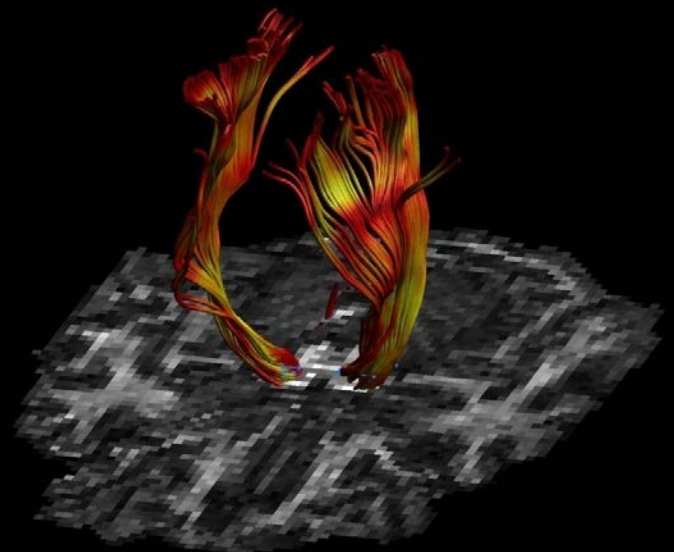
白質

人腦結構

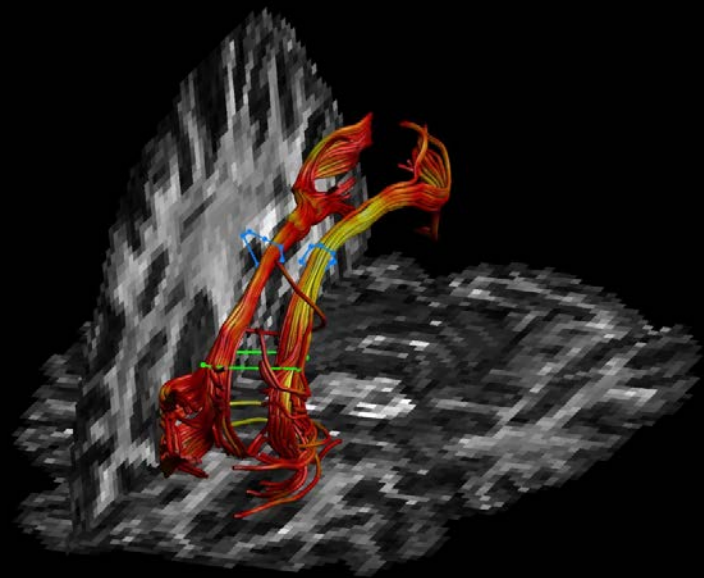




fibers in midbody corpus callosum



Corticospinal track



cingulum bundles

人腦結構

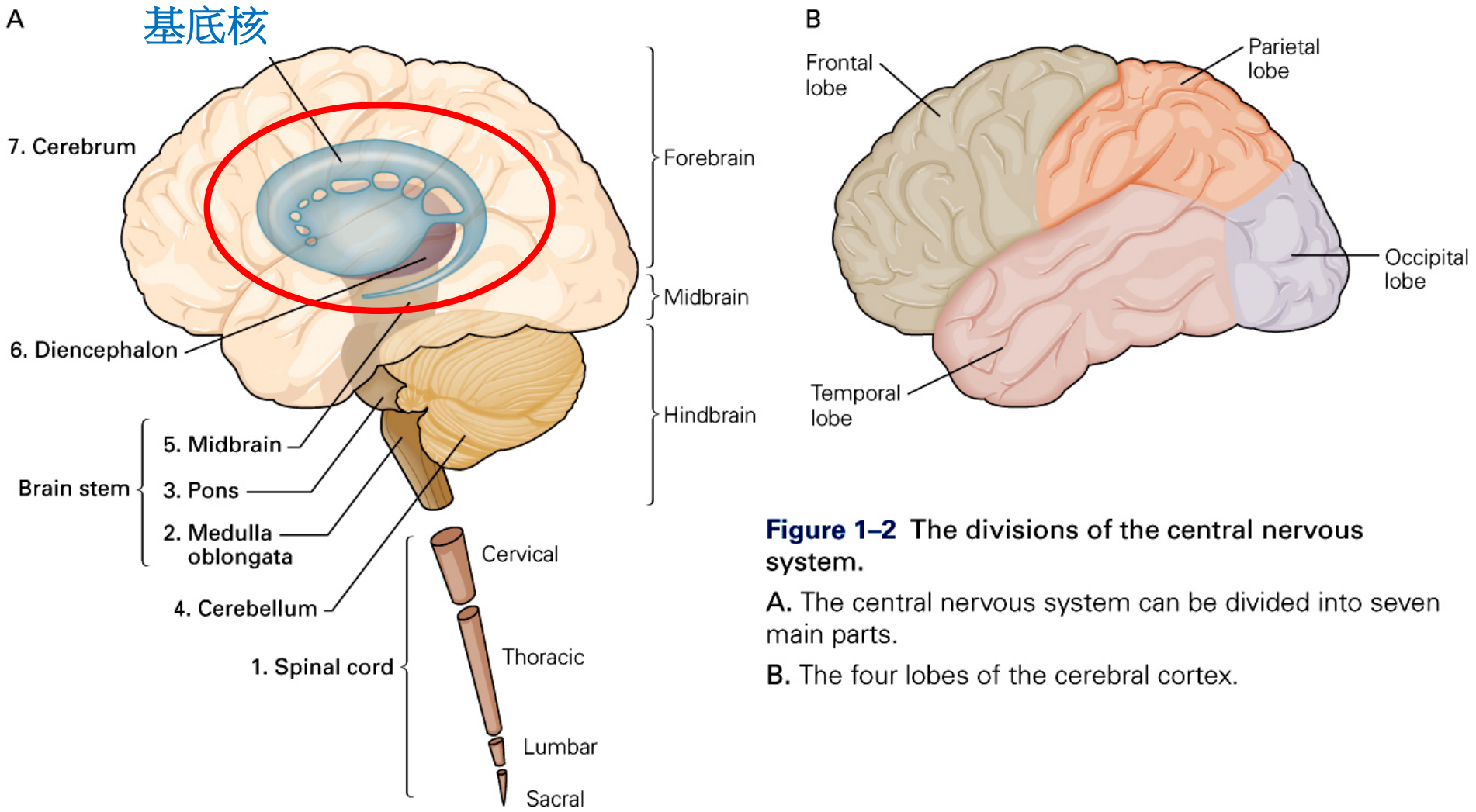


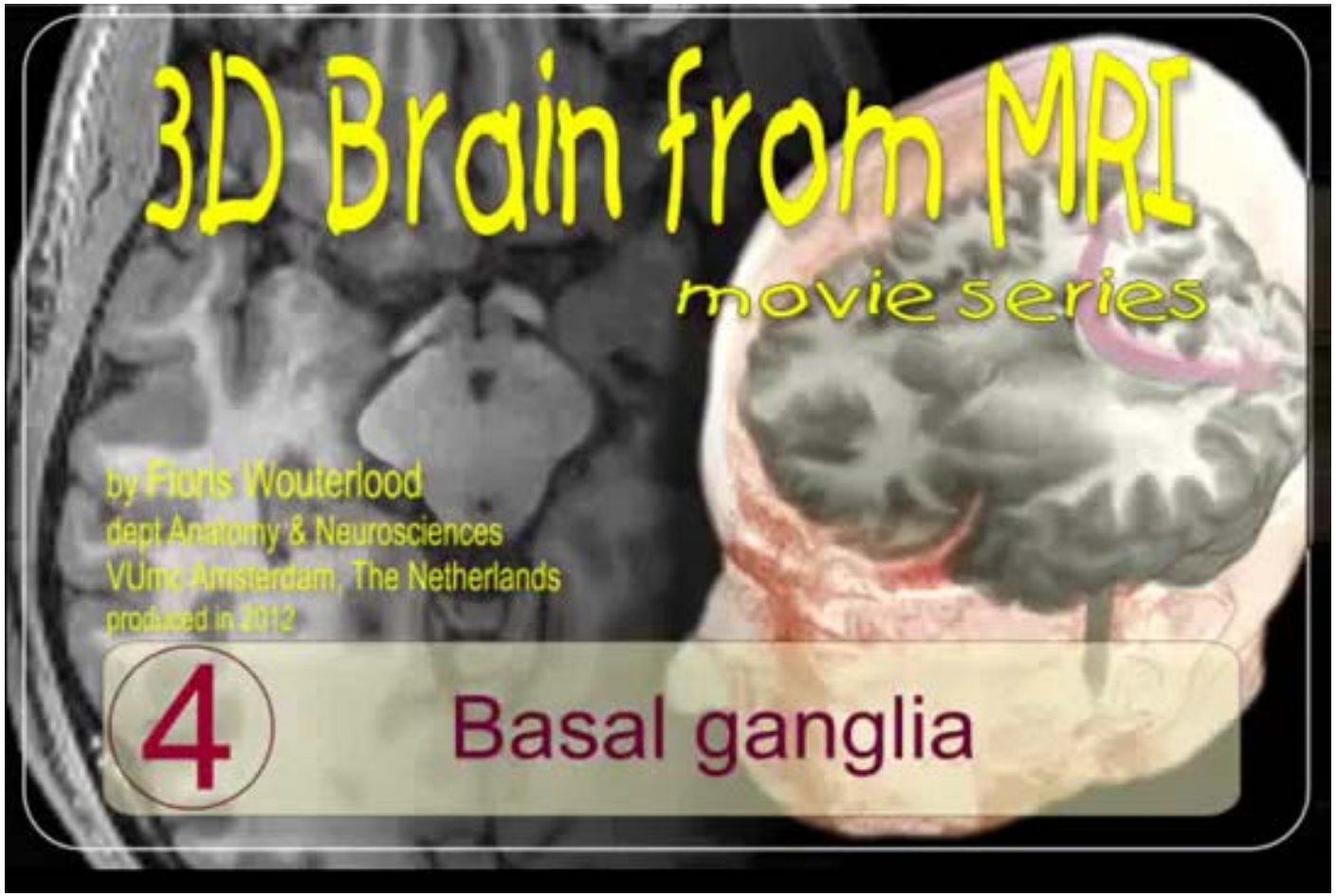
Figure 1–2 The divisions of the central nervous system.

A. The central nervous system can be divided into seven main parts.

B. The four lobes of the cerebral cortex.

人腦結構

基底核


3D Brain from MRI
movie series
by Fioris Wouterlood
dept Anatomy & Neurosciences
VUmc Amsterdam, The Netherlands
produced in 2012
4
Basal ganglia

人腦結構

基底核

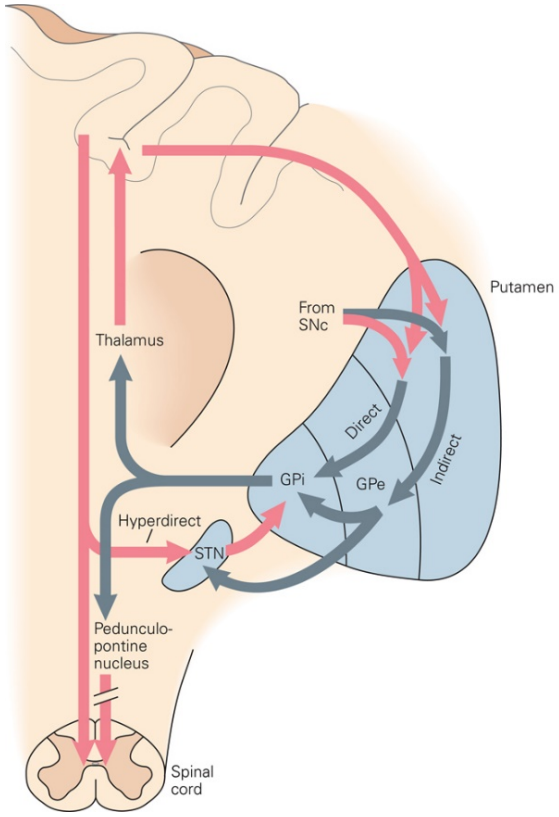
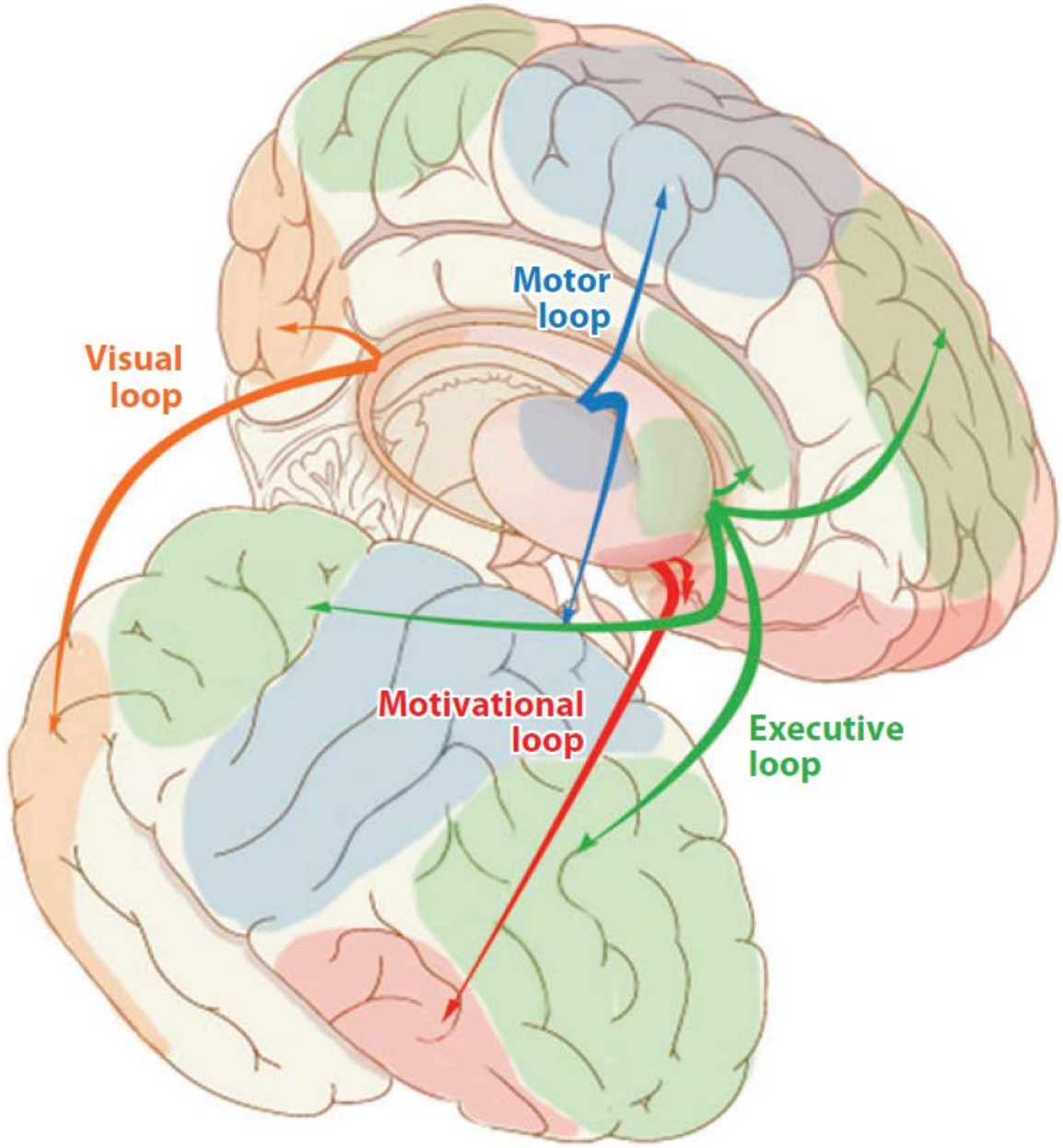
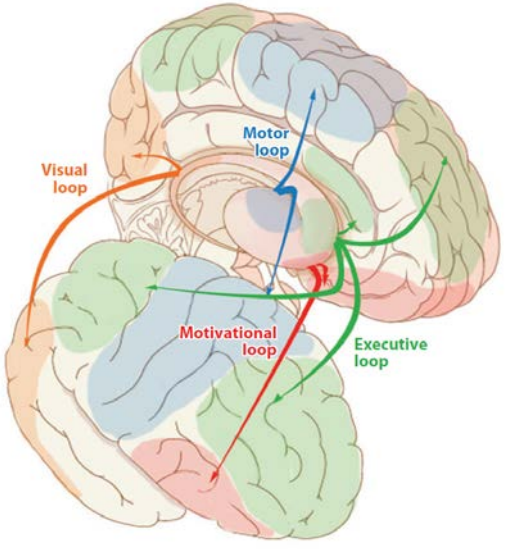


Figure 43–2 The basal ganglia–t
circuitry of the basal ganglia incluc
sented by one of its components,
and internal segments of the glob
respectively), the substantia nigra
and pars compacta (**SNc**), and the
Cortical input enters the striatum
Basal ganglia output is conveyed t
centromedian and parafascicular n
and ventral lateral nuclei) and the
Excitatory connections are shown
in **gray**. The dopaminergic SNc pr
regulates corticostriatal transmiss
pathways.



人腦結構

基底核



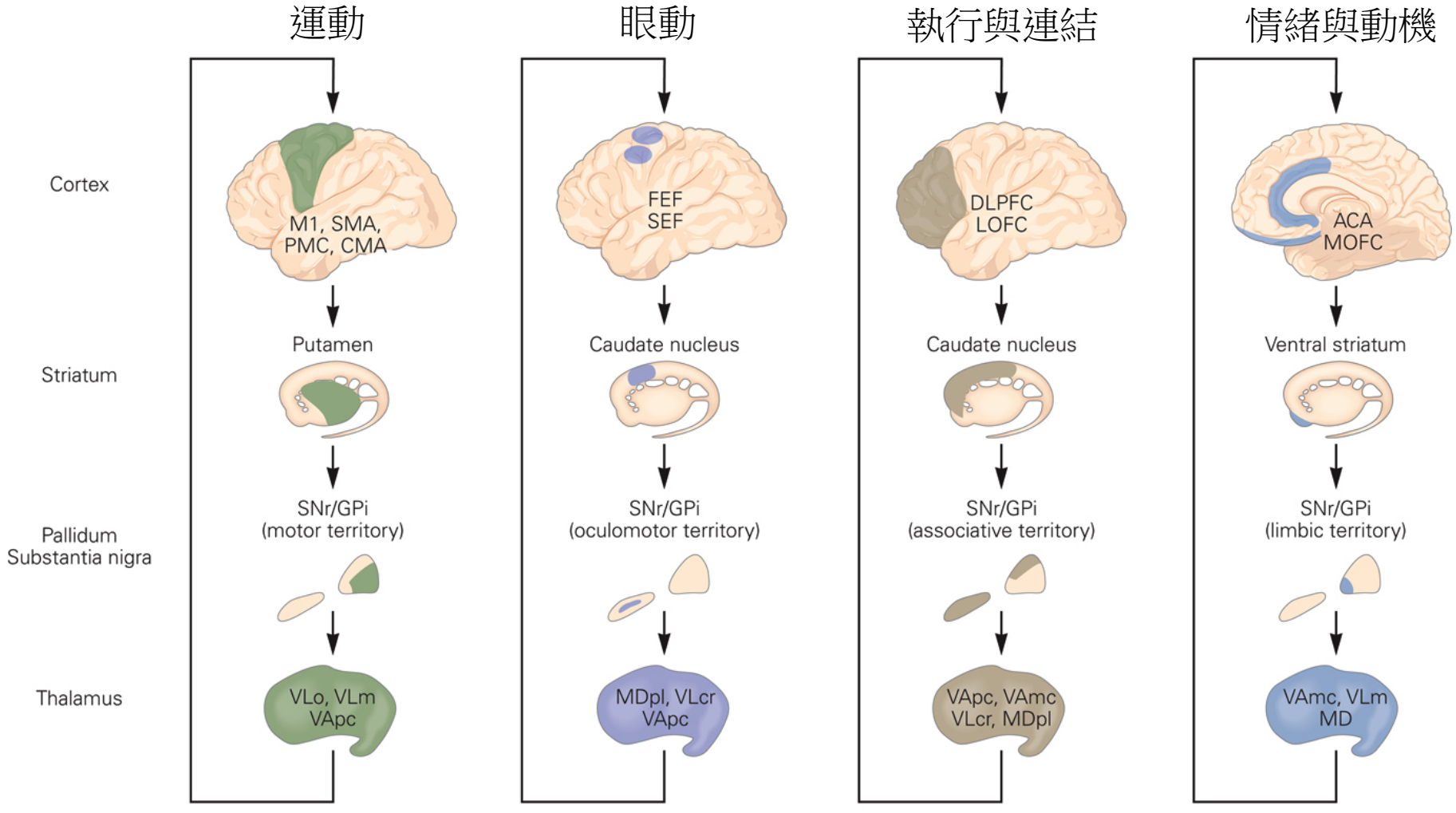
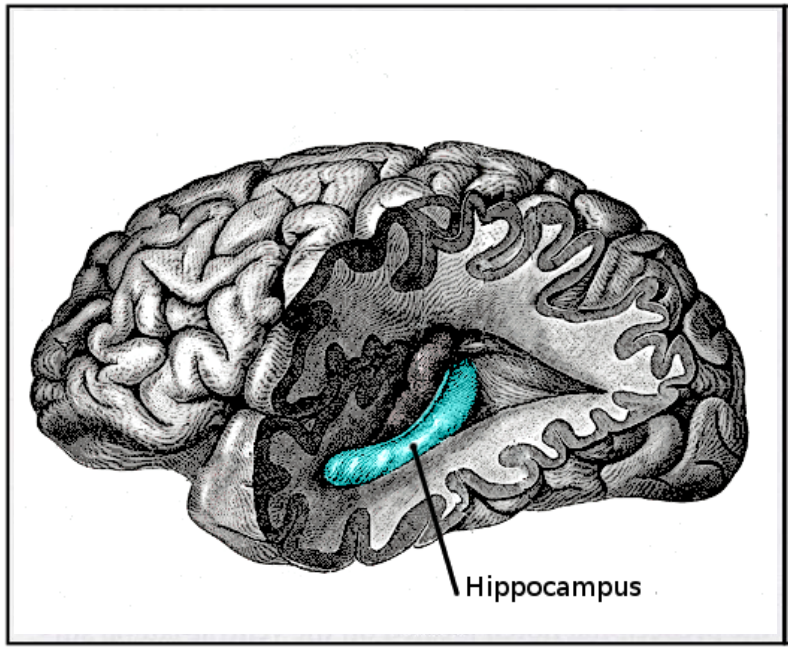


Figure 43–5 Global anatomy of cortico–basal ganglia–thalamocortical circuits. (**ACA**, anterior cingulate area; **CMA**, cingulate motor area; **DLPFC**, dorsolateral prefrontal cortex; **FEF**, frontal eye field; **GPi**, internal segment of the globus pallidus; **LOFC**, lateral orbitofrontal cortex; **M1**, primary motor cortex; **MDpl**, mediodorsal nucleus of thalamus, lateral part; **MOFC**, medial orbitofrontal cortex; **PMC**, premotor cortex; **SEF**, supplementary eye field; **SMA**, supplementary motor area; **SNr**, substantia nigra pars reticulata; **VAmc**, ventral anterior nucleus of thalamus, magnocellular part; **VApc**, ventral anterior nucleus of thalamus, parvocellular part; **VLcr**, ventrolateral nucleus of thalamus, caudal part, rostral division; **VLm**, ventrolateral nucleus of thalamus, medial part; **VLo**, ventrolateral nucleus of thalamus, pars oralis.) (Adapted, with permission, from Wichmann and DeLong 2006.)

人腦結構

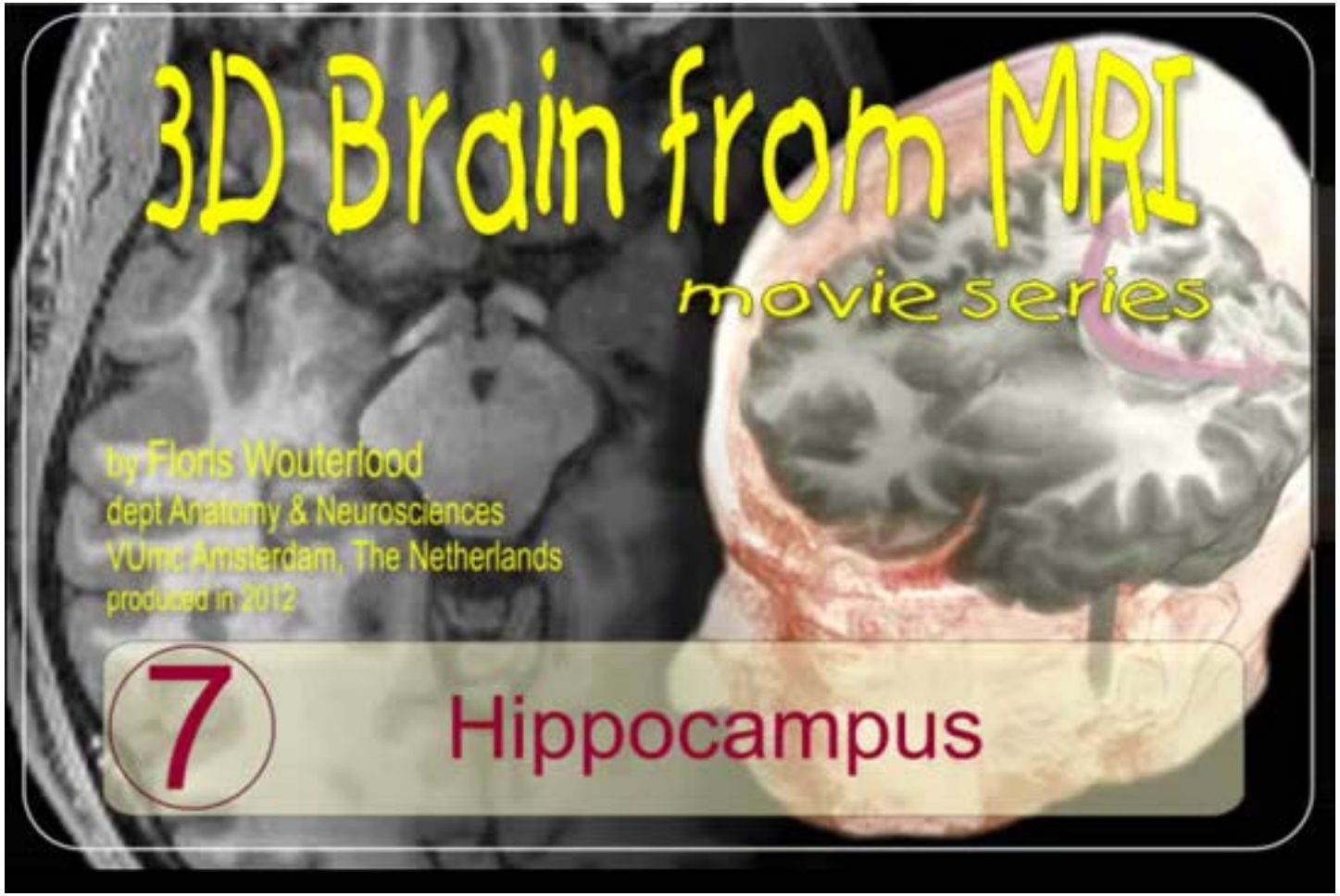
顳葉內側/海馬迴



The Hungarian neuroscientist László Seress' 1980 preparation of the human hippocampus and fornix compared with a seahorse

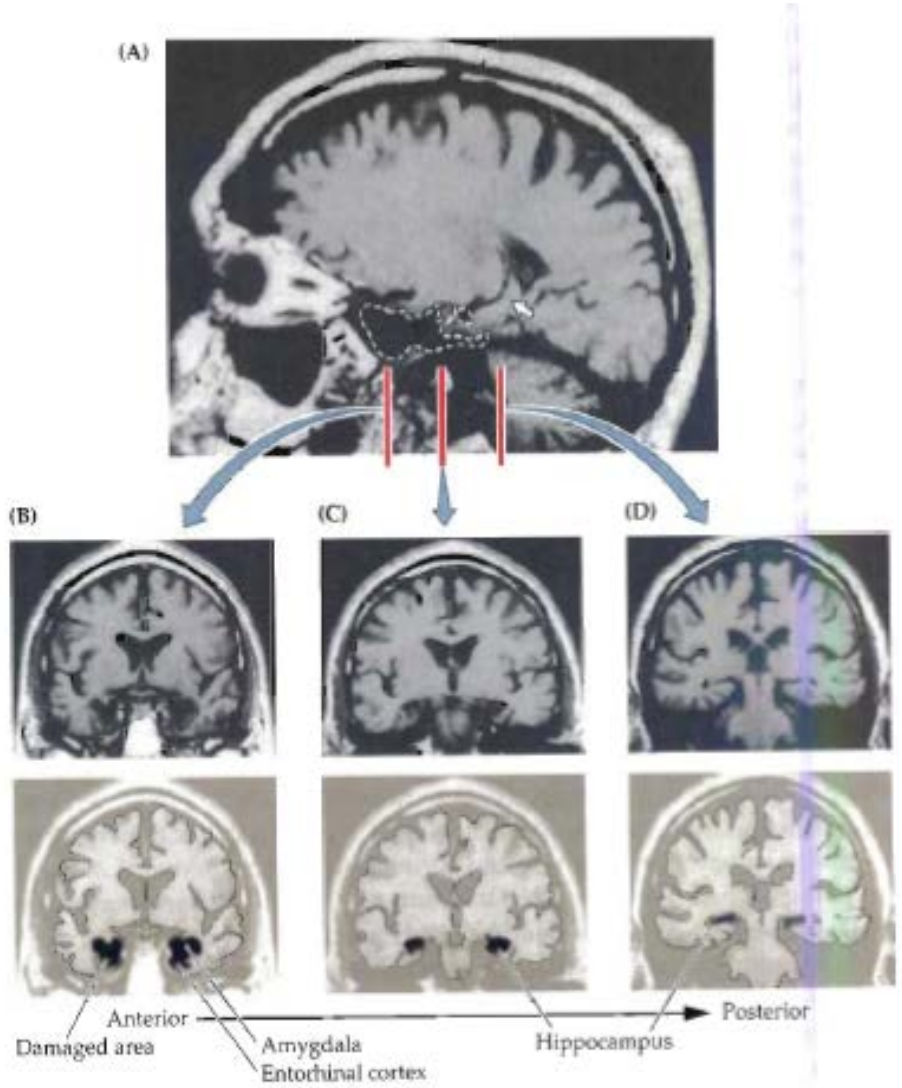
人腦結構

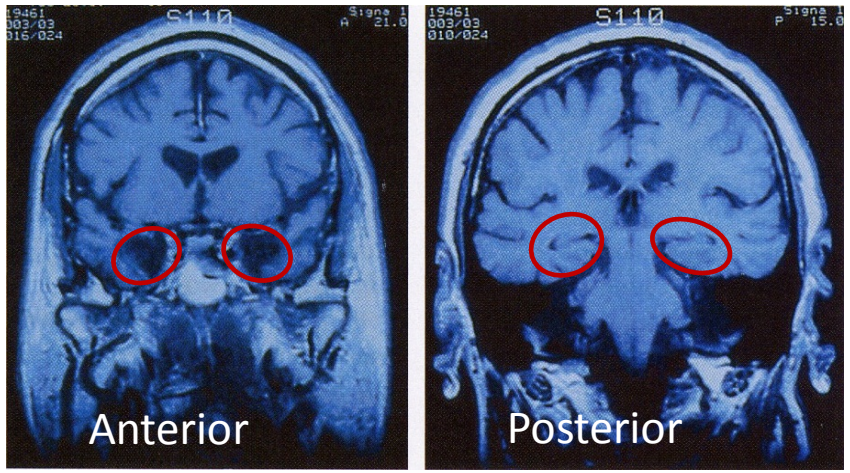
顳葉內側/
海馬迴

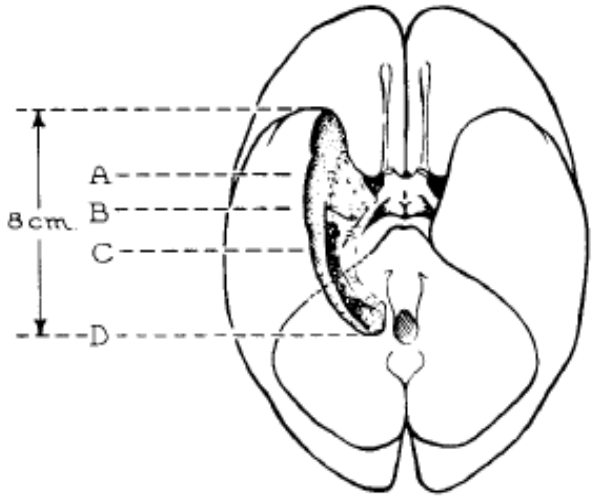


與記憶有關的腦傷研究: ***H.M. & E.P.***

與記憶有關的腦傷研究: H.M.

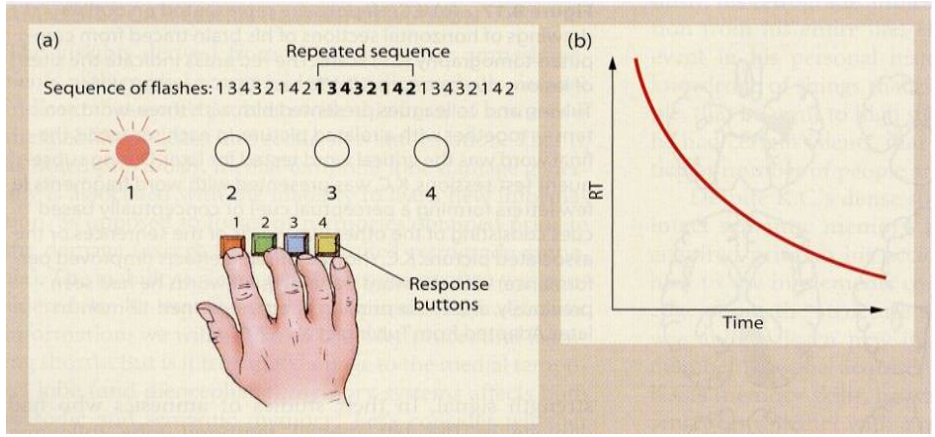


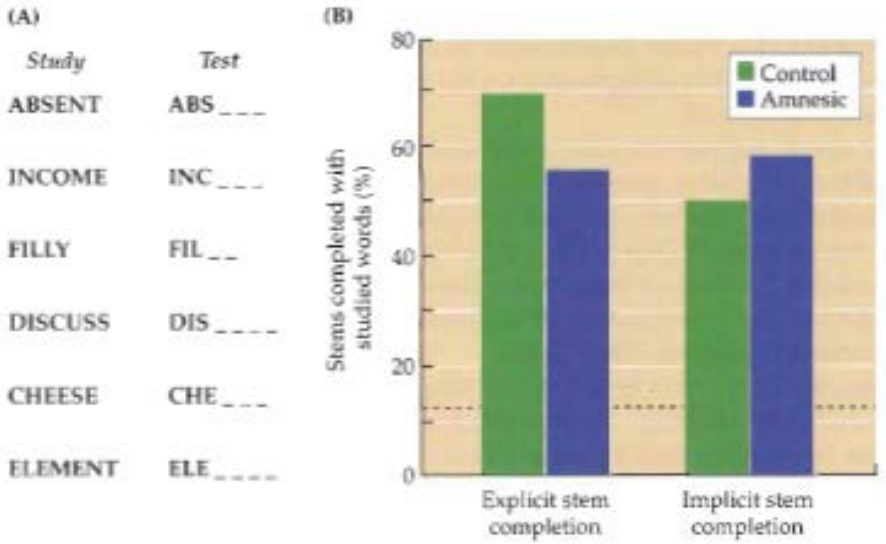


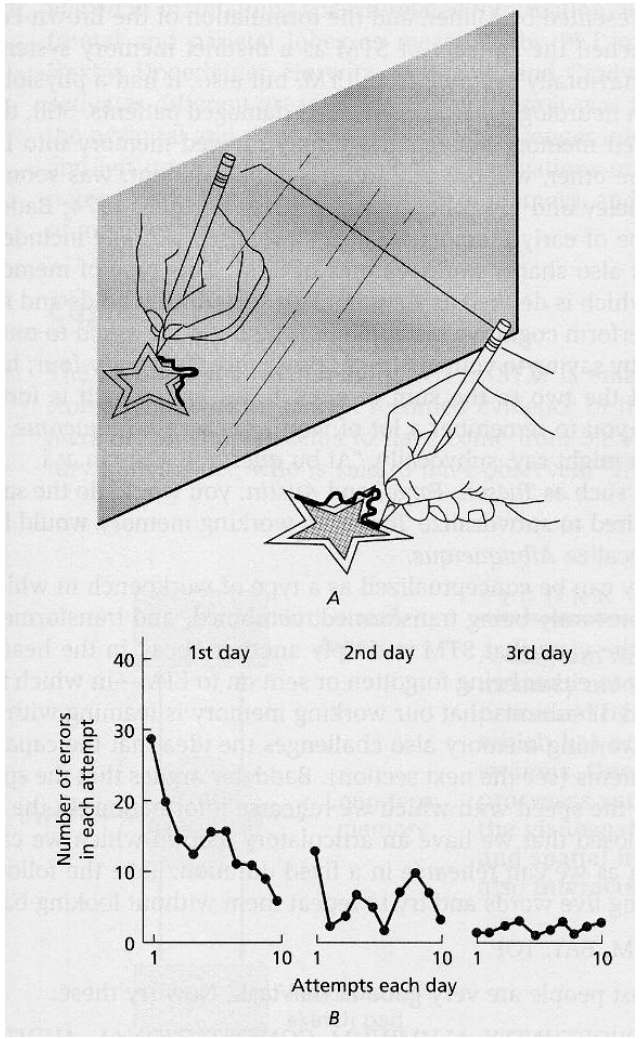


與記憶有關的腦傷研究: H.M.

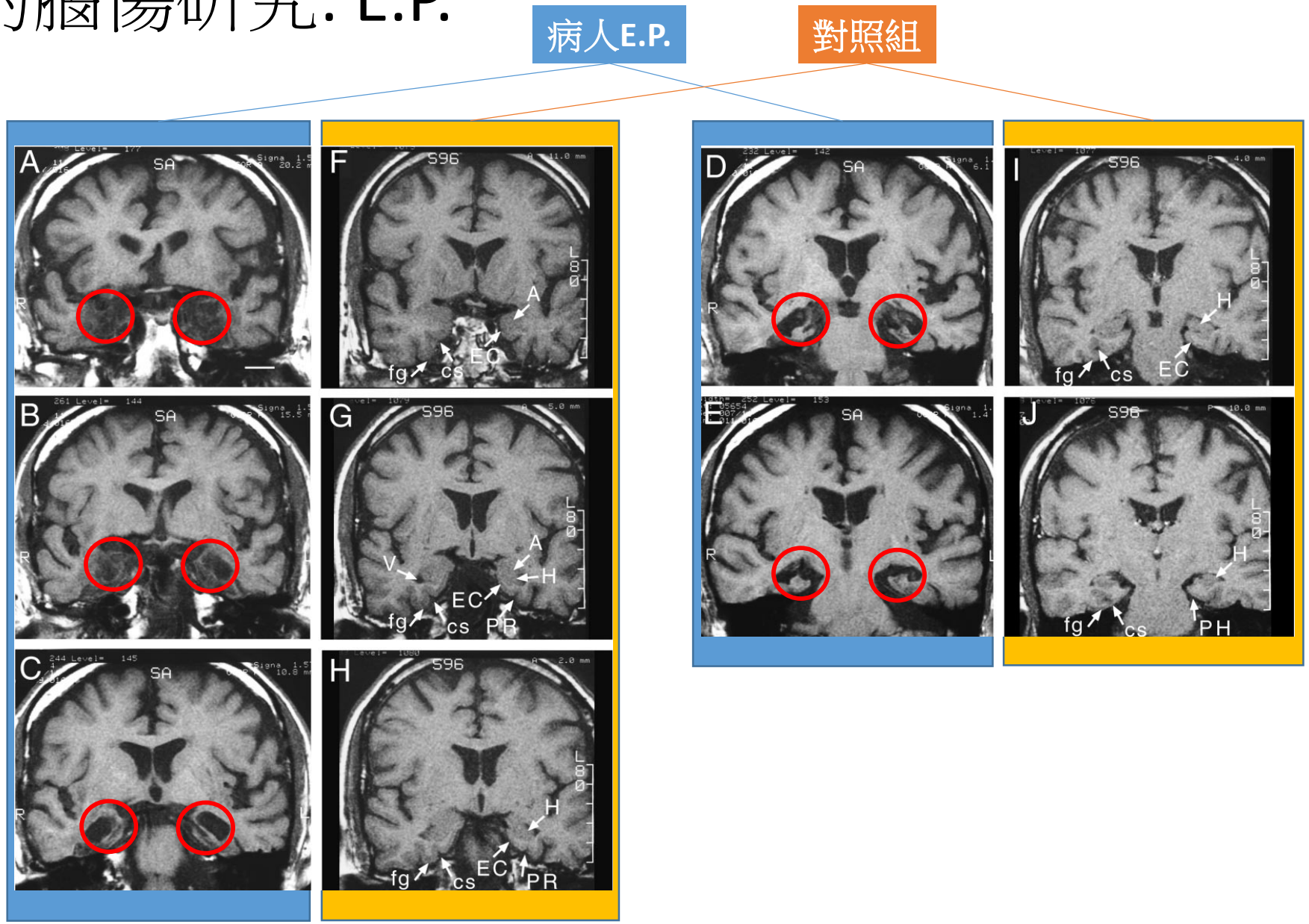
H.M. 保留部分記憶能力







與記憶有關的腦傷研究: E.P.



與記憶有關的腦傷研究

腦傷病人
E.P.

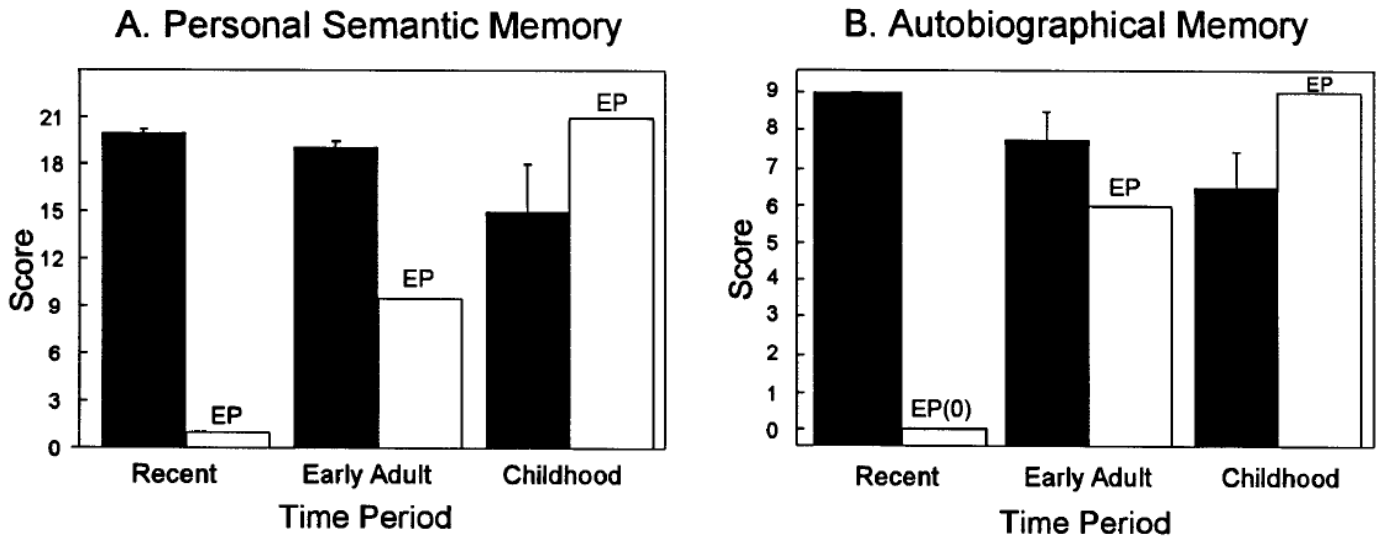
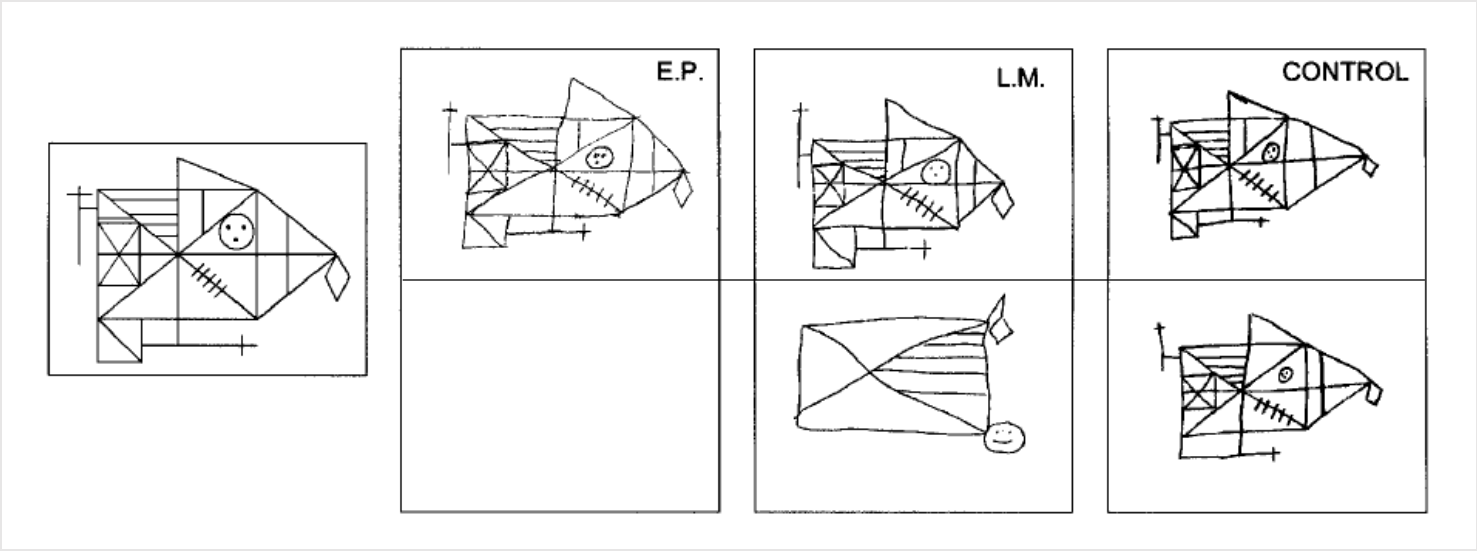


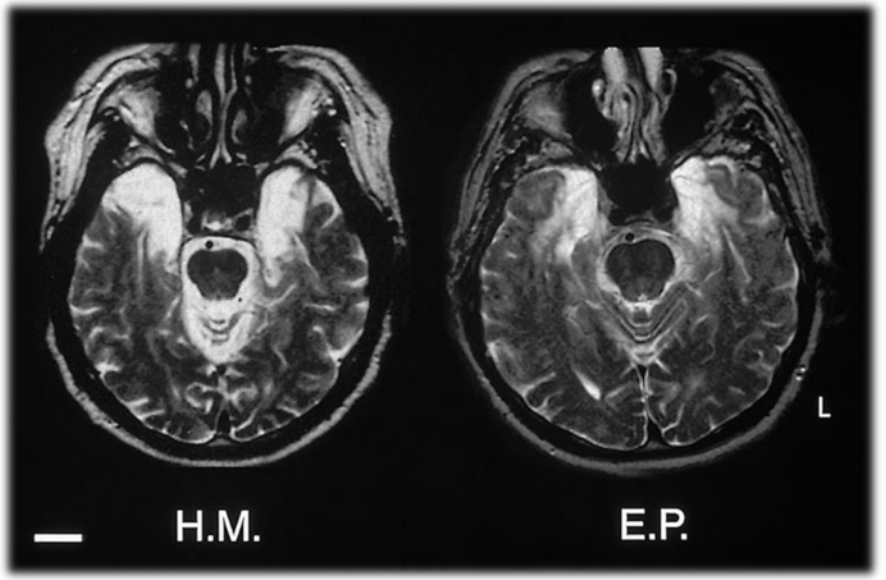
Table 2. Anterograde memory test performance

	E. P.	Control means (n = 8)
Two-choice recognition memory		
Words (50)	24	48.4
Faces (50)	28	41.9
Complex design		
Copy (36)	27	30.3
Recall (36)	0	20.6
Paired-associate learning		
Trial 1 (10)	0	6.0
Trial 2 (10)	0	7.6
Trial 3 (10)	0	8.9
Prose recall		
No delay (21)	3	7.6
Delay (21)	0	6.4

COPY vs. RECALL

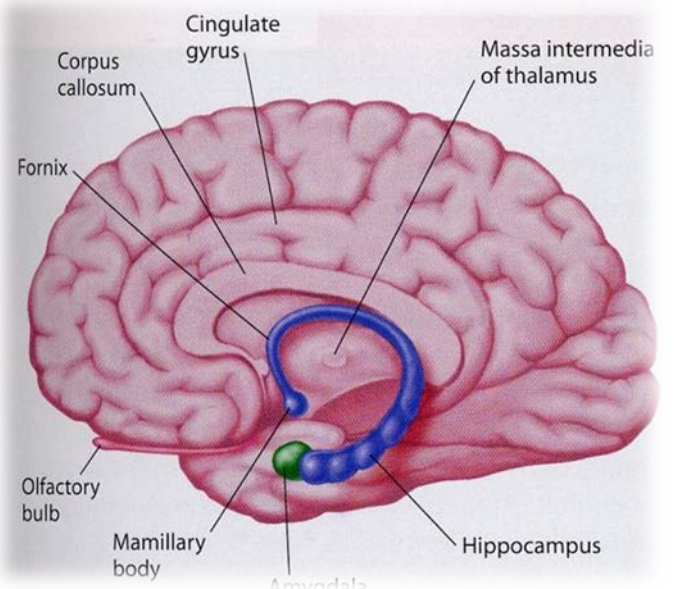


與記憶有關的腦傷研究

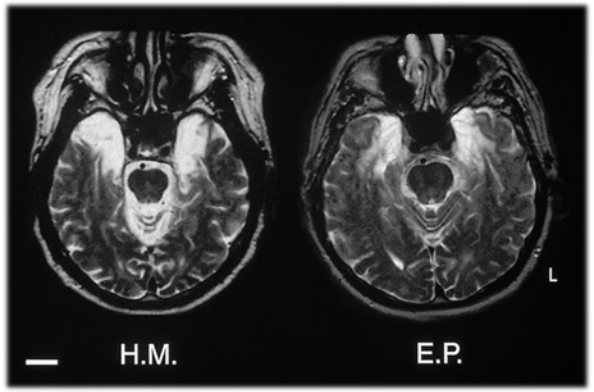


記憶固化 (memory consolidation) & **海馬迴 (MTL/hippocampus)**

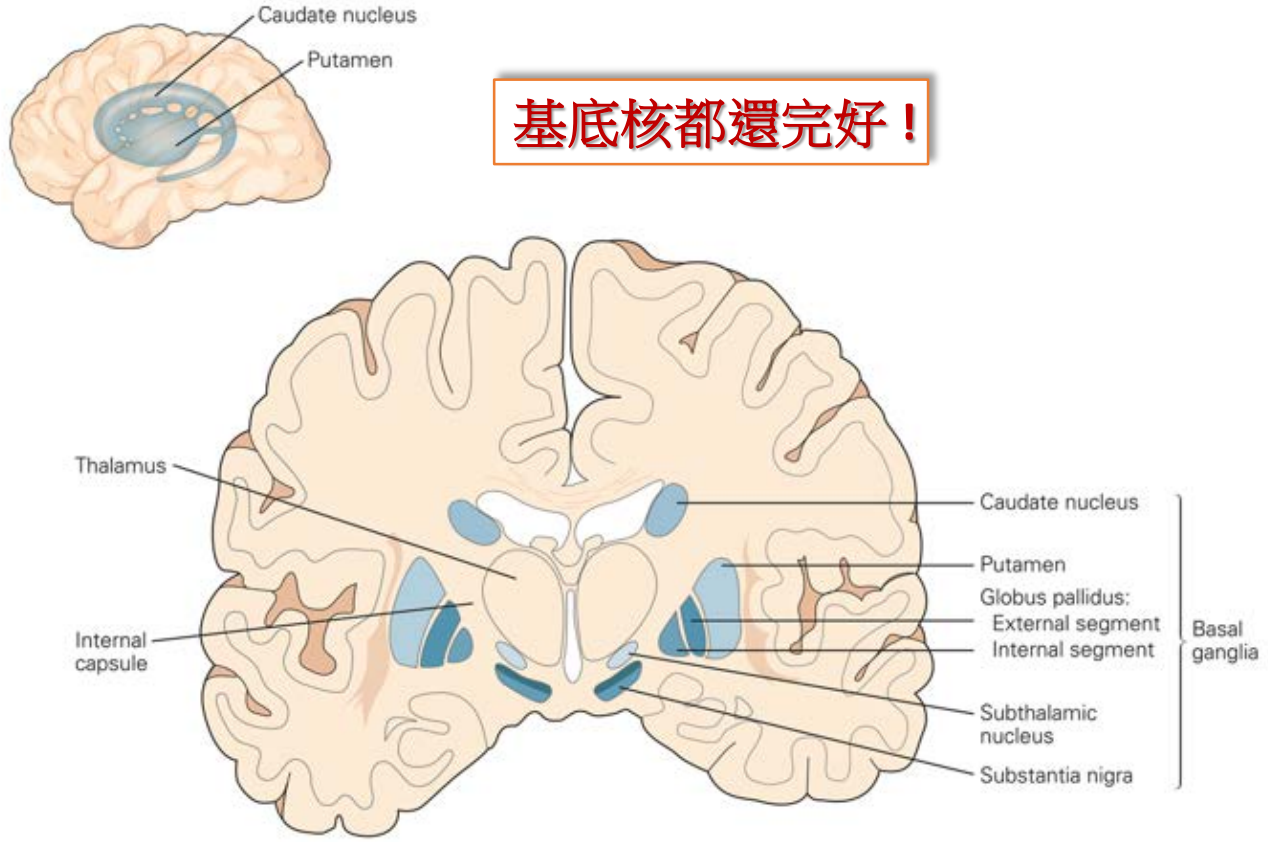
- Medial temporal lobe (MTL) is likely not the locus of LTM storage, because the retrograde amnesia is not total after damage to this area. (e.g. H.M. & E.P.)
- Medial temporal lobes (MTL) is a key component in organizing and consolidation LTM.
- In some models, the neocortex is considered crucial for the storage of fully consolidated LTM.
- Recent neuroimaging studies suggests that memory are stored as distributed representations throughout the neocortex.



習慣學習的神經機制



H.M. & E.P. 的海馬迴結構因手術或病毒而被破壞



習慣學習的神經機制

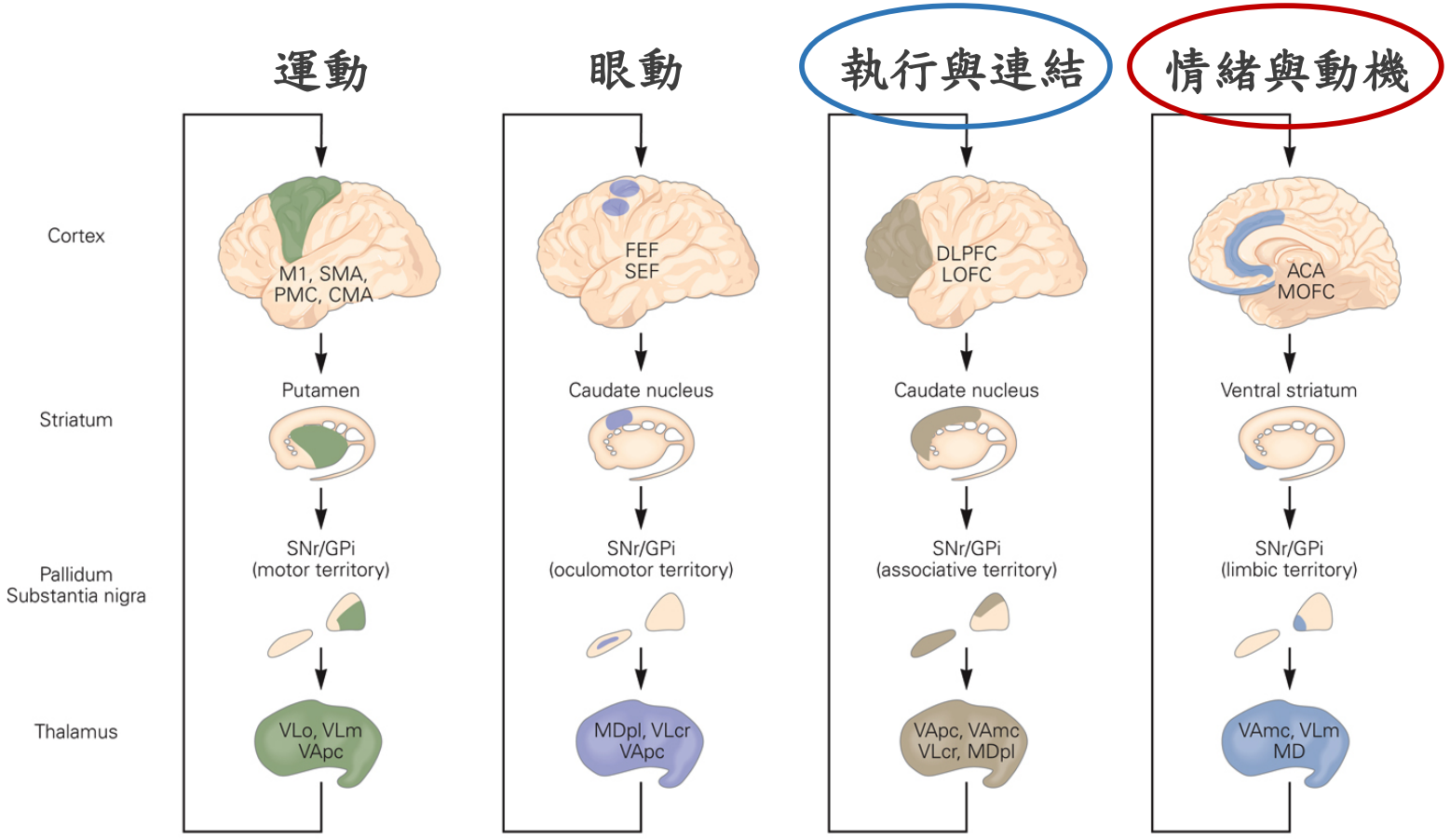
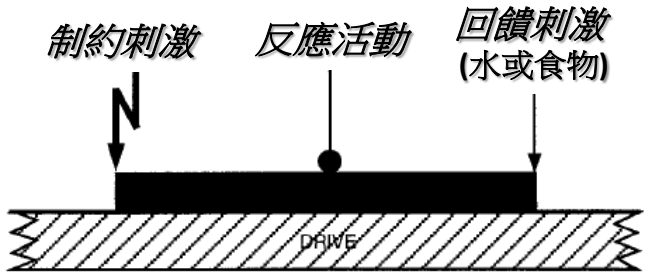
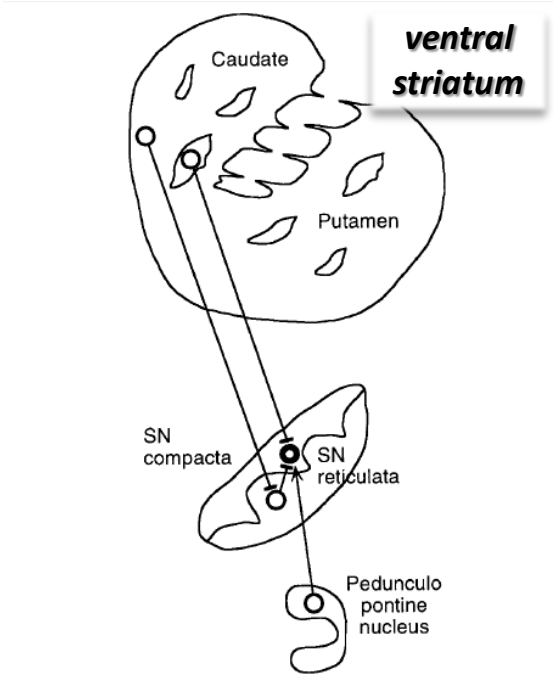
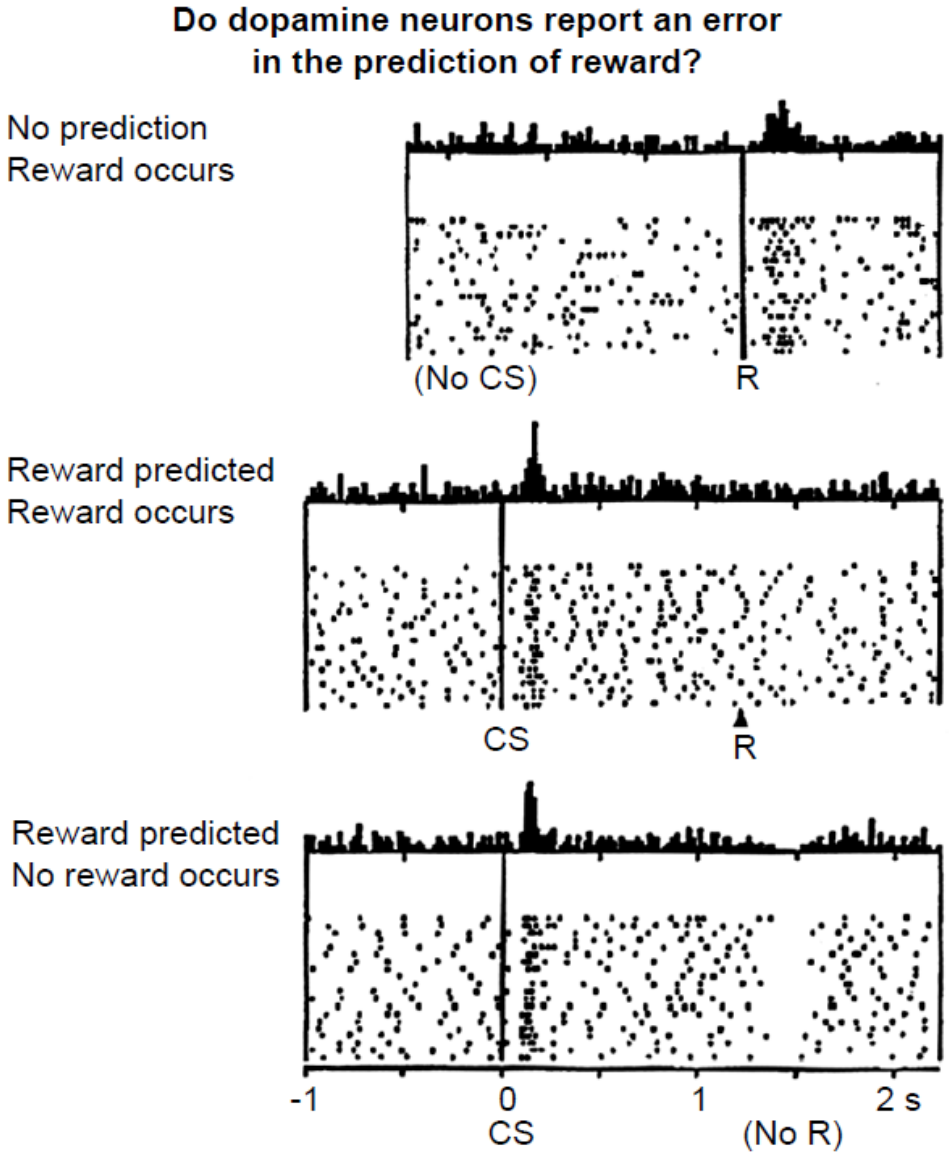


Figure 43–5 Global anatomy of cortico–basal ganglia–thalamocortical circuits. (**ACA**, anterior cingulate area; **CMA**, cingulate motor area; **DLPFC**, dorsolateral prefrontal cortex; **FEF**, frontal eye field; **GPi**, internal segment of the globus pallidus; **LOFC**, lateral orbitofrontal cortex; **M1**, primary motor cortex; **MDpl**, mediodorsal nucleus of thalamus, lateral part; **MOFC**, medial orbitofrontal cortex; **PMC**, premotor cortex; **SEF**, supplementary eye field; **SMA**, supplementary motor area; **SNr**, substantia nigra pars reticulata; **VAmc**, ventral anterior nucleus of thalamus, magnocellular part; **VApc**, ventral anterior nucleus of thalamus, parvocellular part; **VLcr**, ventrolateral nucleus of thalamus, caudal part, rostral division; **VLm**, ventrolateral nucleus of thalamus, medial part; **VLo**, ventrolateral nucleus of thalamus, pars oralis.) (Adapted, with permission, from Wichmann and DeLong 2006.)

習慣學習的神經機制


制約刺激
反應活動
回饋刺激
(水或食物)
N
DRIVE


ventral striatum
Caudate
Putamen
SN compacta
SN reticulata
Pedunculo pontine nucleus


Do dopamine neurons report an error in the prediction of reward?
No prediction
Reward occurs
(No CS)
R
Reward predicted
Reward occurs
CS
R
Reward predicted
No reward occurs
-1
0
1
2 s
CS
(No R)

習慣學習的神經機制

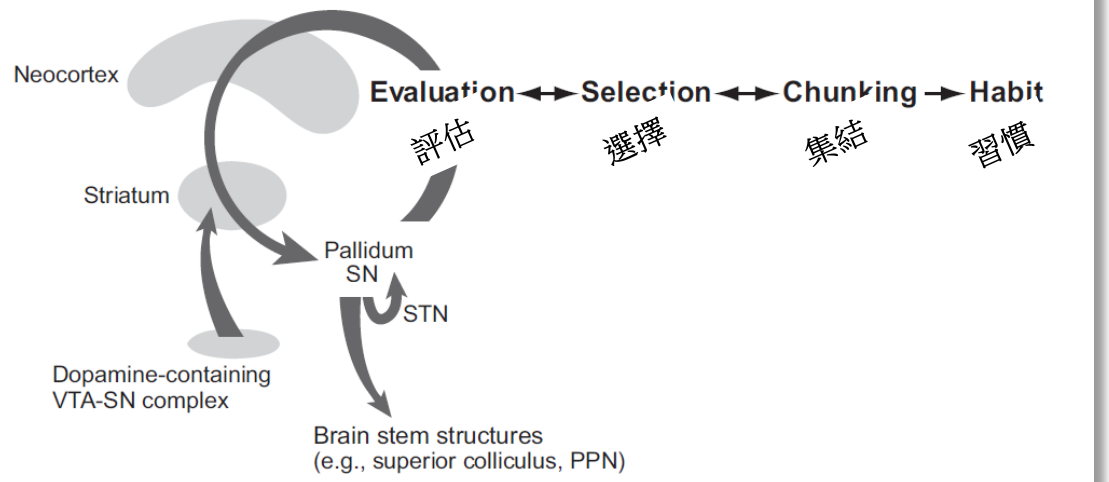
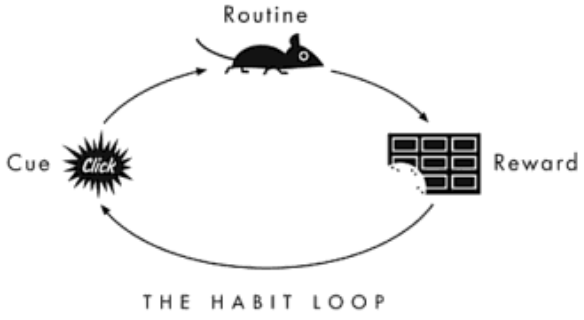


Figure 1

Schematic representation of the development of habits through iterative action of cortico–basal ganglia circuits. Circuits mediating evaluation of actions gradually lead to selection of particular behaviors that, through the chunking process, become habits. PPN, pedunculopontine nucleus; SN, substantia nigra; STN, subthalamic nucleus; VTA, ventral tegmental area.



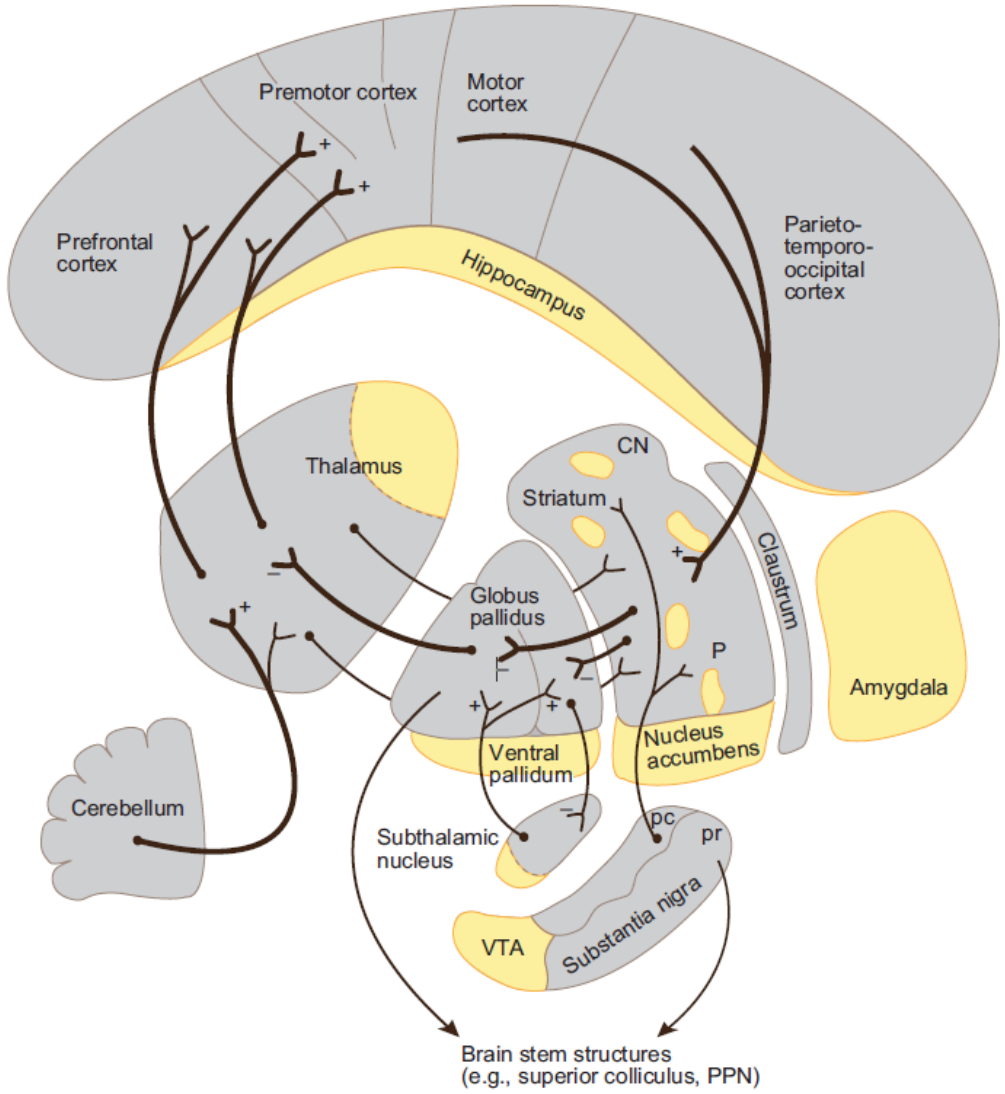
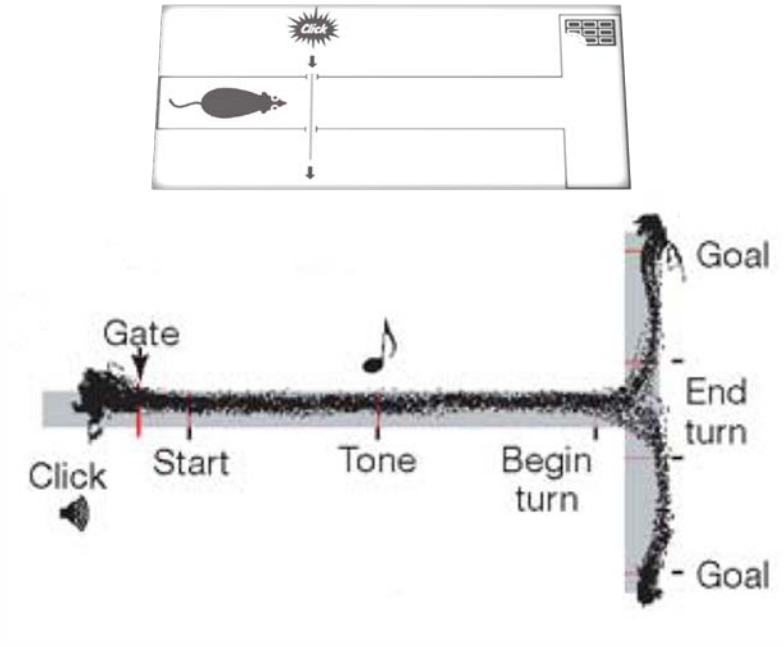
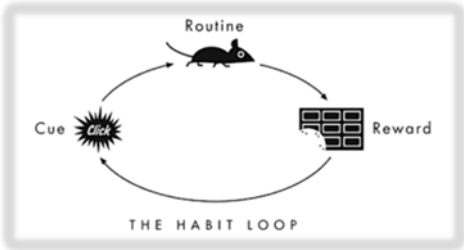


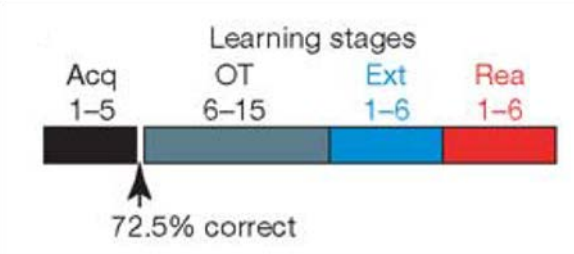
Figure 5

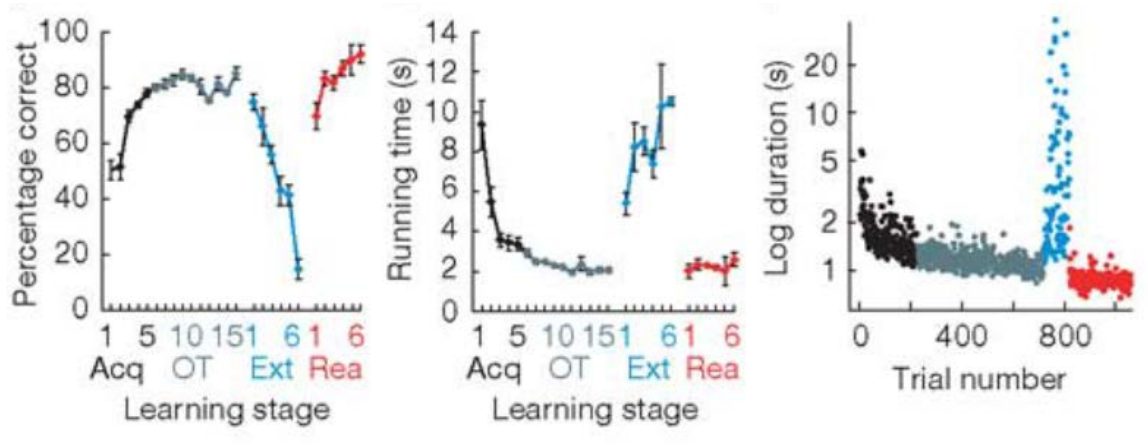
Basal ganglia circuit anatomy shown in simplified form with motor control pathways (*gray*) and regions related to limbic-system function (*yellow*). Descending pathways to brain stem structures (such as the superior colliculus and pedunculopontine nucleus) are not shown in detail. CN, caudate nucleus; P, putamen; pc, substantia nigra pars compacta; pr, substantia nigra pars reticulata; VTA, ventral tegmental area.

習慣學習的神經機制

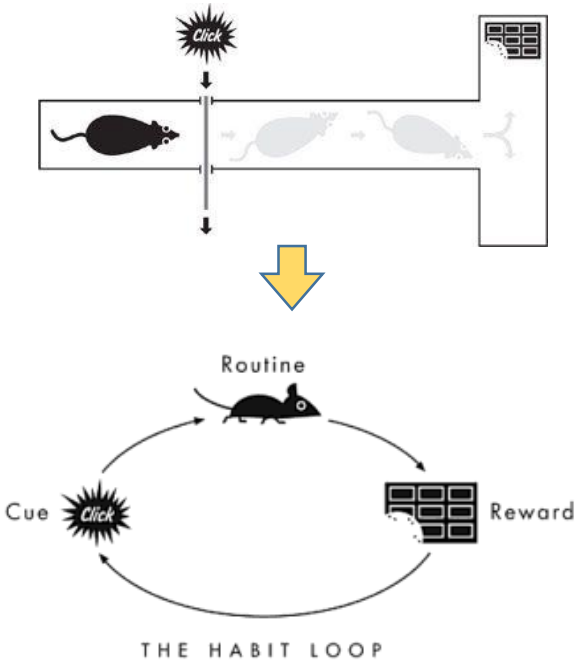

Click
Goal
Gate
End
turn
Click
Start
Tone
Begin
turn
Goal

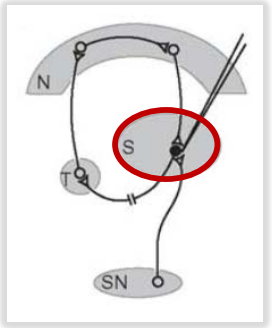

Routine
Cue
Reward
THE HABIT LOOP

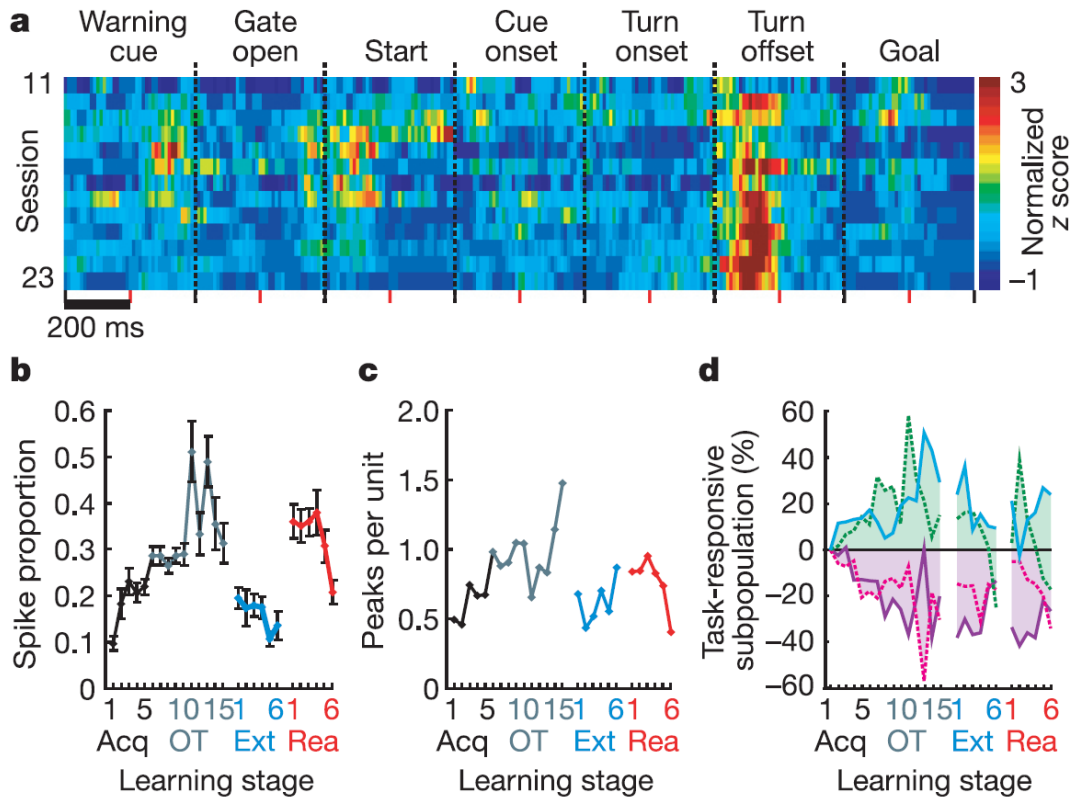

Learning stages
Acq
1–5
OT
6–15
Ext
1–6
Rea
1–6
72.5% correct

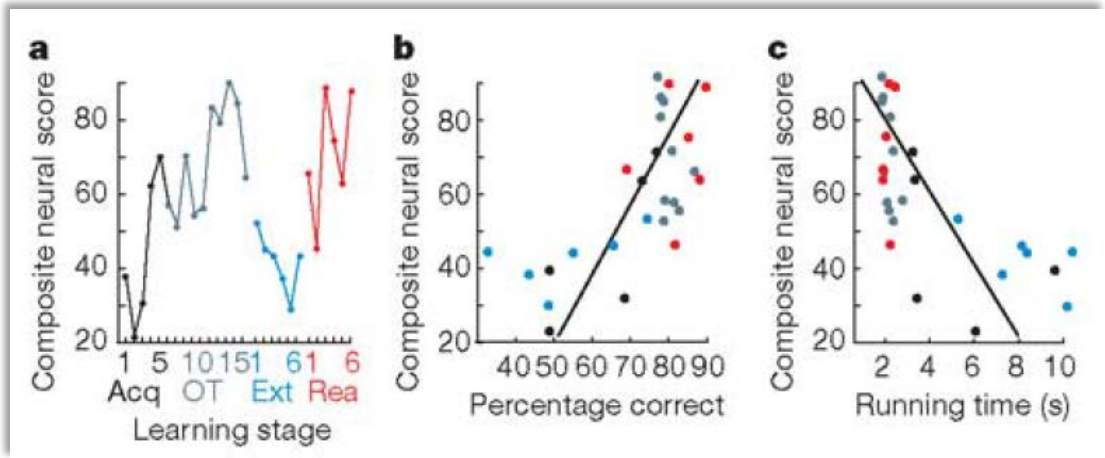

Percentage correct
100
80
60
40
20
0
1 5 10 15 1 6 1 6
Acq OT Ext Rea
Learning stage
Running time (s)
14
12
10
8
6
4
2
0
1 5 10 15 1 6 1 6
Acq OT Ext Rea
Learning stage
Log duration (s)
20
10
5
2
1
0 400 800
Trial number

習慣學習的神經機制

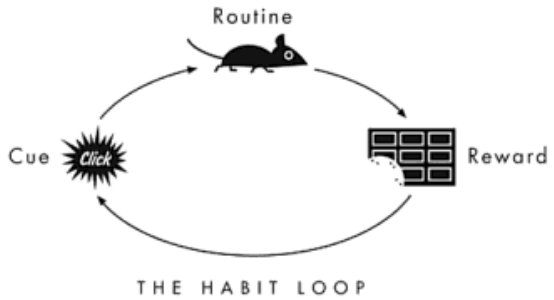

Click
Routine
Cue
Click
Reward
THE HABIT LOOP

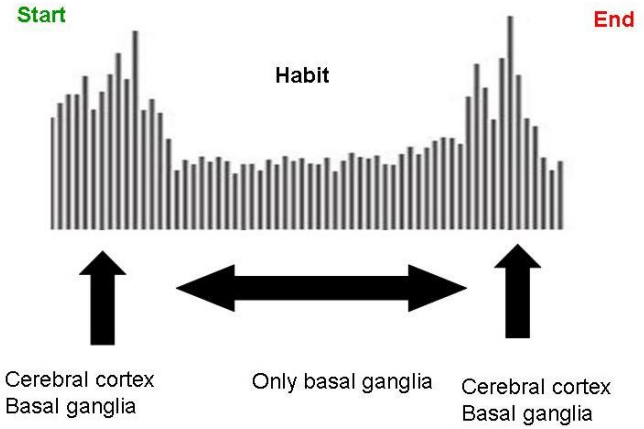

N
S
T
SN

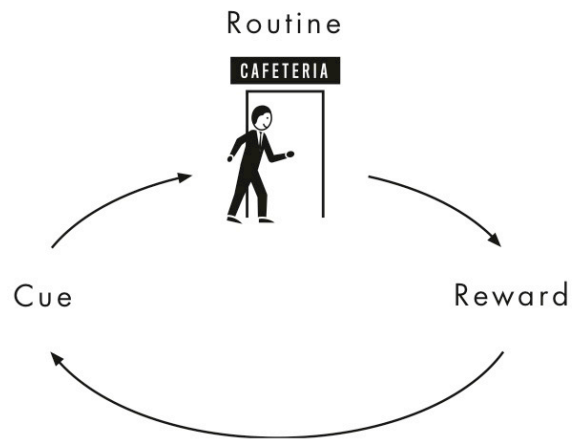

a
Warning cue
Gate open
Start
Cue onset
Turn onset
Turn offset
Goal
11
23
Session
200 ms
3
−1
Normalized z score
b
Spike proportion
Acq OT Ext Rea
Learning stage
c
Peaks per unit
Acq OT Ext Rea
Learning stage
d
Task-responsive subpopulation (%)
Acq OT Ext Rea
Learning stage

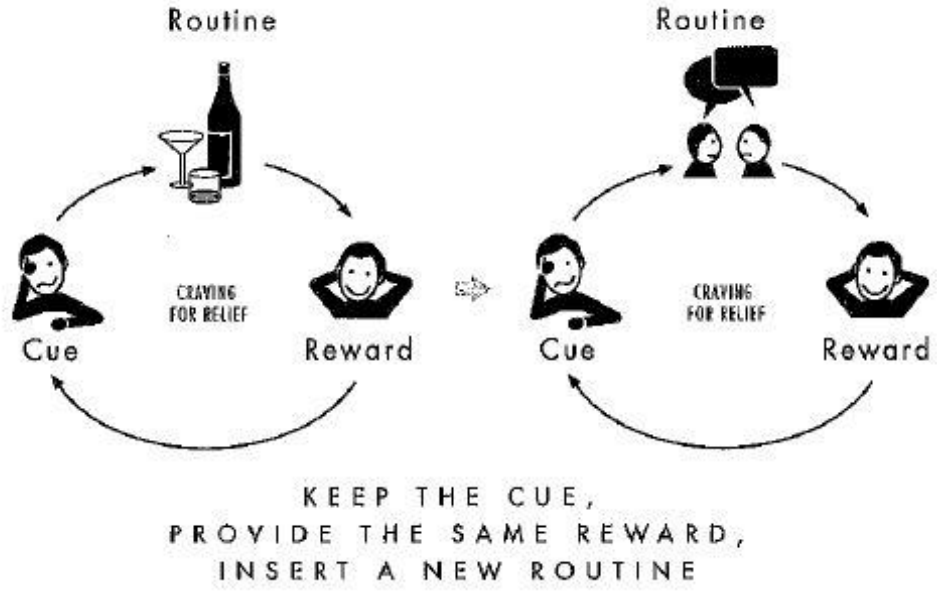

a
Composite neural score
Acq OT Ext Rea
Learning stage
b
Composite neural score
Percentage correct
c
Composite neural score
Running time (s)

結語

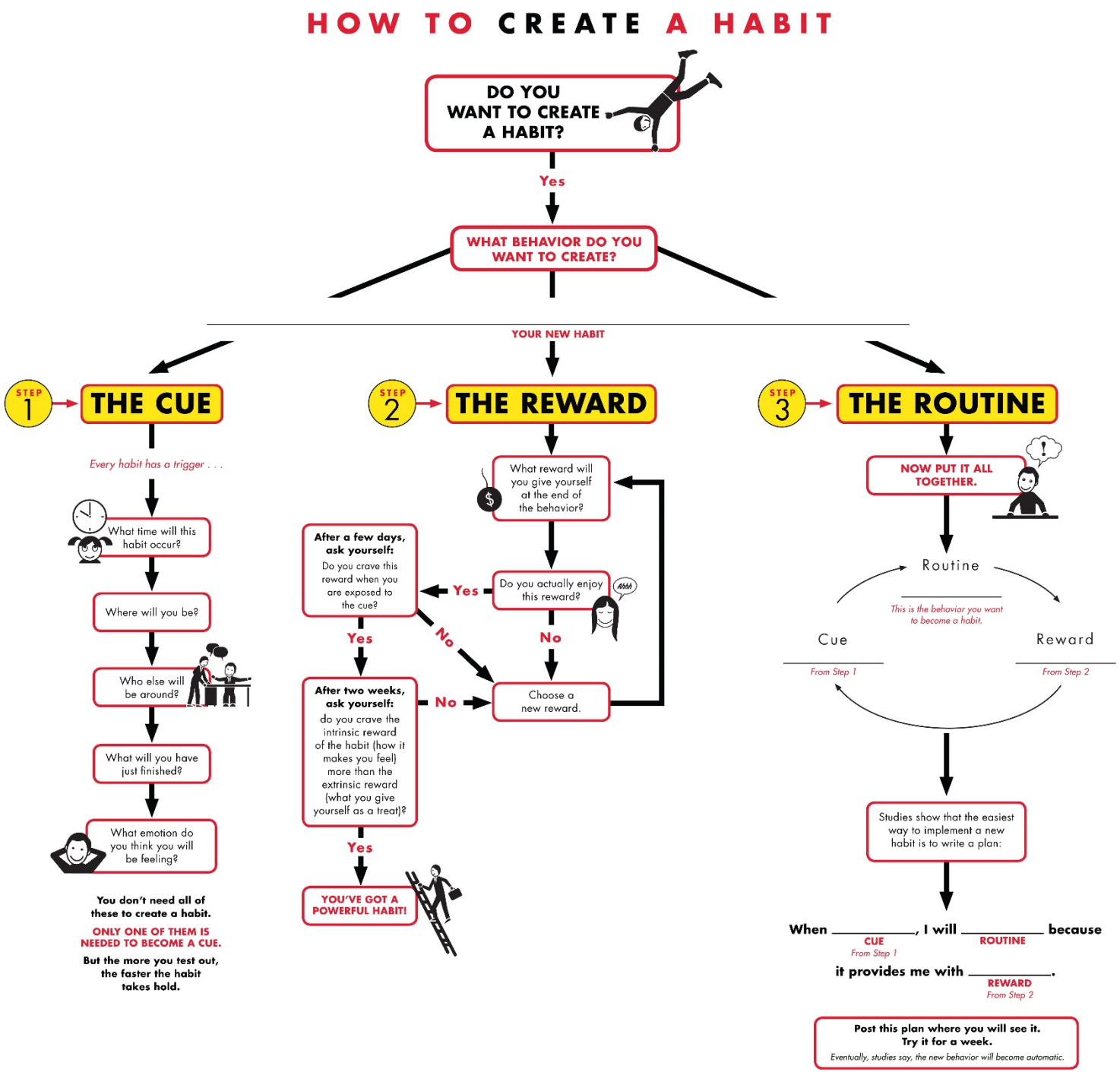

Routine
Cue
Click
Reward
THE HABIT LOOP


Start
End
Habit
Cerebral cortex
Basal ganglia
Only basal ganglia
Cerebral cortex
Basal ganglia


Routine
CAFETERIA
Cue
Reward


Routine
CRAVING FOR RELIEF
Cue
Reward
Routine
CRAVING FOR RELIEF
Cue
Reward
KEEP THE CUE,
PROVIDE THE SAME REWARD,
INSERT A NEW ROUTINE

結語


HOW TO CREATE A HABIT
DO YOU WANT TO CREATE A HABIT?
Yes
WHAT BEHAVIOR DO YOU WANT TO CREATE?
YOUR NEW HABIT
STEP 1
THE CUE
Every habit has a trigger . . .
What time will this habit occur?
Where will you be?
Who else will be around?
What will you have just finished?
What emotion do you think you will be feeling?
You don't need all of these to create a habit.
ONLY ONE OF THEM IS NEEDED TO BECOME A CUE.
But the more you test out, the faster the habit takes hold.
STEP 2
THE REWARD
What reward will you give yourself at the end of the behavior?
Do you actually enjoy this reward?
Yes
No
After a few days, ask yourself:
Do you crave this reward when you are exposed to the cue?
Yes
No
After two weeks, ask yourself:
do you crave the intrinsic reward of the habit (how it makes you feel) more than the extrinsic reward (what you give yourself as a treat)?
Yes
No
Choose a new reward.
YOU'VE GOT A POWERFUL HABIT!
STEP 3
THE ROUTINE
NOW PUT IT ALL TOGETHER.
Routine
This is the behavior you want to become a habit.
Cue
From Step 1
Reward
From Step 2
Studies show that the easiest way to implement a new habit is to write a plan:
When _____, I will _____ because
CUE
From Step 1
ROUTINE
it provides me with _____.
REWARD
From Step 2
Post this plan where you will see it.
Try it for a week.
Eventually, studies say, the new behavior will become automatic.