# Language & Brain

## *across the lifespan.*

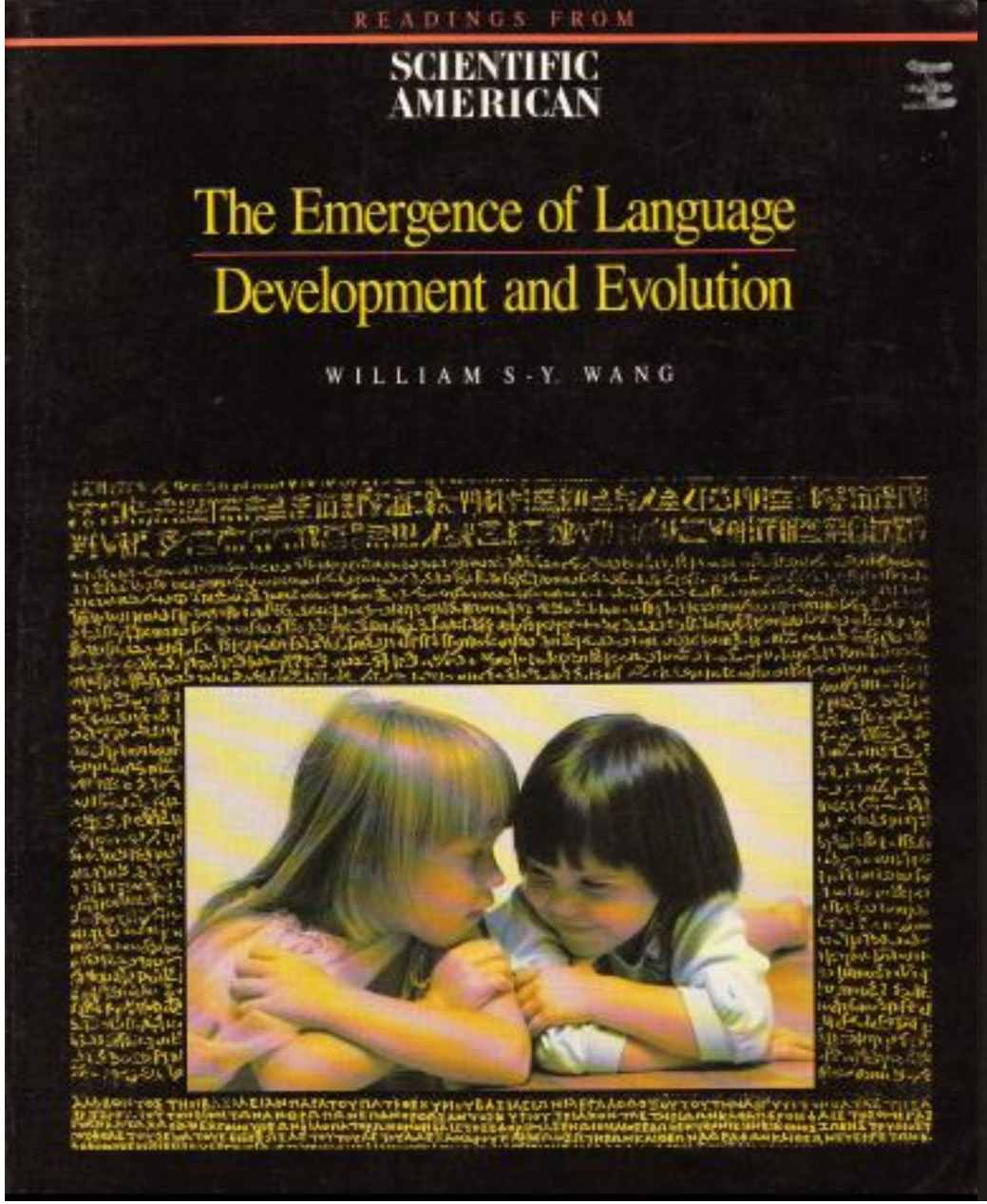
北京语言大学

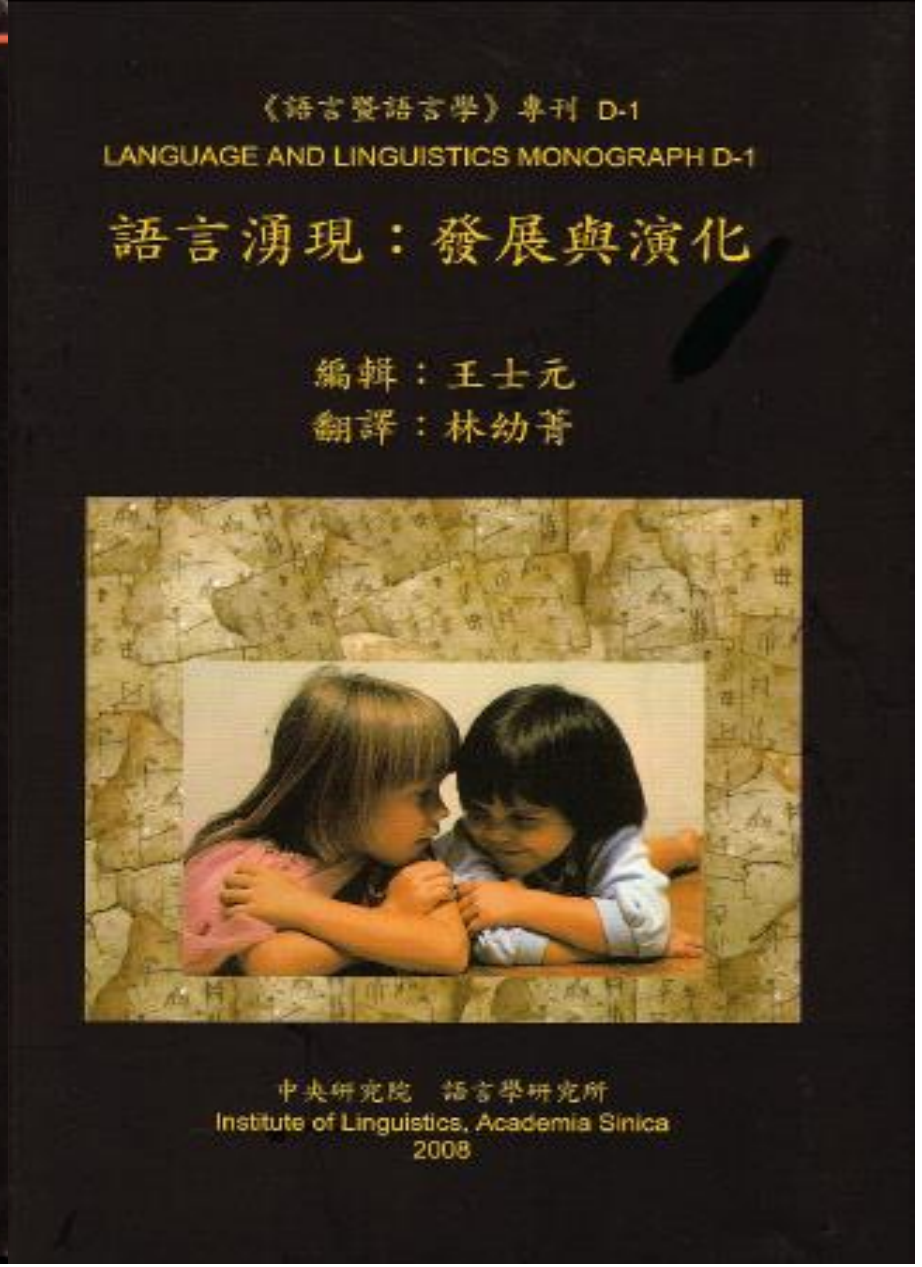
*Beijing Language & Culture University*

2022.12.27.

横看成岭侧成峰
远近高低总不同
不识庐山真面目
只缘身在此山中

W. S-Y. Wang, 王士元
HK Polytechnic University
*wsywang@polyu.edu.hk*



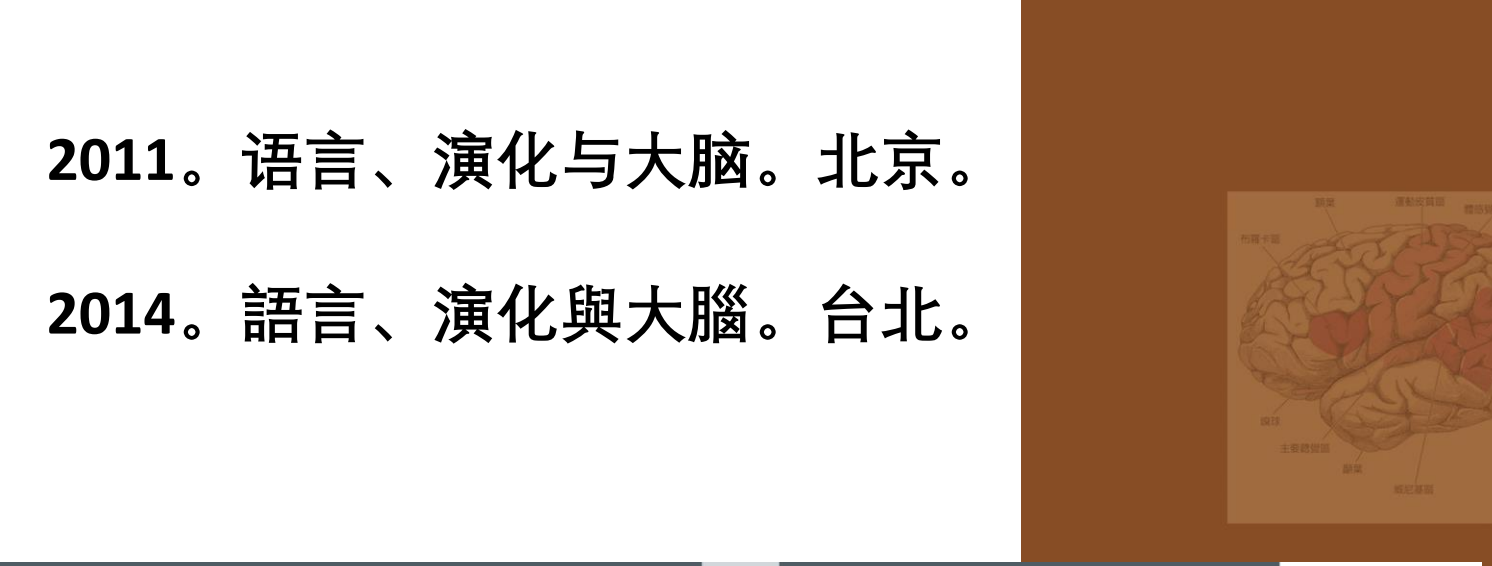



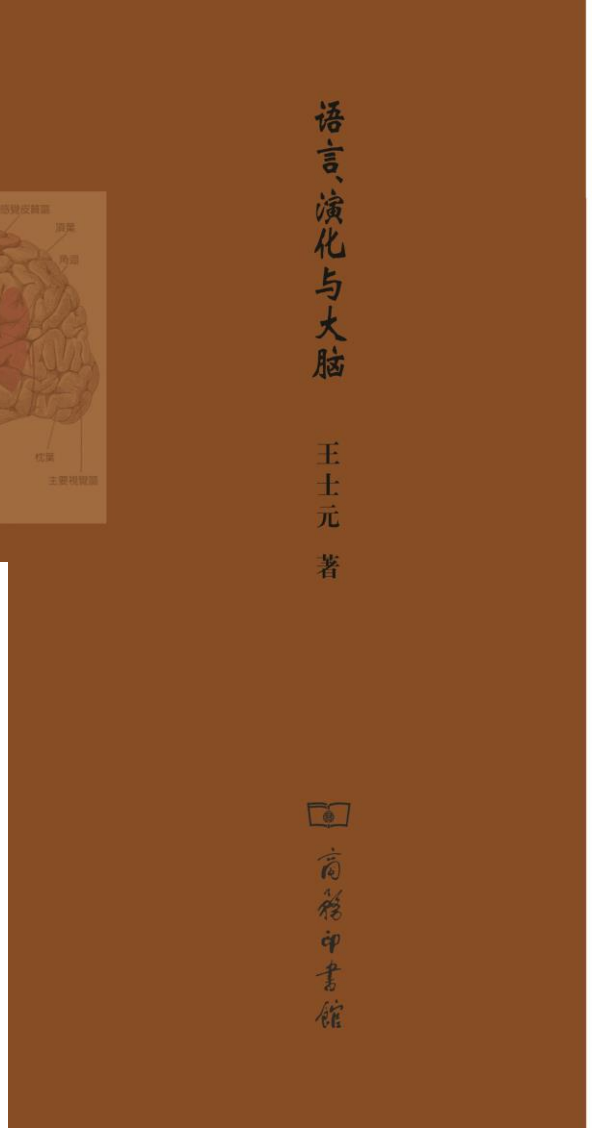

***Wang, W.S-Y. (ed.) 1991. The Emergence of Language: Development and Evolution*. W.H. Freeman**

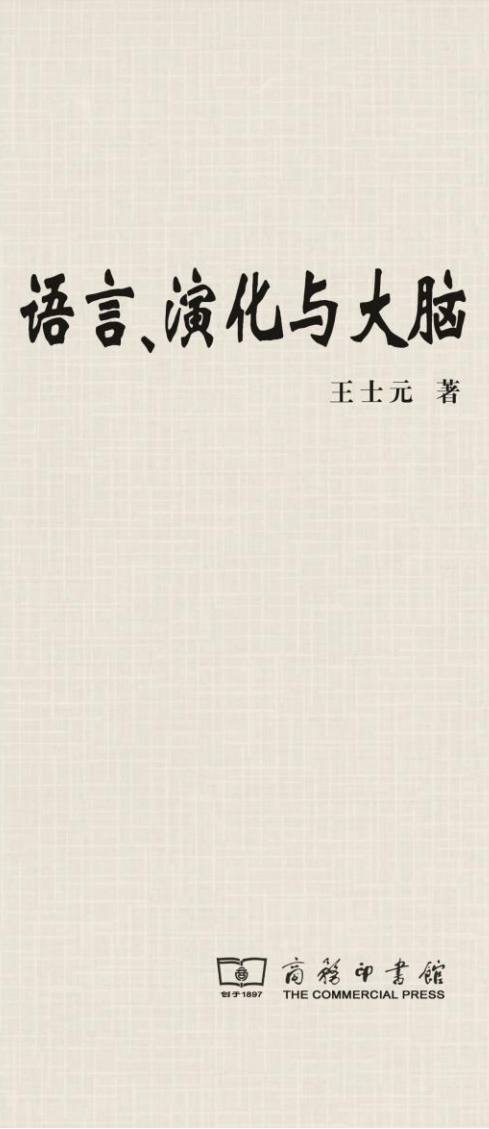
2008. 語言湧現: 發展與演化. 林幼菁譯. 語言暨語言學專刊D-1. 中央研究院 語言學研究所.

**2011。语言、演化与大脑。北京。**

**2014。語言、演化與大腦。台北。**





苏轼 *(1037 – 1101)*《题西林壁》

| | |
|---|---|
| 横看成岭侧成峰 | *Horizontally it is a range, obliquely it is a peak.* |
| 远近高低总不同 | *From far or near, high or low, it always looks different.* |
| 不识庐山真面目 | *We cannot know the true face of Lushan,* |
| 只缘身在此山中 | *Because we are totally immersed in the mountain.* |

Similarly, we it is difficult for us to know the true nature of Language because we are totally immersed in it. We use it internally by thinking, to organize our mental world; we use it externally to interact with others by hearing & speaking, reading & writing. Language enables us to extend beyond the here & now, to reach into the past & to plan for the future. More than anything else, Language has enabled us to become '**Masters of the Planet**.'

Also like the mountain, Language is always changing. It changes at a **phylogenetic** scale of some 2 million years, as our genus evolved from prelanguage, through protolanguage, to the modern languages we have today. Language also changes at an **ontogenetic** scale across the lifespan, as a neonate goes from babbling, followed shortly by rapid lexical growth, to full adult fluency. The health sciences have greatly extended our lifespan, though with it come various risks for neurodegeneration that we are only beginning to cope with. Later, we will briefly look at this challenges that come with our extended sunset years.

Tattersall, I. (2012). *Masters of the Planet: The Search for Our Human Origins*. New York.

Life began on Earth some 3 billion years ago, in the form of simple cells with no nucleus. As biological evolution proceeded, some of these cells eventually acquired a **nucleus**, and joined together to form ever more complex **multicellular** organisms. Over this long time span countless species have emerged, especially around half a billion years ago around the Cambrian period (寒武紀) when most of Earth's major phyla appeared. As cells differentiated in their structures and functions, it was also around this period that the first **nervous systems** can be detected in the fossils.

We trace our ancestry to the class of mammals, so named because of the way neonates are nursed. Closer in time, we belong to the order of **primates** 灵长目, which emerged some 70 mya, distinguished by our stereoscopic vision, dexterous hands, among many other traits. Among the hundreds of species of primates, our closest living relatives are the chimpanzees, of which there are 2 species. Our lineage separated from theirs some 6 mya.

What makes us unique is our super powerful brain, that enabled us to move out of Africa in many successive waves, and colonized the entire planet. The history of these movements is still being written as new fossils are discovered. A recent example is the well preserved skull being analyzed in Yunyang 郧阳, China, of ***Homo erectus*** 直立人 a million years old.

科學對這一段漫長的生命故事的了解，近年來有著大大的進展。之前我們研究這個故事的唯一數據，只有依靠憑運氣挖掘出來的化石，例如在周口店博物館內所展示的北京猿人。可是自從基因學參與了這方面的研究，這一領域的知識最大的突破開始於20世紀中葉Watson-Crick的發現，幫他們獲得1962年的諾貝爾獎。在雙螺旋 DNA的基礎上，基因學（或稱遺傳學）取得了種種突破。同時神經科學研究也在日新月異地進展，幫我們越來越深入地瞭解人類獨特的大腦。我們必須依賴這兩門重要學科的合作，來解釋語言的來源、結構等一些問題。

有人说过，21世纪是生命科学的黄金时代。例如前幾月剛宣布的頒給Svante Pääbo的諾貝爾獎，是為了讚揚他發明的古DNA萃取法，這種方法能夠從幾千年前的化石裡提取出古DNA，来让我們理解現代人跟一些已絕種的古人類之間的關係。比方有一種已滅絕的古人類叫丹尼索瓦人(Denisovan)，經過古DNA的分析，我們知道他們與西藏人的祖先曾共同繁衍過後代子孫，**因此他們遺留在現代藏人身上的基因，協助藏人在生理上可以適應高海拔氧氣少的環境**。

Svante Pääbo

# Neanderthal Man

## In Search of Lost Genomes

New York 2014
Basic Books


Major breakthrough in studying prehistory:

**ANCIENT DNA**

**从化石中萃取DNA!**

Just won the 2022

**NOBEL PRIZE**

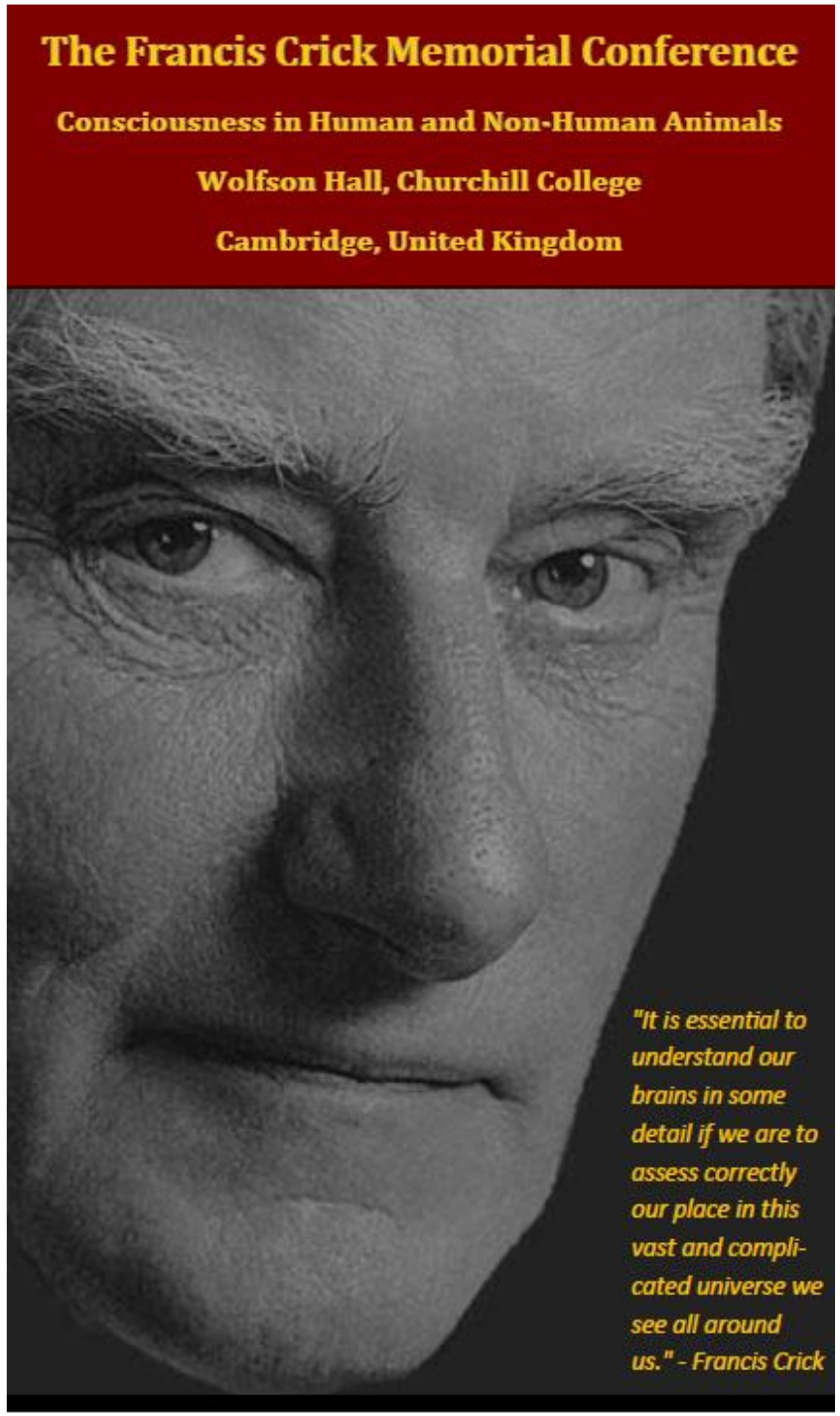
for Physiology or Medicine.

# 蔡元培. 1928. 中央研究院历史语言研究所集刊。发刊词.

- “同是动物，
- 为什么只有人类能不断的进步，能创造文化?
- 因为人类有历史，而别的动物没有。因为他们没有历史，不能够把过去的经验传说下去…
- 为什么只有人类能创造历史，而别的动物没有?
- 因为人类有 **变化无穷的语言**”。

Cai Yuanpei was remarkably insightful, writing this a century ago, before much relevant knowledge in Comparative Biology became available. Indeed, we share a great deal with other animals, having evolved from a common biological origin over billions of years, via similar processes of variation, selection & change. This common ancestry shows up biologically in numerous ways, including the recently discovered frequencies of brain oscillations.

But the rate at which **biological evolution** transmits information for change from generation to generation is much too slow. The critical distinction that makes humans unique is that superimposed on biological evolution, we invented **cultural evolution**. This allows the transmission of abundant information to take place across many individuals simultaneously. Once language was invented, which itself was a product of cultural evolution, the power of cultural evolution was greatly amplified. With the further invention of writing & mathematics, both building upon language as a foundation, our tool kit has become rich enough for us to master and re-shape our planet Earth, as well as to explore the universe beyond.




**We declare the following: "*The absence of a neocortex does not appear to preclude an organism from experiencing affective states. Convergent evidence indicates that non-human animals have the neuroanatomical, neurochemical, and neurophysiological substrates of conscious states along with the capacity to exhibit intentional behaviors. Consequently, the weight of evidence indicates that humans are not unique in possessing the neurological substrates that generate consciousness. Nonhuman animals, including all mammals and birds, and many other creatures, including octopuses, also possess these neurological substrates.*"**

Cambridge Declaration on Consciousness. July 7, 2012.

# 劍橋的意識宣言

2012年7月7日這天，國際上一群頂尖的認知神經科學家、神經藥學家、
神經生理學家、神經解剖學家和計算神經學家，雲集在劍橋大學，
以重新評估人類及人類以外的動物的意識經驗和相關行為的神經生物基質。

……

我們的宣言如下：「缺乏腦皮層似乎不會讓有機體無法體驗到情感狀態。
越趨一致的證據顯示，人類以外的動物也具備意識狀態的神經解剖、
神經化學和神經生理基質，並且有能力展現出有意圖的行為。
因此，證據的重要性顯示，

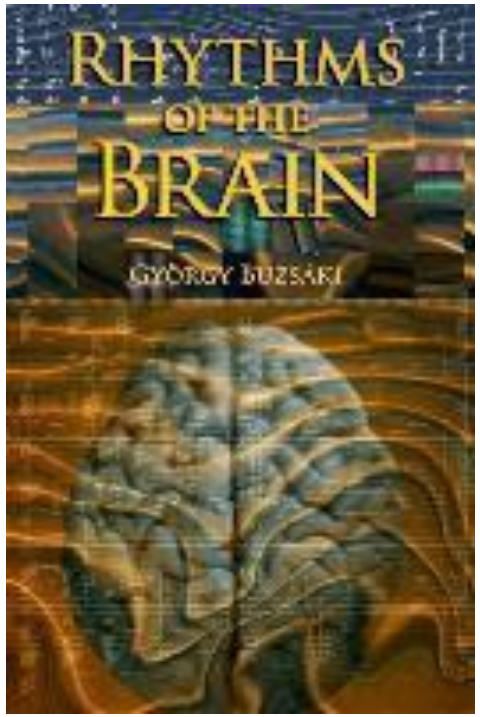
**人類並非擁有能衍生出意識的神經基質的唯一物種**。

人類以外的動物，包括所有哺乳動物、鳥類及許多其他生物如章魚等，
也都擁有這些神經基質。」

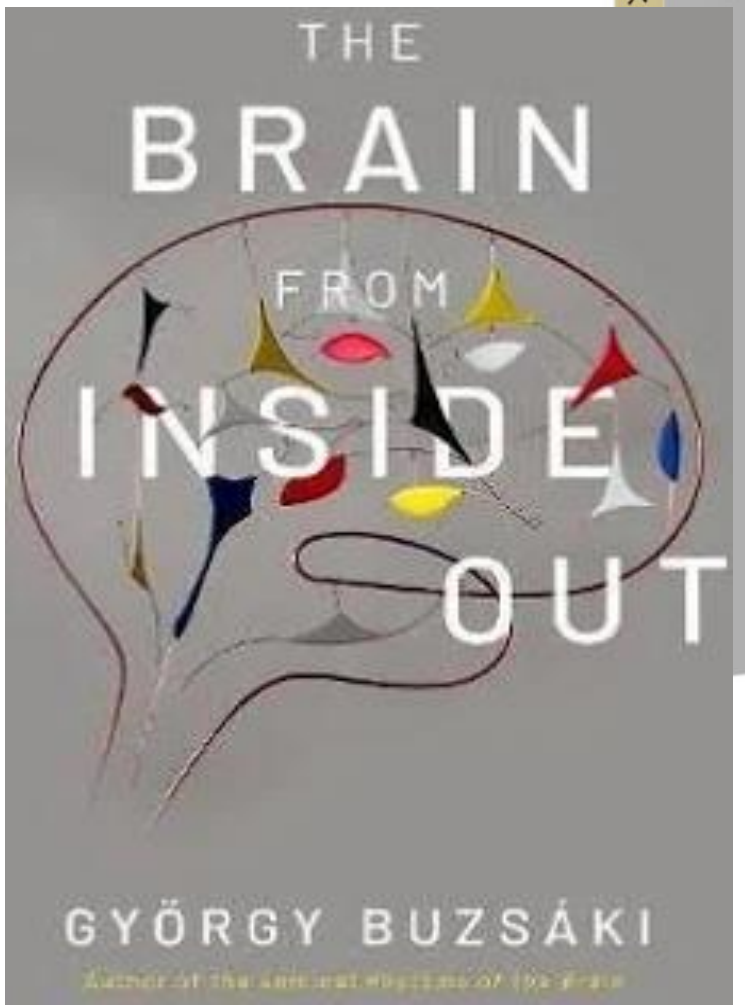
# György Buzsáki

is Biggs Professor of Neuroscience at New York University School of Medicine.

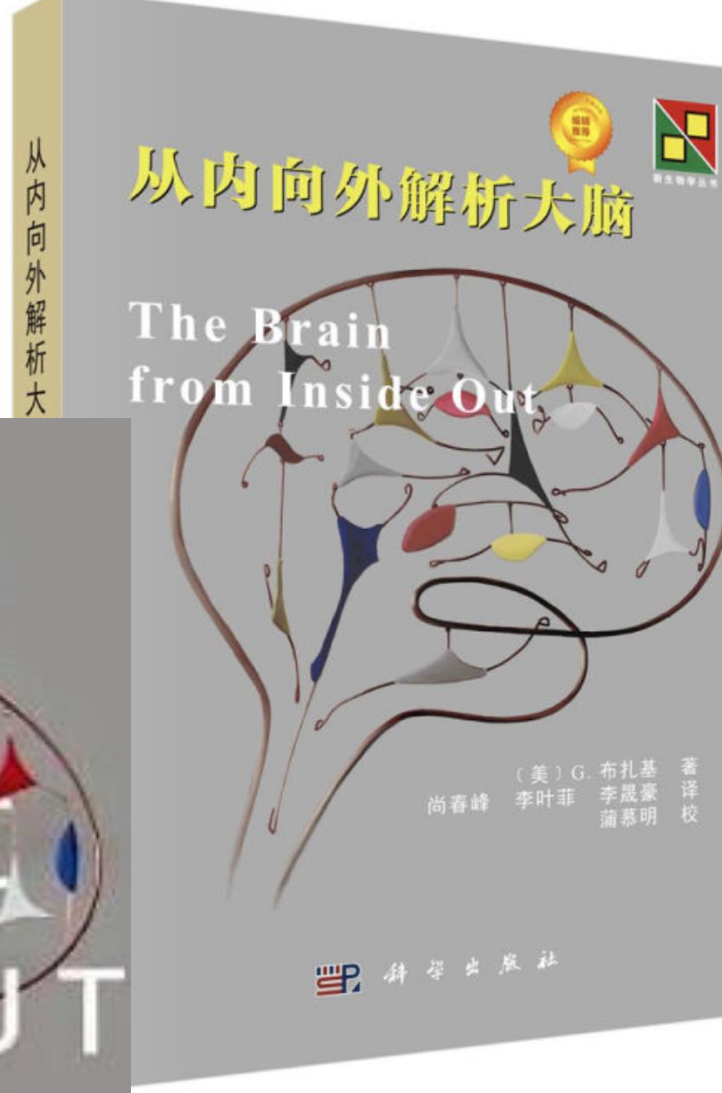
Winner of the inaugural **Brain Prize** in 2011, & recipient of the 2020 **Ralph Gerard Prize**, the highest honor from the Society for Neuroscience.




2006




2019




2022

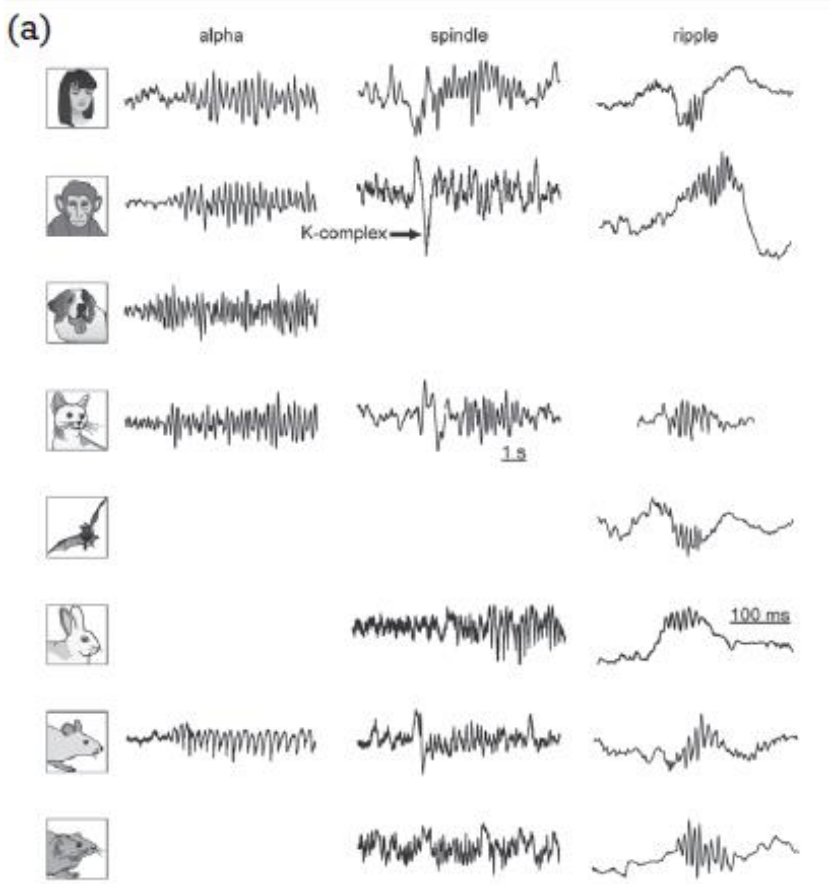
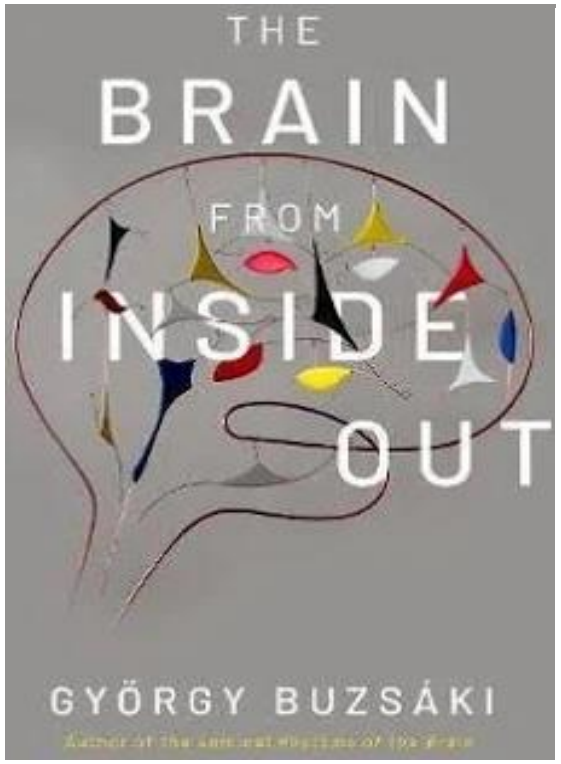
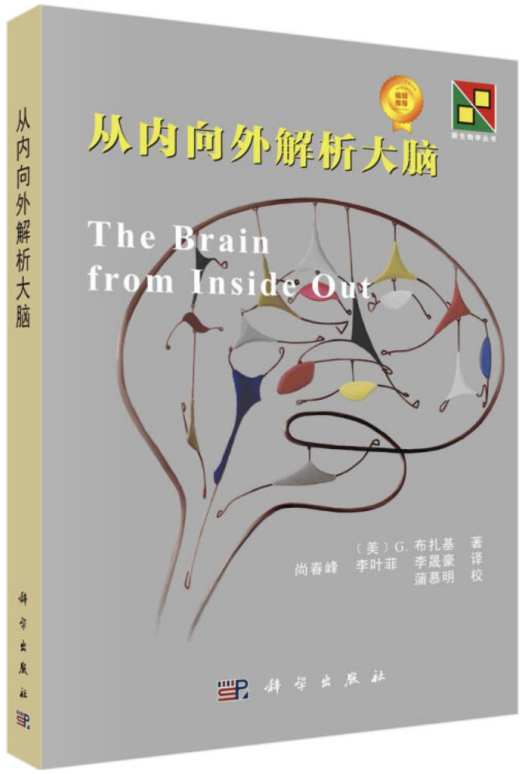



Figure 6.3. Preservation of brain rhythms in mammals.

A: Illustrative traces of neocortical alpha oscillations, sleep spindles, & hippocampal ripples in various species. Note the similarity of frequency, temporal evolution, & waveforms of the respective patterns across species.

B: Relationship between brain weight & frequency of th various rhythm classes on a log- log scale. Note the small variation of frequency changes despite increases in brain weight of several orders of magnitude.



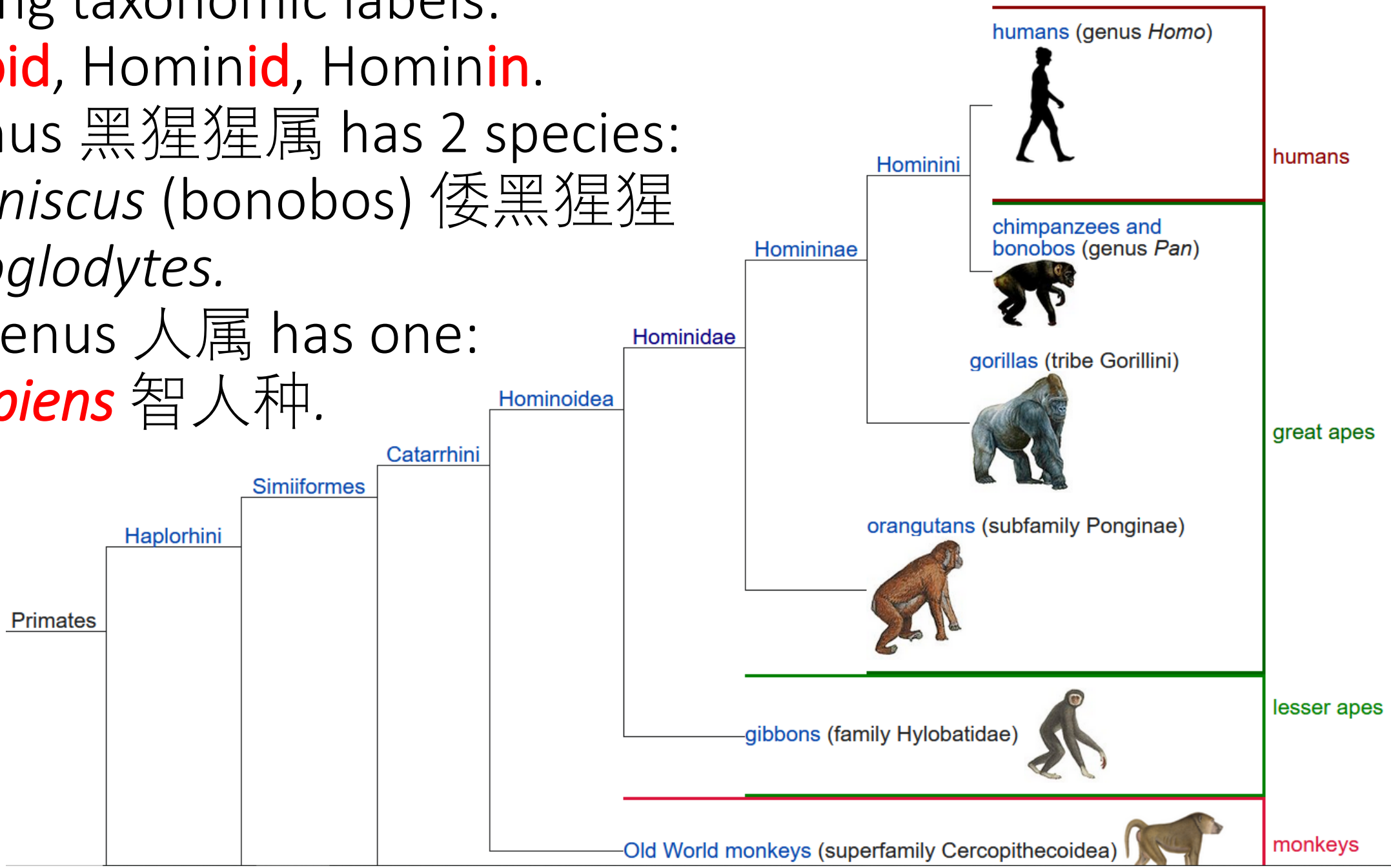

*Buzsaki 2019: 154.*

**Linné 林奈** 1758:
Kingdom 界, Phylum 门, Class 纲, Order 目, Family 科, Genus 属, Species 种.

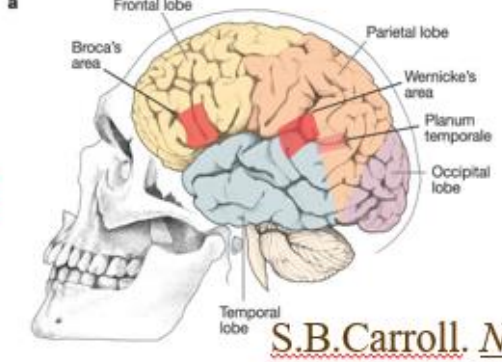
门Chordates Phylum, 540 mya; starting from the Cambrian Period 寒武纪
Vertebrates, spinal cord protected by vertebra.
纲 Mammals Class, 66 mya; offspring feed on mother's milk.
目 Primates Order, 55 mya;
Superfamily Hominoidea
科 Family Hominidae (great apes & humans)
Subfamily Homininae
属 Genus: *Gorilla*
*Pan*
*Homo*
种 Species: *sapiens.*

Confusing taxonomic labels:
Hominoid, Hominid, Hominin.
*Pan* genus 黑猩猩属 has 2 species:
*paniscus* (bonobos) 倭黑猩猩
*troglodytes.*
***Homo*** genus 人属 has one:
***sapiens*** 智人种.

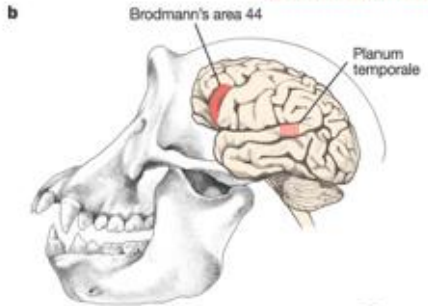
灵长类



**Genetic basis of human brain evolution**. 2008. Vallender, Eric, et al. *Trends in Neuroscience*.




S.B.Carroll. *Nature*. *2003*.




**hominin**

*南方古猿 Australopithecus*
*巧人 Homo habilis*
*直立人 Homo erectus*
*智人 Homo sapiens*

**primates 靈長類**

**hominid**



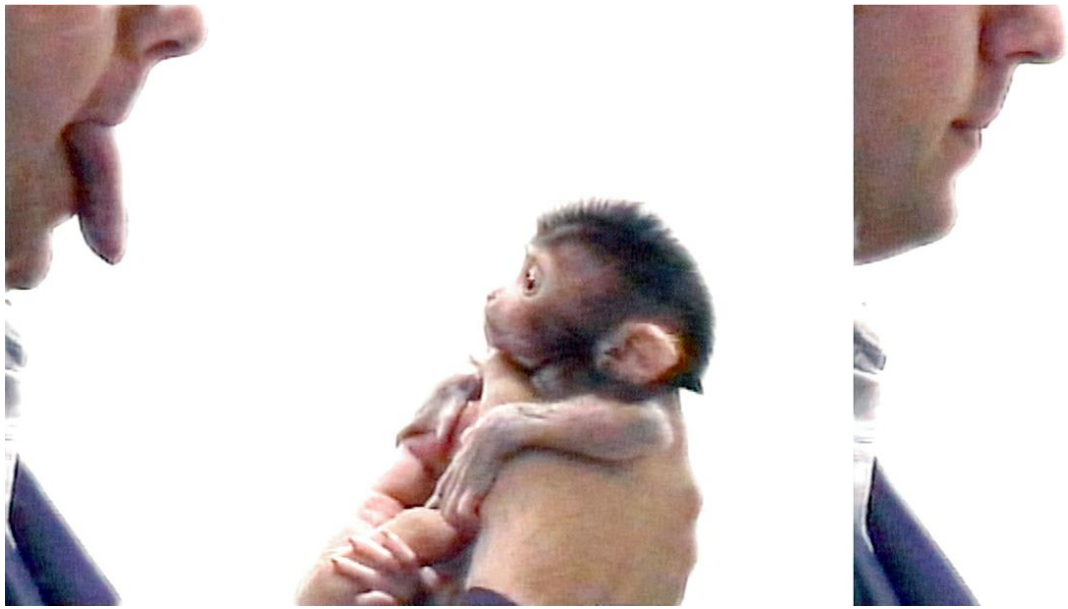
| | Human | Chimpanzee 黑猩猩 | Gorilla 大猩猩 | Orangutan 红毛猩猩 | Gibbon 長臂猿 | Old World monkeys | New World monkeys |
|---|---|---|---|---|---|---|---|
| Millions of years since last common ancestor with human | --- | 5–7 | 7–9 | ~14 | ~18 | ~25 | 35–40 |
| Genetic difference from human | --- | ~1.2% | ~1.6% | ~3.1% | ~4.0% | ~6.5% | ~11.5% |
| Brain volume in $cm^3$ | 1129–1685 | 230–415 | 400–565 | 300–400 | 70–152 | 33–205 | 4–123 |

*TRENDS in Neurosciences*

# Imitation by primates & mirror neurons.

Arbib, M. A. 2013. How the Brain got Language: the Mirror System Hypothesis. *Oxford University Press.*

Gross, Liza. 2006.
Evolution of Neonatal Imitation.
*PLoS Biology* Vol. 4/9/2006, e311.



Meltzoff, A.N. & Moore, M.K. 1977.
Imitation of facial & manual gestures by human neonates.
*Science* 198, 75–78.

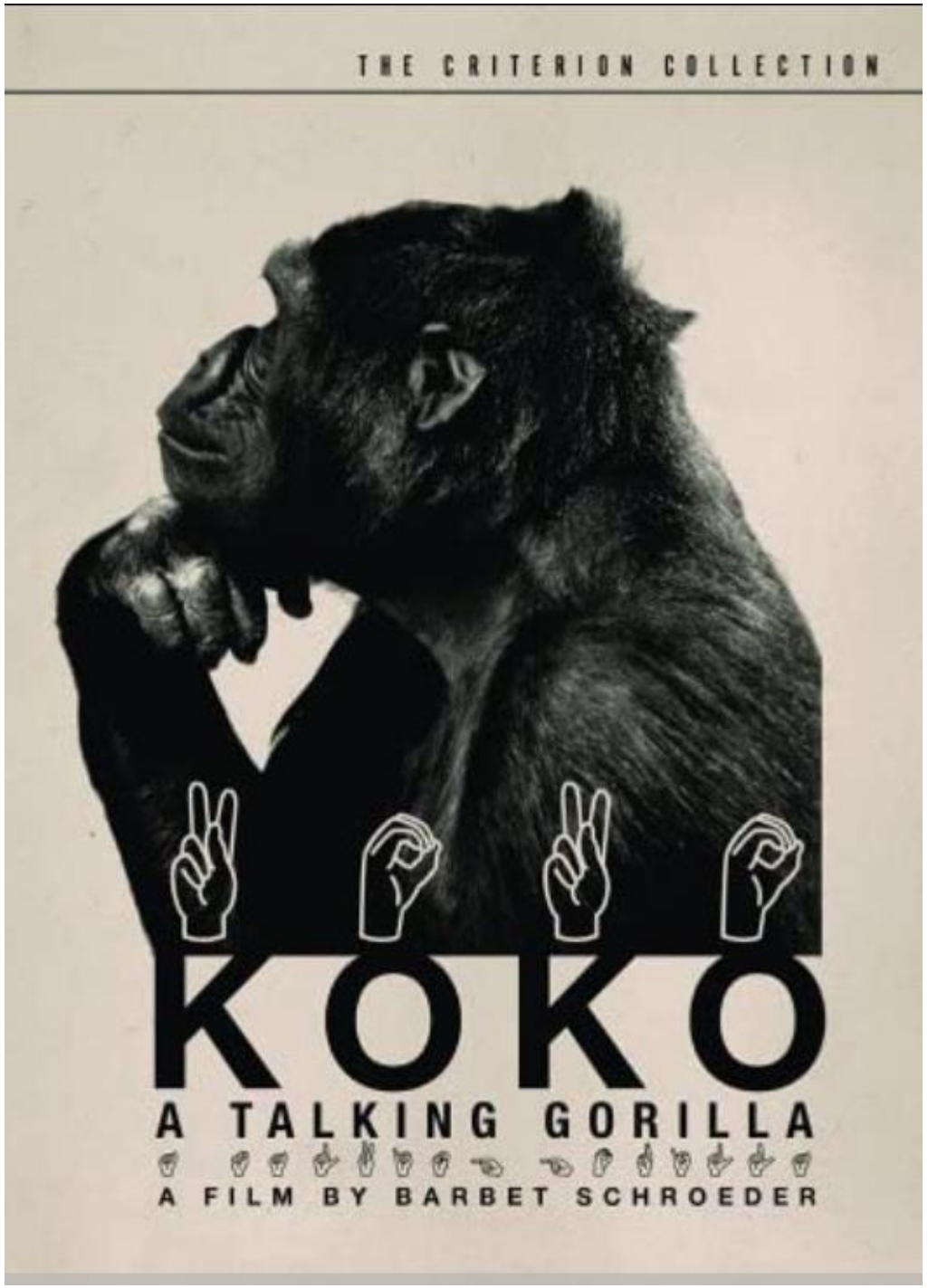
**Capuchin monkeys are found in Central America; separated from human line over 35 Mya..**

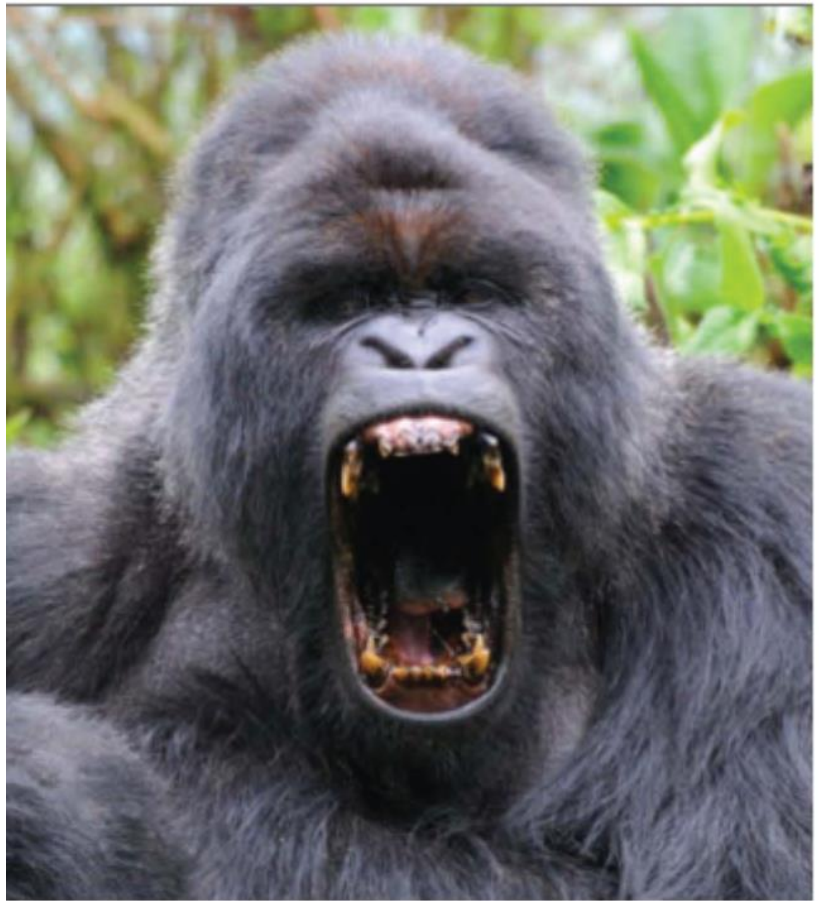
*Experiments of Franz de Waal on Capuchin monkey & concept of fairness.* https://www.youtube.com/watch?v=lKhAd0Tyny0, accessed 20180319.

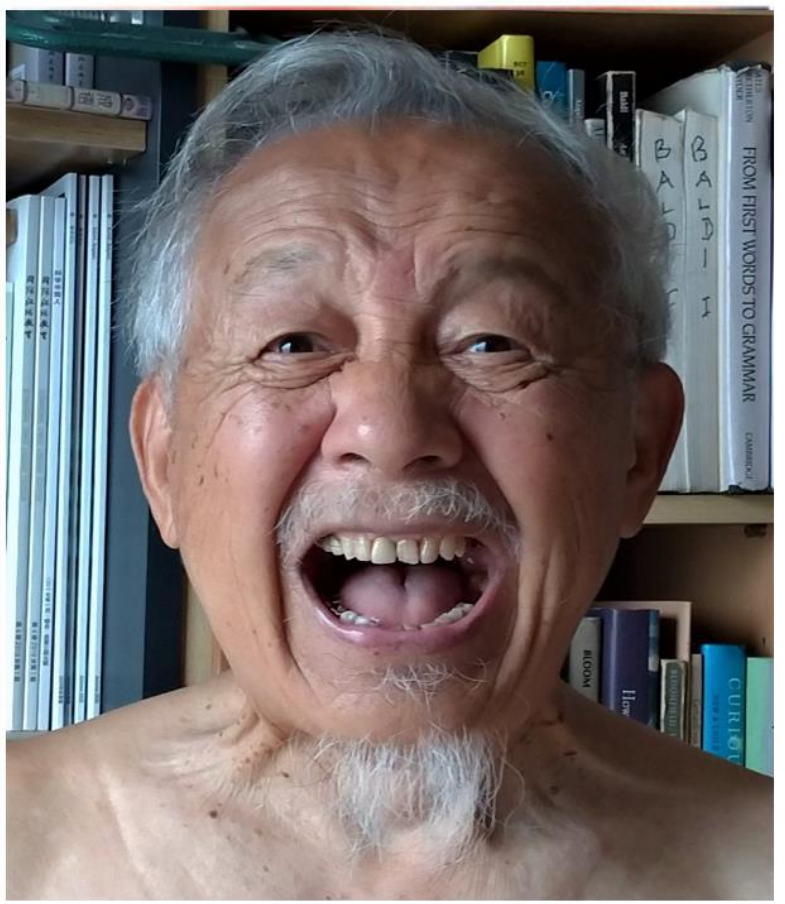
*"Koko: A Talking Gorilla* (French: *Koko, le gorille qui parle*) is a 1978 French documentary film … that focuses on Francine Patterson and her work with Koko, the gorilla. Patterson claims to have taught Koko to communicate with humans using symbols taken from American Sign Language.
The film was screened in the Un Certain Regard section at the 1978 Cannes Film Festival."


Bonvillian, J. D. and F. G. P. Patterson (1999). Early sign-language acquisition: comparisons between children and gorillas. The Mentalities of Gorillas and Orangutans: Comparative Perspectives. S. T. Parker, R. W. Mitchell and H. L. Miles. Cambridge, Cambridge University Press: 240-264.

Patterson, F. G. P. and M. L. Matevia (2001). Twenty-seven Years of Project Koko and Michael. All Apes Great and Small: African Apes. B. M. F. Galdikas, N. E. Briggs, L. K. Sheeran, G. L. Shapiro and J. Goodall, Springer: 165–176.




*Gorilla* *Chimpanzee* *Homo*

Quiz: Which two primates are the closest relatives?

哪兩個靈長類關係最接近?

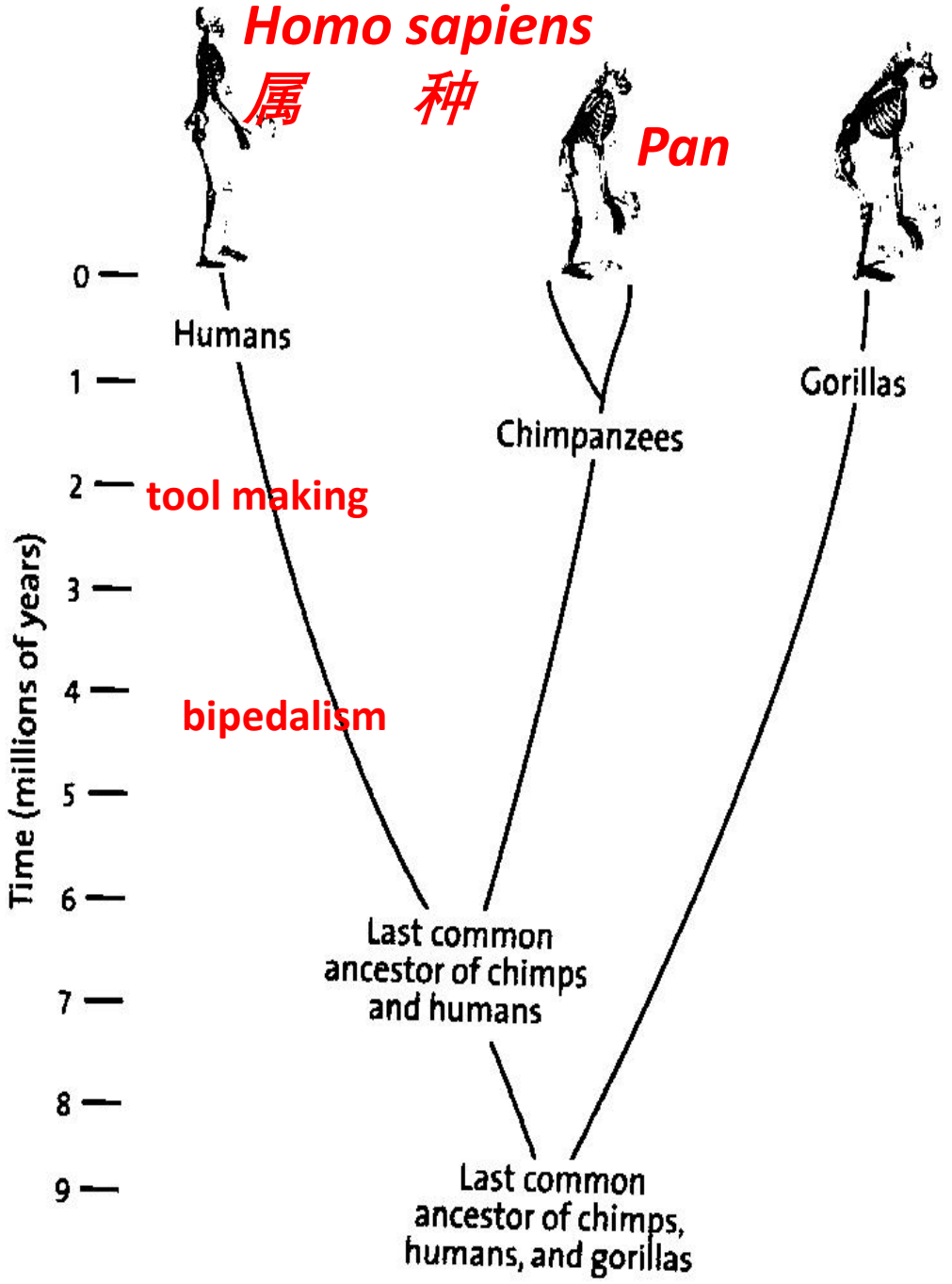
Lieberman, Daniel E. 2013:29.

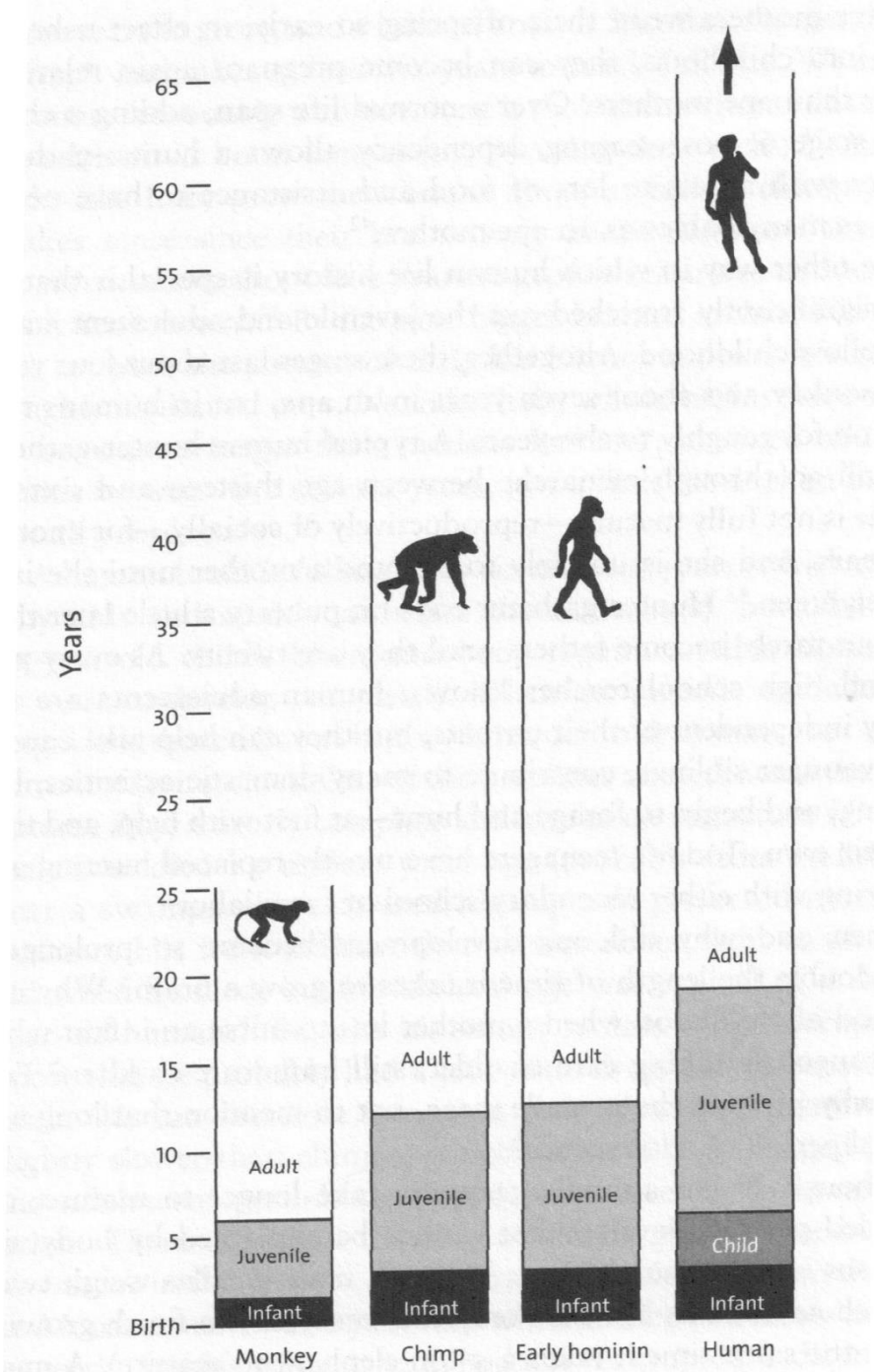
# The Story of the Human Body: Evolution, health, & disease.

Pantheon.

Chimpanzees diverged into two species over a million years ago, separated by the Congo River.

The genus *Pan* divides into *troglodytes* & *paniscus (bonobos)*, with clear physical & social differences.

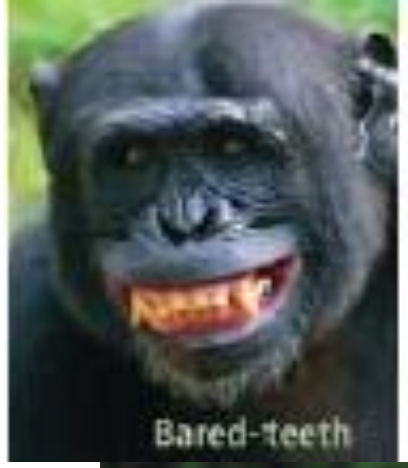


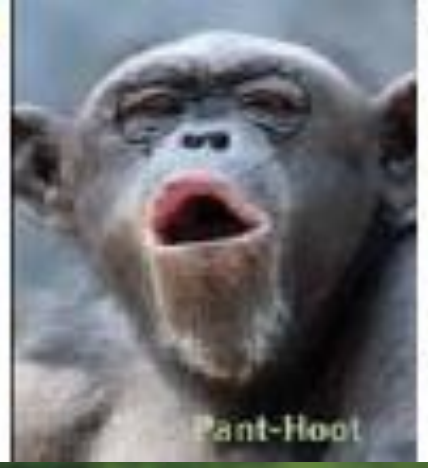


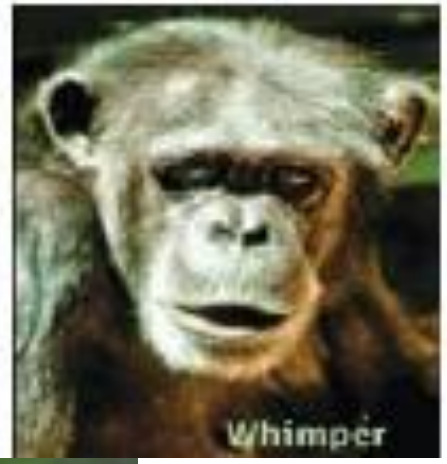

**Lieberman, D.E. 2013. Figure 13.**

***The Story of the Human Body: Evolution, health, & disease*. Pantheon.**

**Humans have added a stage to their life-span, 'childhood', & prolonged the stage of 'juvenile'. These changes have greatly facilitated young ones to learn language & culture, as these become increasingly cumulative & complex. We have become 'Masters of the Planet' because we are uniquely driven by cultural evolution, which soon outpaced biological evolution by an ever larger margin.**






F. B. M. de Waal.
***A century of getting to know the chimpanzee.***
*Nature* 437.56-59, 2005.

与黑猩猩相识**100**年。

1927. Köhler, Wolfgang. The mentality of apes: Harcourt Brace.
1971. Goodall, Jane. In the Shadow of Man: Houghton Mifflin.
1972 Premack, Ann James & David Premack. 1972. Teaching language to an ape. *Scientific American*.
1994. Savage-Rumbaugh, Sue & Roger Lewin. Kanzi: The Ape at the Brink of the Human Mind: John Wiley and Sons.
2007. Herrmann, E. et al. Humans Have Evolved Specialized Skills of Social Cognition: The Cultural Intelligence Hypothesis. *Science* 317.1360-66.
2009. Liszkowski,U.et al. Prelinguistic Infants, but Not Chimpanzees, Communicate About Absent Entities. *Psychological Science* 20.654-60.

# 黑猩猩的空间与数字记忆力

Kawai, N. & Matsuzawa, T. Numerical memory span in a chimpanzee. *Nature* 403:39–40, 2000.

Hilgartner, R. 2022. "See rare photos of **chimpanzees treating their wounds with insects**."
National Geographic **October issue.**

**Mascaro, A. et al. 2022. Application of insects to wounds of self and others by chimpanzees in the wild.**
**Current Biology,**

Mind of chimpanzee:

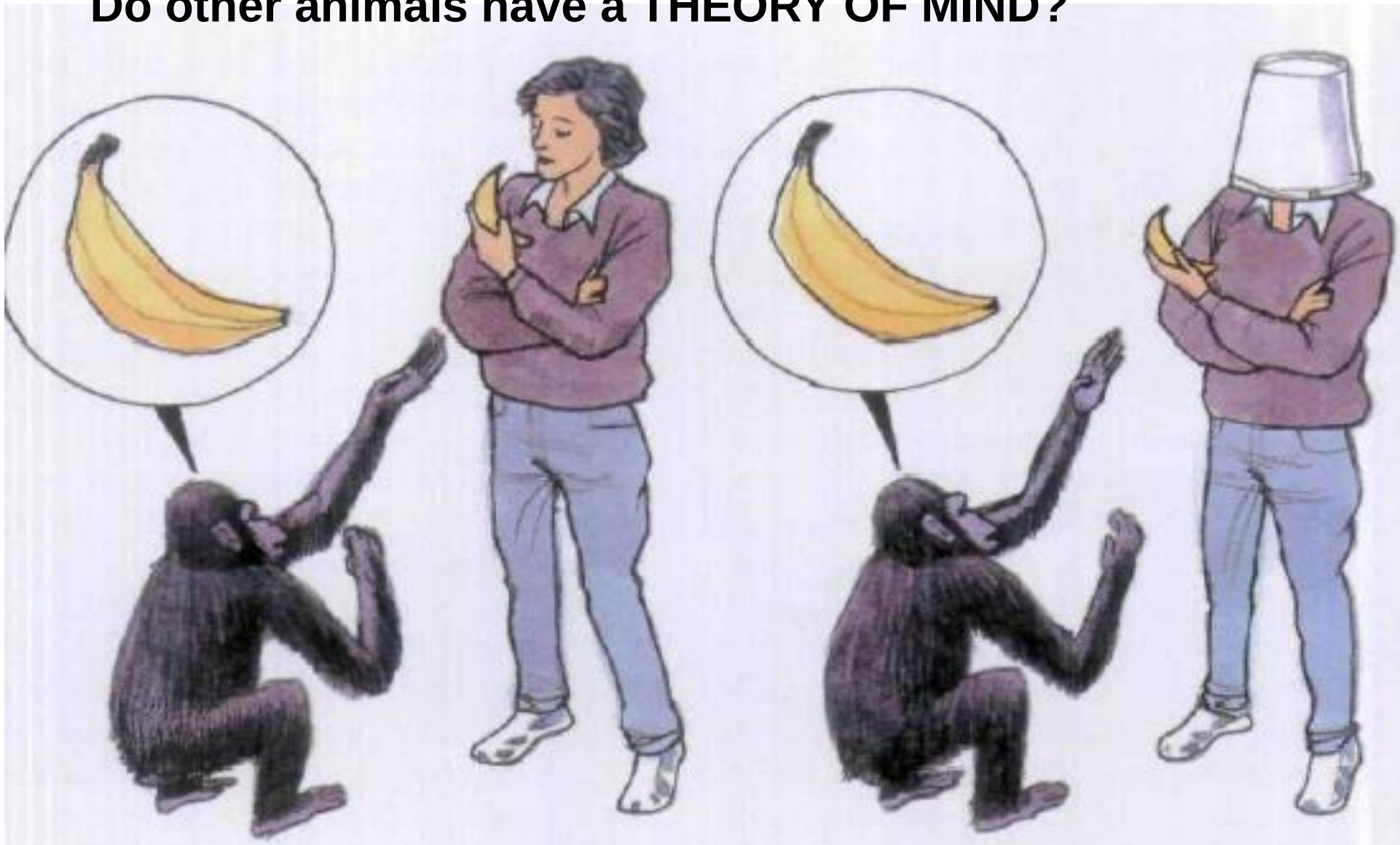
*pass mirror test in self recognition,*
*cooperate in achieving joint goal,*
*high spatio-temporal ability,*
*mutual grooming, social compassion,*
*teach skills to the young,*
*treat wounds with insects in self &*
*in others …*

*no theory of mind in begging,*
*limited ability in language learning.*

Chimpanzees have been studied for over a century by field observation, laboratory experiments, and home raising. They demonstrate many impressive abilities, including self awareness in front of a mirror, cooperation to achieve shared goals such as group hunting, teaching skills to the young, medication of self and others with insects, etc.

They can be taught numerical skills in interacting with a computer, and even lexicons of several hundred words, together with rudimentary syntax. However, they have not achieved various skills associated with a **Theory of Mind**, which typically show up in children 5 or 6 years old.

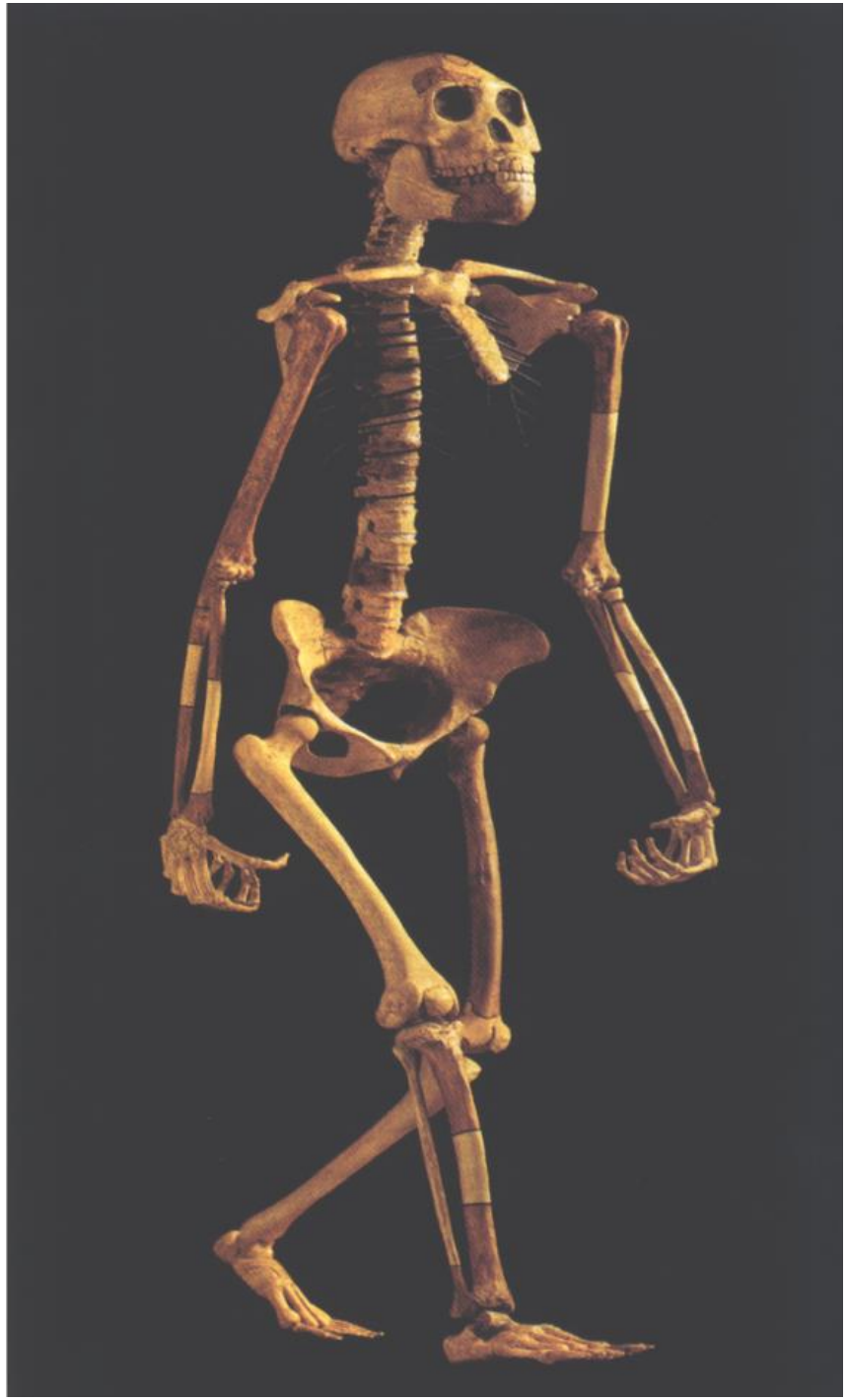
**Corballis, M.C. 2007. *American Scientist* 95.240-48.**
**The Uniqueness of Human Recursive Thinking.**
**Do other animals have a THEORY OF MIND?**



Following the Cambridge Declaration, many animals with large brains have minds, such as the chimpanzee; nonetheless, it is also clear that the human mind is unique. The sequence of major landmarks that separated us from other animals are:

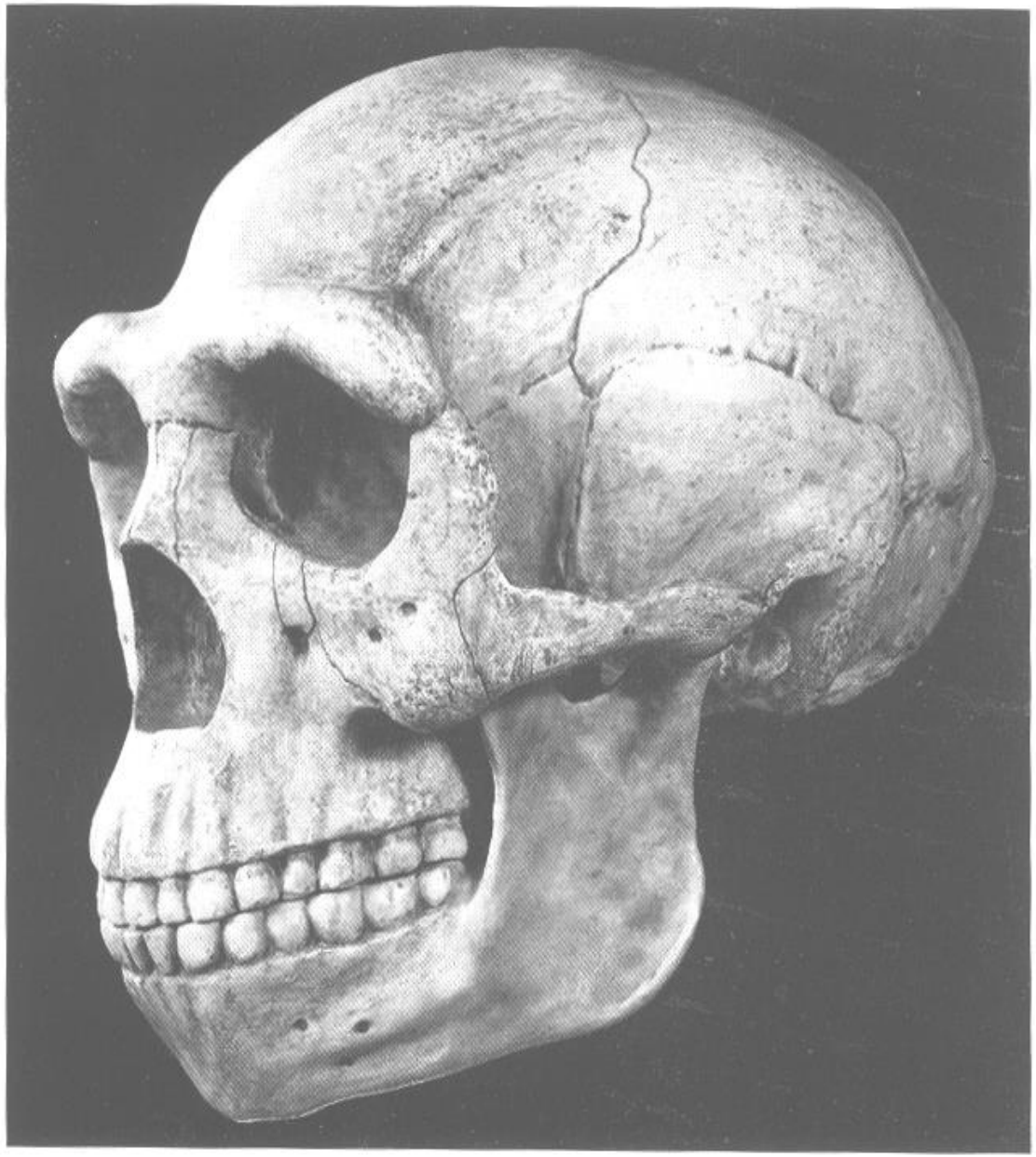
[1] erect posture and freeing the hands for creative activities,
[2] making of tools, thus launching cultural evolution,
[3] mastering symbolization, leading to the invention of language.

These developments brought about **cultural evolution**, enabling humans to modify the environment at a much faster pace than biological evolution alone, which is limited to genetic transmission across generations.



*Johanson, D. and E. Blake (2006). From Lucy to Language, Simon & Schuster.*

*Leakey, M. D. and R. L. Hay (1979). "Pliocene footprints in the Laetolil Beds at Laetoli, northern Tanzania." Nature **278**: 317-323.*



北京猿人 800,000 BP.
中國境內曾挖掘出不少直立人的化石 - *Homo erectrus* ，其中最有名的莫過於1920年代發掘出的周口店北京猿人，依據最近的化學分析所示，這群直立人約80萬年前就已經到達北京.

參見：Shen, Guanjun & Darryl Granger. 2009. Isotopes in quartz reveal the age of China's Peking Man. *Nature* 458.123.

Lewis, Dyani.

***Nature***, Nov 29. 2022

# Ancient skull uncovered in China could be million-year-old *Homo erectus*.

湖北, 郧阳区

doi: 10.1038/d41586-022-04142-0.

LETTER

doi:10.1038/nature15696

# The earliest unequivocally modern humans in southern China

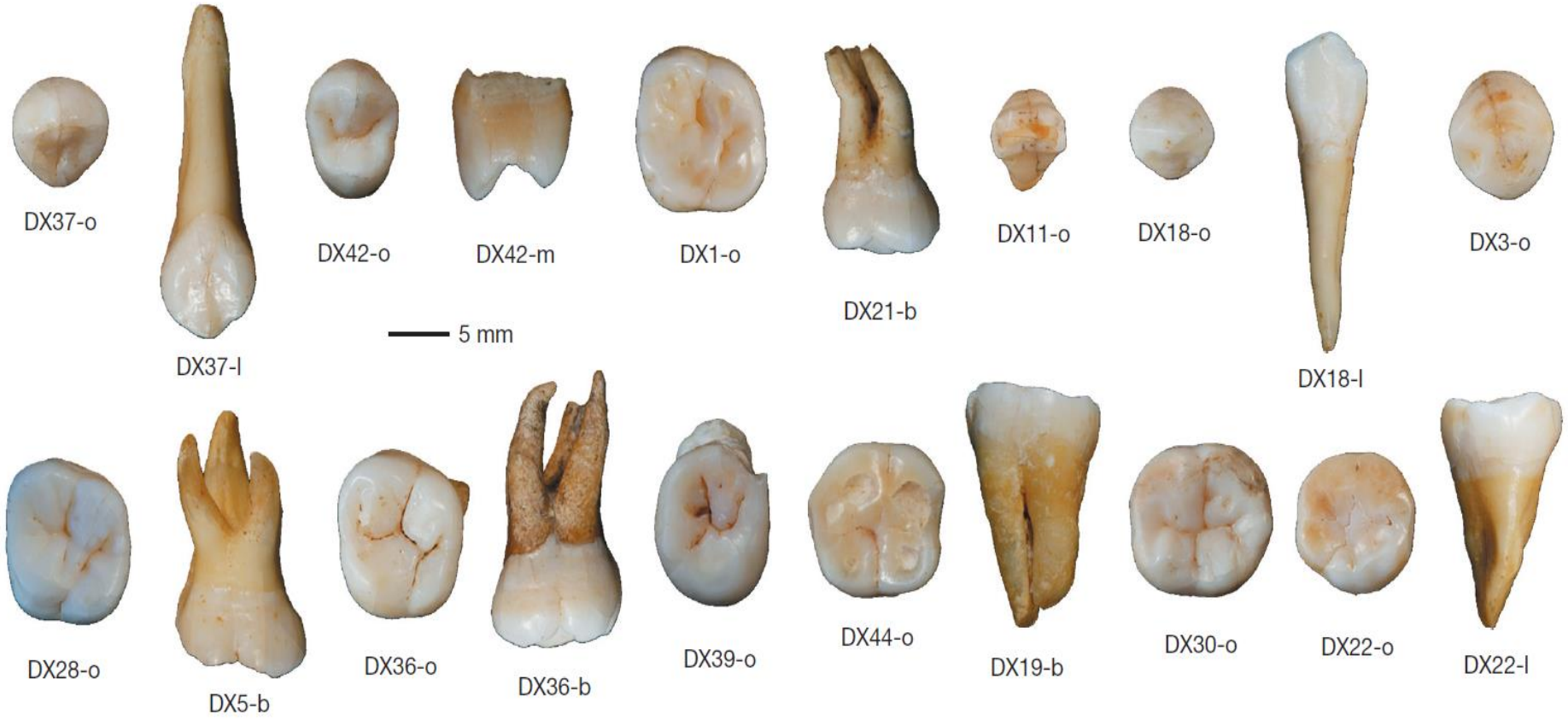



**Figure 2 | Daoxian human teeth (selection).** See Extended Data Table 2 for detailed information about each tooth. b, buccal; d, distal; l, lingual, m, mesial; o, occlusal. Credits: S.X. and X.-J.W.

Liu, W. et al. 2015. *Nature* **526:** 696–699.

Teeth found in Daoxian Hunan date 120 kya.

# Two Million Years of Tool Making

**Stone tools & use of fire** … → **Medieval abacus & compass** … → **Modern rockets & cellphones**

巴比倫
算盤

司南

長征5號
2017.7.2

*p.9."Physiologically, speech is an overlaid function, or, to be more precise,* ***a group of overlaid functions****. It gets what service it can out of organs and functions, nervous and muscular, that have come into being and are maintained for very different ends than its own."*

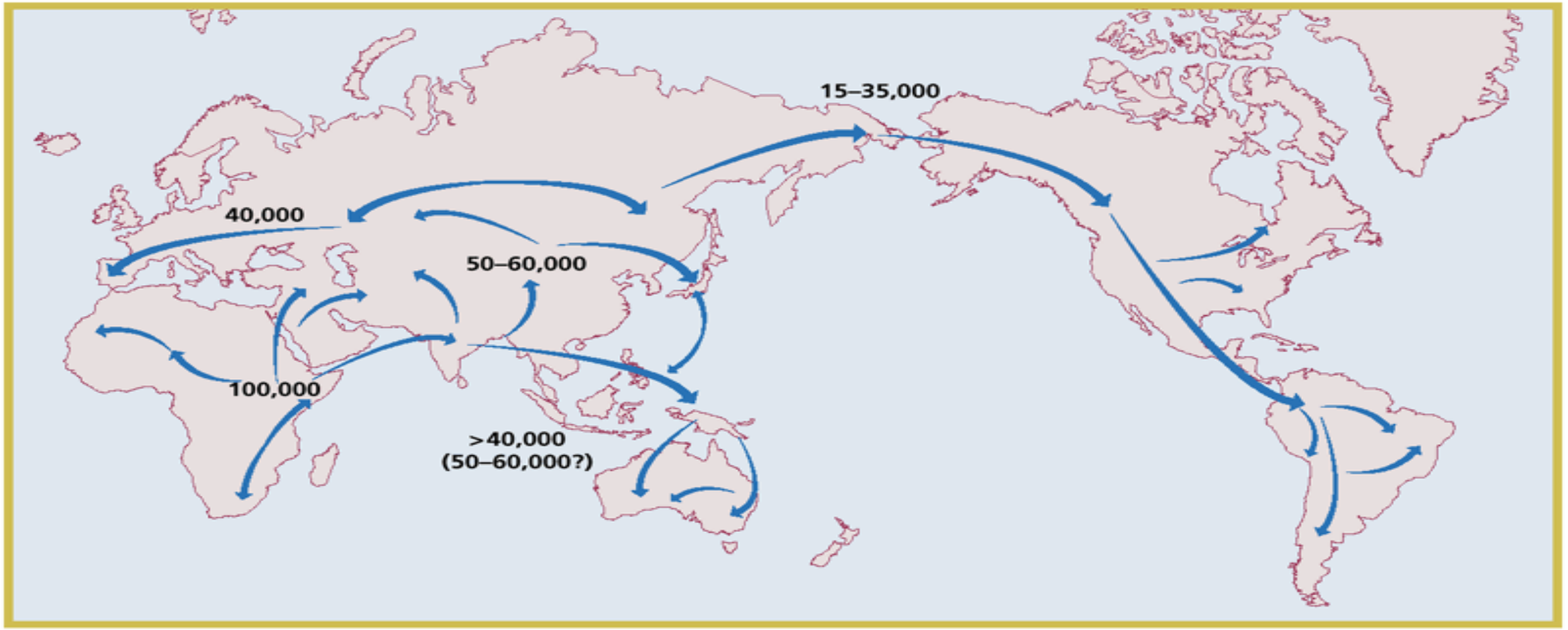
*p.23."The universality and the diversity of speech lead to a significant inference. We are forced to believe that* ***language is an immensely ancient heritage of the human race, whether or not all forms of speech are the historical outgrowth of a single pristine form. It is doubtful if any other cultural asset of man, be it the art of drilling for fire or of chipping stone, may lay claim to a greater age****. I am inclined to believe that it antedated even the lowliest developments of material culture, that these developments, in fact, were not strictly possible until language, the tool of significant expression, had itself taken shape."*

Edward Sapir (1884-1939).
1921. **Language**. *Harcourt.*

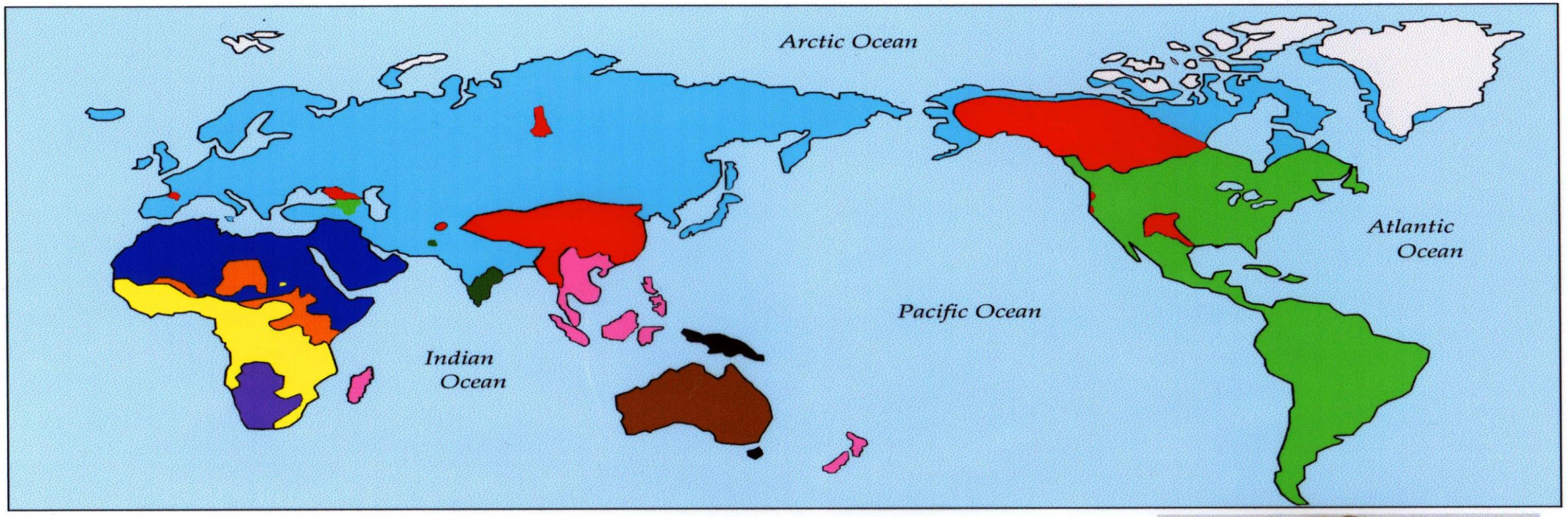
Language emerged as a **mosaic** to interface many basic skills, including the formation of various types of memories to store and retrieve experiences, the sequencing and grouping of thoughts to predict future or imaginary events, the development of sensory and motor skills for processing information within one's own mind as well as exchanging information with others. Various aspects of language were invented at different ancestral sites at different times over a million years or more, e.g., **polygenesis**.

Wang, W. S.-Y. (1982). Explorations in Language Evolution. Hyderabad, India, Osmania University Press.
Freedman, D. A. and W. S.-Y. Wang (1996). "Language polygenesis: a probabilistic model." Anthropological Science **104.2: 131-138.**
Chinese translation: 2000. 石鋒譯. 語言的多源性: 一個概率論模型.

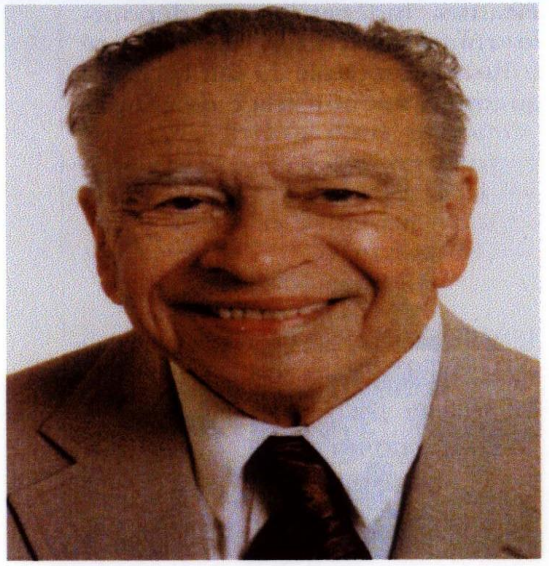
L.L.Cavalli-Sforza & M.W.Feldman. . *Nature Genetics Suppl.* 33.266-75. 2003.
The application of molecular genetic approaches to the study of human evolution.




Spoken languages were invented well over 100,000 years ago, & played decisive roles in our social conquest of the earth.
Written languages were invented much later in independent parts of the world, the earliest some 6,000 years ago.
Many spoken languages have never been written. A language may change its writing system as its culture changes.

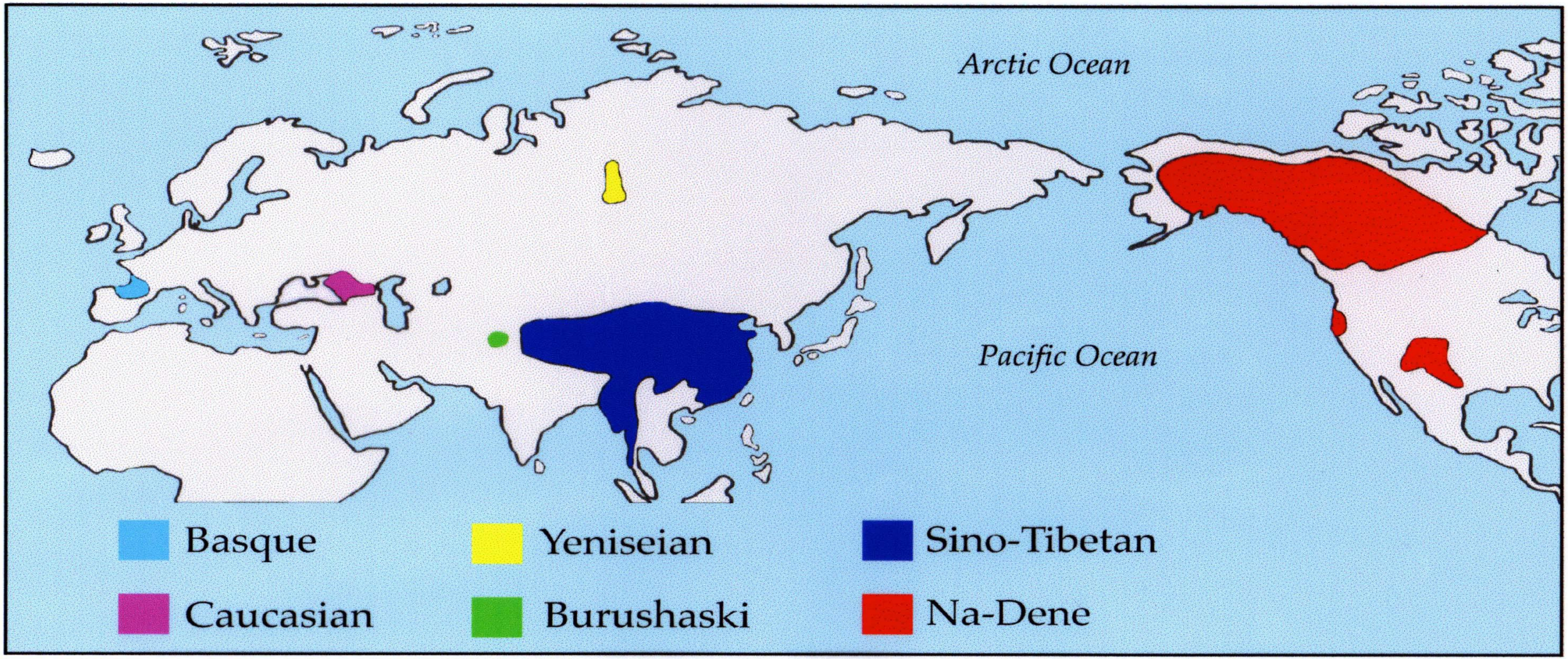



Language Families of the World (after Greenberg)

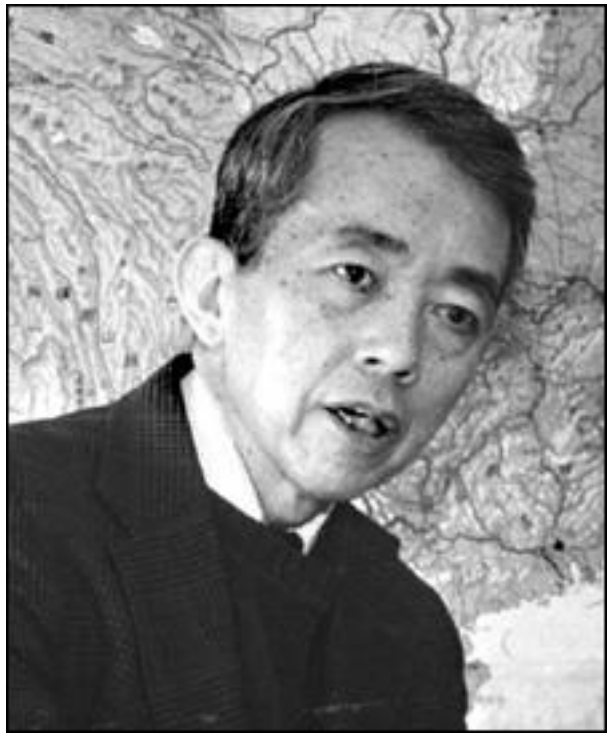


www.ethnologue.com reports 7099 languages, September 2017.

http://wals.info/ World Atlas of Language Structures.

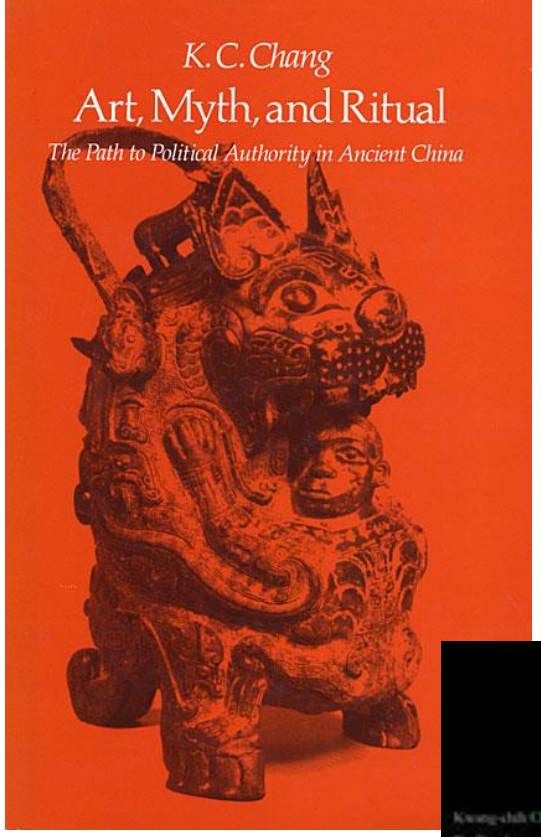



The Dene-Caucasian Family

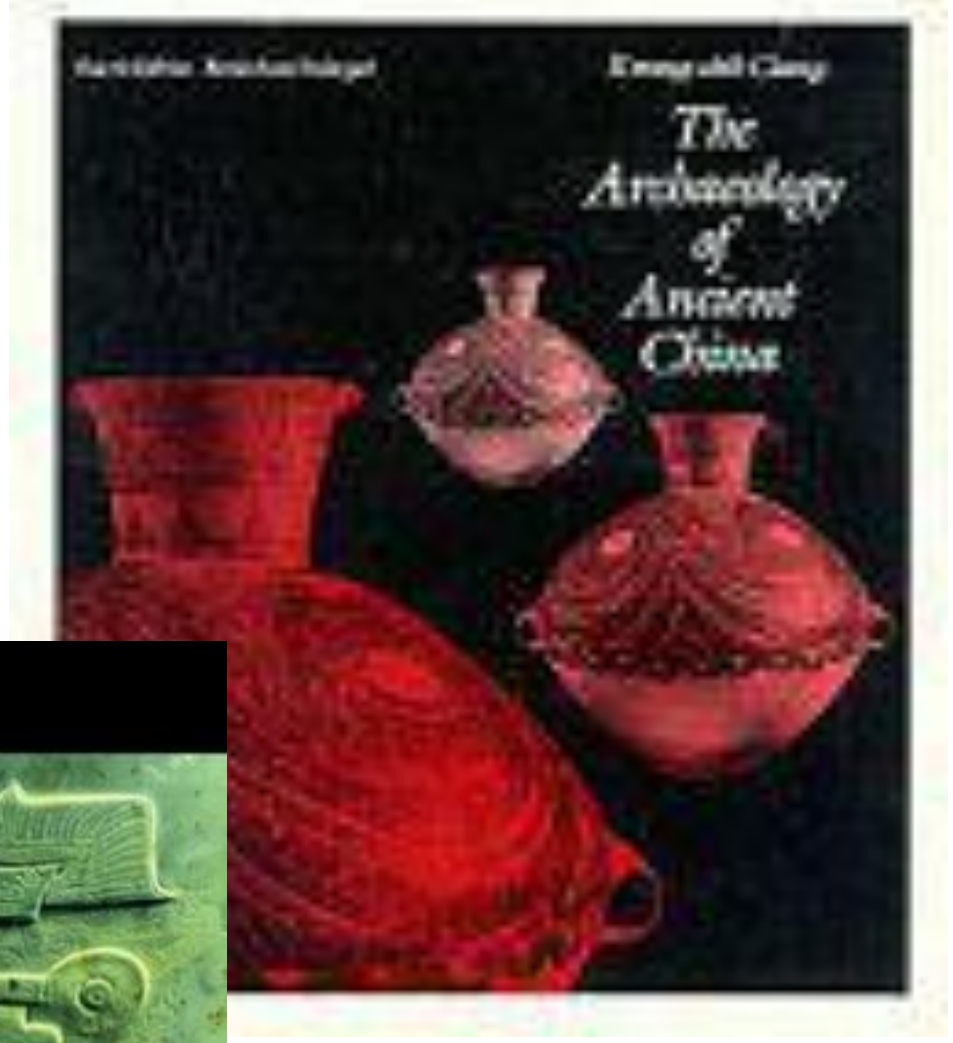


Chang, Kwang-Chih

张光直 1931 – 2001.

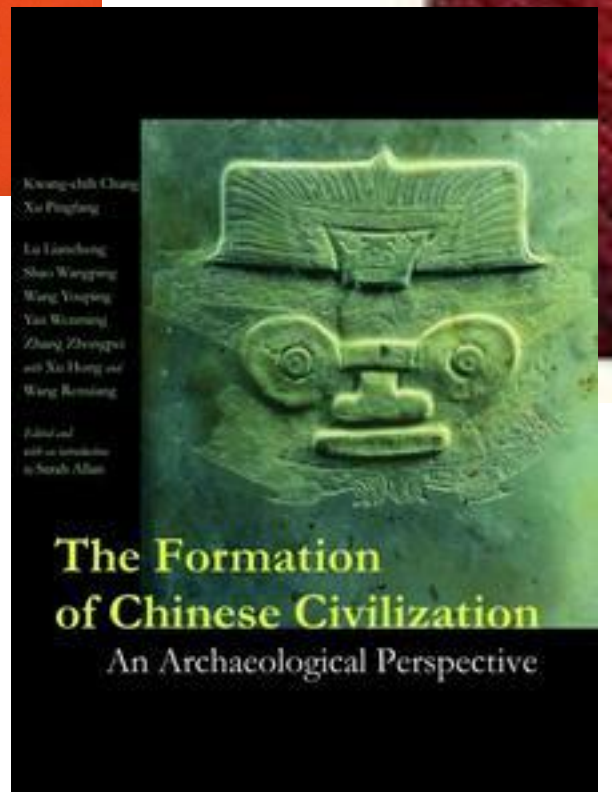



1983

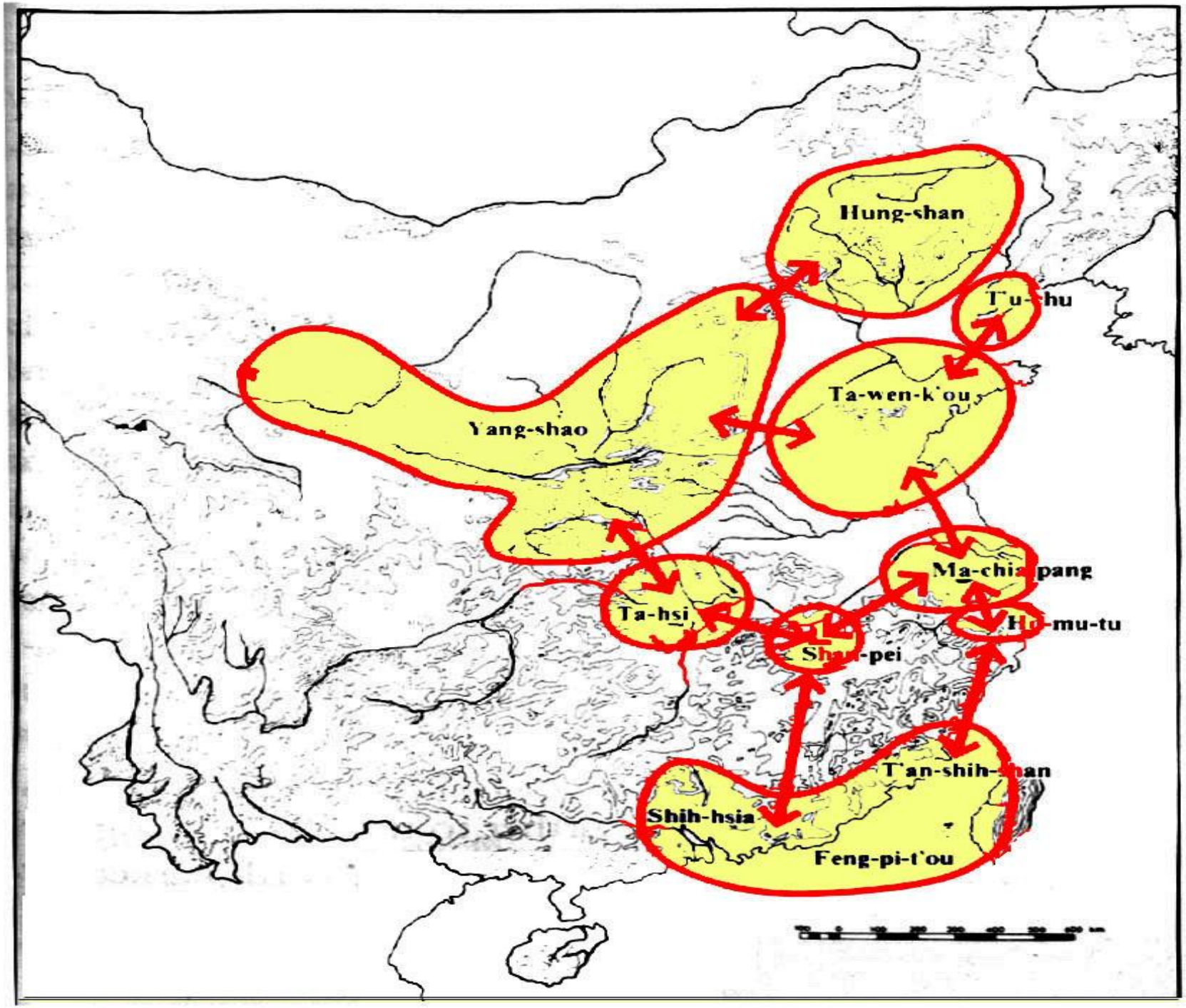



Yale University Press

1st edition 1963,
2nd " 1968,
3rd " 1977,
4th " 1985.




2005




# 6000 B.P.

# "Initial China"

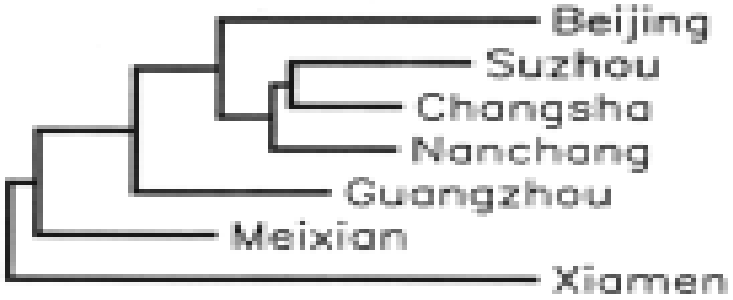
## 张光直：初始的中国

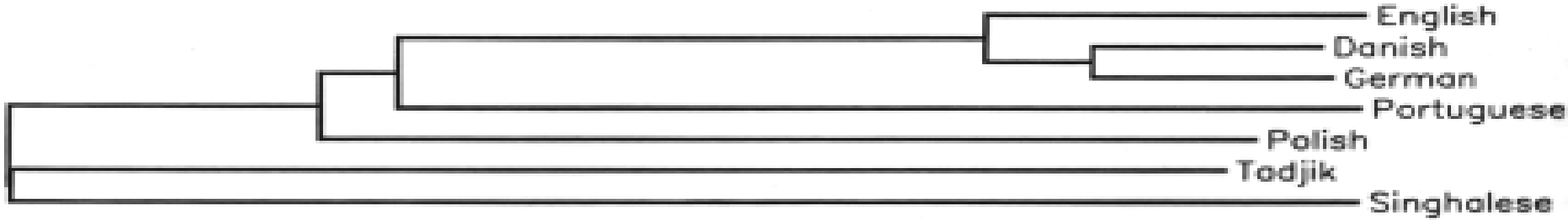
Chang, Kwang-chih. 1986.
The Archeology of Ancient China.
4th Edition.
Yale University Press.

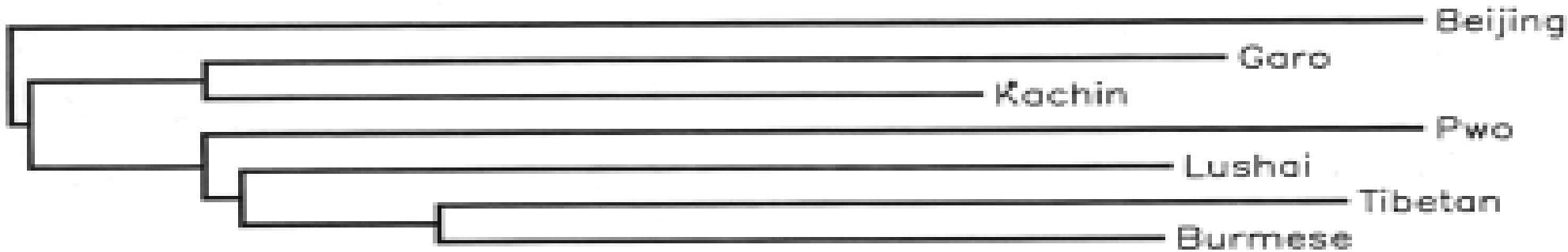
Wang, W.S-Y. 1998.

***Three windows on the past.***

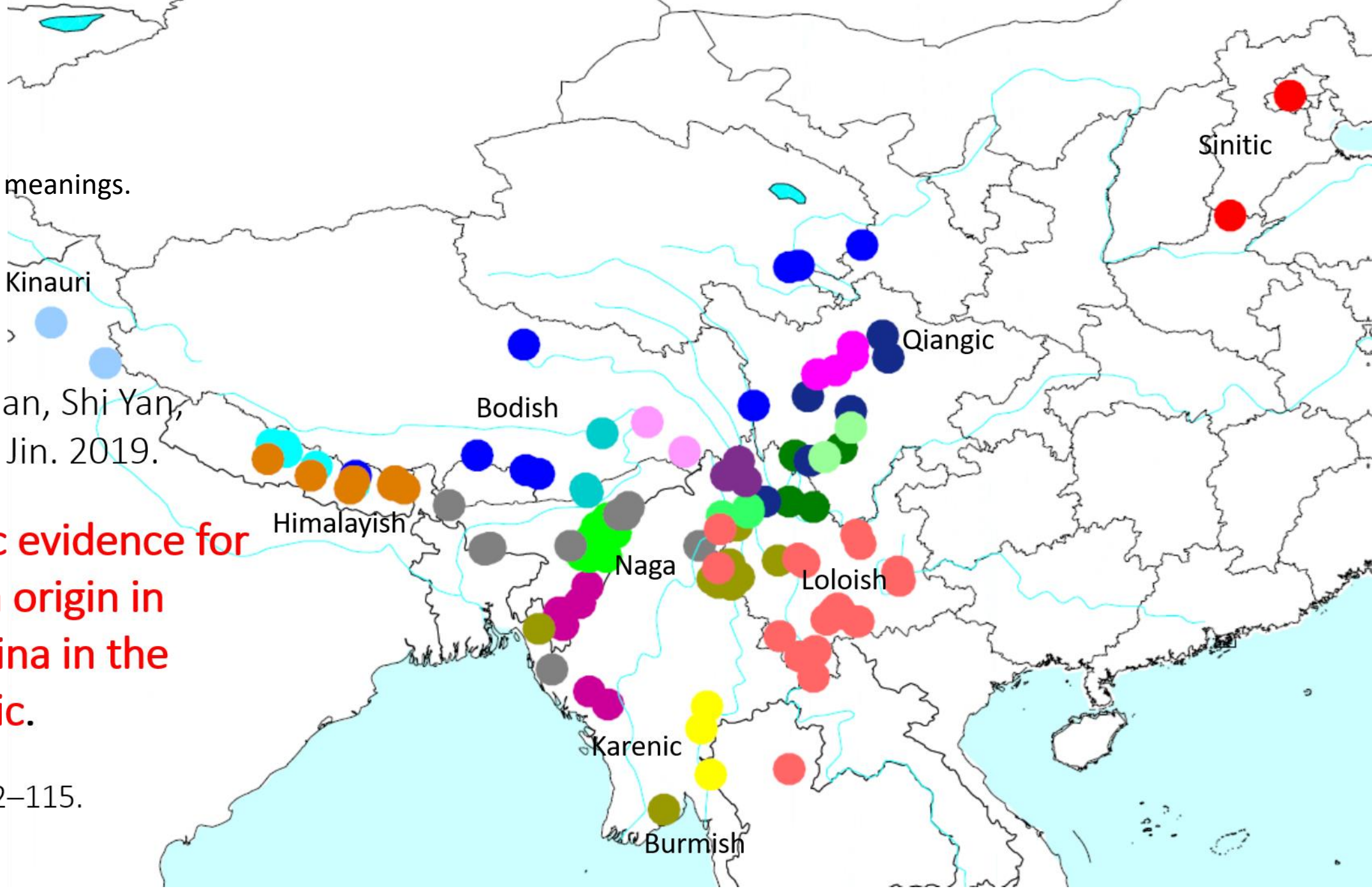
Pp.508-534 in V.H.Mair, ed.



109 languages,
19 groups,
949 lexical root meanings.




Zhang, Menghan, Shi Yan, Wuyun Pan, Li Jin. 2019.

**Phylogenetic evidence for Sino-Tibetan origin in northern China in the Late Neolithic.**

*Nature* 569: 112–115.

贾敬颜.“汉人”考“中华民国代替了清王朝，清朝的满、蒙古、汉三个民族等级之成法自然在革除之列。中华民国申明，**汉、满、蒙古、回 藏是民国的五大民族**…表示了中国是一个统一的多民族国家。其实，当时的蒙古、回、藏并不限于单一的民族，蒙古中至少包括达斡尔、鄂温克等，回部中包括回族、维吾尔、哈萨克等新疆地区伊斯兰教的各民族。藏族则包括了羌族以至甘、青、川境内的一些语言属汉藏语系的民族。大概也只是在**‘五族共和’之说倡导以后，‘汉人’才正式改称‘汉族’”**。*费孝通 2018:164.*

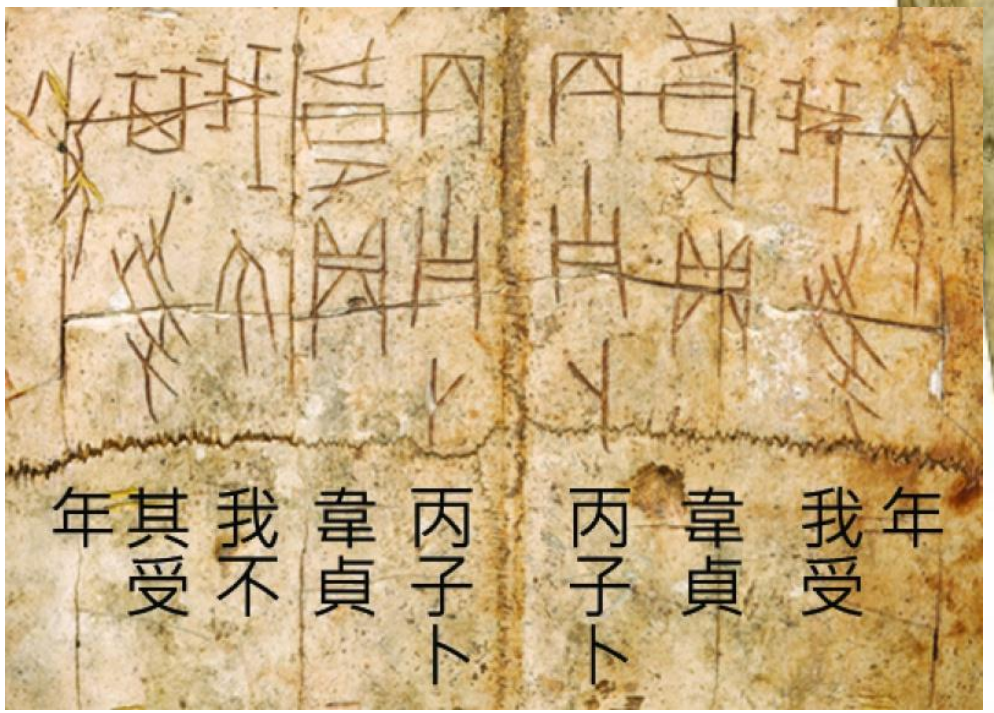
The term ‘Han’ is a cultural-political concept that has been conveniently used to refer to many mainstream establishments in China, though it is often associated with the prominent Han dynasty. The term is also used as a common noun, as in 男子汉, 好汉, 老汉, 汉子 as well as a modifier in constructions like 汉语, 汉字. However, it has little biological support as a method of classifying peoples.

*For further discussion see: 吴锐 (2020). 你不可能是汉族. 台北: 八旗文化.*

徐中舒 1990.
甲骨文字典, 四川辭書出版社

陳光宇, et al. 2017. 商代甲骨中英讀本, 上海人民出版社.

《乙編》第867號,
「韋」是貞人。




Takashima, K.-i. and A. O. Yue 2000.

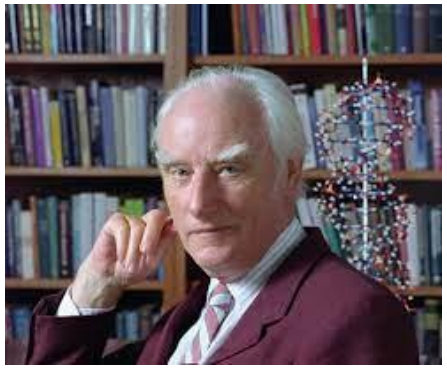
# Evidence of possible dialect mixture in Oracle-Bone Inscriptions.

In Memory of
Professor Li Fang-Kuei:
Essays on Linguistic Change
and the Chinese Dialects.
P.-H. Ting and A. O. Yue, eds.
University of Washington: 1-52.

我們的大腦很獨特，但是直到近幾百年，才開始有系統性的大腦研究。19世紀中葉的幾類病人，讓我們知道大腦損傷怎樣影響行為，有的會導致不同型態的失語症或失讀症，有的是性格大變，完全成了另一個人。

目前全球的人口都在老化。 隨著年齡的增長許多神經退化及認知障礙的問題都大量地進入社會。面臨這個迫切挑戰，語言學家也可以用先進的方法，與很多別的學科同心協力應對這個挑戰，把「生老病死」這四個步驟中的「病」減低，讓老人能健康地繼續工作或安享晚年。我們若能結合多學科研究做到這一點，將是非常有意義的事，對社會，對語言學、認知科學、基因學和神經學也都會是莫大的貢獻。

**Crick, F.** Nobel 1962 for explaining double helix of DNA. (1994). **The Astonishing Hypothesis.** Touchstone.



- "The Astonishing Hypothesis is that YOU, your joys and your sorrows, your memories and your ambitions, your sense of personal identity and free will, are in fact no more than the behavior of a vast assembly of nerve cells and their associated molecules. As Lewis Carroll's Alice might have phrased it, **'You are nothing but a pack of neurons**.' This hypothesis is so alien to the ideas of most people alive today that it can truly be called astonishing."
- "Our minds – the behaviour of our brains – can be explained by the interactions of nerve cells (and other cells) and the molecules associated with them."
- "The single most characteristic human ability is that we can handle a complex language fluently.
- "Man is endowed with a relentless curiosity about the world … We must hammer away until we have forged **a clear and valid picture not only of this vast universe in which we live but also of our very selves**."

「這個驚人的假說是，你，你的喜與悲，你的記憶與抱負，你的身分認同與自由意志，其實都不過是龐大的神經細胞及其相關分子之間的行為而已。正如 Lewis Carroll筆下的愛麗絲可能會說的：

『**你不過是一堆神經元而已**。』這個假說與當今世上多數人的理念如此格格不入，因此的確可以稱得上是驚人的。」

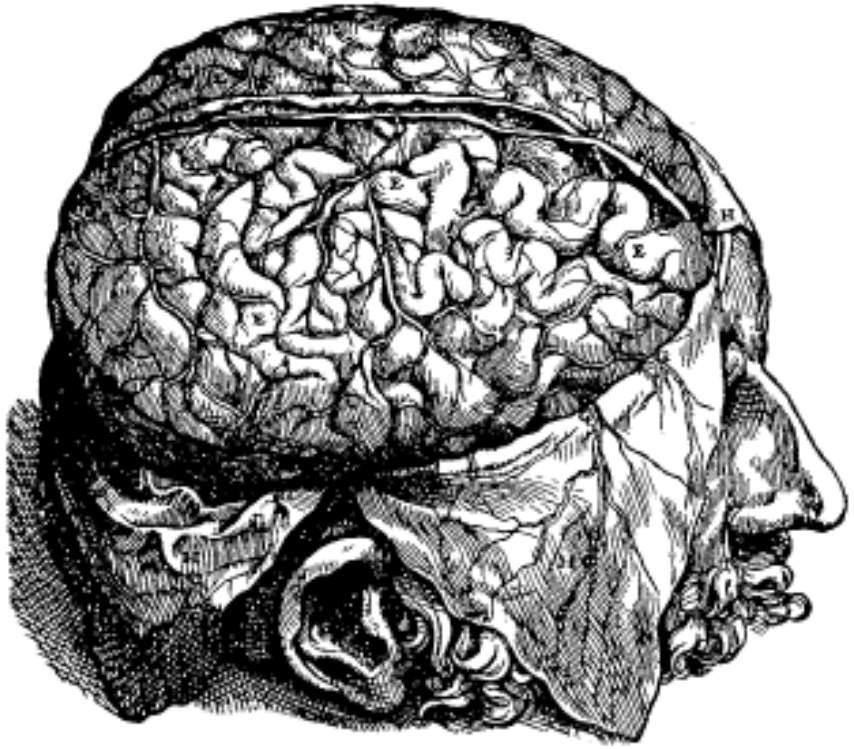
「我們的心智——也就是我們大腦的行為—可以用神經細胞（與其他細胞）和與其相關的分子之間的互動來解釋。」

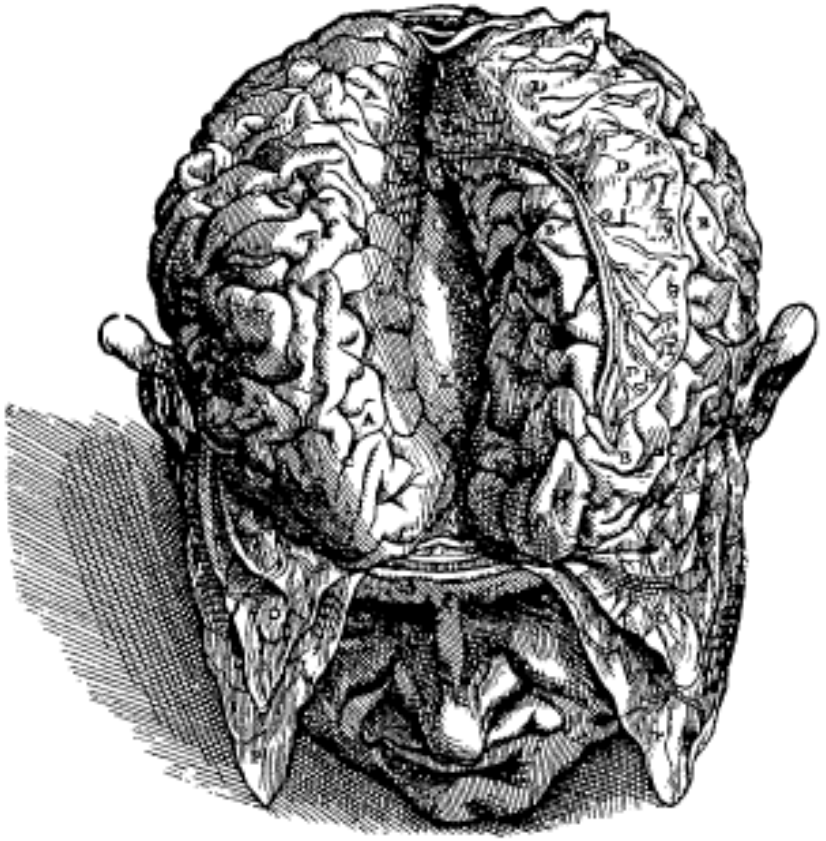
「人類最富特色的一項能力就是，我們能流利地掌握一個複雜的語言。」

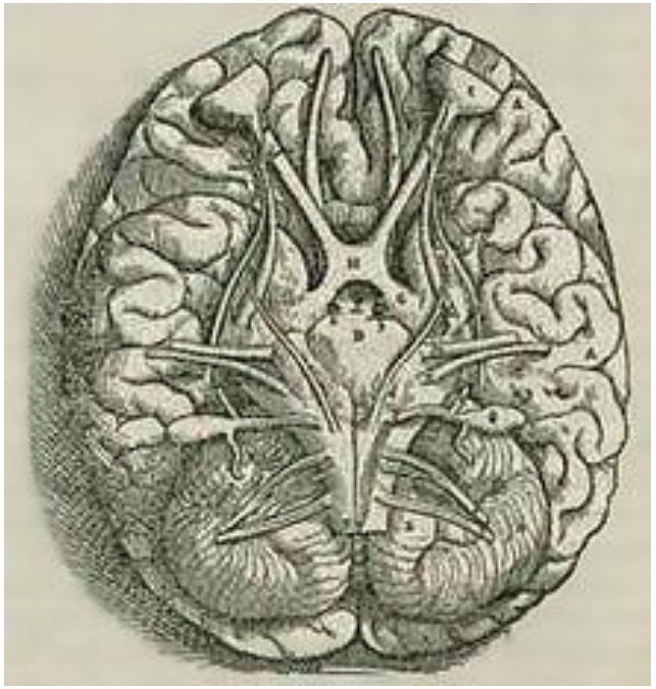
「人類被賦予了對世界的無盡好奇心…我們必須持續努力，才能**對我們所處的這個龐大宇宙，也對我們自己本身，勾勒出一幅明晰且有效的圖像**。」

‘This is from perhaps the most important book in the history of medicine, the "***Fabric of the Human Body***", published in 1543 by Andreas Vesalius.’

*Fundamental Neuroscience*, 2 ed. 2003:40.







Three pioneers in studies of Language Disorders & Brain.

研究語言障礙的三位先驅。

Paul Pierre Broca
(1824-1880)

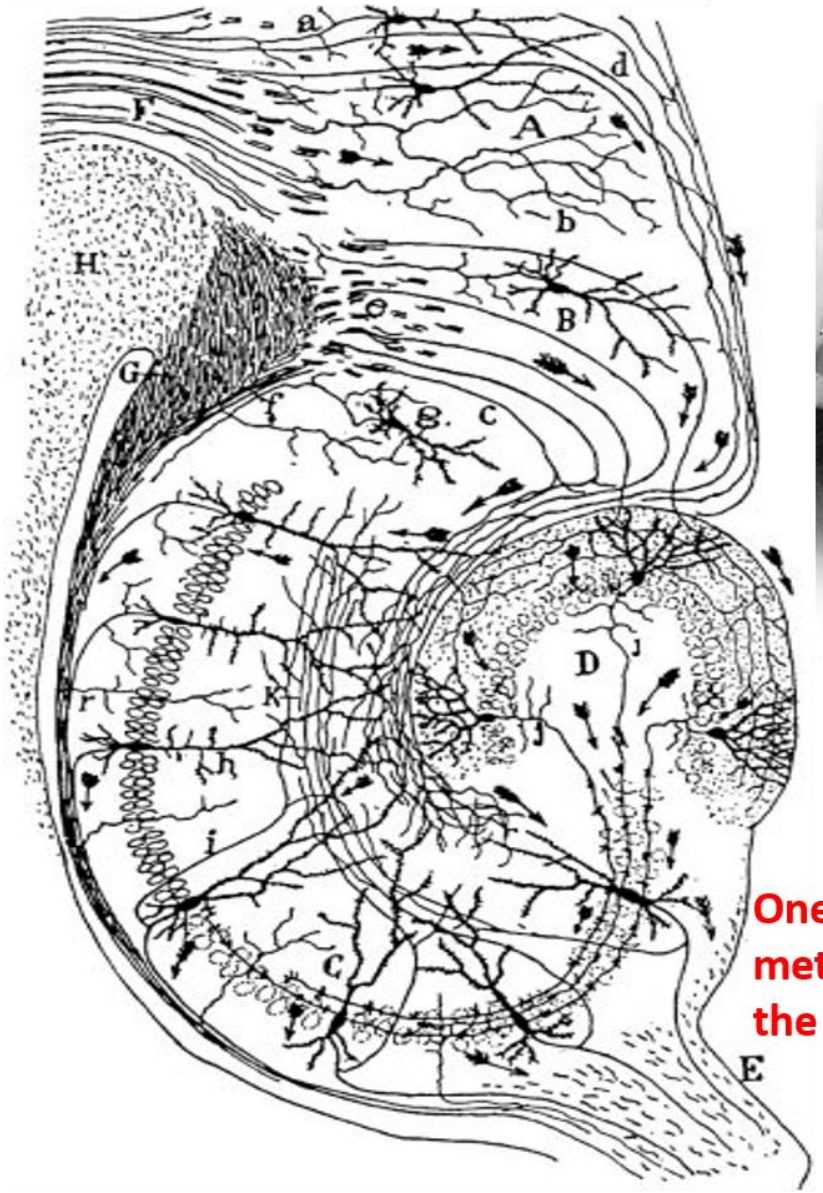
Carl Wernicke
(1848-1904)

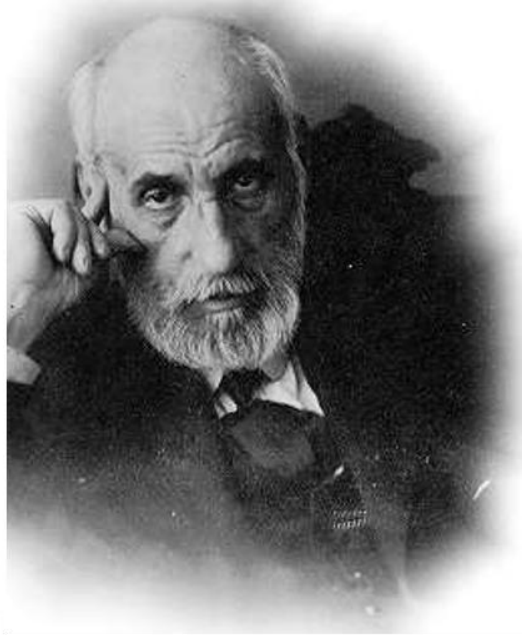
Jules Dejerine
(1849-1917)

Aphasias of various sorts are typically caused by some local trauma, whether introduced from outside, such as concussions, or internally generated, as with cerebral vascular accidents. Aside from these, there are forms of language disorders, usually accompanied by other syndromes, whose causes are much more elusive, that elderly people are especially at risk for. Most prominent among these disorders is **Alzheimer's Disease**, first reported by Alzheimer in **1911**.

# Ramon Santiago y Cajal

1852-1934. Nobel Prize 1906.

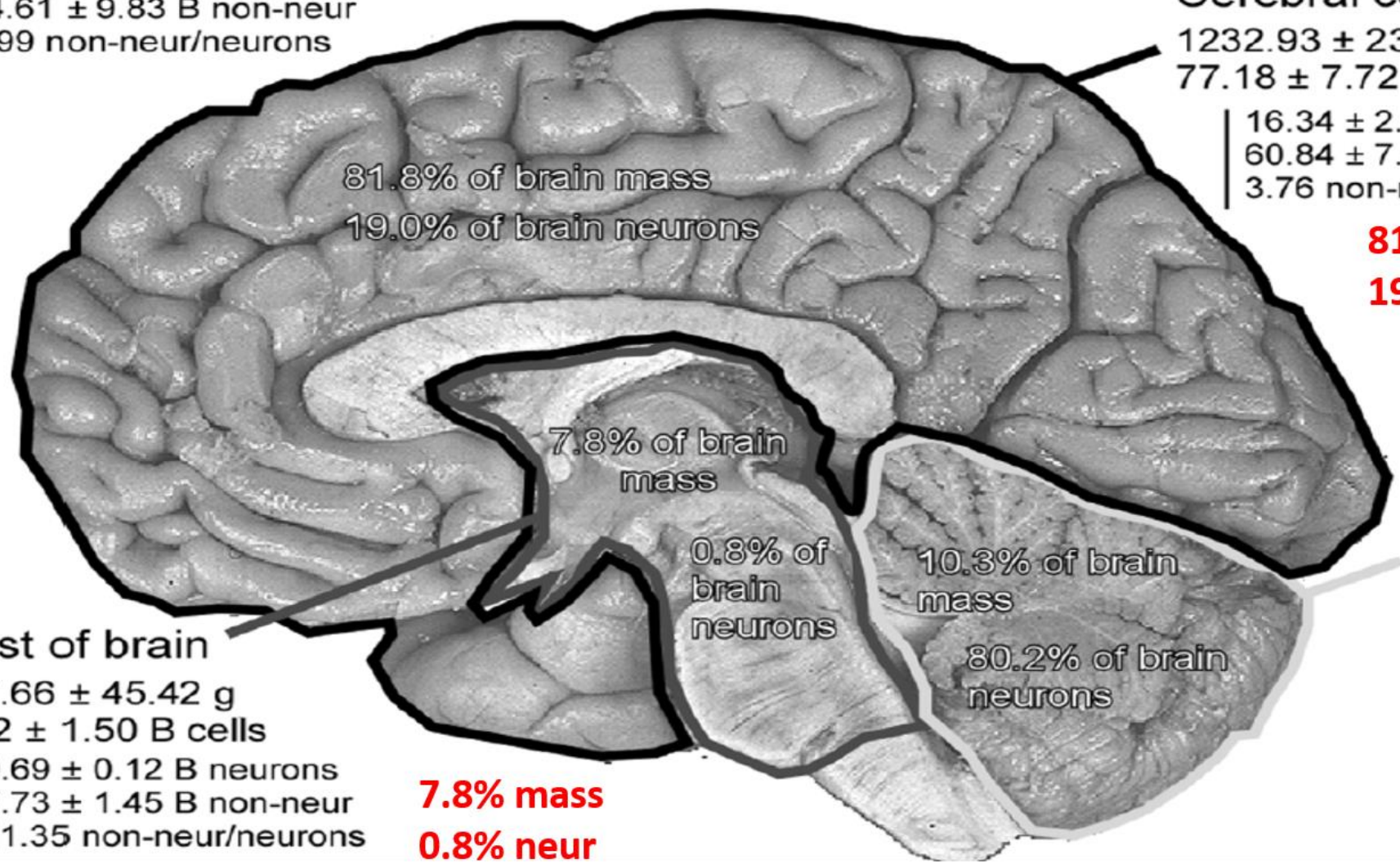


**One of Cajal's numerous meticulous drawings of the brain's neural circuits.**

Azevedo, F. et al. 2009. Equal numbers of neuronal and nonneuronal cells make the human brain an isometrically scaled-up primate brain. *Journal of Comparative Neurology* 513.532-41.

## Whole brain
1508.91 ± 299.14 g
170.68 ± 13.86 B cells
- 86.06 ± 8.12 B neurons
- 84.61 ± 9.83 B non-neur
- 0.99 non-neur/neurons




## Cerebral cortex (GM+WM)
1232.93 ± 233.68 g
77.18 ± 7.72 B cells
- 16.34 ± 2.17 B neurons
- 60.84 ± 7.02 B non-neur
- 3.76 non-neur/neurons

**81.8% mass**
**19.0% neur**

## Rest of brain
117.66 ± 45.42 g
8.42 ± 1.50 B cells
- 0.69 ± 0.12 B neurons
- 7.73 ± 1.45 B non-neur
- 11.35 non-neur/neurons

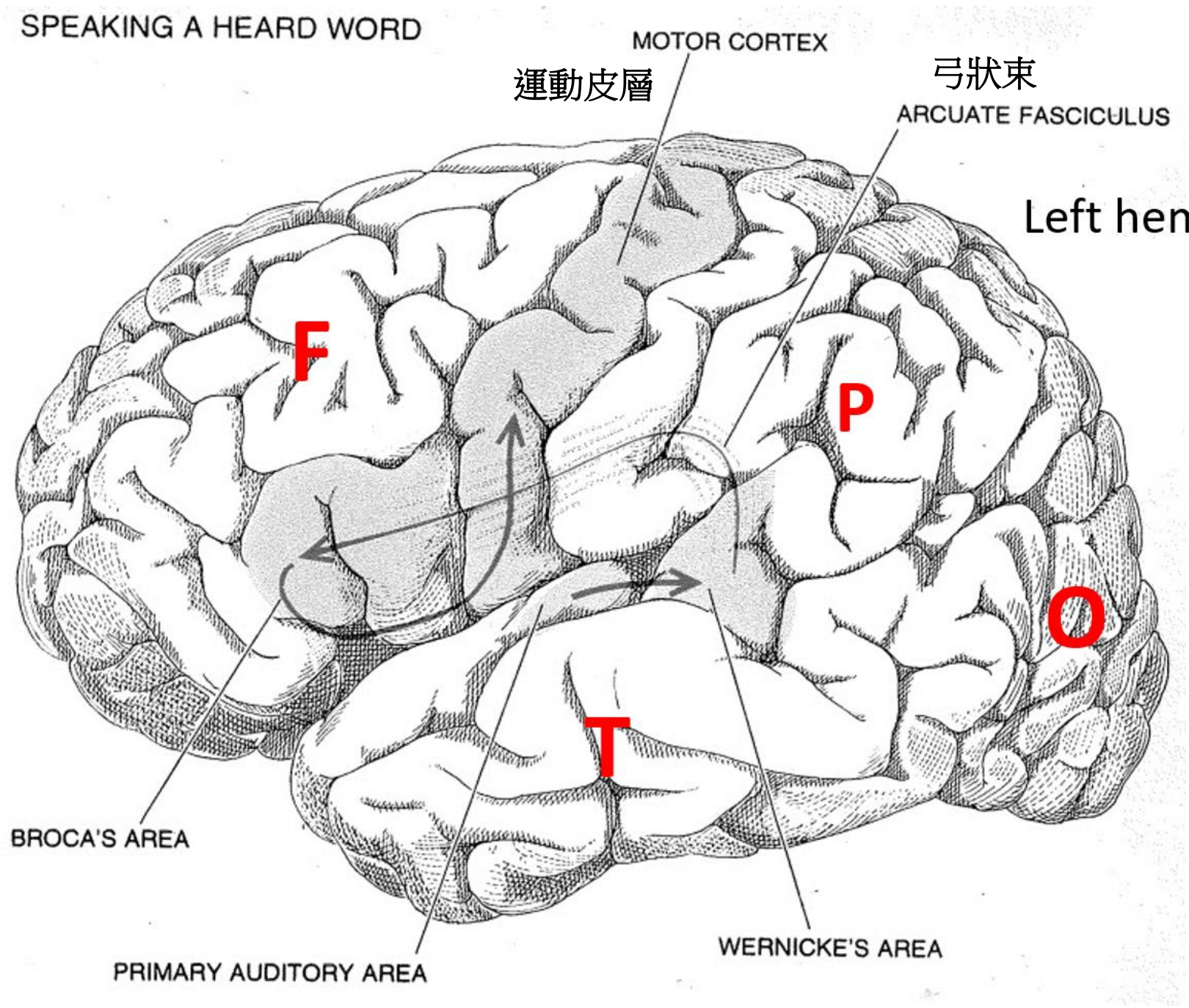
**7.8% mass**
**0.8% neur**

## Cerebellum
154.02 ± 19.29 g
85.08 ± 6.92 B cells
- 69.03 ± 6.65 B neurons
- 16.04 ± 2.17 B non-neur
- 0.23 non-neur/neurons

**10.3% mass; 80.2% neur**

Connecting the brain to language, however, had to wait some 300 years, and began with **Broca**'s famous article of 1861 on two patients who lost their ability to speak, but understanding speech remained intact. Upon autopsy, he identified a region on the left frontal lobe responsible for this loss that came to be known as Broca's Area. This pioneering work was quickly followed by other pioneers of neurolinguistics, notably **Wernicke** for speech comprehension, and **Dejerine** for written language.

These achievements of the early pioneers were brought together with later research into a masterful synthesis in the writings of Geschwind. The synthetic model that **Geschwind** put together has remained the **classic model** in neurolinguistics for many decades.




*Reprinted in 王士元 2008.*
*語言湧現: 發展與演化.*
*中央研究院 語言學研究所.*

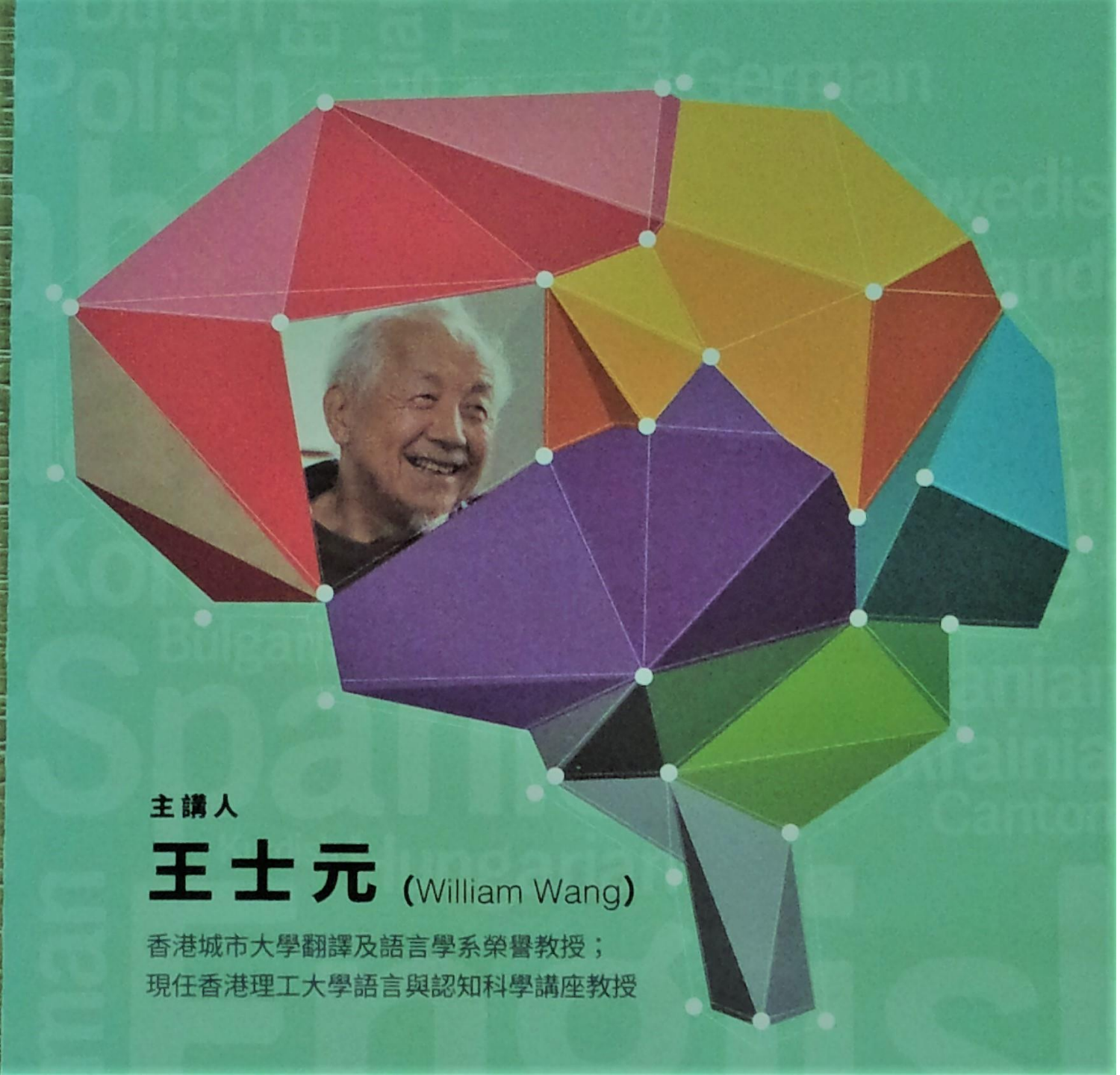
Left hemisphere & its four lobes:

**F**rontal, 額葉
**P**arietal, 頂葉
**T**emporal, 顳葉
**O**ccipital. 枕葉

Geschwind, Norman. 1979.

# Specializations of the human brain.

*Scientific American* 241.158-68.




1. Frontal Lobe 额叶

*Prefrontal Cortex*

*Motor Gyrus*

*Broca's Area*

Central Sulcus 中央沟

2. Parietal Lobe 顶叶

*Sensory Gyrus*

Lateral Sulcus 外侧沟

3. Temporal Lobe 颞叶

*Auditory Area*

*Wernicke's Area*

4. Occipital Lobe 枕叶

*Visual Area*

Cerebellum 小脑

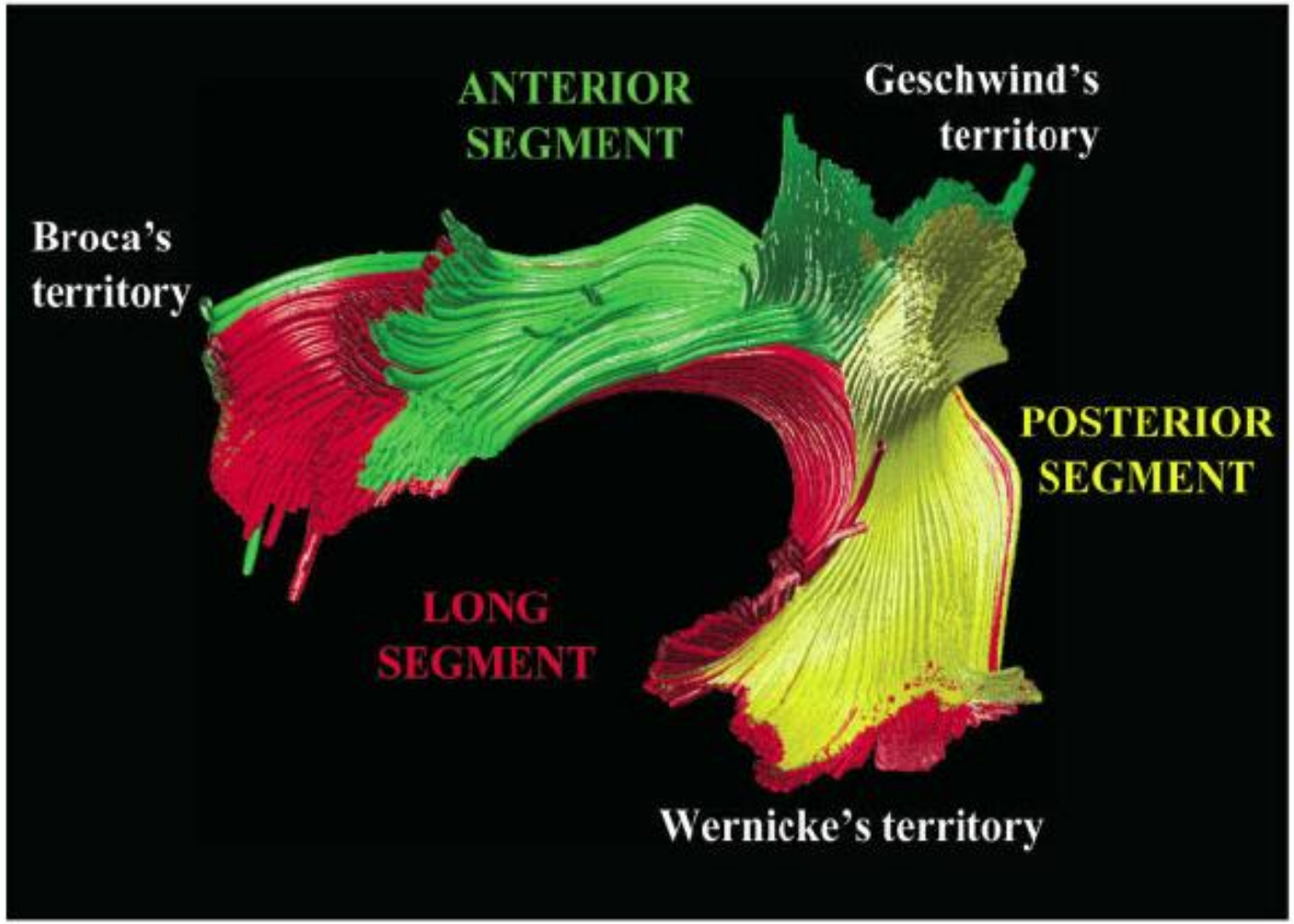
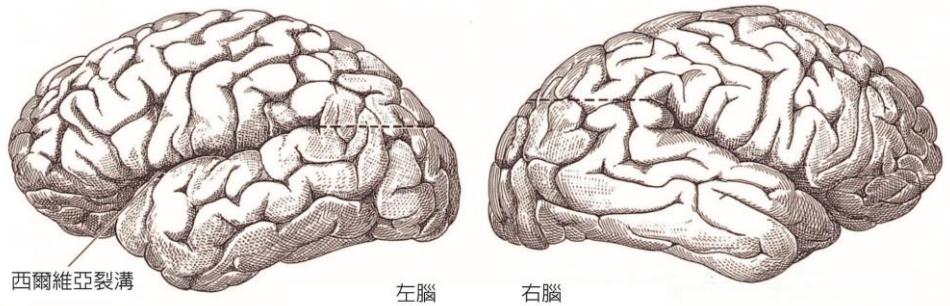
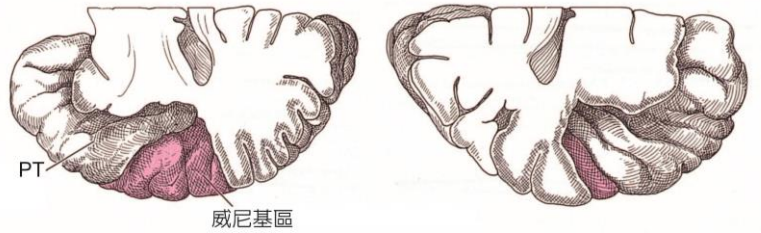


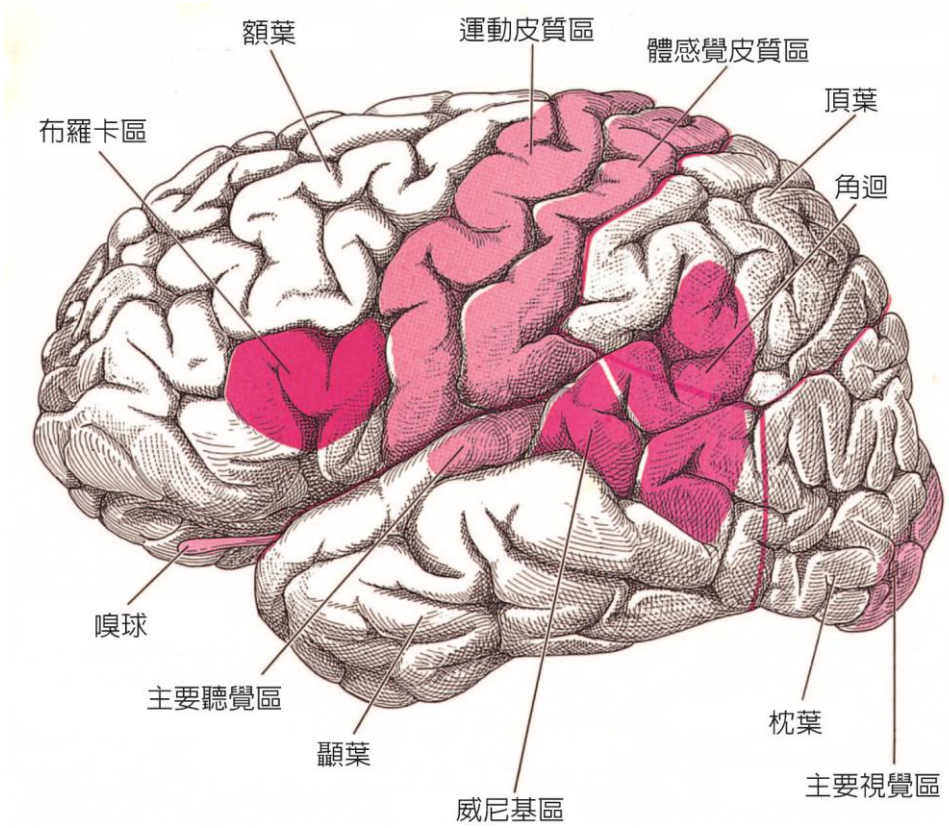

*Fig 3. Tractography reconstruction of the arcuate fasciculus using the two-region of interest approach. Broca's and Wernicke' territories are connected through direct and indirect pathways in the average brain. The direct pathway (long segment shown in red) runs medially and corresponds to classical descriptions of the arcuate fasciculus. The indirect pathway runs laterally and is composed of an anterior segment (green) connecting the inferior parietal cortex (Geschwind's territory) and Broca's territory and a posterior segment (yellow) connecting Geschwind's and Wernicke's territories. Note the color coding in this figure differs from that used in Figures 1 and 2.*

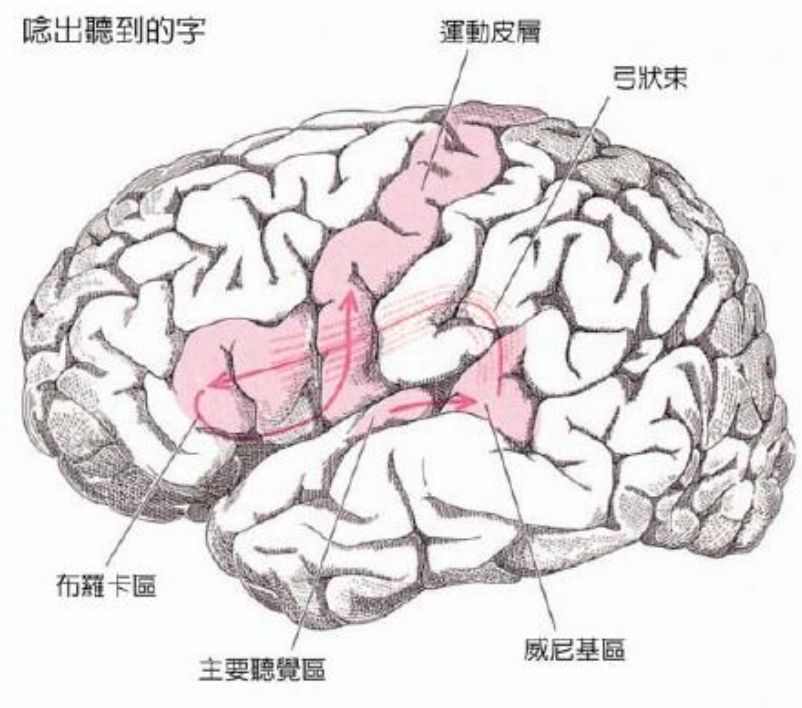
Geschwind, N. and W. Levitsky (1968). "Human Brain: Left-Right Asymmetries in Temporal Speech Region." Science **161( ): 186-187, 112 July.**

Geschwind, N. (1979). "Specializations of the human brain." Scientific American **241(3): 158-168.**



Geschwind 1976: 88:

***'…a real understanding of language will not be achieved until we have a reasonable notion of its neurological mechanisms' .***

除非我們對**語言的神經機制**有合理的概念，

否則無法真正理解語言。

Broca was mindful of how little was known of the brain at his time, and with remarkable foresight, stored the two brains away in jars in Paris for possible use in the future. That foresight paid off rich dividends when brain imaging became available.

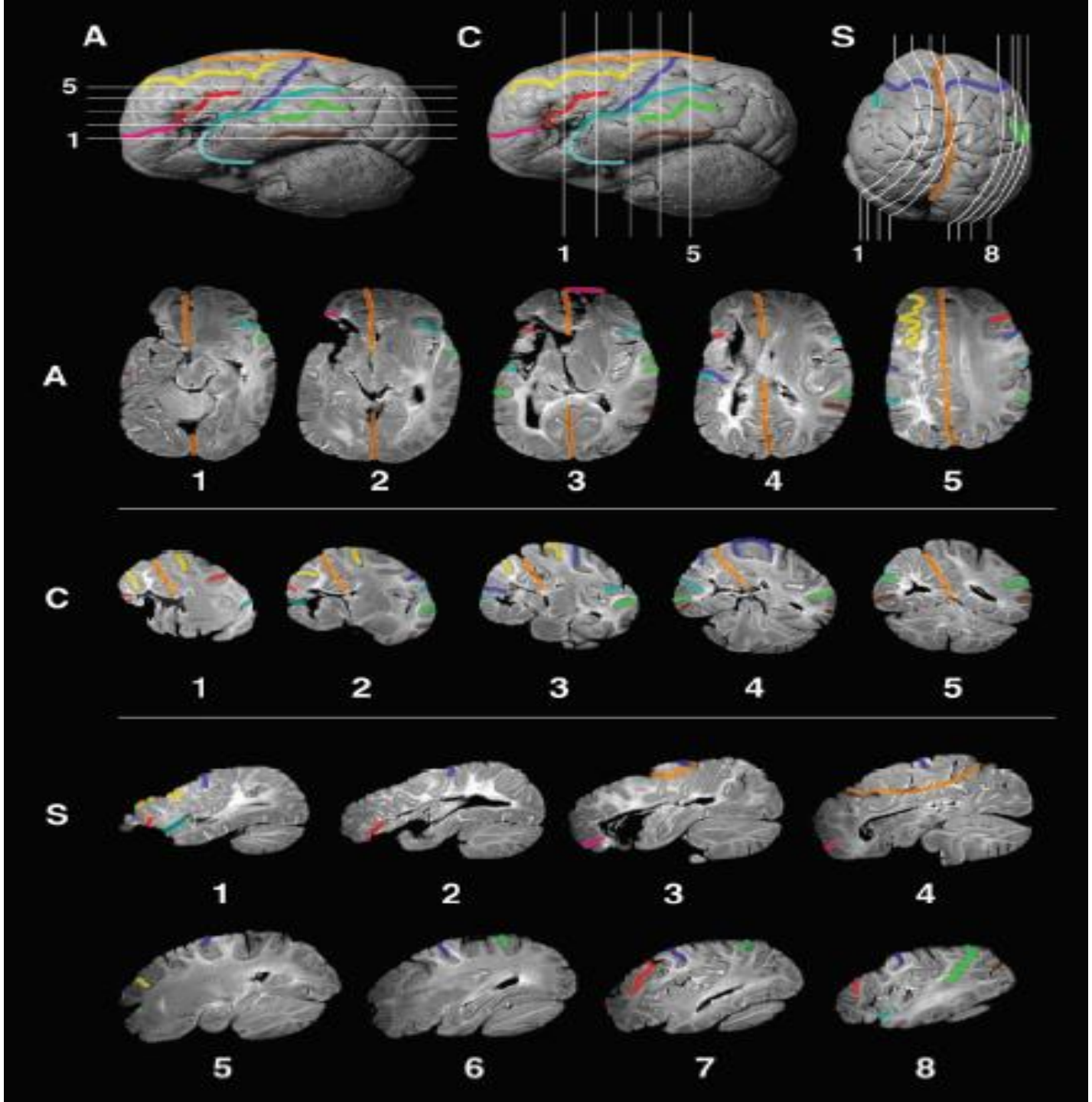
Dronkers went back to those brains more than a century later,and analyzed them in great detail with the methods of **Magnetic Resonance Imaging**, MRI. Rather than the small localized region on the surface of the cortex that Broca identified, Dronkers found that the neural damage in both cases were much more extensive, going deeply into the interior of the brain. **It is therefore grossly inaccurate to associate the language pathology with just that one region**.

Dronkers, N. F., O. Plaisant, M. T. Iba-Zizen & E. A.Cabanis. 2007. Paul Broca's historic cases: high resolution MR imaging of the brains of Leborgne and Lelong. *Brain* 130.1432-41.



A

B




Dronkers, N. et al. 2007.

## Paul Broca's historic cases: high resolution MR imaging of the brains of Leborgne & Lelong.

*Brain* 130.1432-41. Fig.4.

"Sagittal, axial and coronal slices through the brain reveal lesions in the left inferior frontal gyrus, deep inferior parietal lobe and anterior superior temporal lobe. In addition, there is extensive subcortical involvement including the claustrum, putamen, globus pallidus, head of the caudate nucleus and internal and external capsules. The insula is completely destroyed. The entire length of the superior longitudinal fasciculus is also obliterated, along with other frontal-parietal periventricular white matter. The medial subcallosal fasciculus is also affected." *p.1436.*

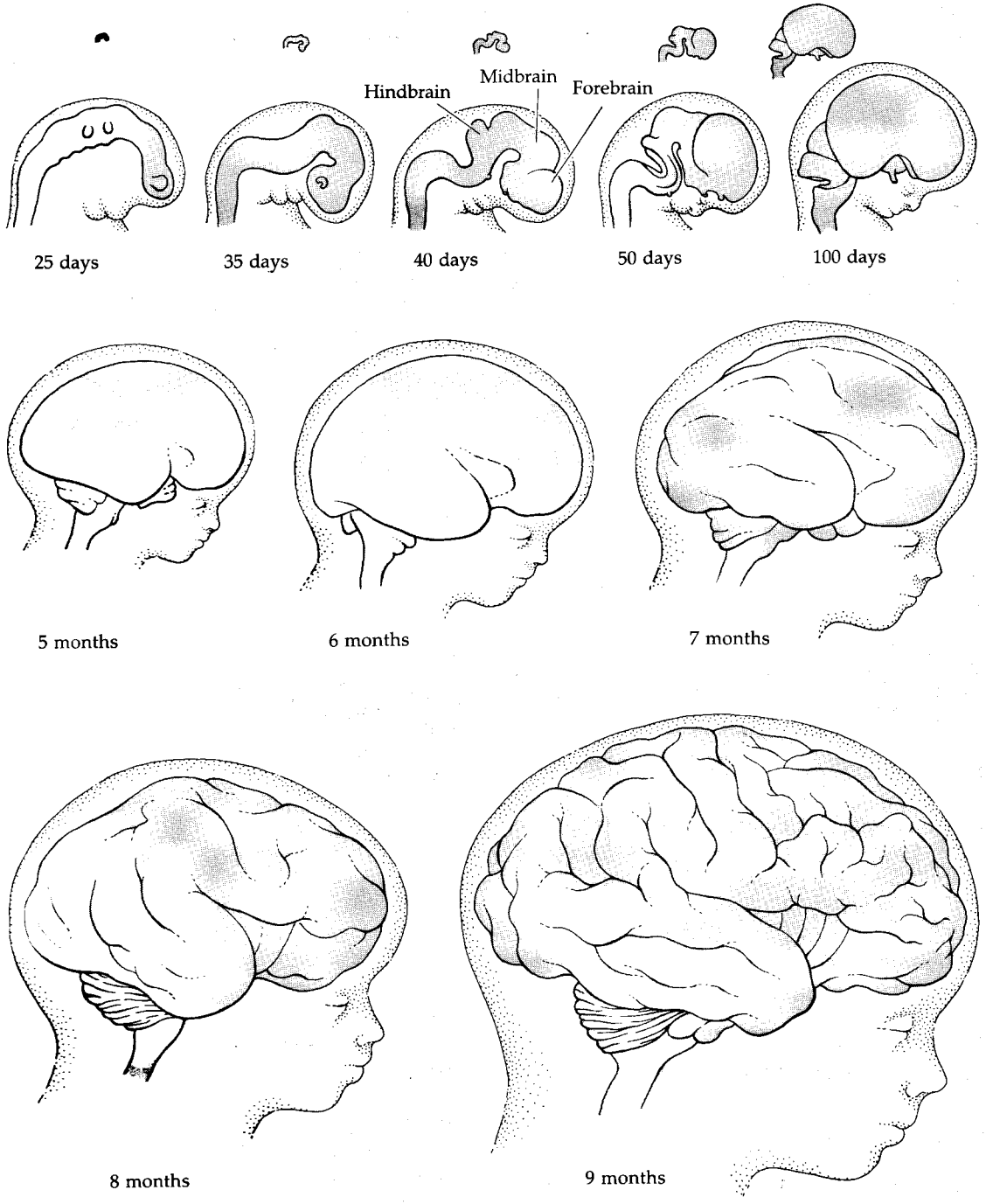
Findings such as those by Dronkers have moved the field much past the classic model presented by Geschwind. This is announced aggressively in the title of a paper published in 2016 in Brain & Language, which is "***Broca and Wernicke are dead***, *or moving past the classic model of language neurobiology*."

Indeed, with an abundance of new data, methods, and technology to help, the neurobiology of language has been making progress in great strides.

Tremblay, P. and A. S. Dick (2016). "Broca and Wernicke are dead, or moving past the classic model of language neurobiology." Brain & Language **162: 60-71.**

**Beginnings:**

Systematic investigations on the brain began in 1543 with Vesalius and his atlas, leading to neuroscience as a discipline when Cajal discovered the neuron in Spain & was awarded the Nobel Prize in 1906. Linguistics began as a discipline in 1786 when William Jones connected Sanskrit to Greek and Latin, & proposed a proto-language for Indo-European languages in a lecture in India. Brain & language came together in 1861 with Paul Broca's study of aphasia. Psychology emerged as a discipline when William James published his *The Principles of Psychology* in 1890. Brain & cognition came together in the late 1970s, & was named cognitive neuroscience.




Purves, Dale, & Lichtman, Jeff W. 1985: 18. Figure 11.

# *Principles of Cognitive Neuroscience.*

Development of the human brain. Assuming that the fully developed human brain contains approximately 100 billion neurons and that they do not divide after birth, the developing brain must add an average of 250,000 neurons per minute of early development.

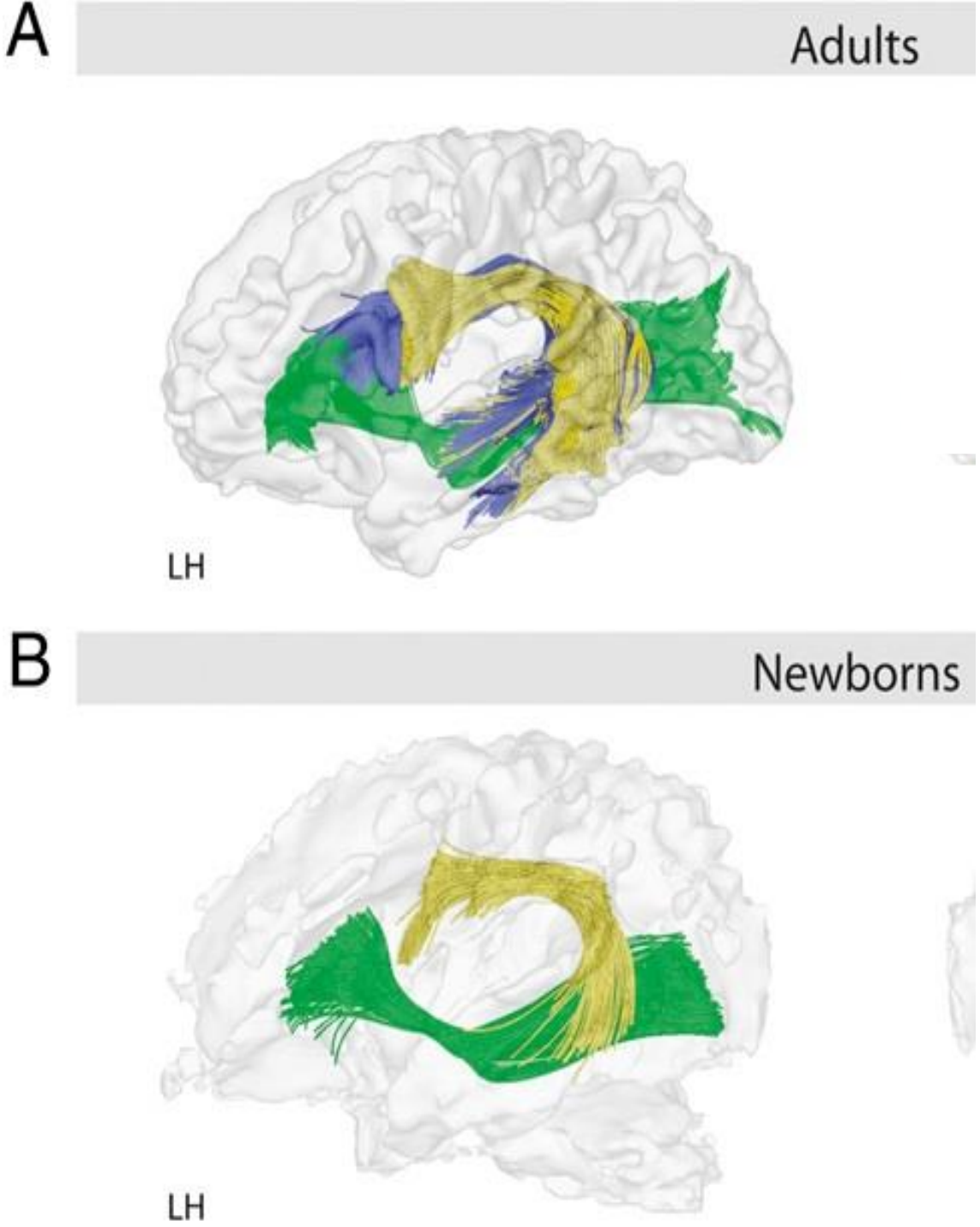
"Four orofacial gestures of a fetus at approximately 28 weeks GA.

(Top left) Grimacing;
(Top right) Finger sucking;
(Bottom left) TP to the side;
(Bottom right) tongue thrust. "

Keven, N. & K.Akins. 2016.

Neonatal Imitation in Context: Sensory-Motor Development in the Perinatal Period.

*Behavioral and Brain Sciences* Fig.2.




Perani, Daniela, et al. 2011.

Neural language networks at birth.

***PNAS*** 108.16056–61.

Kuhl, P. & M. Rivera-Gaxiola.

**Neural Substrates of Language Acquisition**.

Annual Review Neuroscience 31.511-34. 2008.

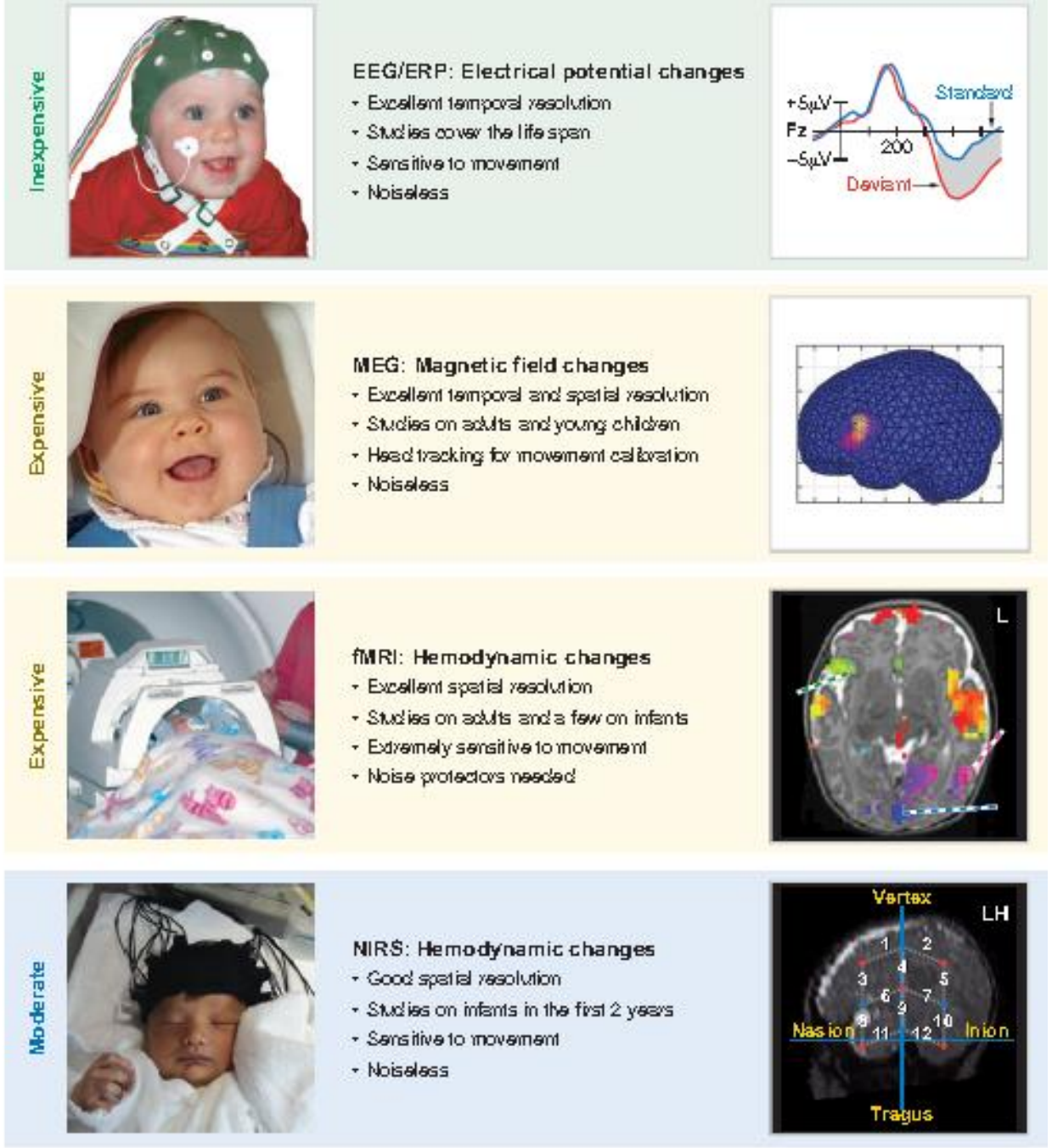
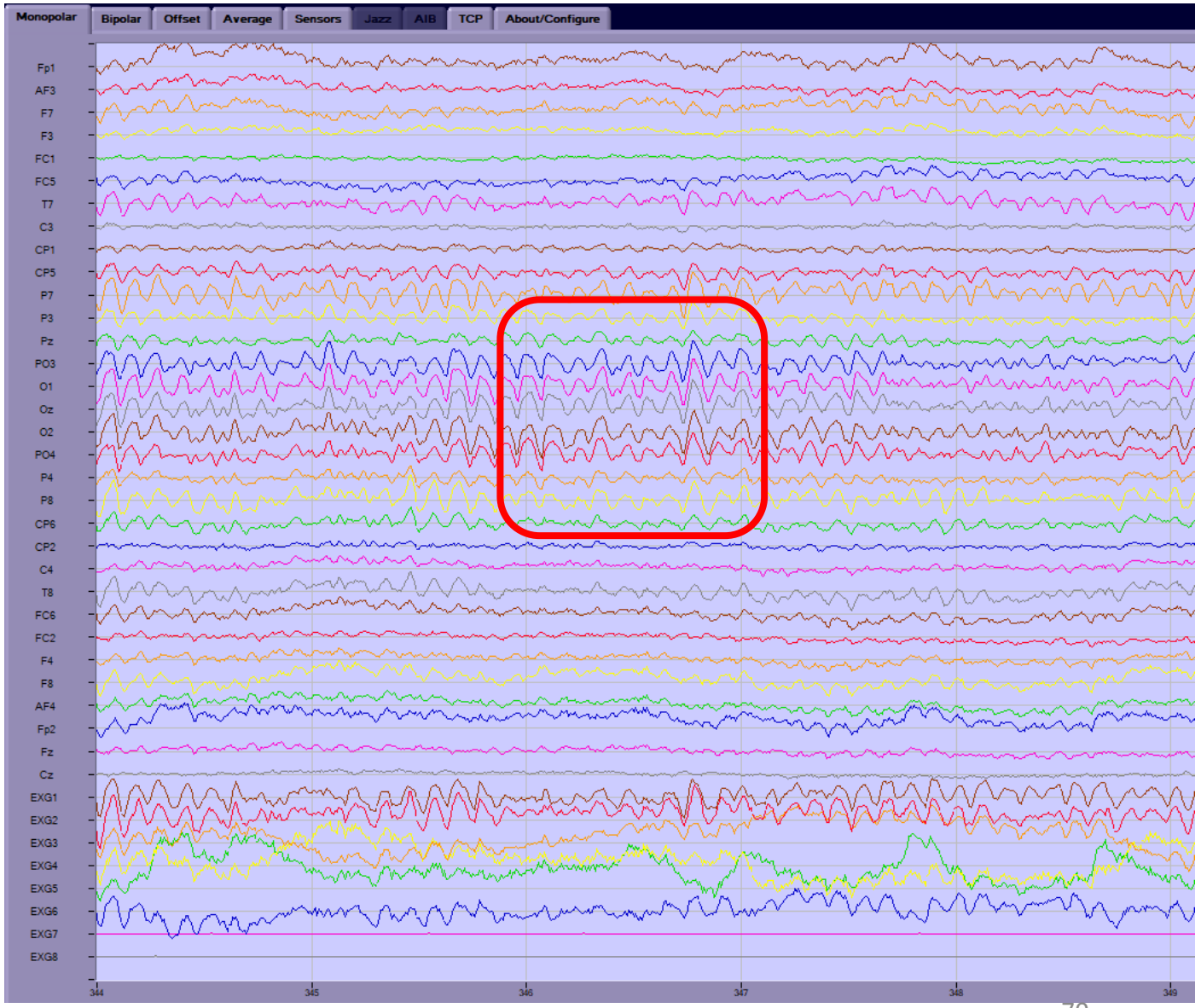


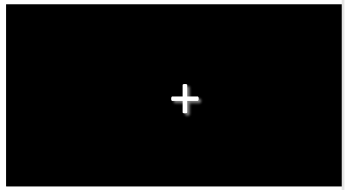

Figure 1

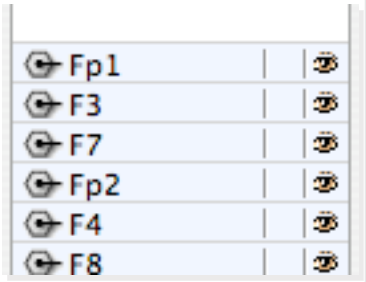
Four neuroscience techniques now used with infants and young children to examine their brain responses to linguistic signals.

# Electroencephalography 腦電圖

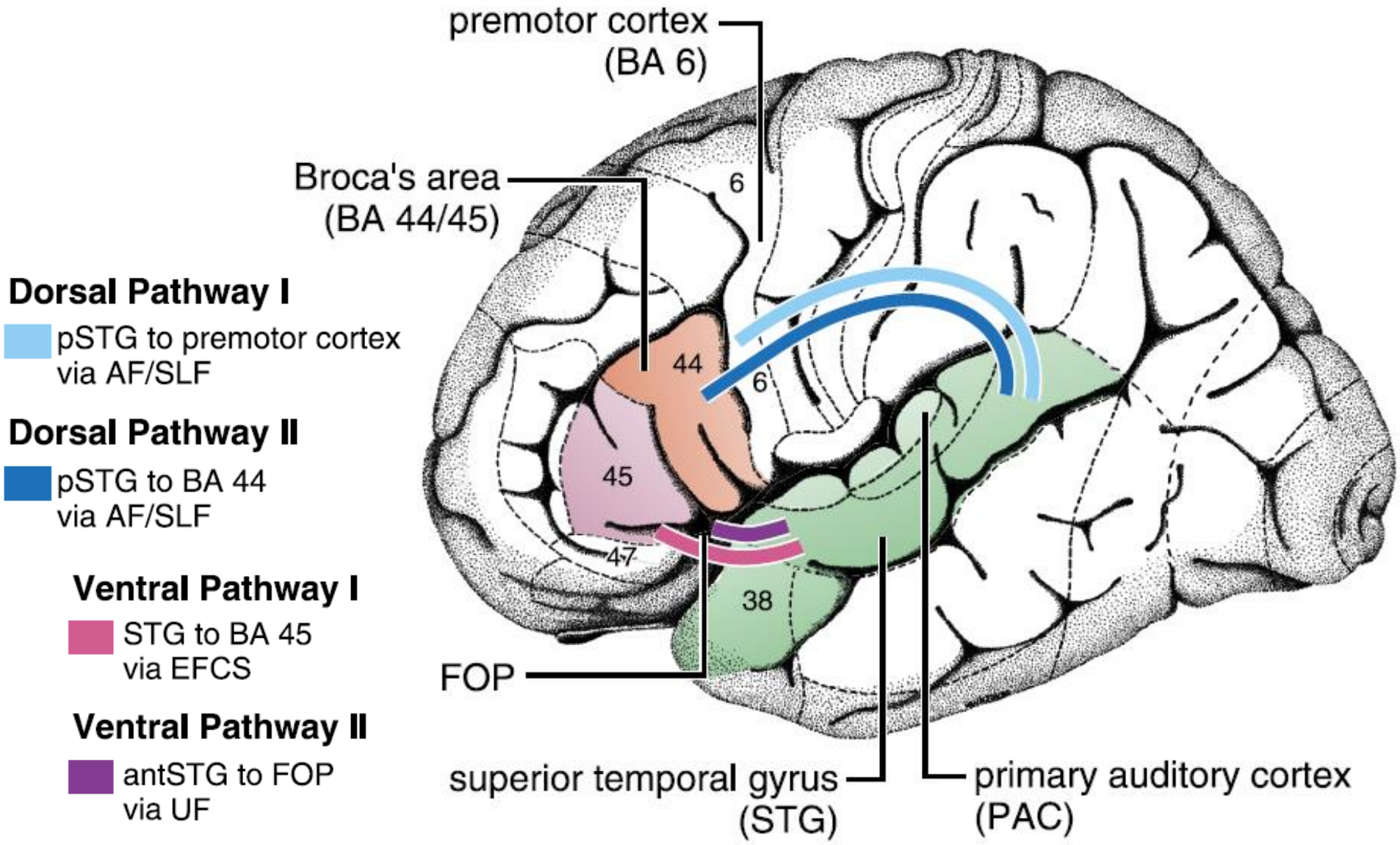



BioSemi 32 channel. 20160414 @ GH146 HKPolyU

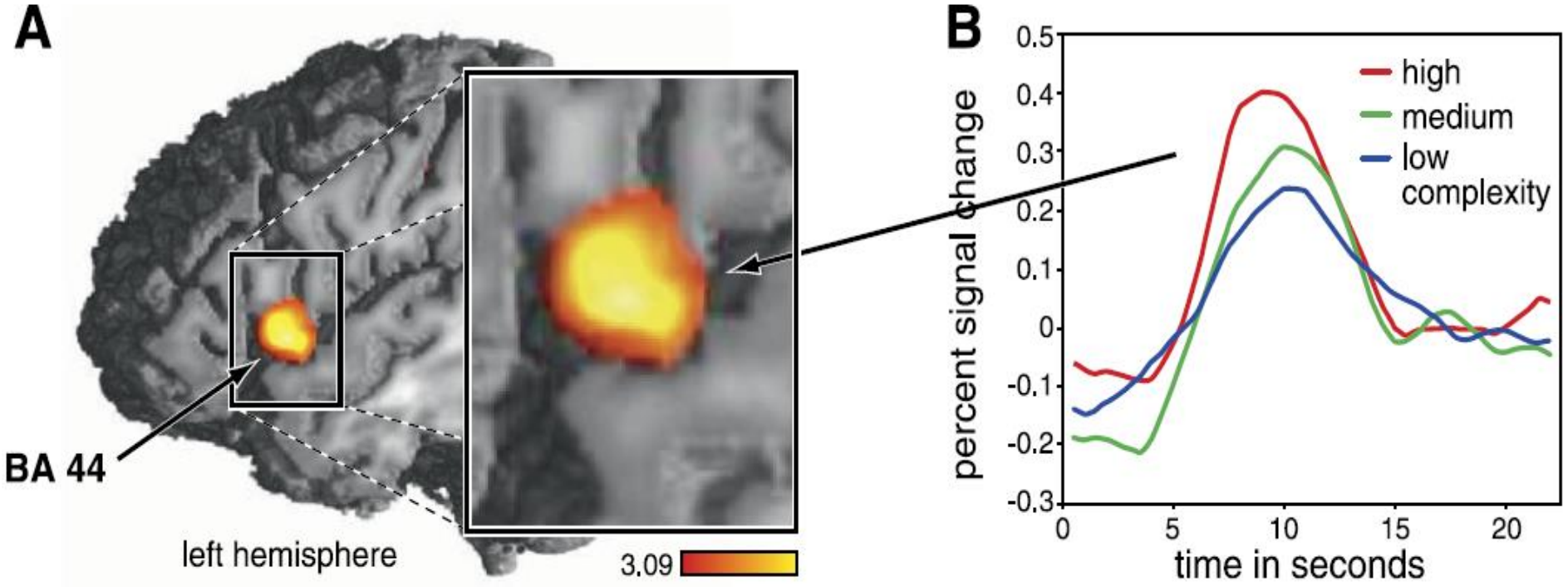



Fp1
F3
F7
Fp2
F4
F8

Friederici, A.D.  2011:1360.



Friederici, A.D. 2011:1371.




| | |
|---|---|
| Low | *Heute hat der Opa dem Jungen den Lutscher geschenkt.*<br>Today has the grandfather (NOM) to the boy (DAT) the lollipop (ACC) given. |
| Medium | *Heute hat **dem Jungen** der Opa den Lutscher geschenkt.* |
| High | *Heute hat **dem Jungen den Lutscher** der Opa geschenkt.* |

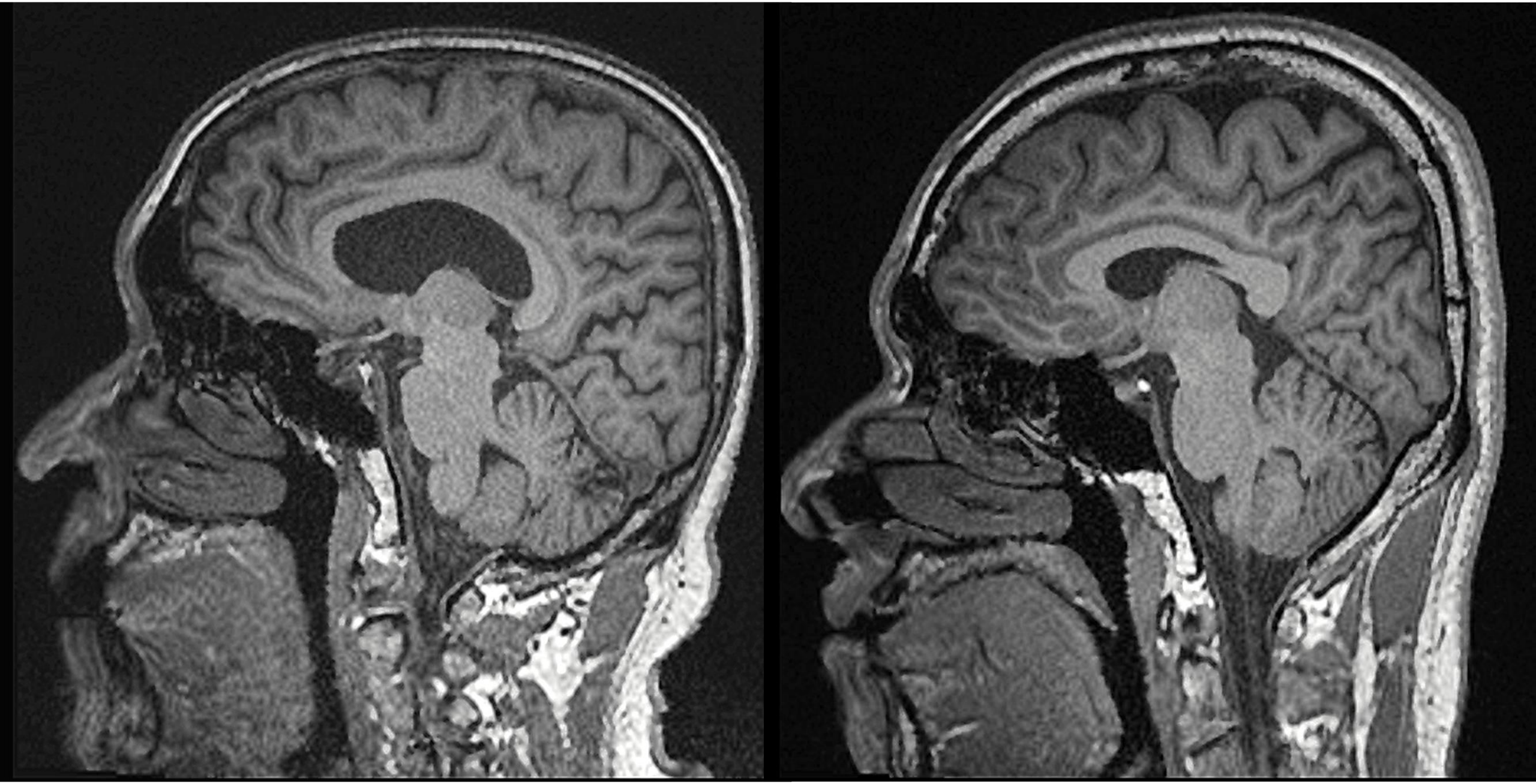
# T1 MP-RAGE TE = 2.29 ms TR = 2000 ms TI = 900 ms

*Video produced by Manson Fong, 2017.*



**Young** **Old**

LEFT VENTRICLE: Frame number = 87 35,254 c.m. Frame number = 91 5,256 c.m.



笛卡儿

# René Descartes

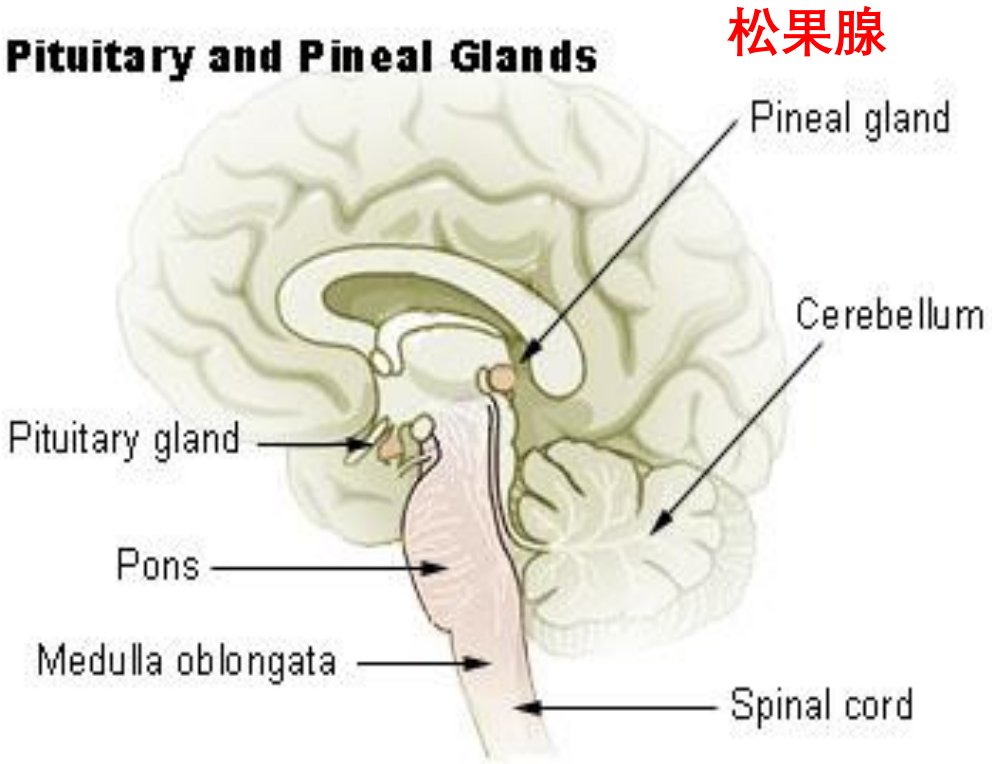
(1596 – 1650) was a French philosopher, mathematician, scientist and lay Catholic who invented analytic geometry, linking the previously separate fields of geometry and algebra. … Descartes is also widely regarded as one of the founders of modern philosophy.

*wikipedia*

**Descartes, R. 1637**/1970. The Philosophical Works of Descartes rendered into English. Columbia University Press.

"Je pense donc je suis." "Cogito ergo sum." "I think therefore I am."

Descartes 1637- "… the soul by which I am what I am, is entirely distinct from body, and is even more easy to know than is the latter; and even if latter were not, the soul would not cease to be what it is."



Damasio 1994:249.

"This is Descartes' error: the abyssal separation between the body and mind, between the sizable, dimensional, mechanically operated, infinitely divisible body stuff, on the one hand, and the unsizable undimensioned, un-pushpullable, mind stuff; the suggestion that reasoning, and moral judgment, and the suffering that comes from physical pain or emotional upheaval might exist separately from the body. Specifically: the separation of the most refined operations of mind from the structure and operations of a biological organism."

「這正是笛卡兒的錯：身與心之間有如深淵般的分離，
也就是一方面是有尺寸、有空間維度、機械運作且可
無限分割的身體，與沒有尺寸、沒有空間維度、
推不了也拉不了的心智之間有如深淵般的分離；
這意味著推理和道德判斷，以及因身體疼痛或情感
起伏而來的苦楚，都可以脫離身體而存在。
尤其是，把最精密的心智運作，與生物有機體的構造
和運作區隔開來。」

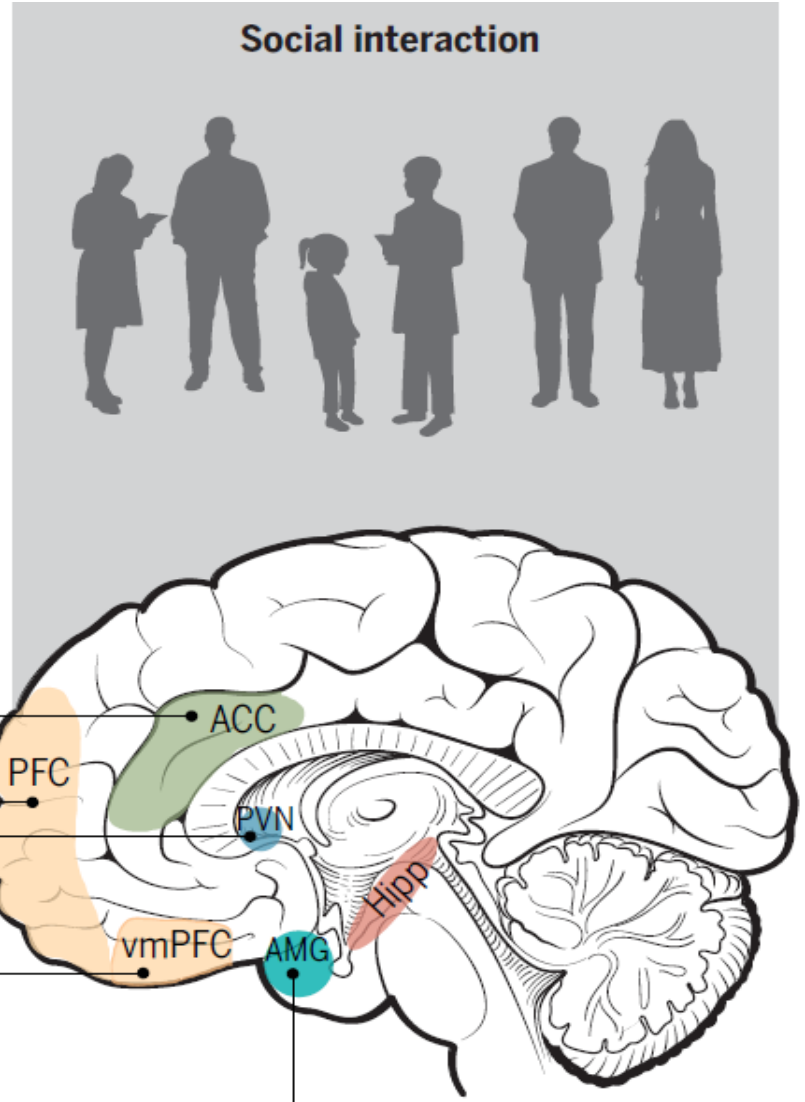
**Anterior cingulate cortex (ACC)**
This brain region functions in the detection and valuation of social processes such as interactions with dominant males and females in primates, and decision-making games in humans.

**Prefrontal cortex (PFC)**
In humans, this brain region is activated in response to various social cognitive tasks such as empathy, moral decision making, and judging the mental states of others. In rodents, stimulation of excitatory neurons abolishes social exploration and preference.

**Paraventricular nucleus of the hypothalamus (PVN)**
Magnocellular neurons of the PVN produce the neuropeptide oxytocin. Oxytocin is secreted to brain regions involved in sociability and social cognition, such as the ventral tegmental area and PFC. Reduced levels of oxytocin are documented in autism.

**Ventromedial prefrontal cortex (vmPFC)**
Lesions to this part of PFC result in social isolation and apathy in humans. The vmPFC is also important in the learning of cues that predict social reward. Children with ASD display reduced vmPFC activation in response to social reward.

**Amygdala (AMG)**
Amygdalar volume correlates with the size and complexity of social networks in humans. This brain region functions in the analysis of social situations. Individuals with autism demonstrate reduced activation of this brain region in response to social judgment tasks.




Sherwin, E., et al. 2019.Microbiota & the social brain. *Science* **366.**

Fig. 1. Social behavior is governed by multiple interconnected limbic brain regions. Preclinical and clinical imaging studies have helped delineate the neurocircuitry underlying social behavior in humans and other mammals. Social interaction is governed by several subcortical forebrain structures such as the prefrontal cortex (PFC), anterior cingulate cortex (ACC), amygdala (AMG), hippocampus (Hipp), and hypothalamus (paraventricular nucleus, PVN), which form part of an integral interconnected network to facilitate this complex behavior. Damage or dysfunction to any one of these brain regions can give rise to perturbations in social behavior. Indeed, the neurobiology of regions such as the AMG and PFC have been shown to be altered in disorders of the social brain such as autism spectrum disorders (ASDs).

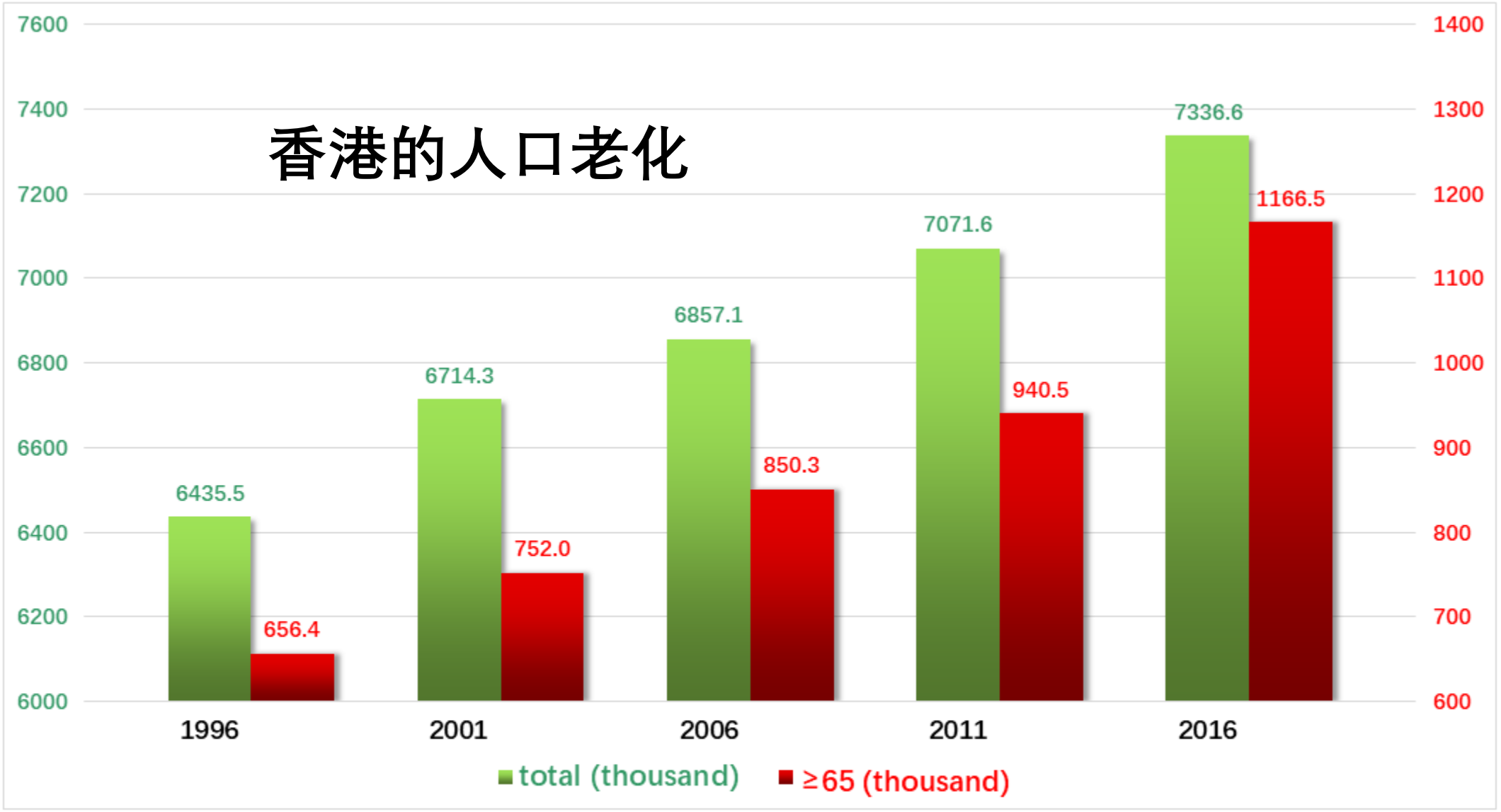
*Sherwin, E., et al. 2019.Microbiota & the social brain. Science* ***366.***

With the numerous advances in the medical sciences, from personal hygiene to public health, people are living longer across the world, with dramatic advances in longevity over the past century and half.

The increase of people over 65 has been dramatic, especially in China. To take some numbers from the Chinese National Bureau of Statistics, the total population of China in 2005 changed from 1,307 million in 2005 to 1,412 million in 2021, an increase of 8%.

Of this population, the people aged **65 or greater** increased from 101 million to 201 million, essentially **doubling in number over just 16 years**. This large change in demographic distribution poses immense challenges for society at every level.

# 香港的人口老化




**POPULATION AGEING in HONGKONG**

**GREEN**: Total population in thousands.

**RED**: Elders ≥ 65 population in thousands.

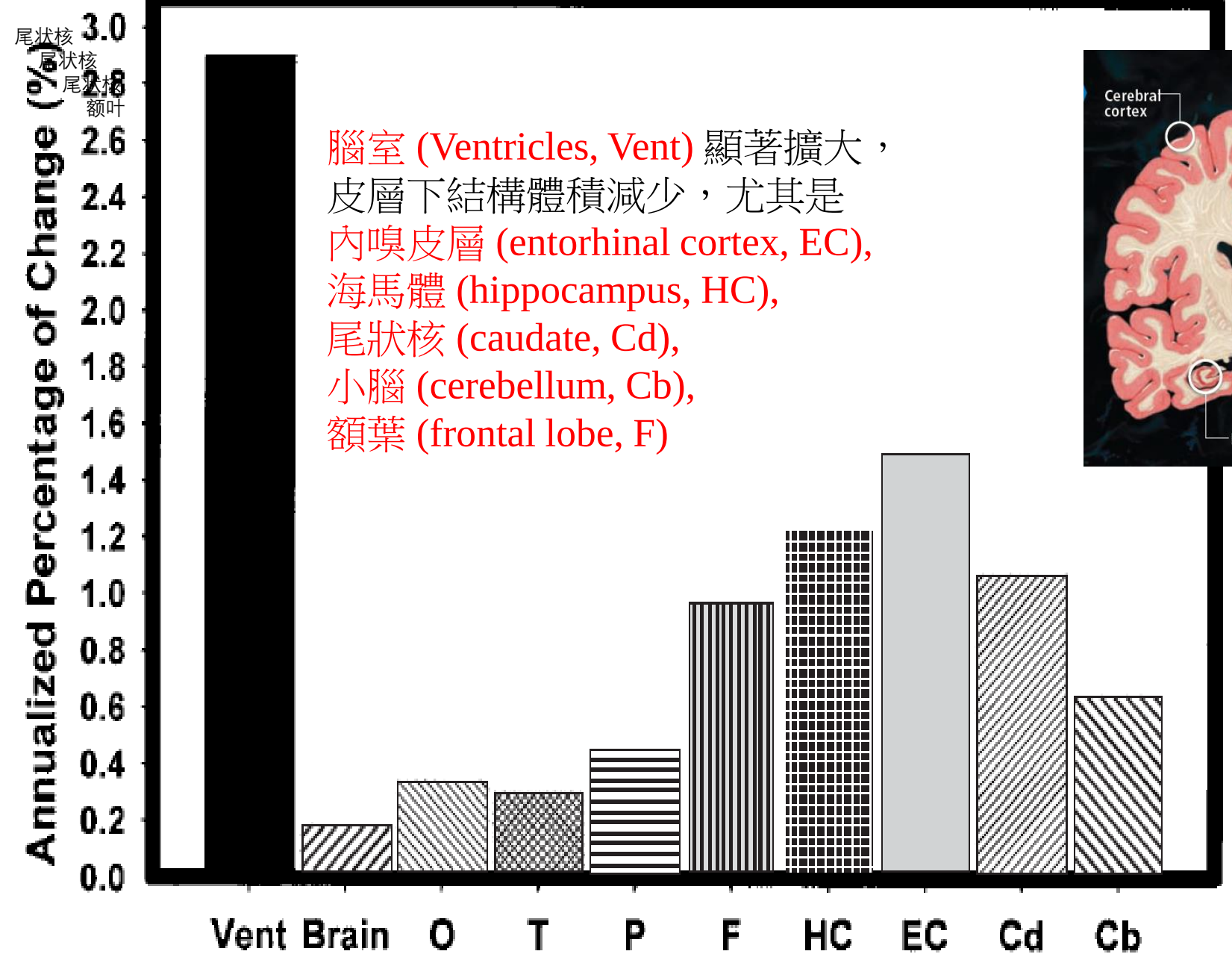
In 1996, elders ≥65 were **10%** of the total population; in 2016 they have risen to **16%**. Over this period, the total population has risen by **14%**; the elder has risen by **78%**.

Government survey: https://www.censtatd.gov.hk/hkstat/sub/sp150_tc.jsp?productCode=B1120017.

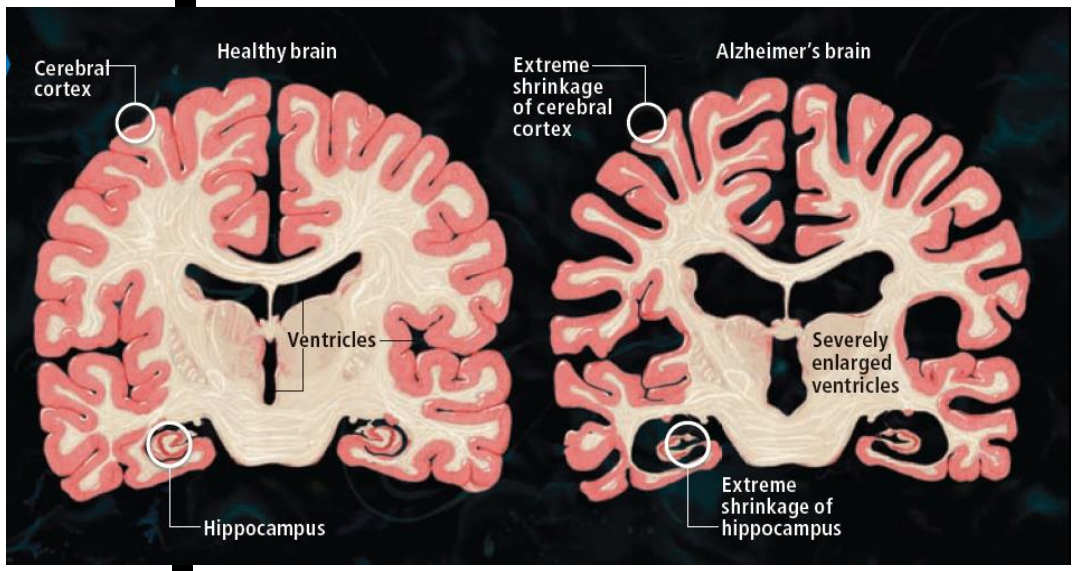
| 香港 政府統計處 人口估計 2022 年 8 月 11 日 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Age** | All | 0 – 14 | 15 – 59 | ≧60 | | 60 - 64 | **≧65** |
| **#** | 7292 K @ | 773 K | 4376 K | 2142 K | | 622.5 K | **1520 K** |
| **(%)** | 2022 | (10.60%) | (60.02%) | (29.38%) | | (8.54%) | **(20.85%)** |
| **10-yr** | 7150 K @ | **-0.77%** | **-8.91%** | **+9.69%** | | | |
| **Diff.** | 2012 | | | | | | |
| **(%)** | **+1.98%** | | | | | | |

| 第七次 全國人口普查 國家統計局局長 甯吉喆 2021 年 5 月11 日 | | | | | | | |
|---|---|---|---|---|---|---|---|
| **#** | 1.41 B @ | 253 M | 894 M | 264 M | | 73 M | **191 M** |
| **(%)** | 2021 | (17.95%) | (63.35%) | (18.70%) | | (5.20%) | **(13.50%)** |
| **10-yr** | 1.34 B @ | **+1.35%** | **-6.79%** | **+5.44%** | | | |
| **Diff.** | 2011 | | | | | | |
| **(%)** | **+5.22%** | | | | | | |

Using brain imaging, Raz has reported some figures on regions of the brain as cognition declines. The volume of several subcortical structures reduce significantly, especially the entorhinal cortex and the hippocampus. The frontal lobe, the last lobe to mature fully in early adulthood is also the first to atrophy. As the volumes of these structures reduce, the space is taken up by expanding ventricles, often to several times their original sizes.




腦室 (Ventricles, Vent) 顯著擴大，
皮層下結構體積減少，尤其是
內嗅皮層 (entorhinal cortex, EC),
海馬體 (hippocampus, HC),
尾狀核 (caudate, Cd),
小腦 (cerebellum, Cb),
額葉 (frontal lobe, F)



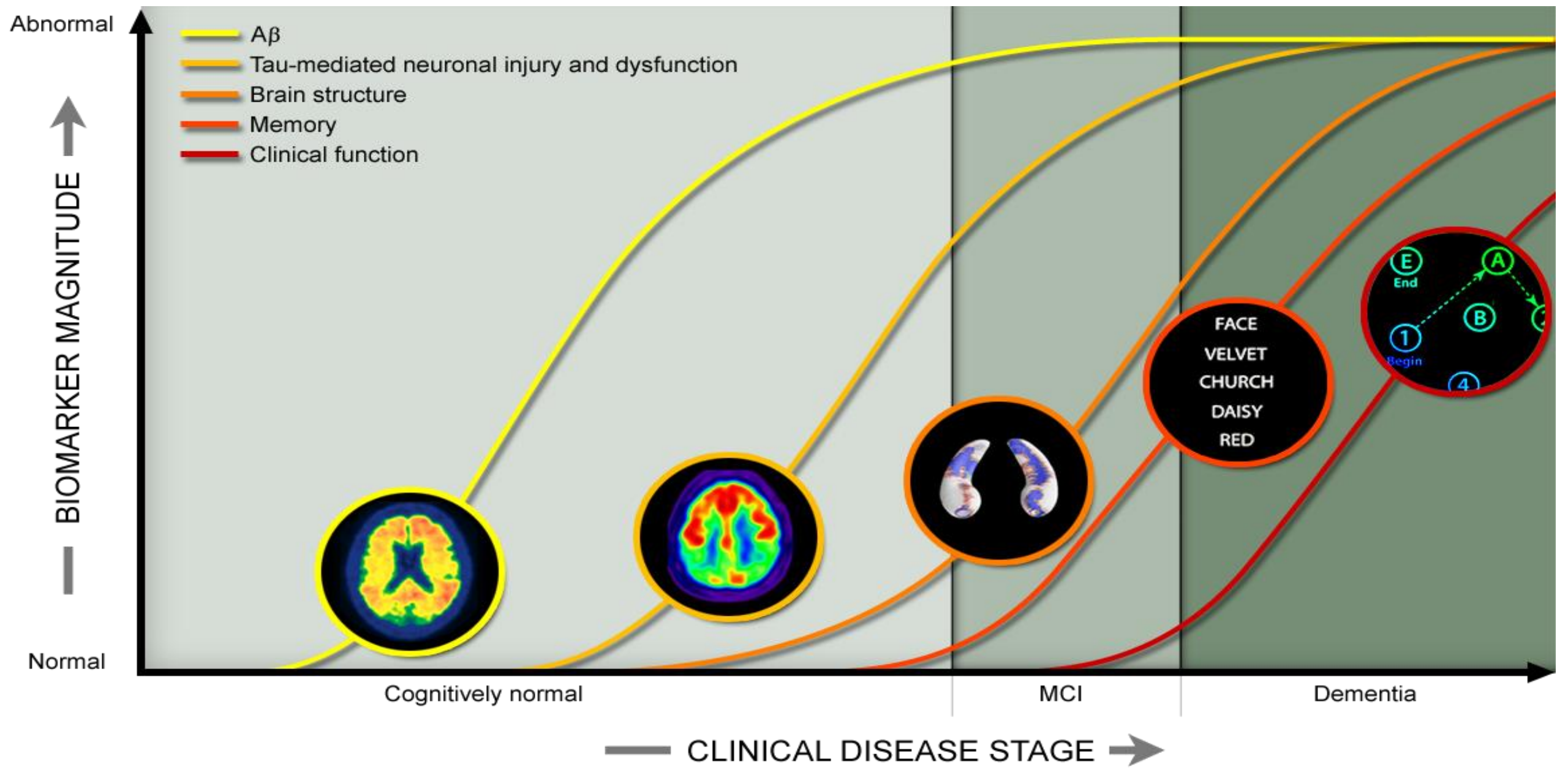

Raz, N. 2005:41.
In Cabeza, R.et al. eds. *Cognitive Neuroscience of Aging: Linking Cognitive and Cerebral Aging*: Oxford University Press.

Stix, G. 2010. Alzheimer's: Forestalling the darkness. *Scientific American* 50-7.

In 2010, C.R. Jack et al proposed a hypothetical model of what they called the “Alzheimer’s pathological cascade”. Beta amyloid and tau may start invading the brain decades before the patient confirms the disorder, and get diagnosed clinically as Mild Cognitive Impairment, MCI.

By that time, the damage to his brain can be readily seen via brain imaging. His performance on the various cognitive tests, such as MMSE (Mini-Mental State Examination) or MoCA (Montreal Cognitive Assessment) gets increasingly poorer until severe dementia sets in, when he becomes completely incapable to take care of himself.

Unfortunately, at present there is no cure for Alzheimer’s Disease, only feeble methods to delay the tragic end.




http://adni.loni.usc.edu/studydesign/background-rationale/ Based on Jack, C.R., et al. (2010). Hypothetical model of dynamic biomarkers of the Alzheimer's pathological cascade. *Lancet Neurol.* *9*(1), 119-128.

Given this long incubation time, the hope is that the disease can be detected as early as possible so that intervention can be planned. The critical issue here for us is whether the patient's **language and cognitive behavior** can give us some clues on the nature of disorder, in addition to the physician's biomarkers.

Over the past many decades, numerous studies have been made on children's language and aphasic speech. But the language and speech that accompany neurodegeneration has not been given much attention.

Furthermore, the relatively few studies that have been reported in this direction are almost exclusively done in a so-called **WEIRD** context, so their results may not be generalizable to Asian populations.

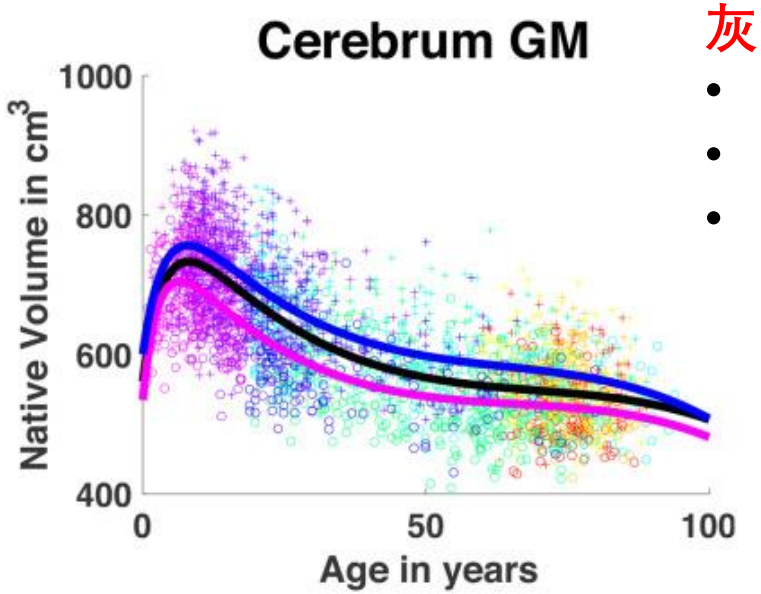
But the situation appears to be getting better. With the high visibility and high finance of the China Brain Project, 2016-2030, launched by the government, more and more teams have joined the effort to meet the challenges that large scale ageing has brought. This is no doubt due in part to the conviction that knowledge about the brain will not only help us cure neurodegenerative diseases one day, but will also provide a source of insights for computer sciences.

See the views of the neuroscientist 蒲慕明 on this dual perspective: *Poo, Muming, et al. (2016).* ***China Brain Project****: Basic Neuroscience, Brain Diseases, and Brain-Inspired Computing.* *Neuron 92(3): 591-596.*

The brain orchestrates every aspect of our behavior, sensory, motoric, memorial, emotional, etc. The effects of these losses of its cells may be subtle as first, though detectable by means of various experiments. But when such losses in neurons are exacerbated by other factors, such as beta amyloid, tau, or dysfunctional mitochondria within or malignant glia cells in the environment, severe pathologies will surely follow.

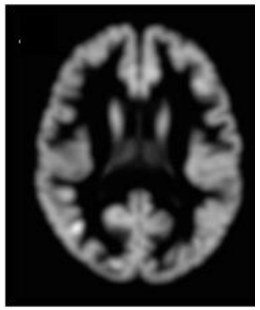
Without a functioning brain, there is little mind left. Long lifespan must be accompanied by long health span.

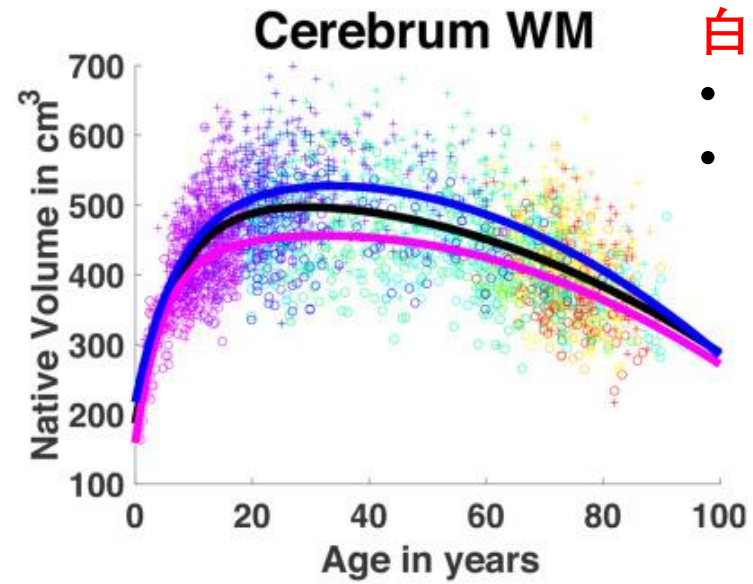
# 腦部及認知能力的變化. Brain and cognitive ageing.




**灰質 Grey matter**

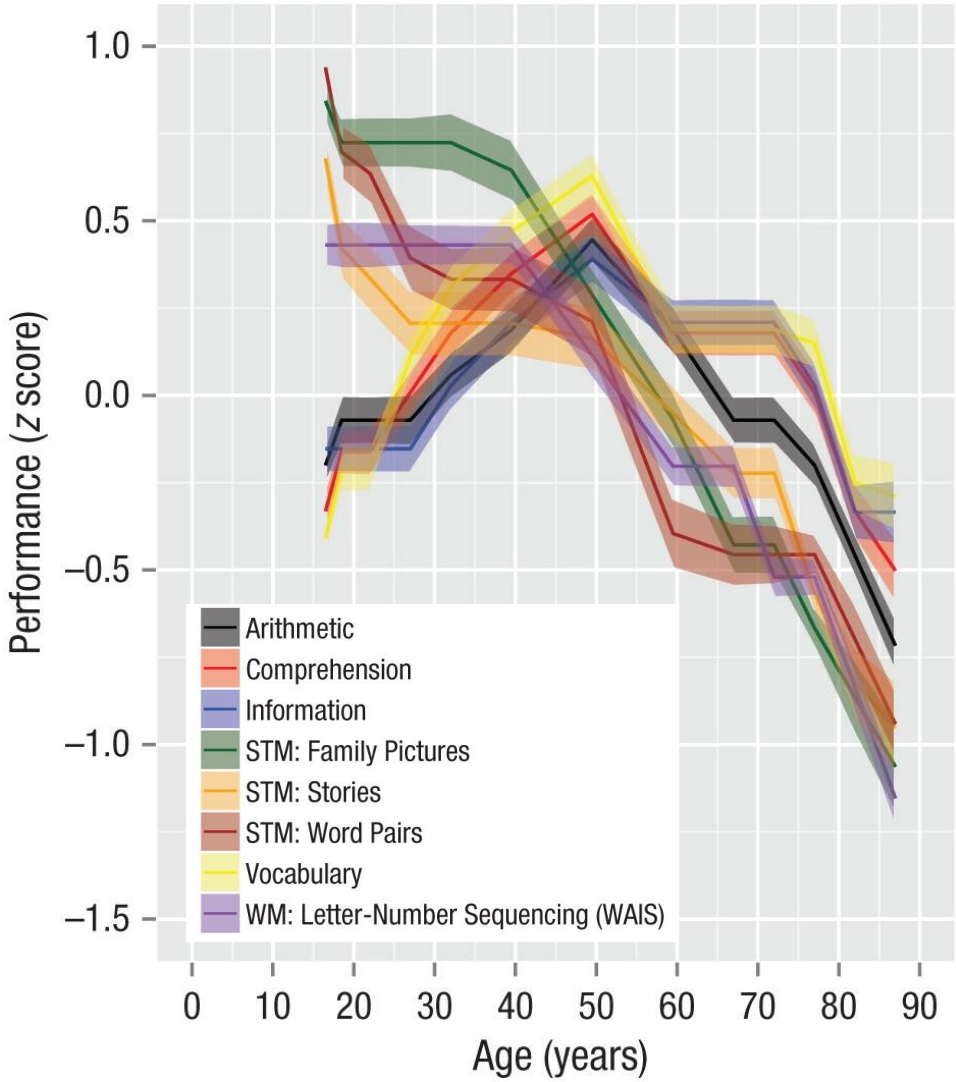
- 神經元的細胞體
- 於 11 歲左右到頂峰
- 突觸修剪 (synaptic pruning)






**白質 White matter**

- 神經元的神經纖維
- 於 30 歲左右才到頂峰




Hartshorne, J. K., & Germine, L. T. (2015). *Psychological science*, *26*(4), 433-443.

Tzeng, O. J. L. and W. S.-Y. Wang. 1983. The first two R's. American Scientist **71**: 238-243.

Stroop, J. R. 1935. Studies of interference in serial verbal reactions. Journal of Experimental Psychology **18**: 643-662.

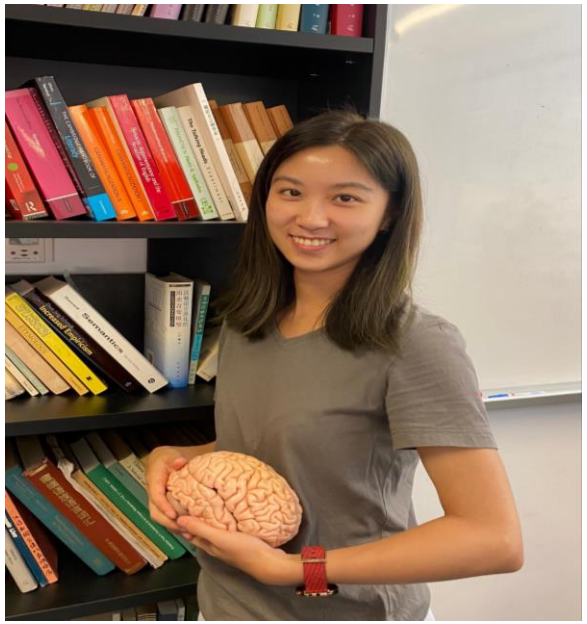
**BLUE** **PURPLE** **GREEN** **RED**

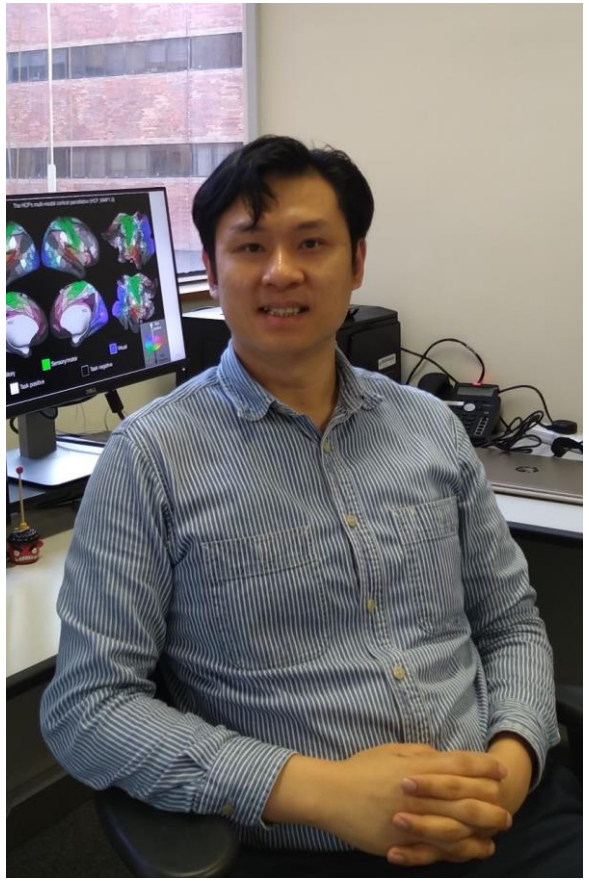
**GREEN** **BLUE** **RED** **PURPLE**

紅 紫 綠 藍

藍 綠 紅 紫

**Feng, Yun, et al. (2022). Electrophysiological evidence for aging effects on automatic semantic processing in semantic priming. *BrainConnects*, Aug. 8-15, Japan.**



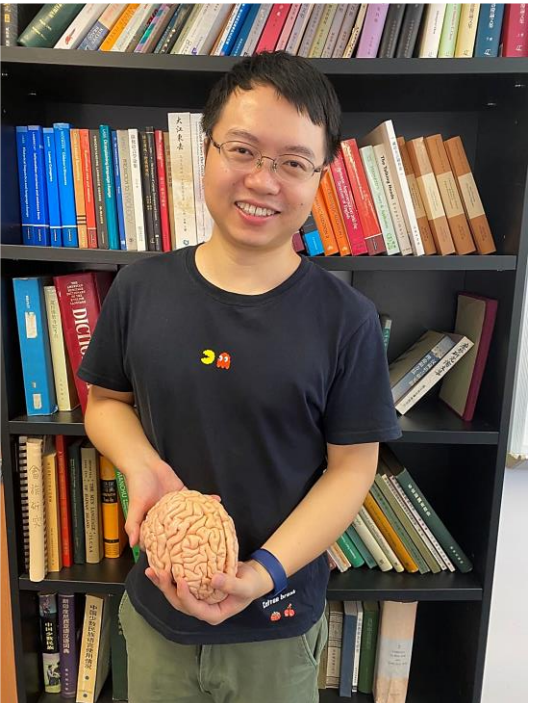


**Fong, M. C.-M., et al. (2021). "Can inhibition deficit hypothesis account for age-related differences in semantic fluency? Converging evidence from Stroop color and word test and an ERP flanker task." *Brain and Language* 218: 104952.**

**Fong, M. C.-M., et al. (2022). "Foreign Language Learning in Older Adults: Anatomical and Cognitive Markers of Vocabulary Learning Success." *Frontiers in Human Neuroscience* 16.**

**Hui, N-Y., et al. (2022). Successful older language learners show changes in cognitive abilities towards the pattern of lifelong bilinguals, Bilingualism Matters Research Symposium, Edinburgh.**


**Ma, M. K.-H., et al. (2021). Regularity and randomness in ageing: Differences in resting-state EEG complexity measured by largest Lyapunov exponent. *Neuroimage: Reports*, *1*(4), 100054.**



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Thank you !!

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谢谢!!!

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