University of Science and Technology of China

中国科学技术大学 2019.09.21

高更三问

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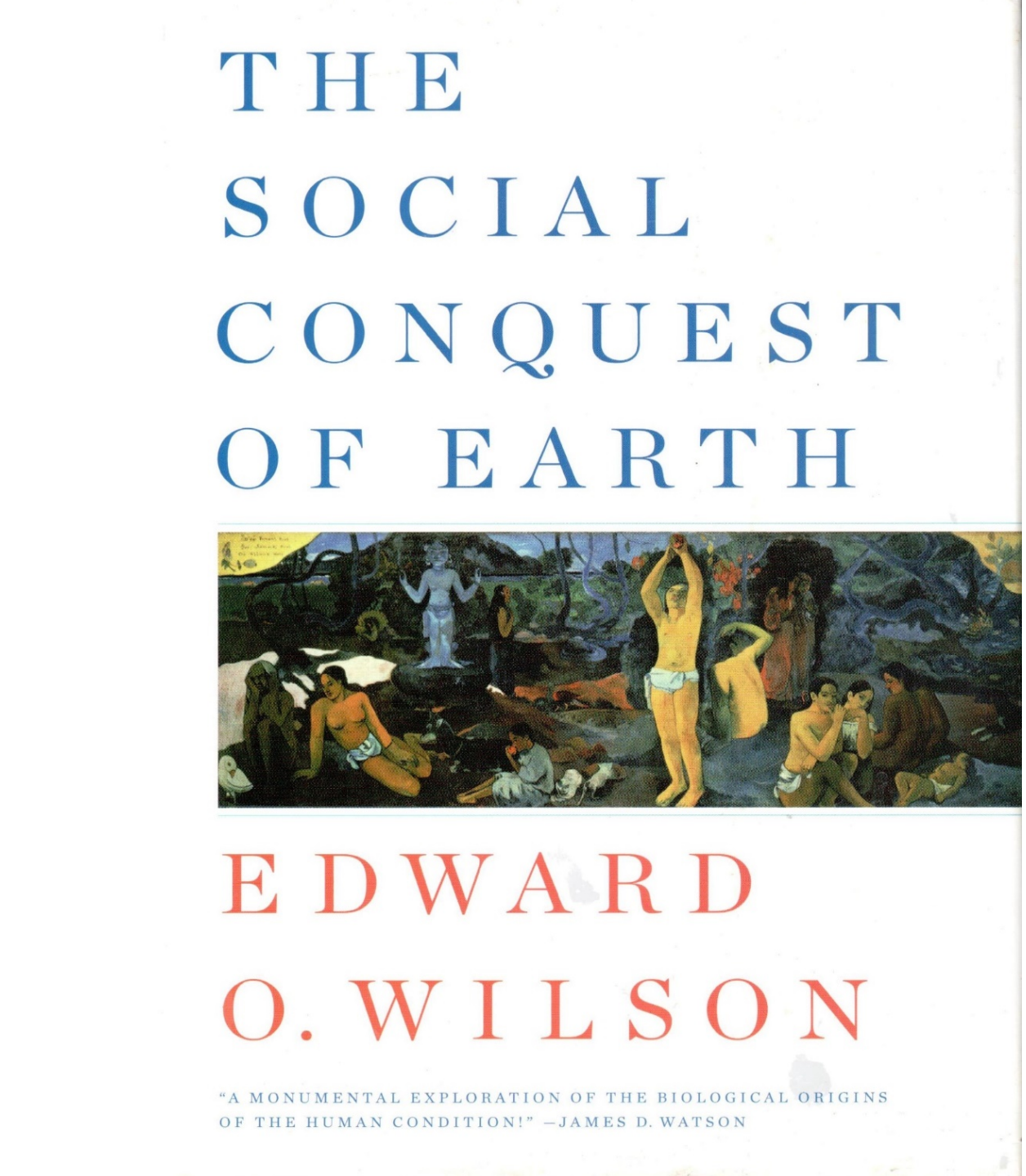

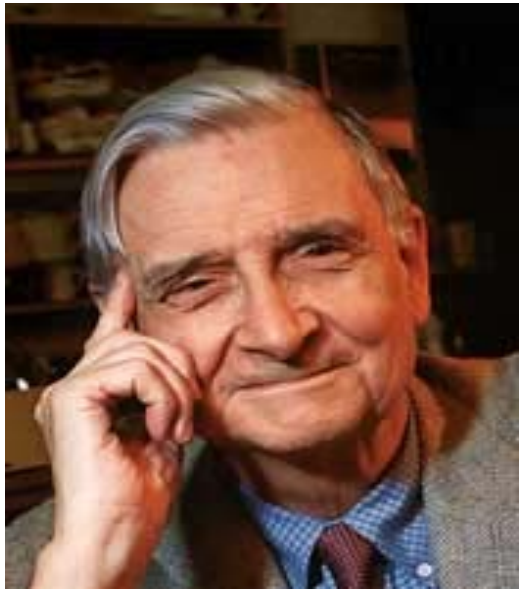

Edward O. Wilson
b. 1929

1971. The Insect Societies.
1975. Sociobiology: the New Synthesis.
1981. Genes, Mind and Culture: the coevolutionary process.
1998. Consilience: the Unity of Knowledge.

2012. The Social Conquest of Earth.
"**A monumental exploration of the biological origins of the human condition**."
James D. Watson, Nobel Prize 1962.

Paul Gauguin, 1897.

D'où venons nous? 从何处来?
que sommes nous? 人是何物?
où allons nous? 向何处去?

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**”。

高更的三个问题，我们 从何处来？ 人是何物？向何处去？

都和语言有著密不可分的关系，因为**语言是人类最重要的指标**，不仅是区别**人类和动物的分水岭**，也是**人工智能还无法让电脑掌握的能力**。自从达尔文提出演化论起，许多学科在这三个问题上都已取得不少研究成果。我希望把这些多学科的成果做个綜合性的讨论。不过知识总是在进步的，今日的理论，很可能明日就被新的发现或想法所取代，这一点是我们必须始終留意的。

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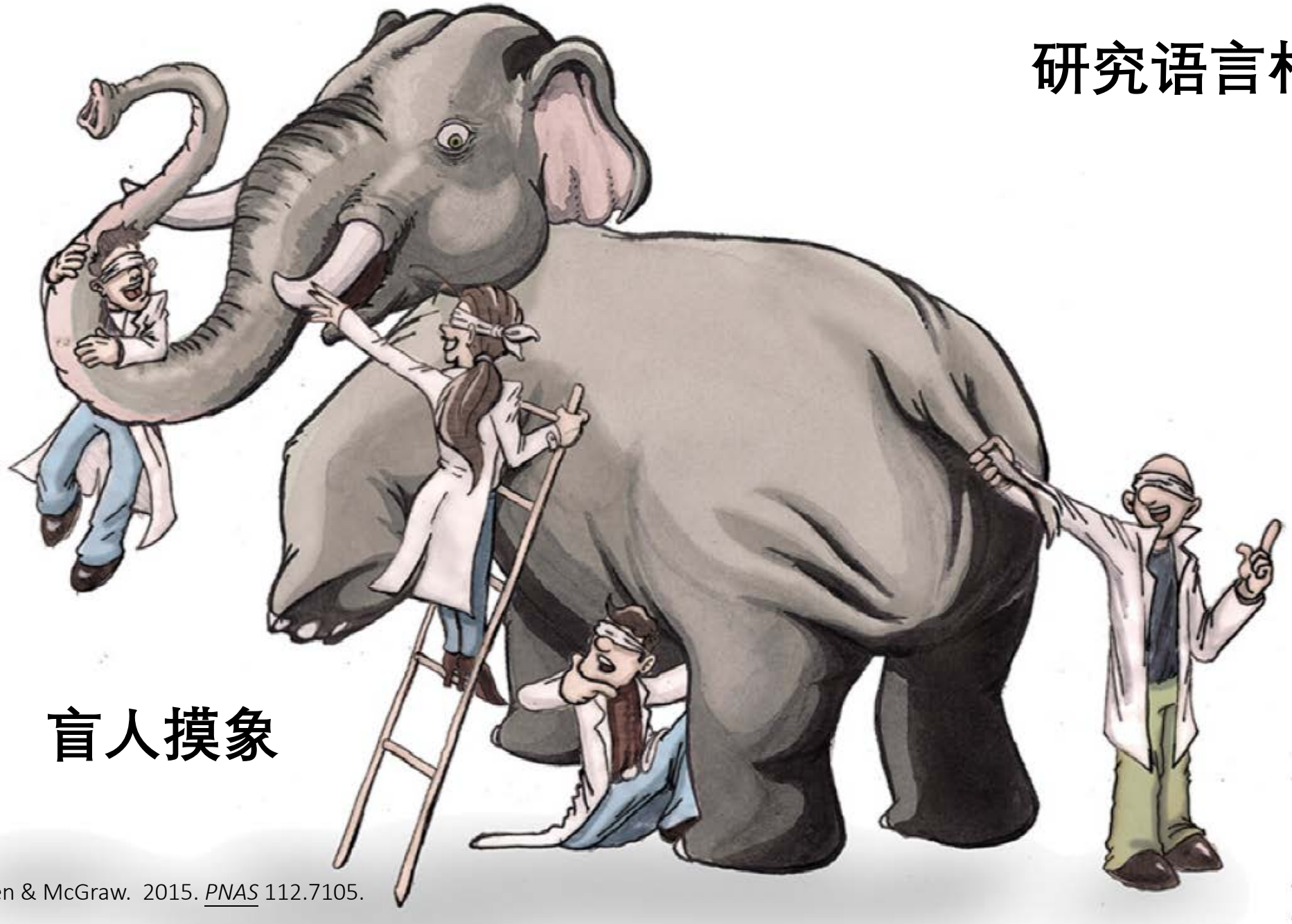


盲人摸象

研究语言相关学科：

语言学
人类学
民族学
社会学
考古学
历史学
心理学
生物学
神经学
遗传学
统计学
计算机学

Warren & McGraw. 2015. *PNAS* 112.7105.

Where do we come from?

We are members of the biological order of Primates, which arose some 60 million years ago. Our taxonomic family of Hominids includes four genera, exemplified by the Orang Utan, the Gorilla, and the Chimpanzee, our closest relative, and ourselves. We separated from the Chimpanzee and went on an independent evolutionary path some 6 million years ago. In brief, our species evolved in Africa, and then colonized our entire planet.

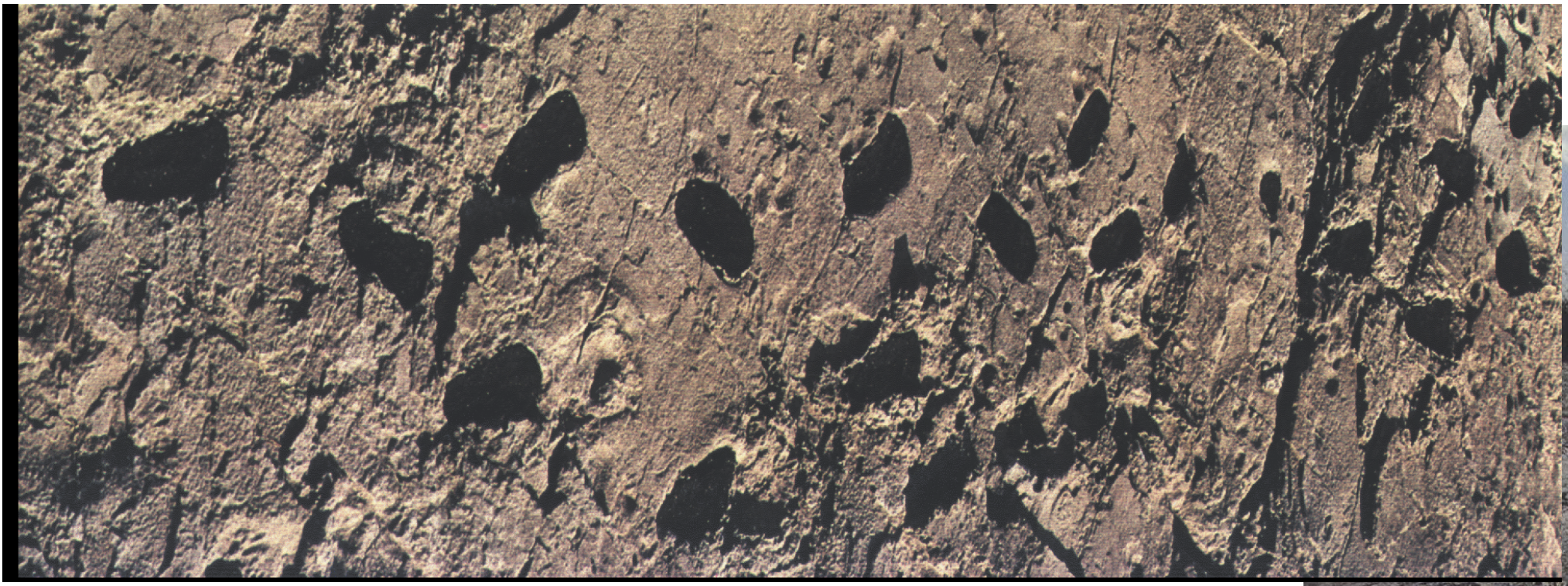
Skeletons of the

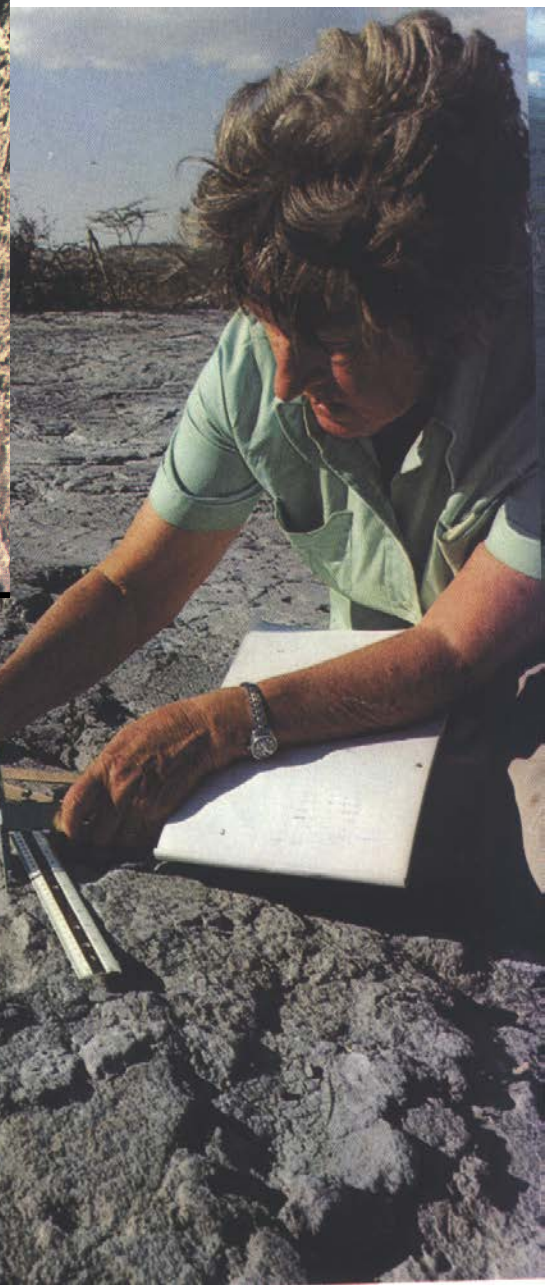
GIBBON. ORANG. CHIMPANZEE. GORILLA. MAN.

Photographically reduced from Diagrams of the natural size (except that of the Gibbon, which was twice as large as nature), drawn by Mr. Waterhouse Hawkins from specimens in the Museum of the Royal College of Surgeons.

Huxley, T. H. 1863. Evidence as to Man's place in nature. London.
Hockett, C. F. 1973. Man's place in nature. New York.

Johanson, D. &
B. Edgar. 1996.
From Lucy to Language.
Simon & Schuster.





Hay, Richard L. & Mary D. Leakey.

Fossil footprints of Laetoli.

Scientific American 1982.50-57.

from 3,500,000 b.p.

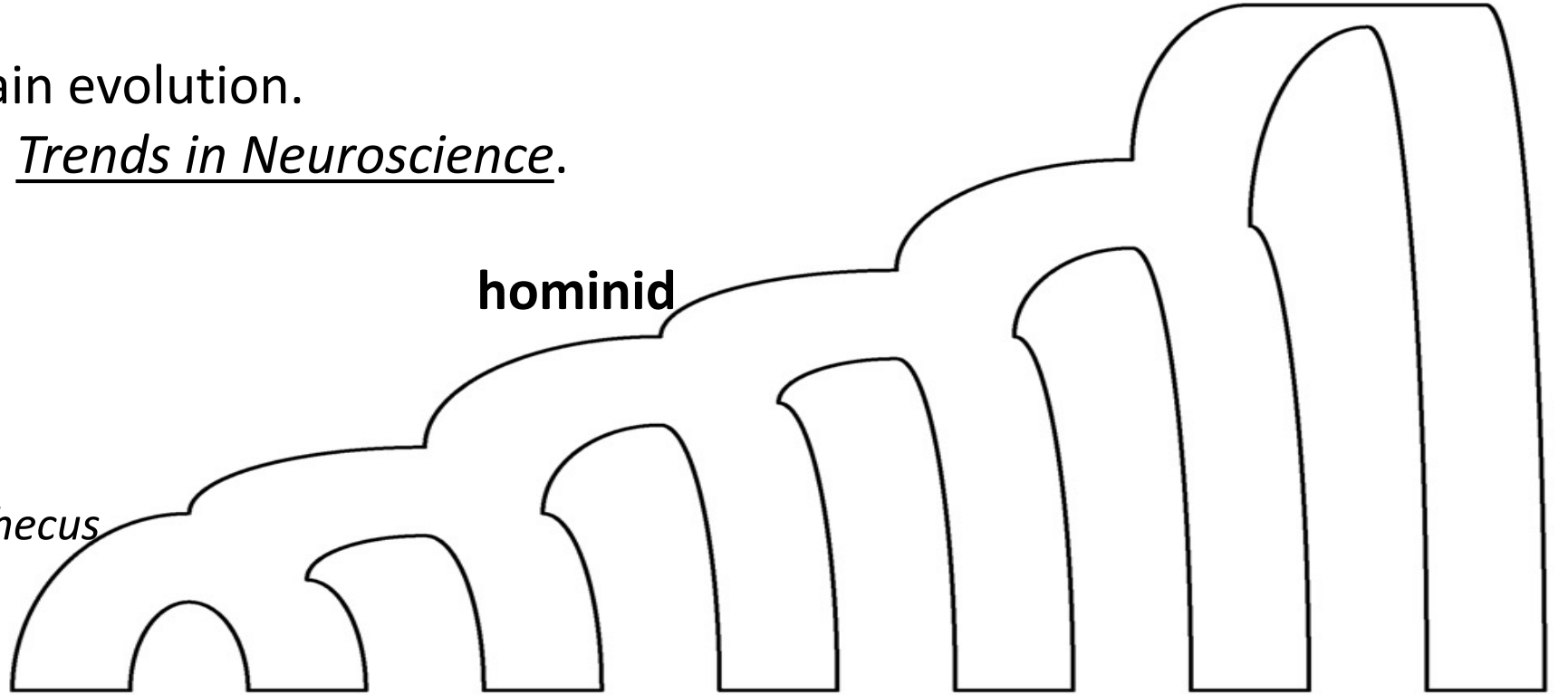
Genetic basis of human brain evolution.
Vallender, Eric, et al. 2008. *Trends in Neuroscience*.

primates 靈長類

hominid

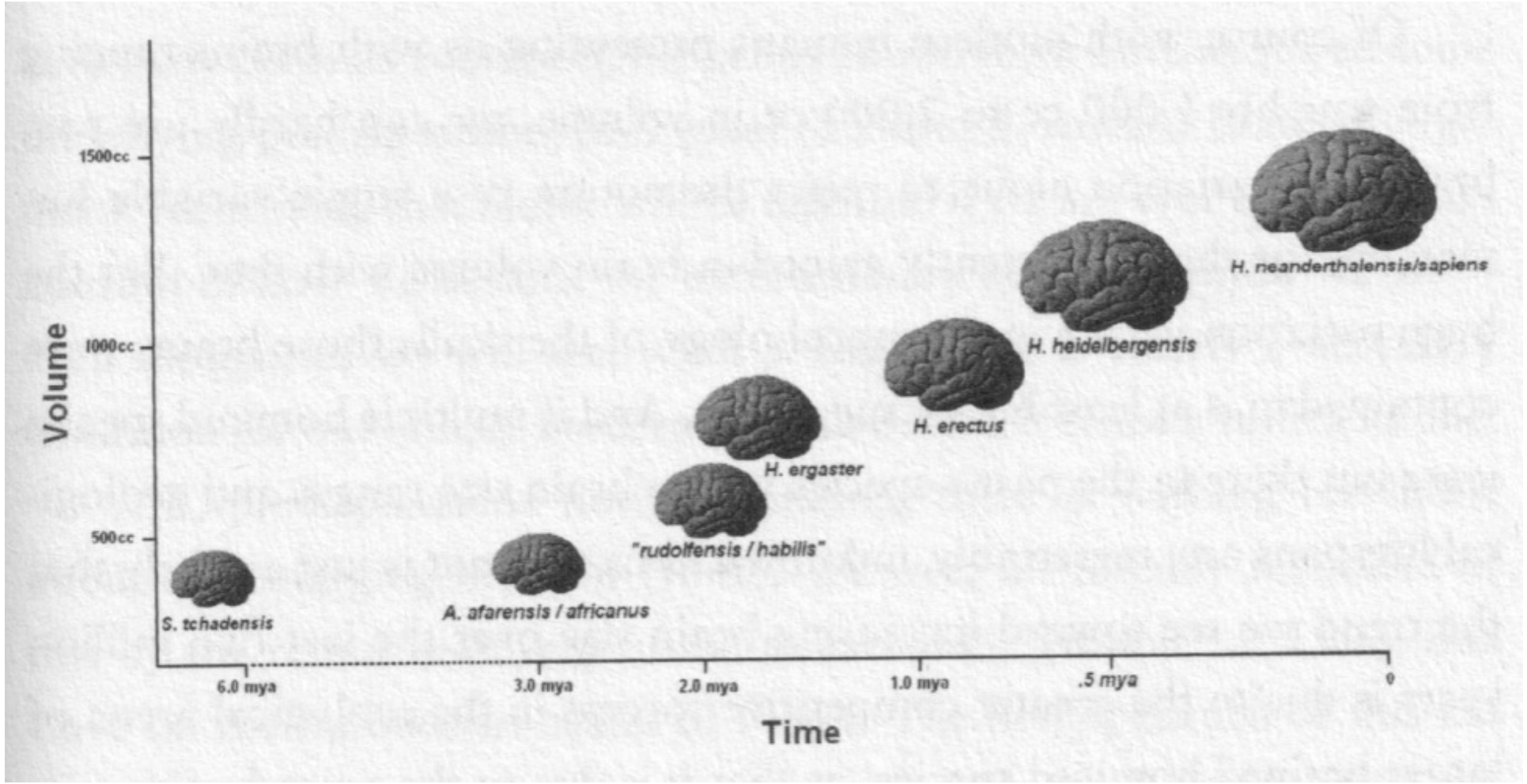
hominin

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



	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

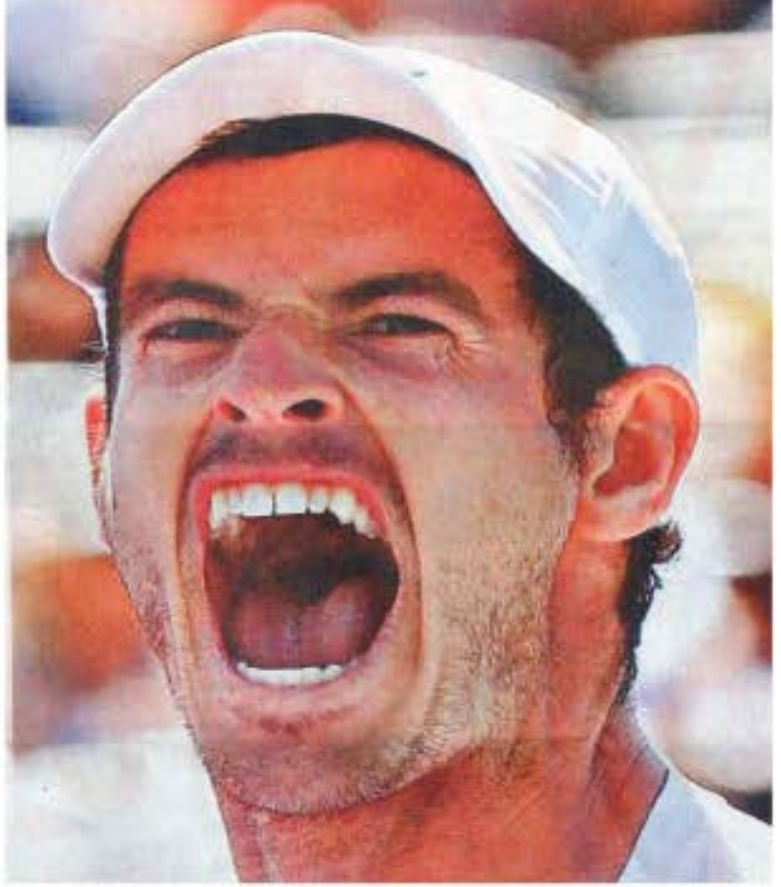
TRENDS in Neurosciences



"… After an initial flatlining, this plot appears to indicate a consistent enlargement of the hominid brain over the last two million years. …"
Tattersall 2012:131.

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

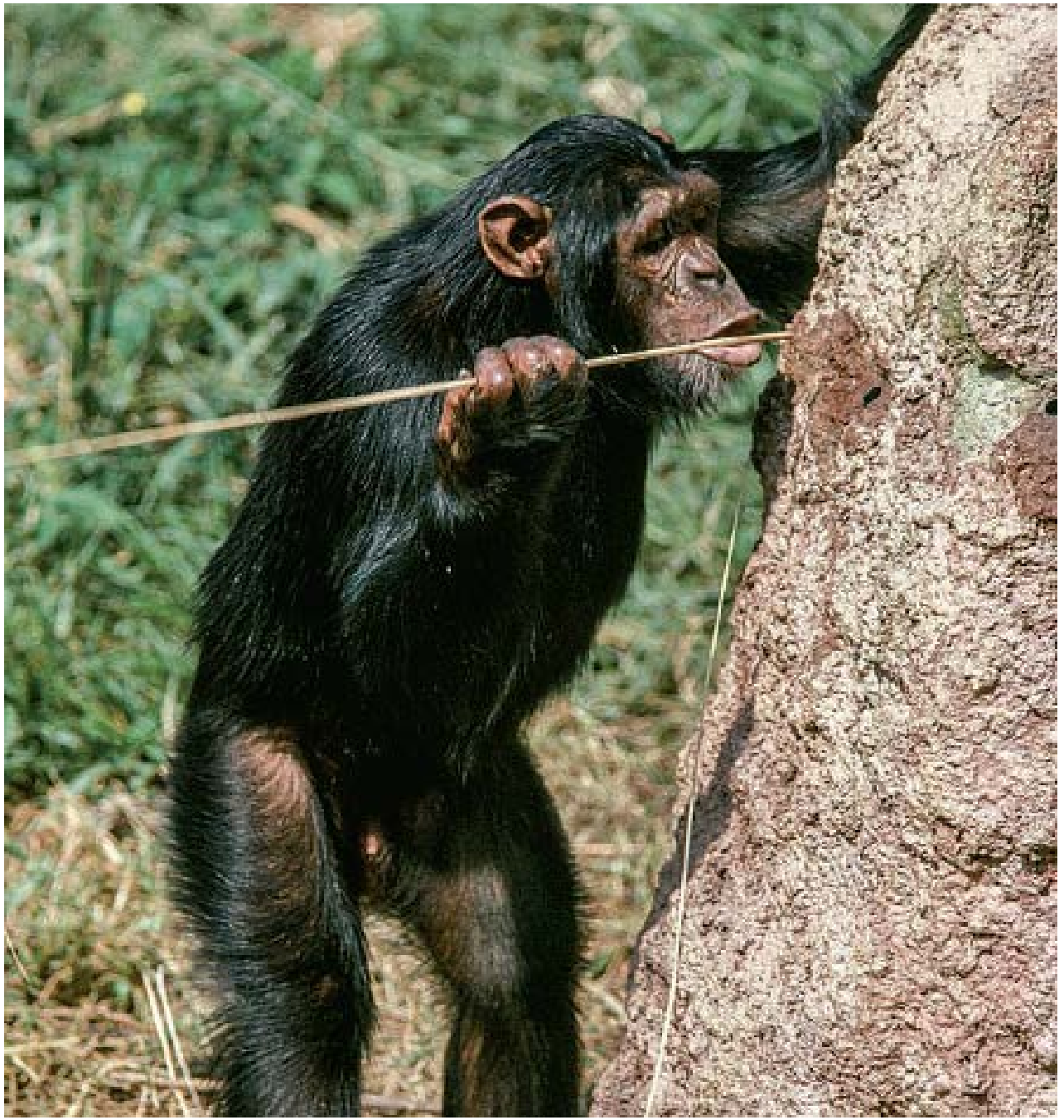
Experiments of Franz de Waal on Capuchin monkey & concept of fairness. https://www.youtube.com/watch?v=lKhAd0Tyny0, accessed 20180319.



Gorilla *Chimpanzee* *Homo*

Quiz: Which two primates are the closest relatives?

哪兩個靈長類關係最接近?



Gibbons, Ann. 2016.
Science 352:639.

黑猩猩有能力
制作并使用工具。

Povinelli, D.J. & J.Vonk. 2003. **Chimpanzee minds: suspiciously human?**
Trends in Cognitive Sciences 7.157-60..

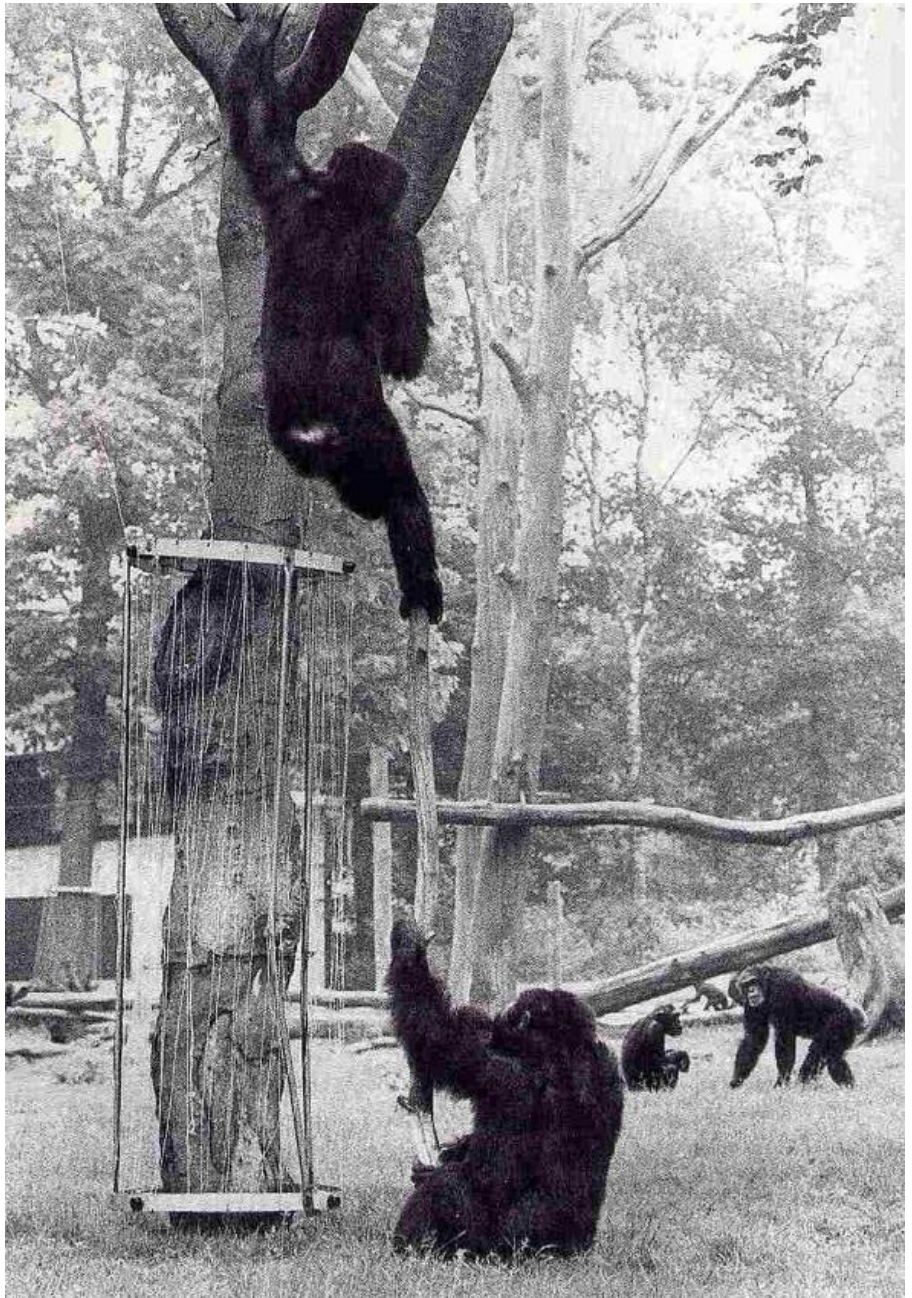
黑猩猩有自我意识。

黑猩猩的空间与数字记忆力。

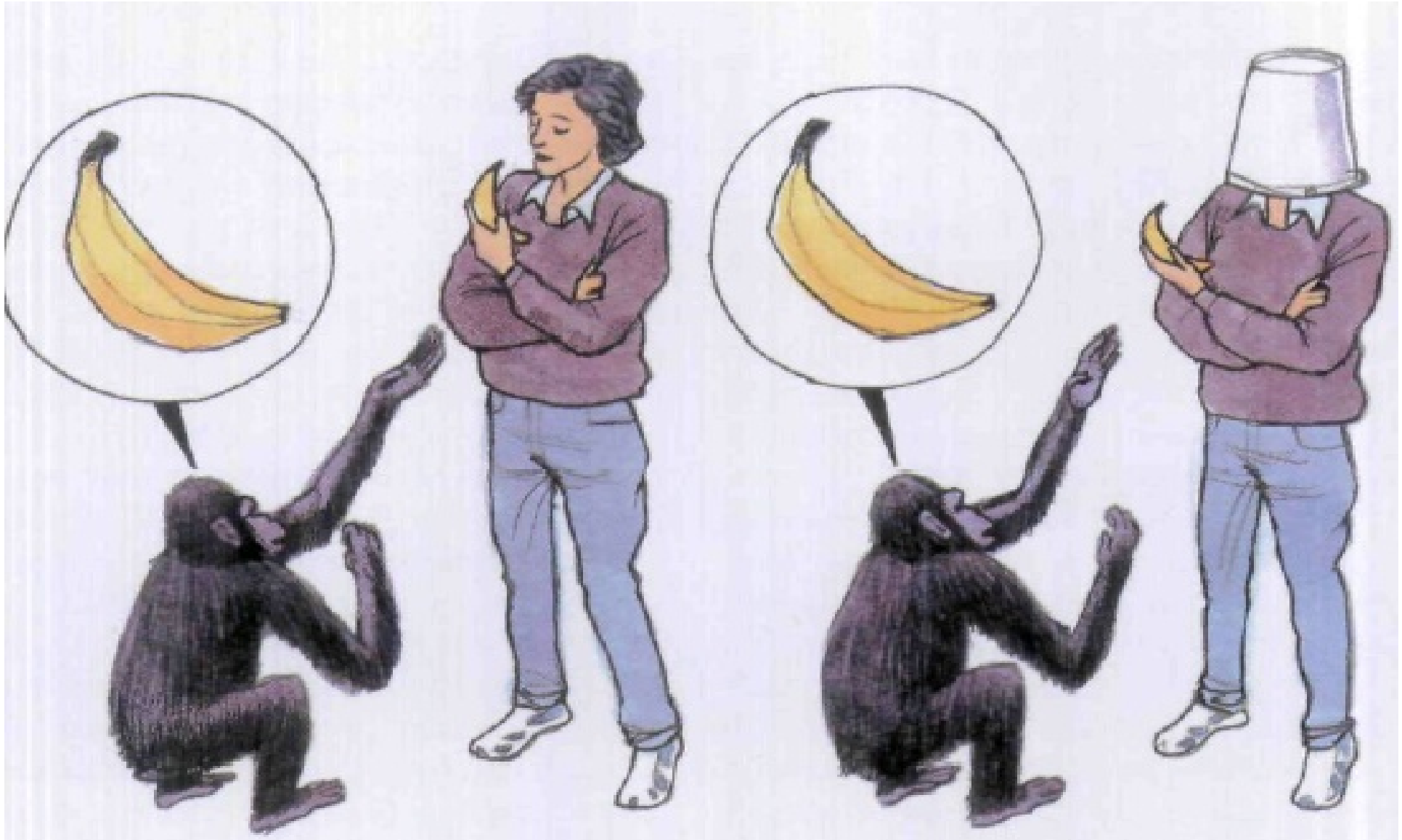
Kawai, N. & Matsuzawa, T. Numerical memory span in a chimpanzee. *Nature* 403:39–40, 2000.

Pictured are **bonobos** (*Pan paniscus*), a highly sociable ape species that is one of the closest extant relatives to humans. Kret et al. found that bonobos' attention is biased toward images of scenes with emotional behaviors relative to neutral images of their own species. **Among emotional images, bonobos were most drawn to images of prosocial behaviors such as grooming**, unlike species that are biased toward images of distress or aggression, such as humans and chimpanzees. …
PNAS April 5, 2016.

Tool Use and Cooperation by Chimpanzees. Frans de Waal *Chimpanzee Politics* 1998:194



Corballis, M.C. 2007. *American Scientist* 95.240-48.
The Uniqueness of Human Recursive Thinking.



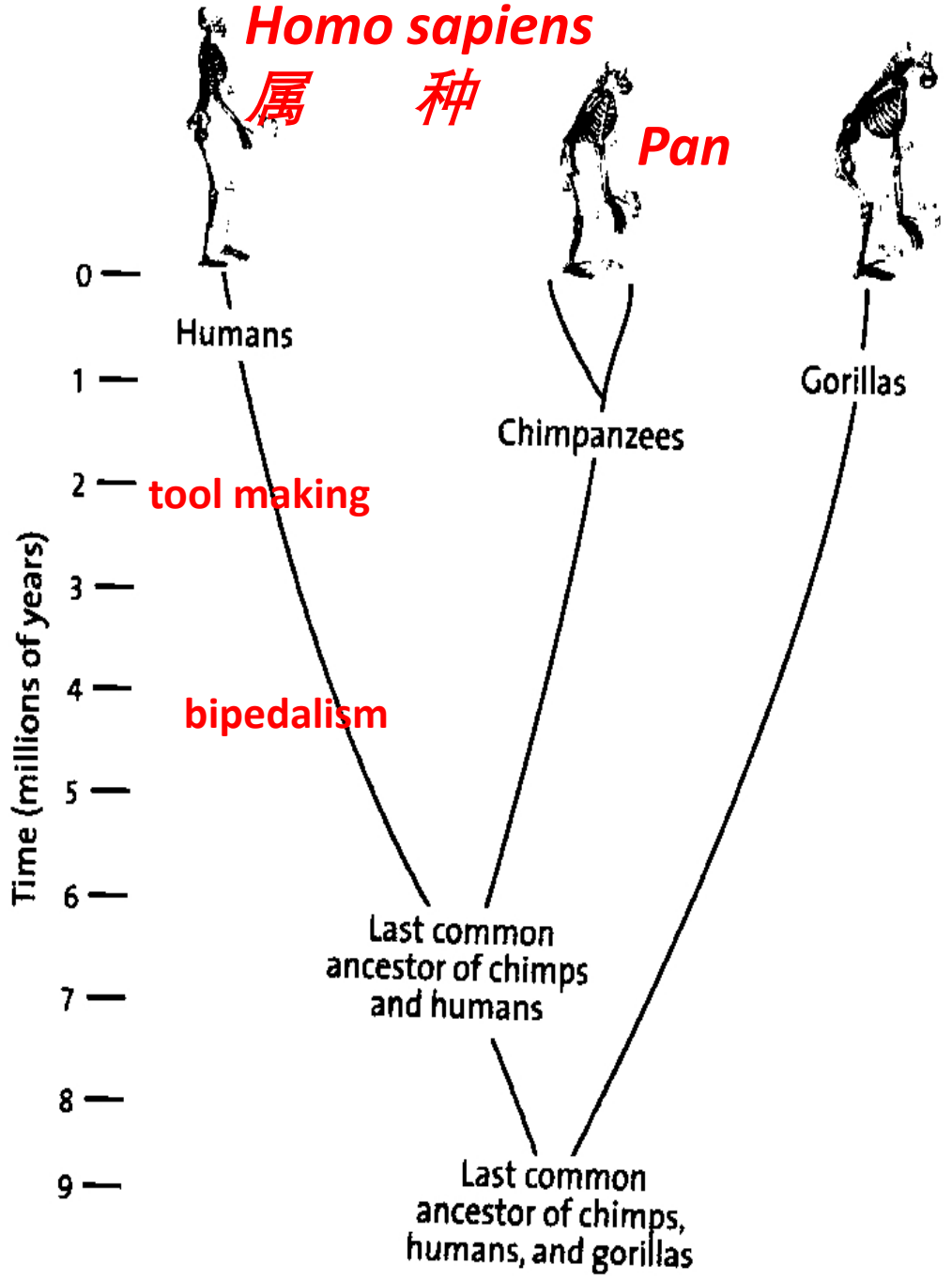
Lieberman, Daniel E. 2013:29.

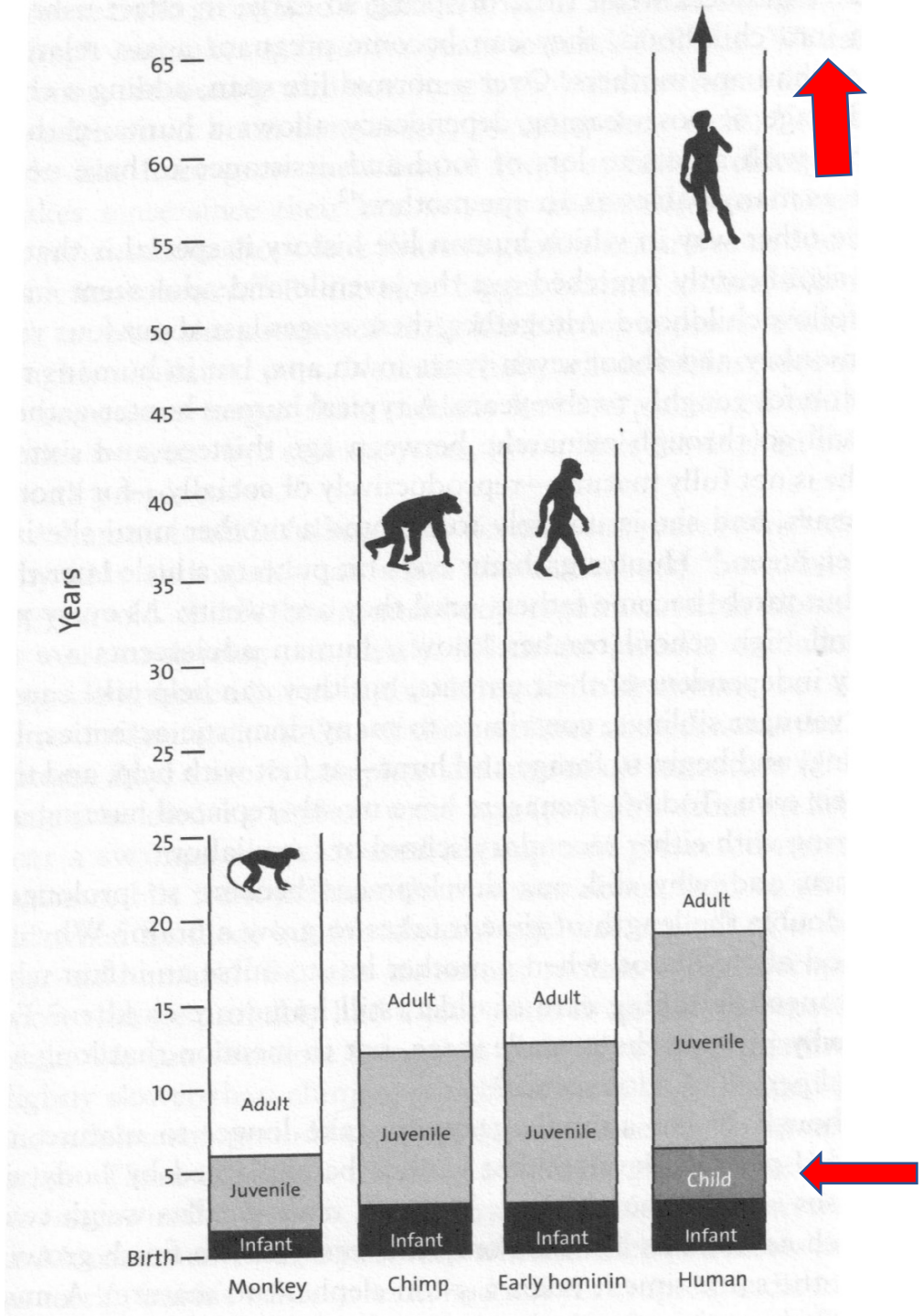
The Story of the Human Body: Evolution, health, & disease.

Pantheon.

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

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





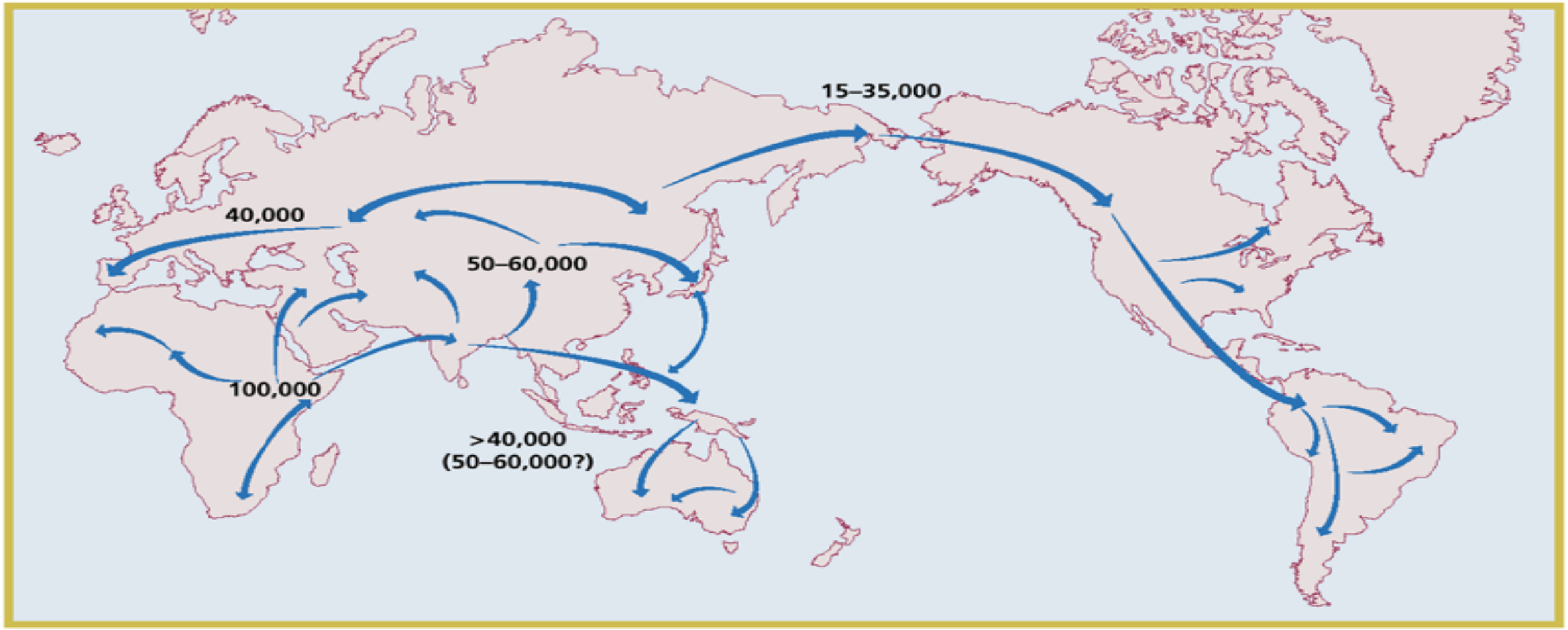
Lieberman, D.E. 2013.
Figure 13.

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

Humans have added a stage to their life-span, ‘childhood’, & prolonged the stage of ‘juvenile’.

,论语 ：
“吾十有五而志于學，
三十而立，
四十而不惑，
五十而知天命，
六十而耳順，
七十而從心所欲，不踰矩。”

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.

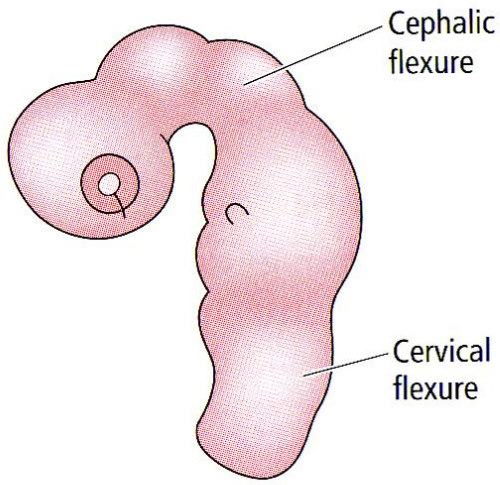


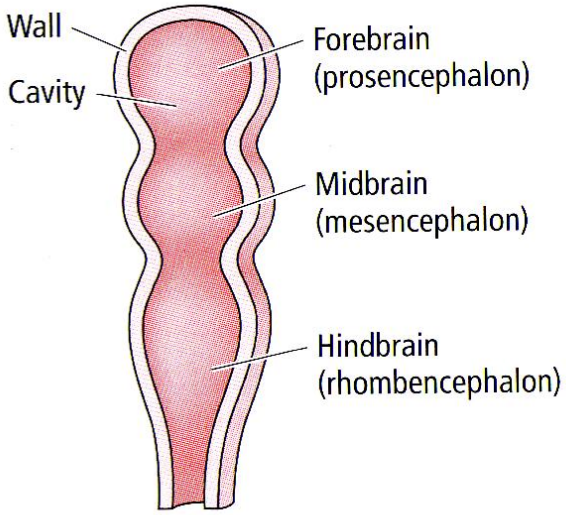
Spoken languages were invented well over 100,000 years ago, & played decisive roles in our social conquest of the earth.
Written languages were invented much later in independent parts of the world, the earliest some 6,000 years ago.
Many spoken languages have never been written. A language may change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

What are we?

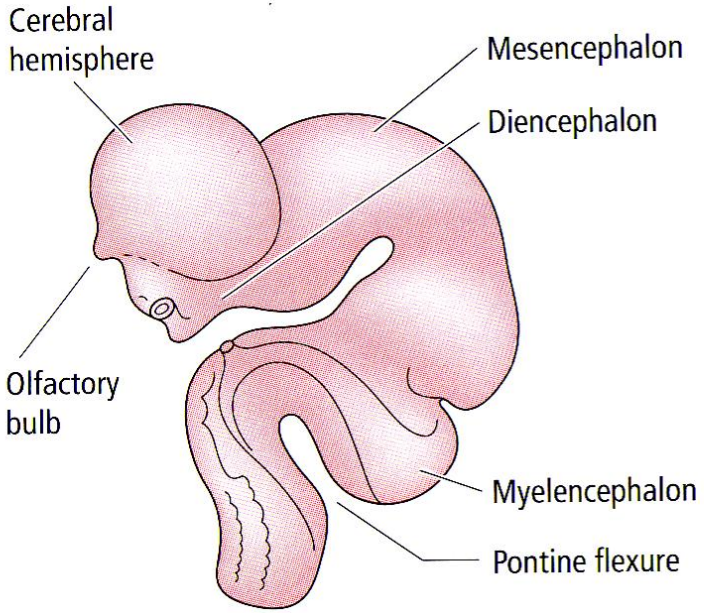
the first step toward making us unique was taken some 3 million years ago when our remote ancestors changed from walking on all fours to a bipedal posture. This allowed our hands to develop dexterity, to start inventing and making tools of ever increasing complexity, which in turn stimulated the remarkable growth of our powerful brain. A large and well connected brain enabled us to invent language, first spoken language some 200,000 years ago, then written language no later than 6,000 years ago.

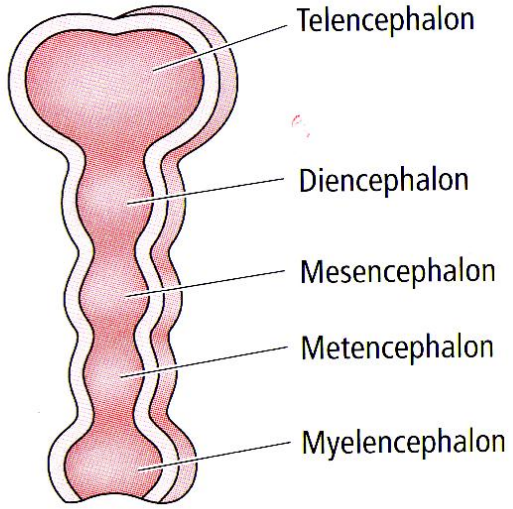
Language is by far the most important tool humans invented that made possible the cumulative sharing of information among numerous individuals across vast spans of space and time, giving rise to science and technology in the 16th century. Recently, an acronym has been invented, STEM, Science, Technology, Engineering, and Mathematics, in contrast with HASS, Humanities, Arts, and Social Sciences. In brief, we are the primate defined by our STEM and HASS, both parts absolutely essential.



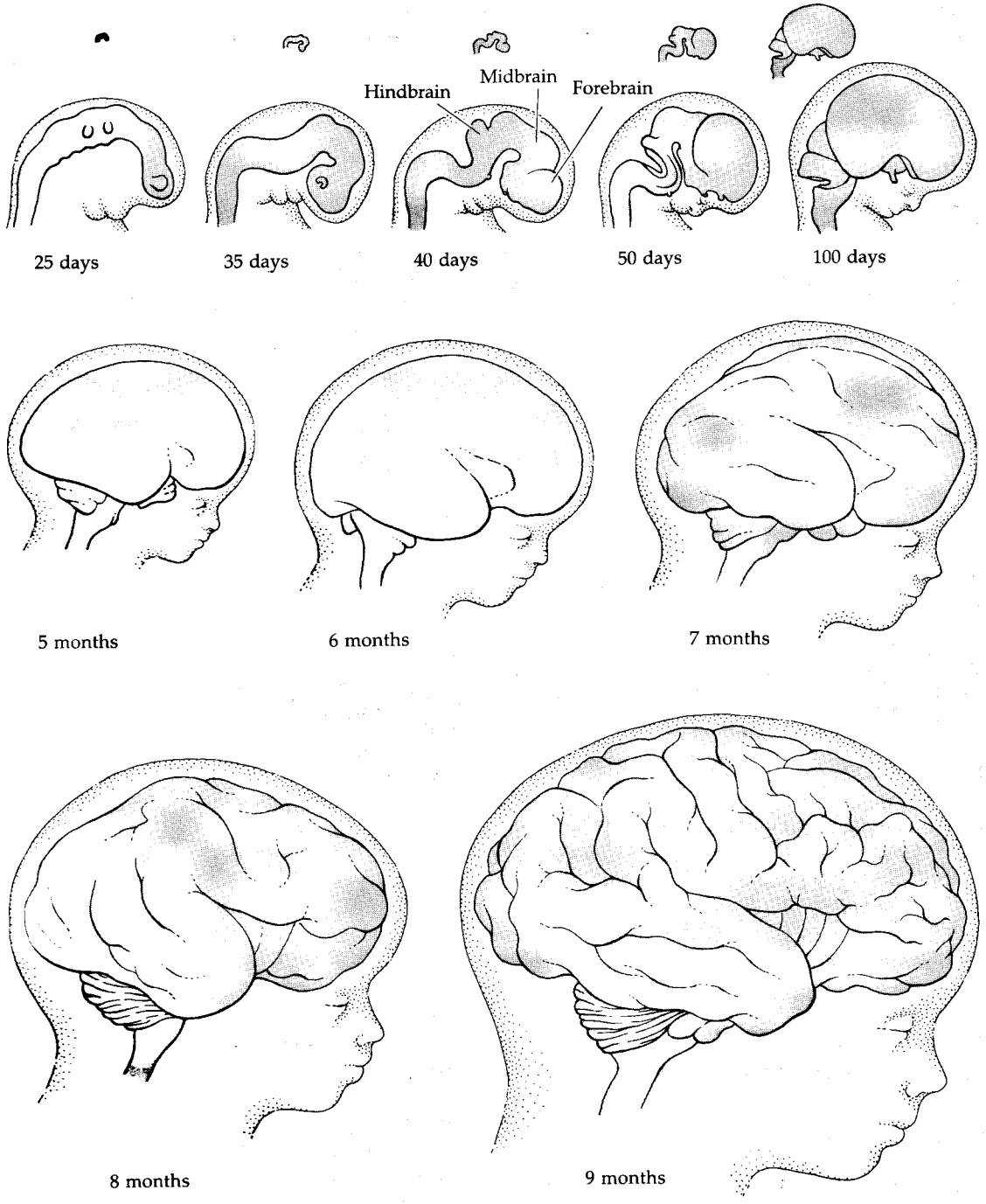


Human brain at 6 mm





Human brain at 27 mm



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

Principles of Cognitive Neuroscience.

Sinauer Associates.

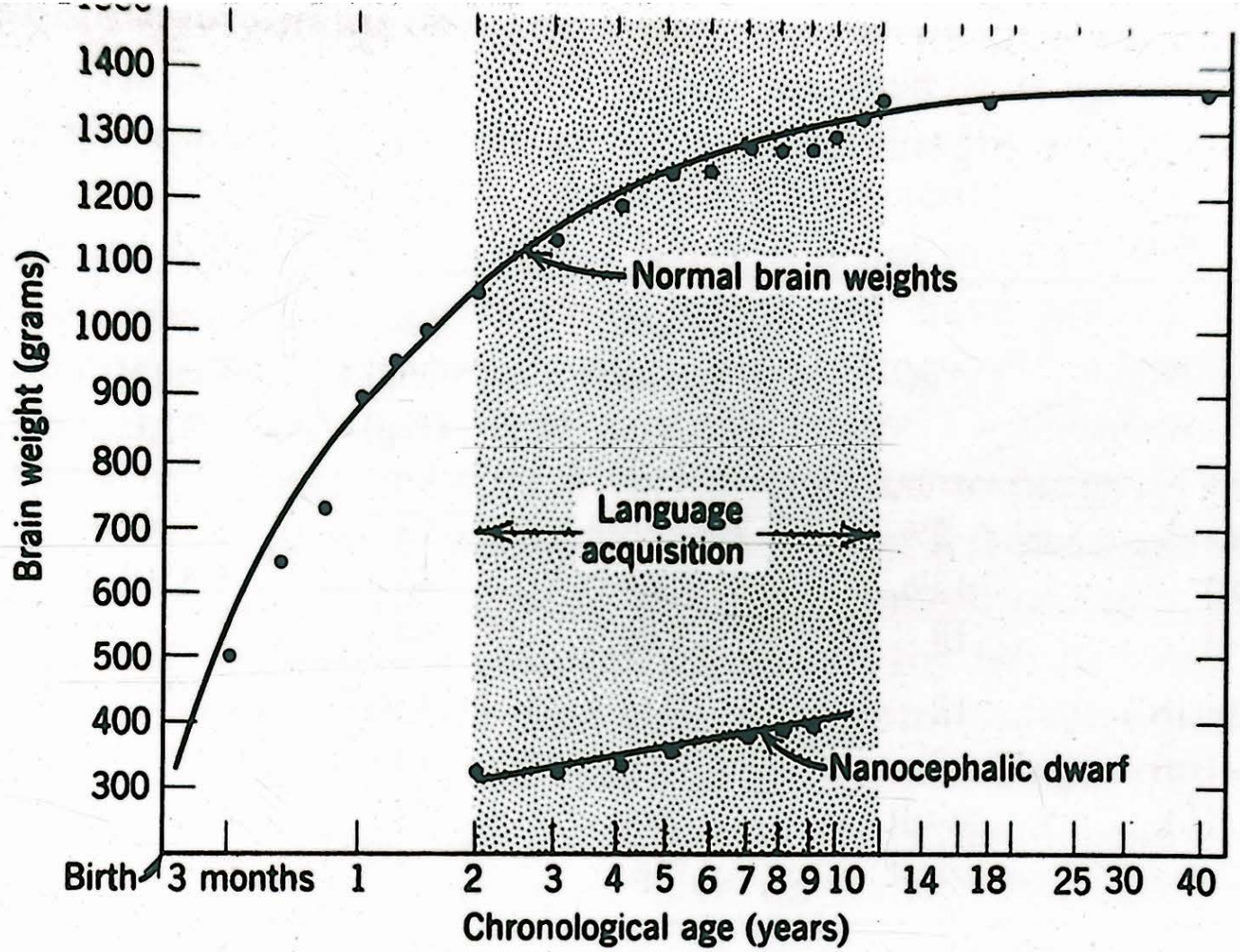


FIG. 2.25. Brain weights determined at autopsy plotted as function of patients' chronological age; data from Coppoletta and Wolbach (1933). *Bottom plot:* various measurements of head-circumference of patient described by Secker (1960), converted to estimates of brain weight.

Lenneberg, E. (1967).

Biological Foundations of Language.

Wiley.

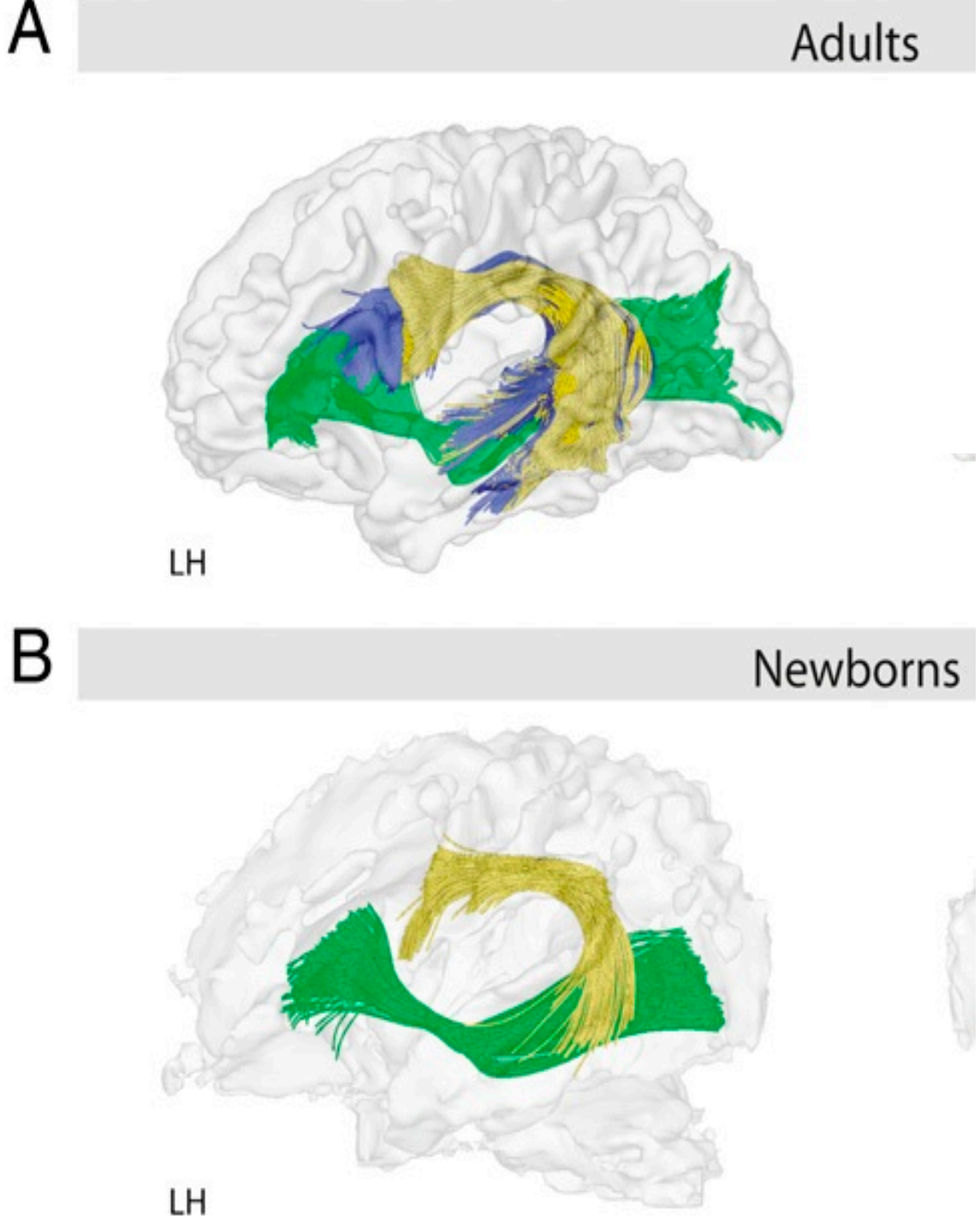
"Four orofacial gestures of a fetus at approximately 28 weeks GA.

(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.

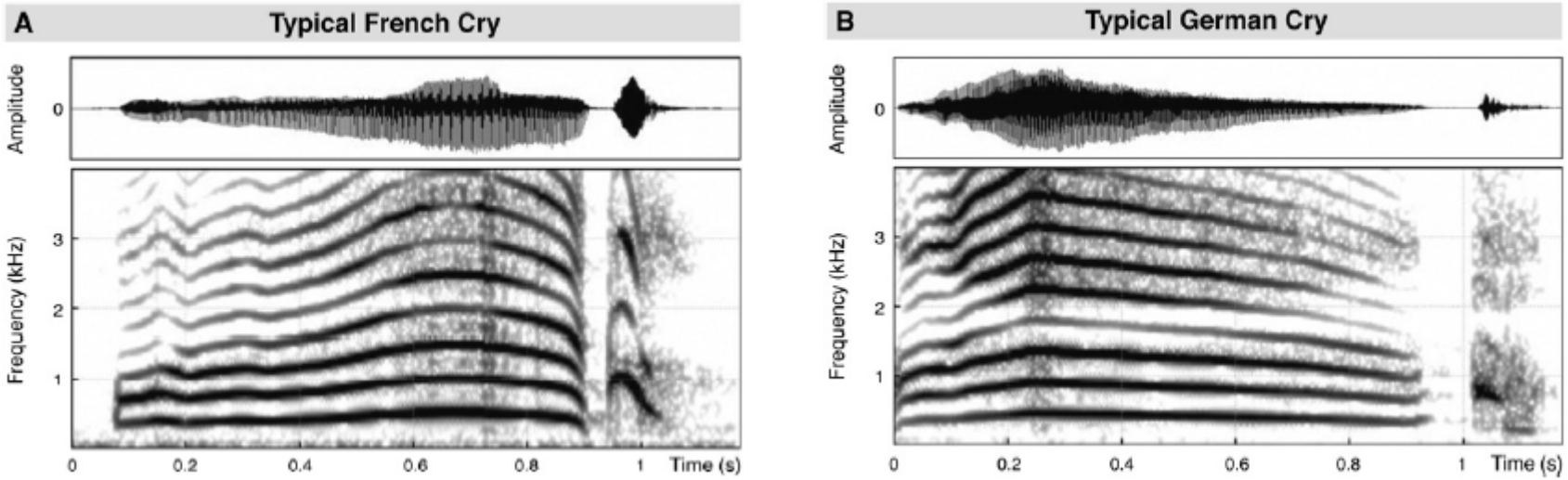
Behavioral and Brain Sciences Fig.2.



Perani, Daniela, et al. 2011.

Neural language networks at birth.

PNAS 108.16056–61.

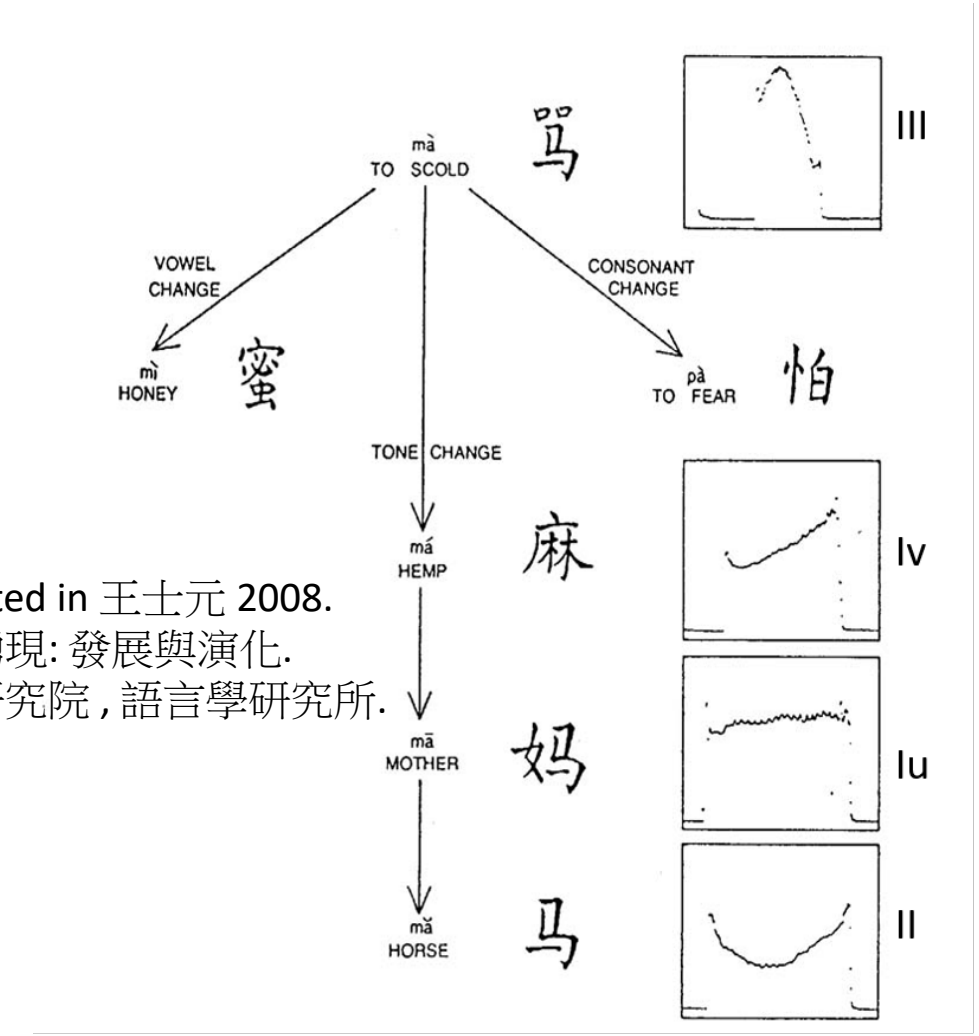


Time Waveform and Narrow-Band Spectrograms of a Typical French Cry and a Typical German Cry. Mampe et al., 2009. *Current Biology* 19: 2.

The data show an influence of the surrounding speech prosody on newborns' cry melody.

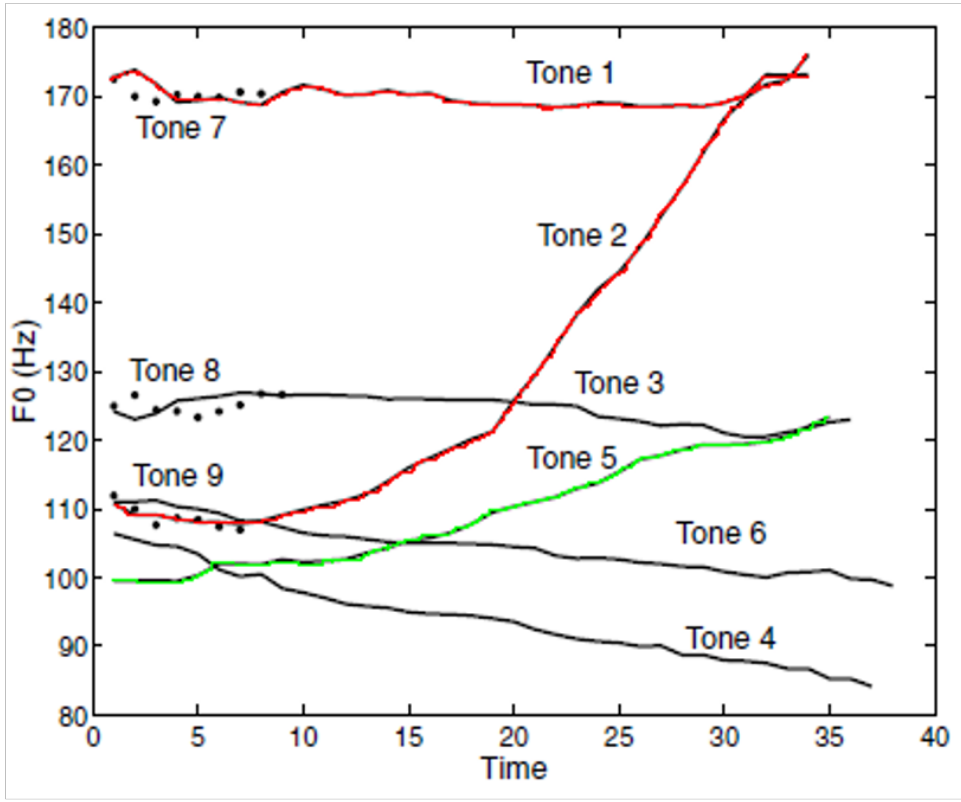
《梁書•**沈約傳**》

又撰《四聲譜》，以爲在昔詞人累千載而不悟，而獨得胸衿，窮其妙旨。自謂入神之作。高祖雅不好焉。帝嘗向周捨曰：“**何謂四聲？**”捨曰：“‘**天子聖哲**’是也。”然帝意不遵用。



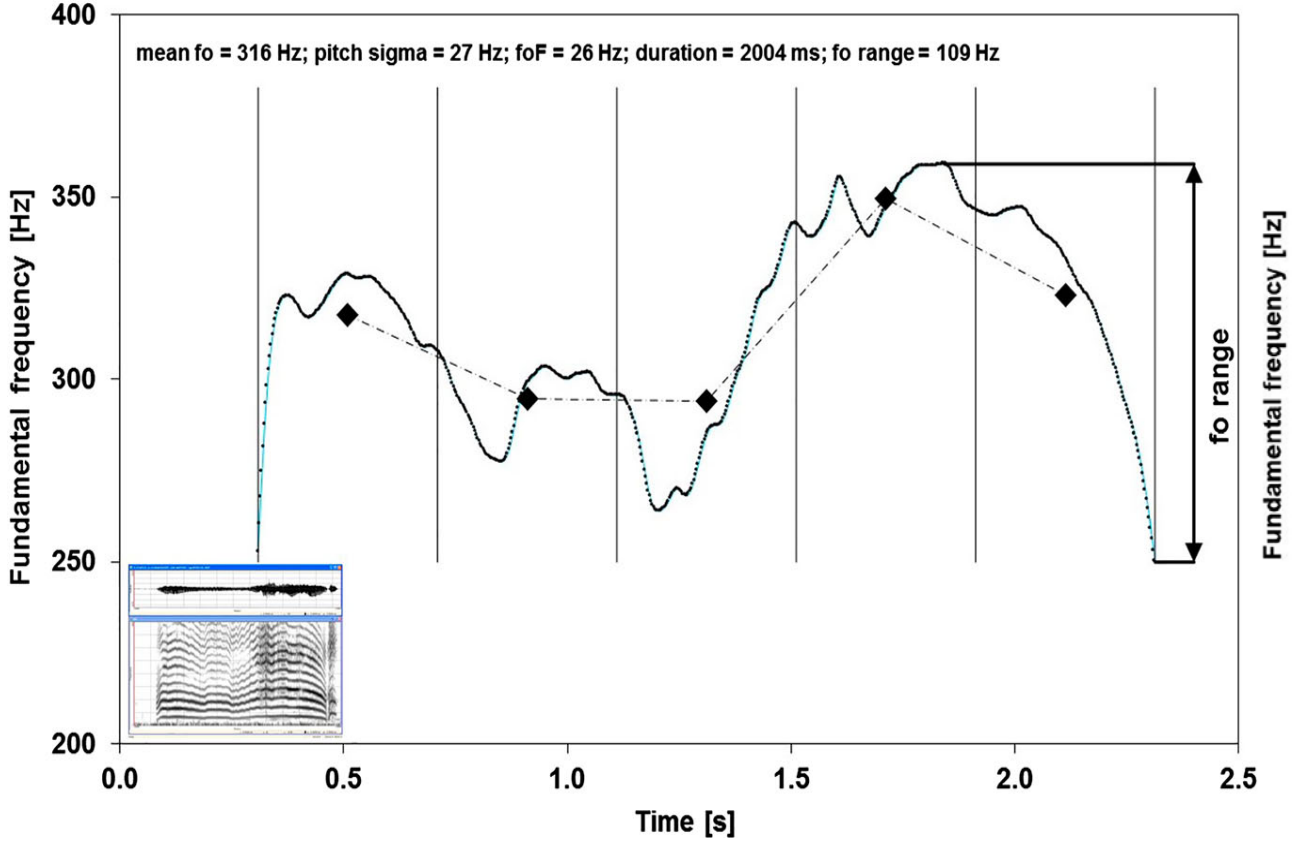
Reprinted in 王士元 2008.
語言湧現: 發展與演化.
中央研究院 , 語言學研究所.

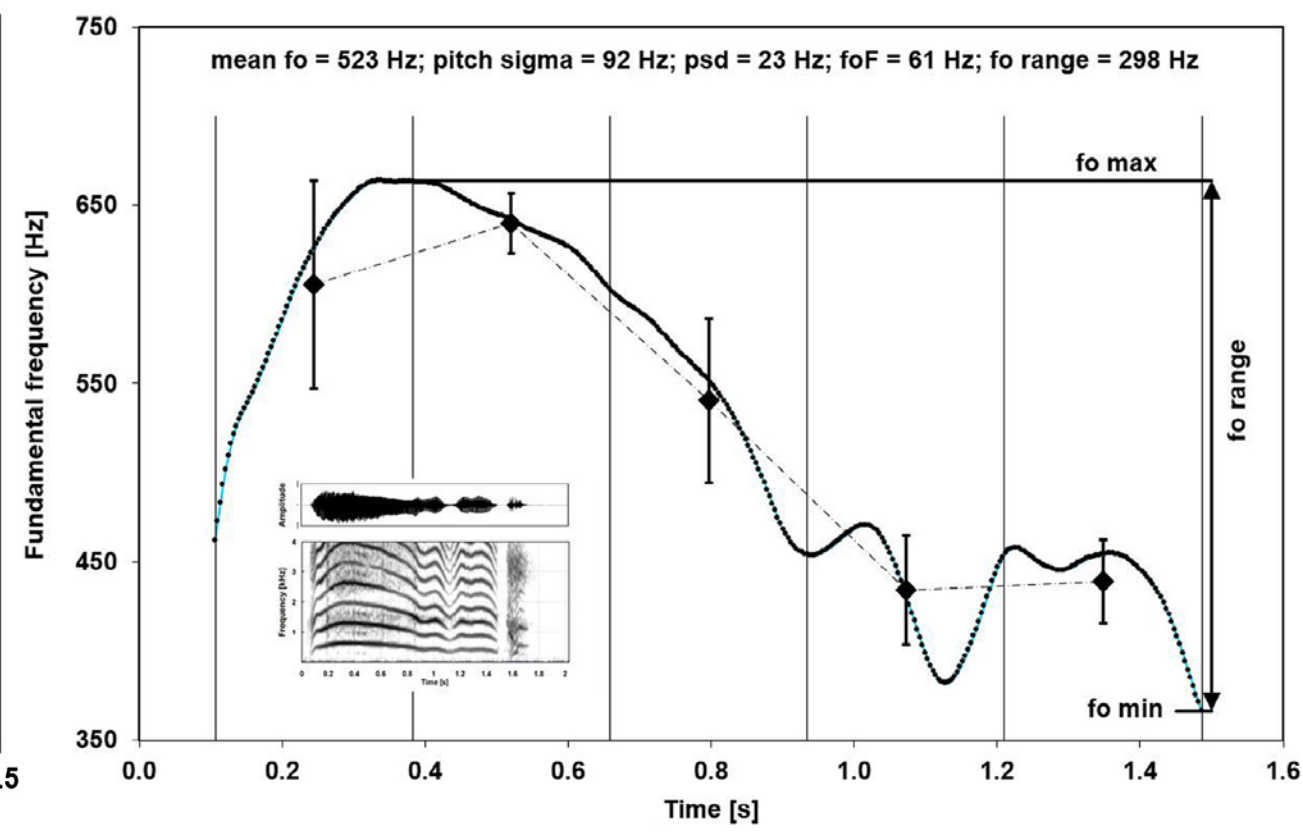
W.S-Y. Wang. Feb.1973.
***Scientific American*.**



Cantonese tones in the monosyllable /i/ uttered in isolation. The solid lines are for long tones on unchecked syllables, while the dotted lines are for short tones on checked syllables. (Adapted from Peng & Wang, 2005)

1 衣 Iu
2 椅 IIu
3 意 IIIu
4 兒 Iv
5 以 IIv
6 二 IIIv
7 忆 yik IVua
8 约 yuek IVub
9 亦 yik IVu





Wermke K, et al. 2016. Fundamental frequency variation within neonatal crying: does ambient language matter? *Speech, Language & Hearing* 19.211-7. Wermke, K., et al. 2016. Fundamental Frequency Variation in Crying of Mandarin and German Neonates. *Journal of Voice*.

"Indeed, both the Chinese & the Nso neonates had experienced the typical acoustic cues of a tone language in utero, & both groups exhibited significantly more fo variation in their crying than the respective German control groups. However, the F0 variation was slightly lower in the Chinese than in the Nso neonates, respectively: fo range: 171 versus 204 Hz; pitch sigma: 39 versus 46 Hz; and foF: 33 versus 39 Hz." *from Wermke K. et al. 2016.*

Meltzoff, A.N., & Moore, M.K. 1977.

Imitation of facial and manual gestures by human neonates.

Science *198*, 75-78.

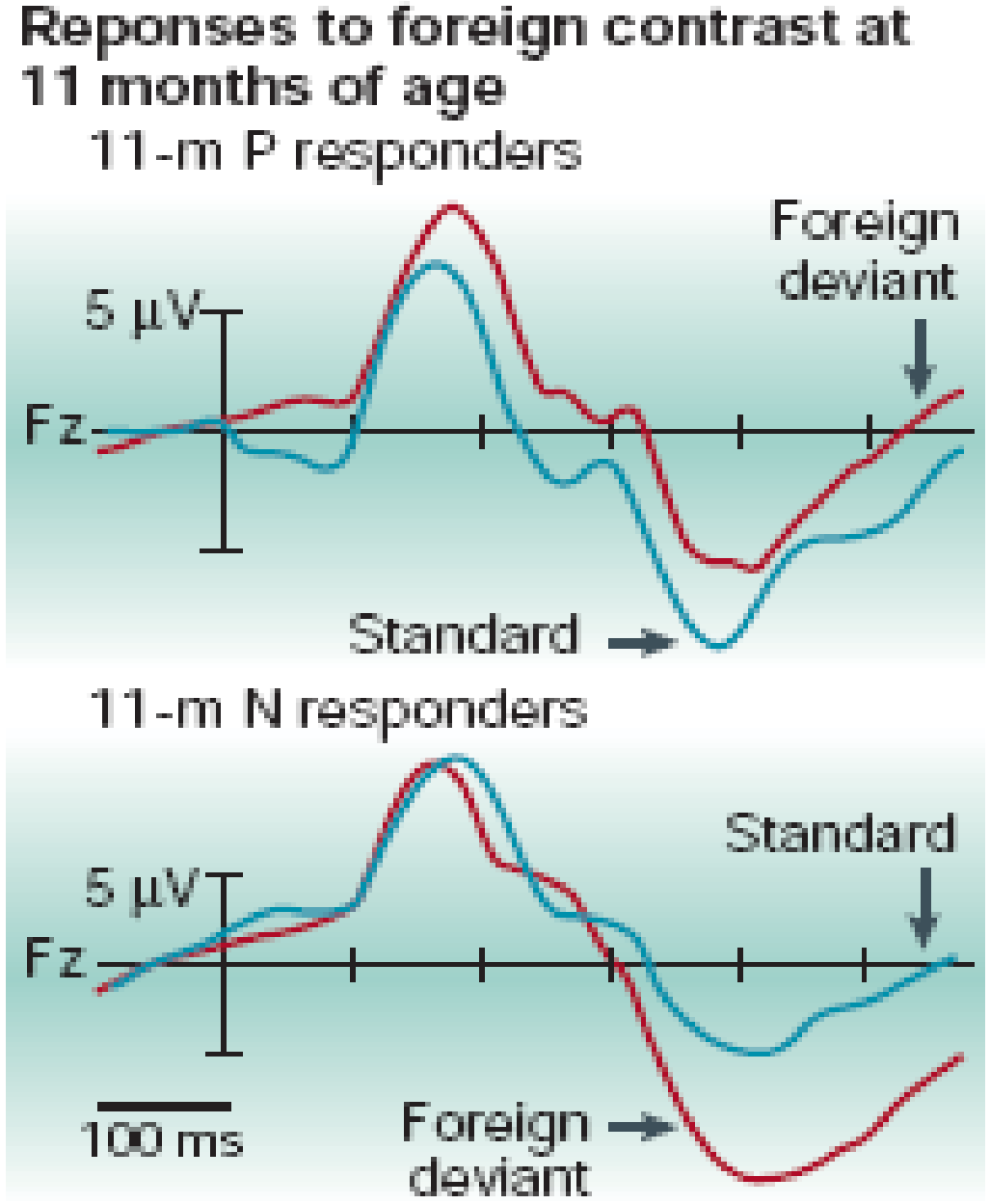
Foreign phonetic test:

'ta-ta-ta-DA' (Spanish)

English listeners hear the Spanish syllable 'ta' as 'da'

Native contrast:

'da-da-da-T^{H}A' (English)



Patricia K. Kuhl. 2004. EARLY LANGUAGE ACQUISITION: CRACKING THE SPEECH CODE. *NATURE REVIEWS NEUROSCIENCE* 5.**831- 843.**

Kuhl, P. K., et al. 2008. Phonetic learning as a pathway to language. *Phil. Trans. R. Soc. B* 363.979–1000.

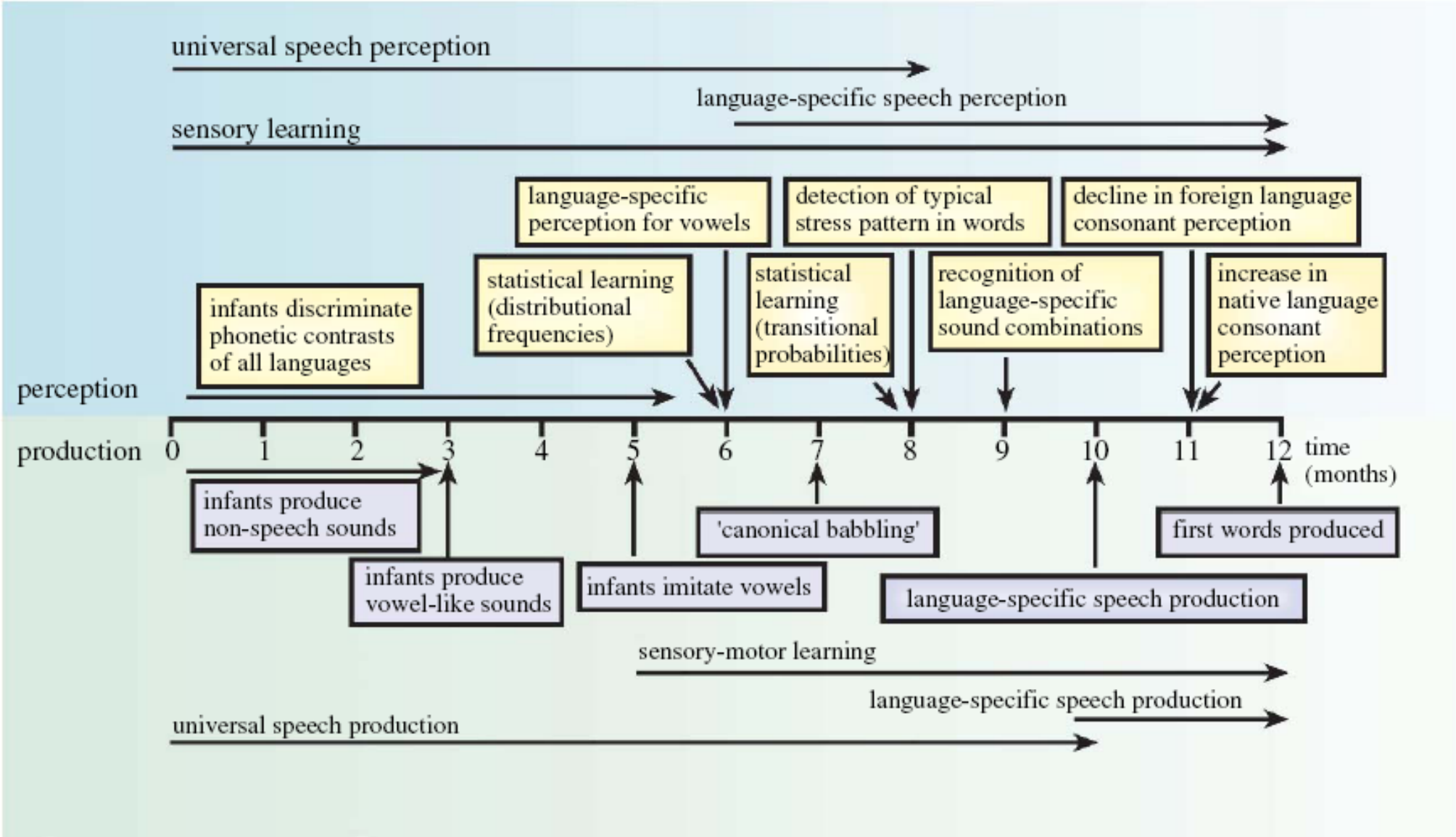


Figure 1. Universal timeline of infants' perception and production of speech in the first year of life. Modified from Kuhl (2004).

Saffran, J.R., et al. 1996. Statistical Learning by 8-Month-Old Infants. *Science* 274.1926-28.

tupirogolabubidakupadoti

padotibidakutupirotupiro

golabubidakupadotigolabu

bidakutupirogolabupadoti

Saffran, J.R., et al. 1996. Statistical Learning by 8-Month-Old Infants. *Science* 274.1926-28.

tupirogolabubidakupadoti

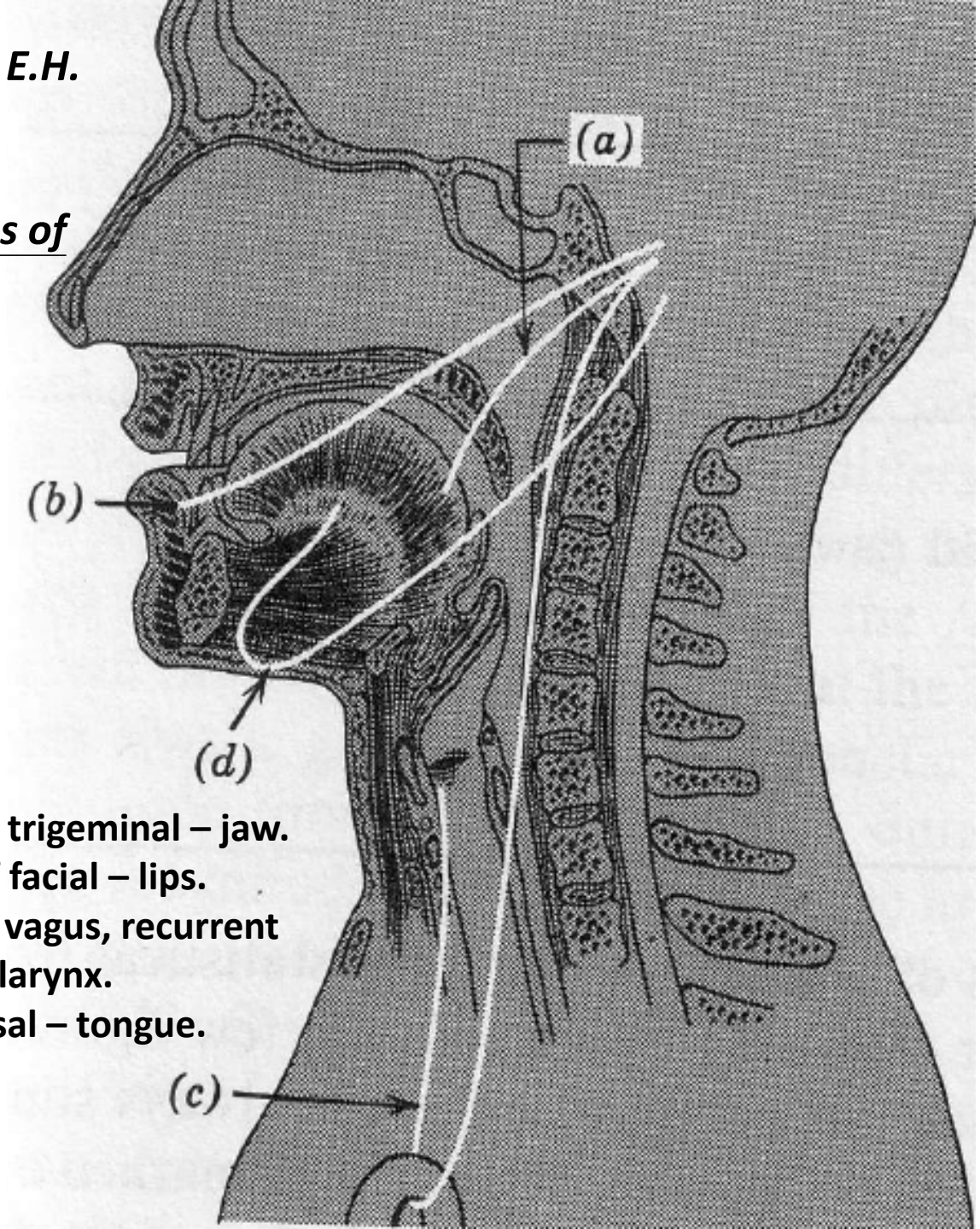
padotibidakutupirotupiro

golabubidakupadotigolabu

bidakutupirogolabupadoti

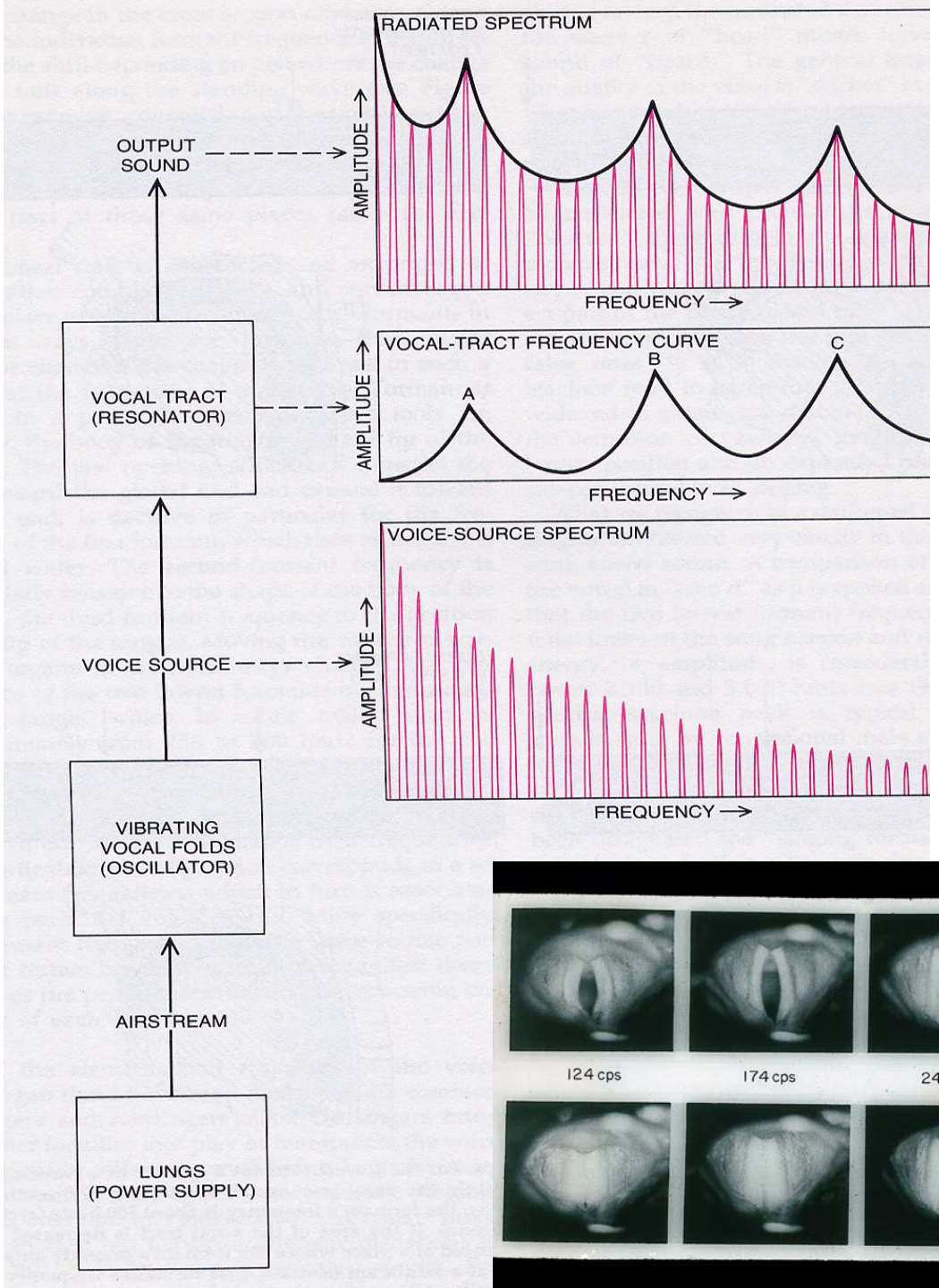
Lenneberg, E.H. 1967:95. Biological Foundations of Language.

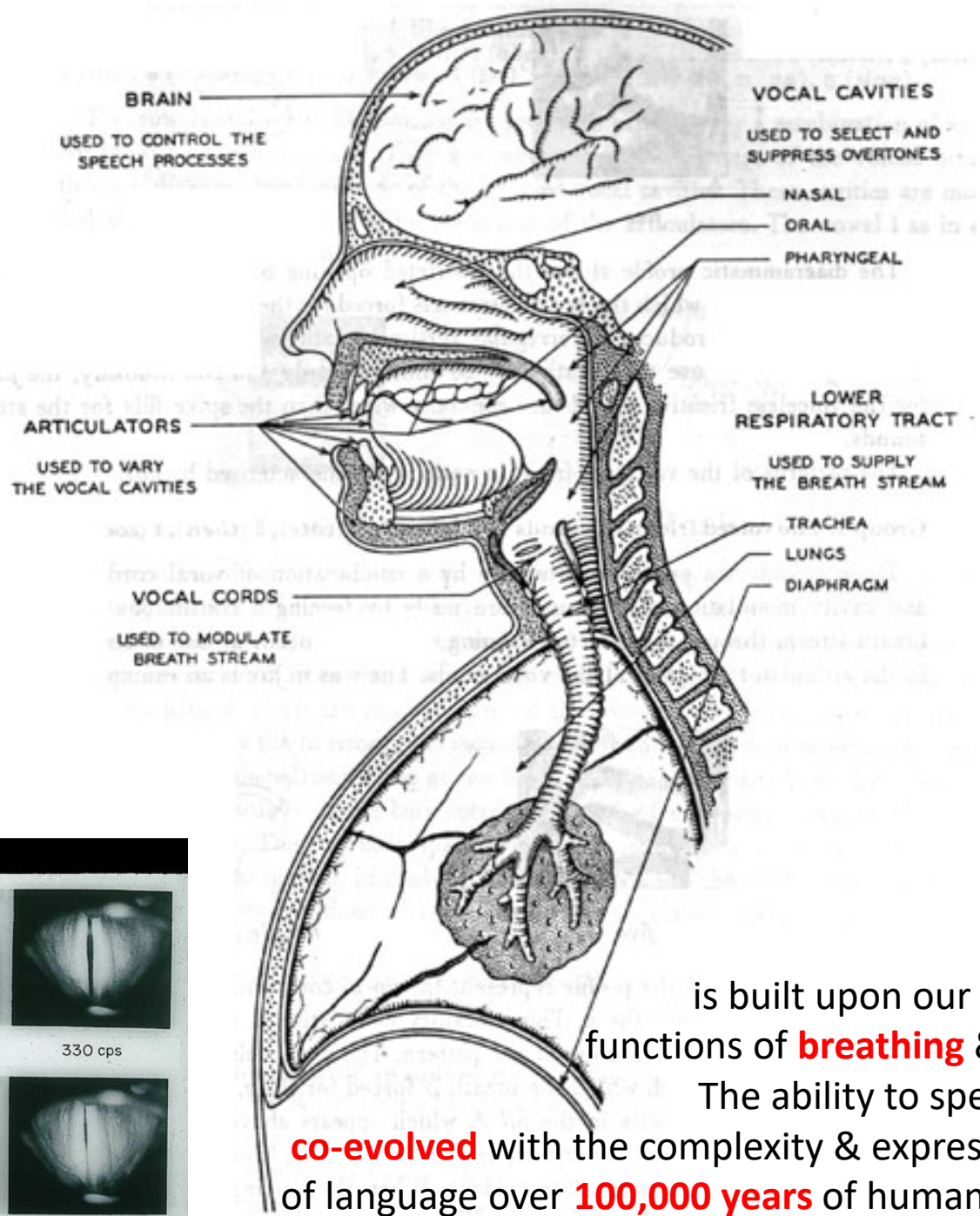
说话需要很多不同的神经系统准确的配合。由于身体在演化过程的改造，有的神经通路从大脑下部下降绕过心脏的大动脉，再上升到喉咙去控制声带的抖动。



a: branch of trigeminal – jaw.
b: branch of facial – lips.
c: branch of vagus, recurrent nerve – larynx.
d: hypoglossal – tongue.

Open & closed formation of vocal folds. 聲帶開和閉.





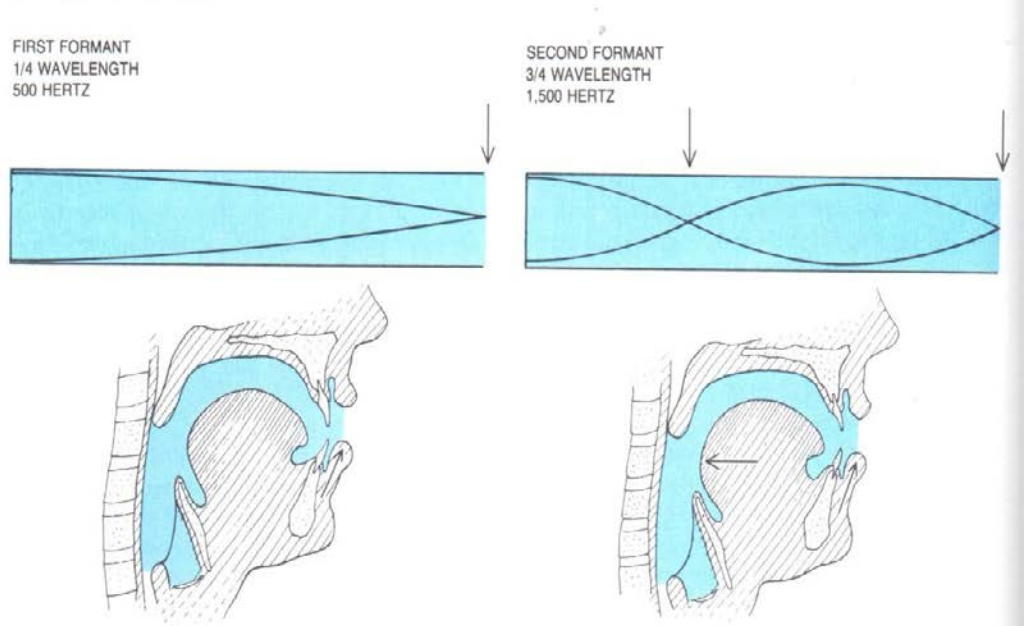
Speech
is built upon our more basic functions of **breathing** & **chewing**.
The ability to speak fluently **co-evolved** with the complexity & expressive power of language over **100,000 years** of human evolution.

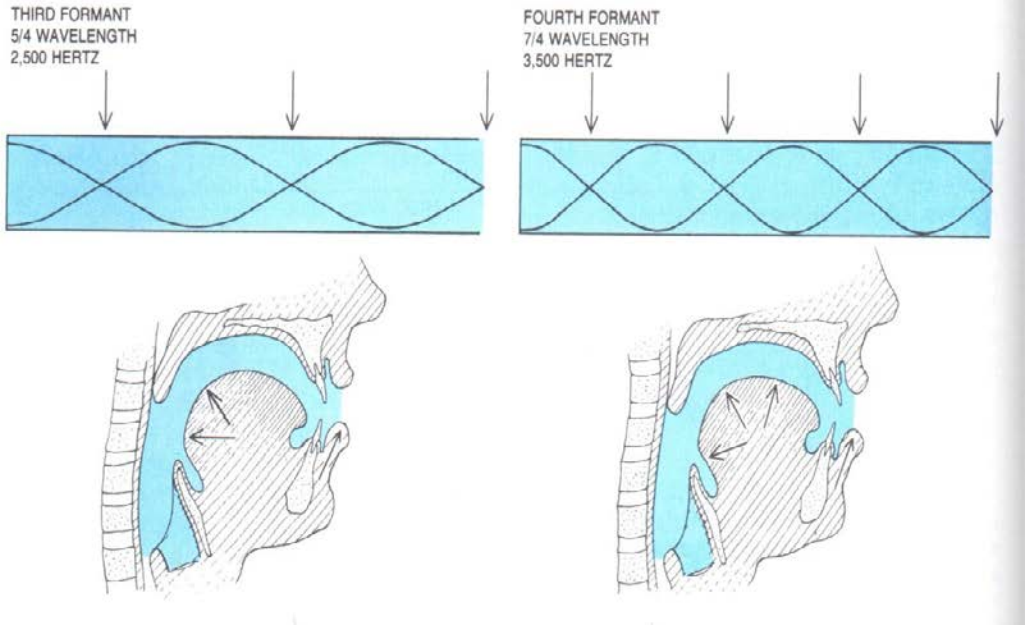
Sundberg, Johan. 1977.

The acoustics of the singing voice. *Scientific American*, March issue.

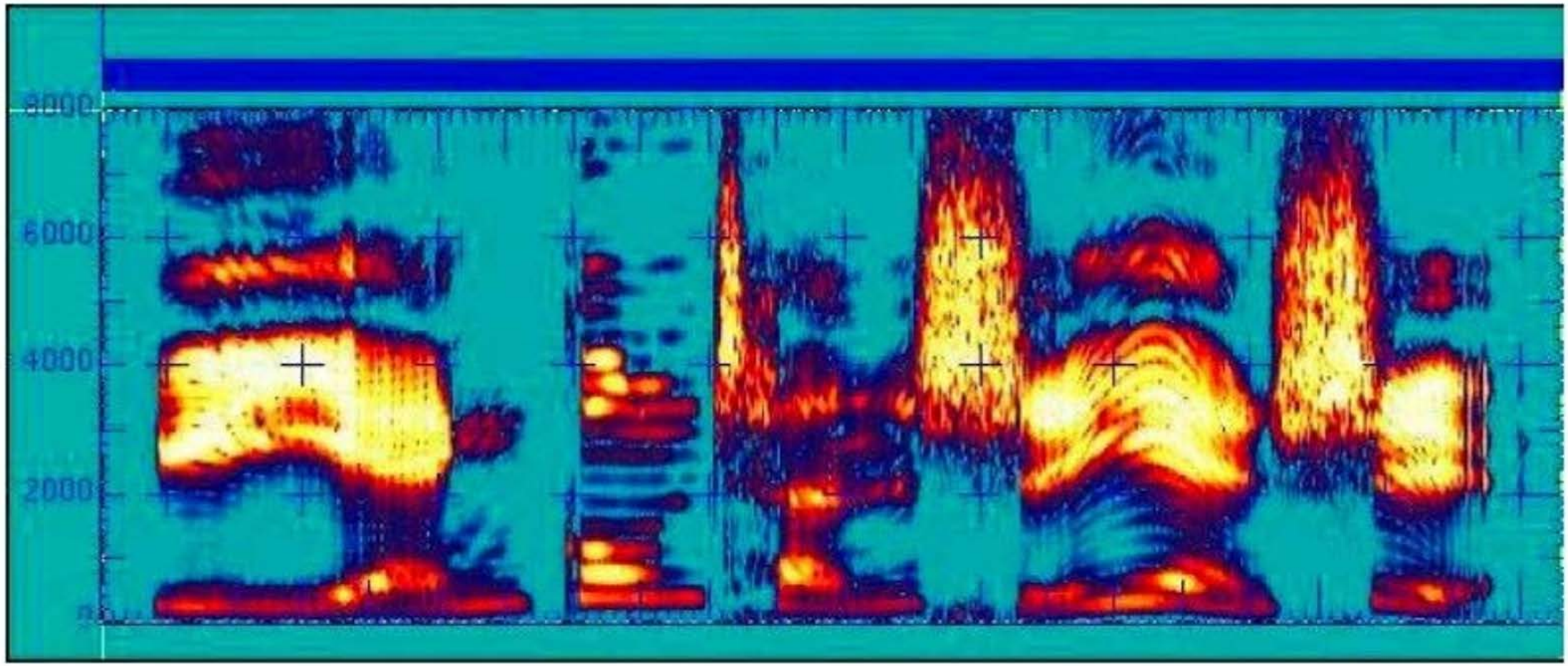
reprinted in:

W.S-Y.Wang, ed.
The Emergence of Language: Development and Evolution.
1991:107.
王士元編，林幼菁譯。
語言湧現：發展與演化。
2008：164。





http://www.fon.hum.uva.nl/praat/ developed @ University of Amsterdam.



“语 言 工 程 实 验 室”的频谱图

IPA: [y j ɛ n k u ŋ tʂ’ə ŋ ʂ ɪ j ɛ n ʂ ɪ]

Fundamental Neuroscience, 2 ed. 2003:40

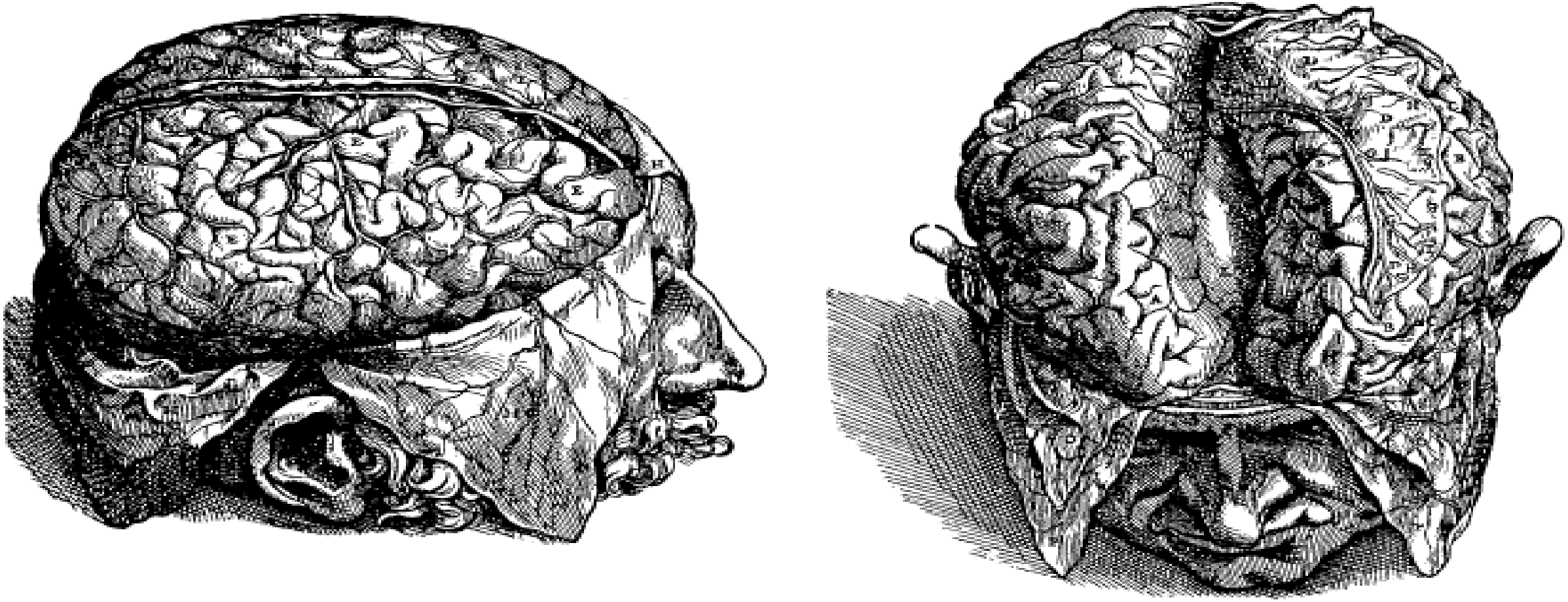
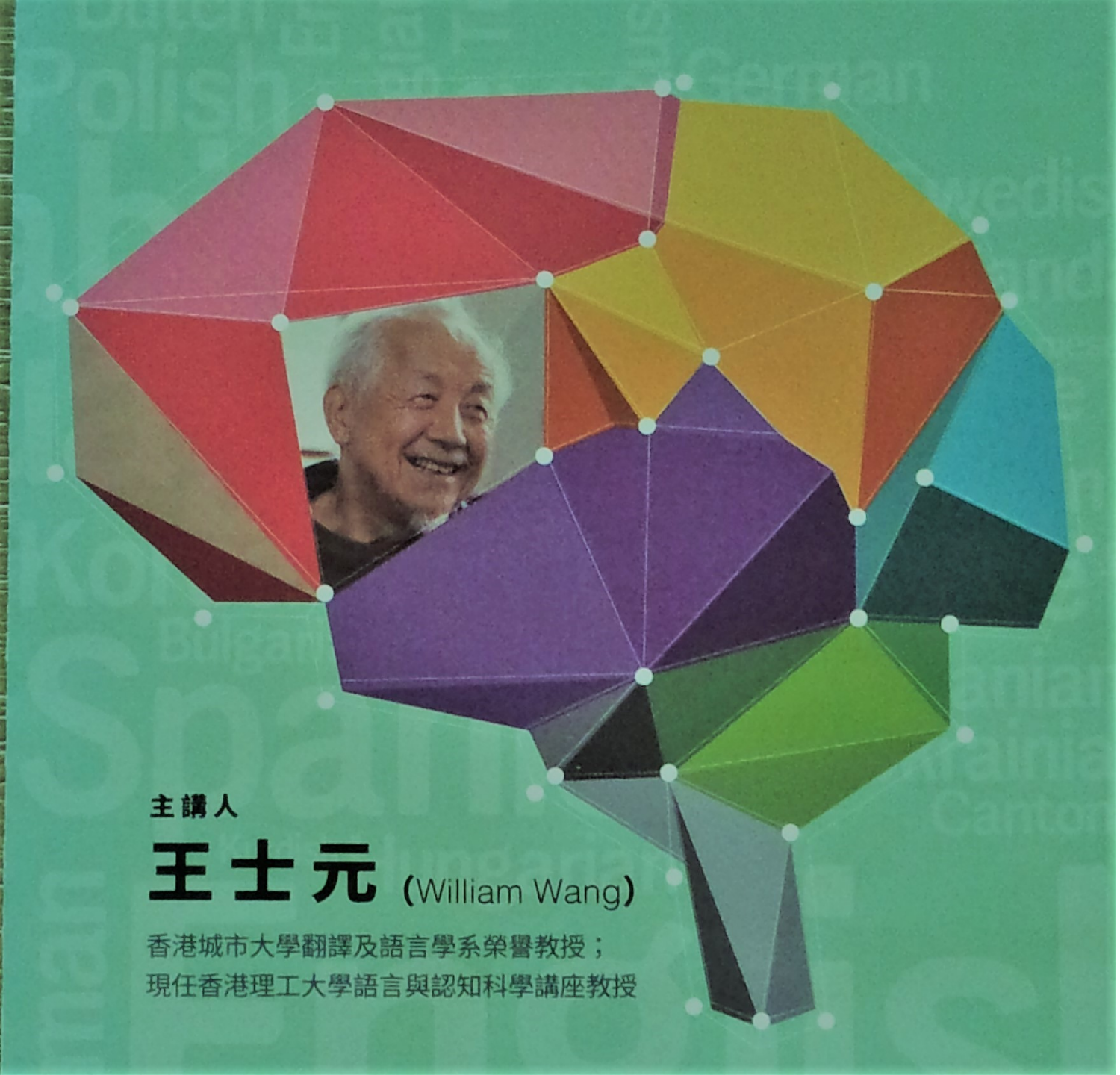


FIGURE 22 The surface structure of the human cerebral cortex, which is thrown into folds (gyri) separated by depressions (sulci). In the figure on the right, the two hemispheres have been pulled apart at the interhemispheric or longitudinal fissure to reveal the corpus callosum that interconnects the two cerebral hemispheres. 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.

See also: Pevsner, Jonathan. (2002). Leonardo da Vinci's contributions to neuroscience. *TRENDS in Neurosciences, 25* (4), 217-220, for discussion of another explorer of the brain.



1. Frontal Lobe

Prefrontal Cortex
Motor Gyrus
Broca's Area

Central Sulcus

2. Parietal Lobe

Sensory Gyrus

Lateral Sulcus

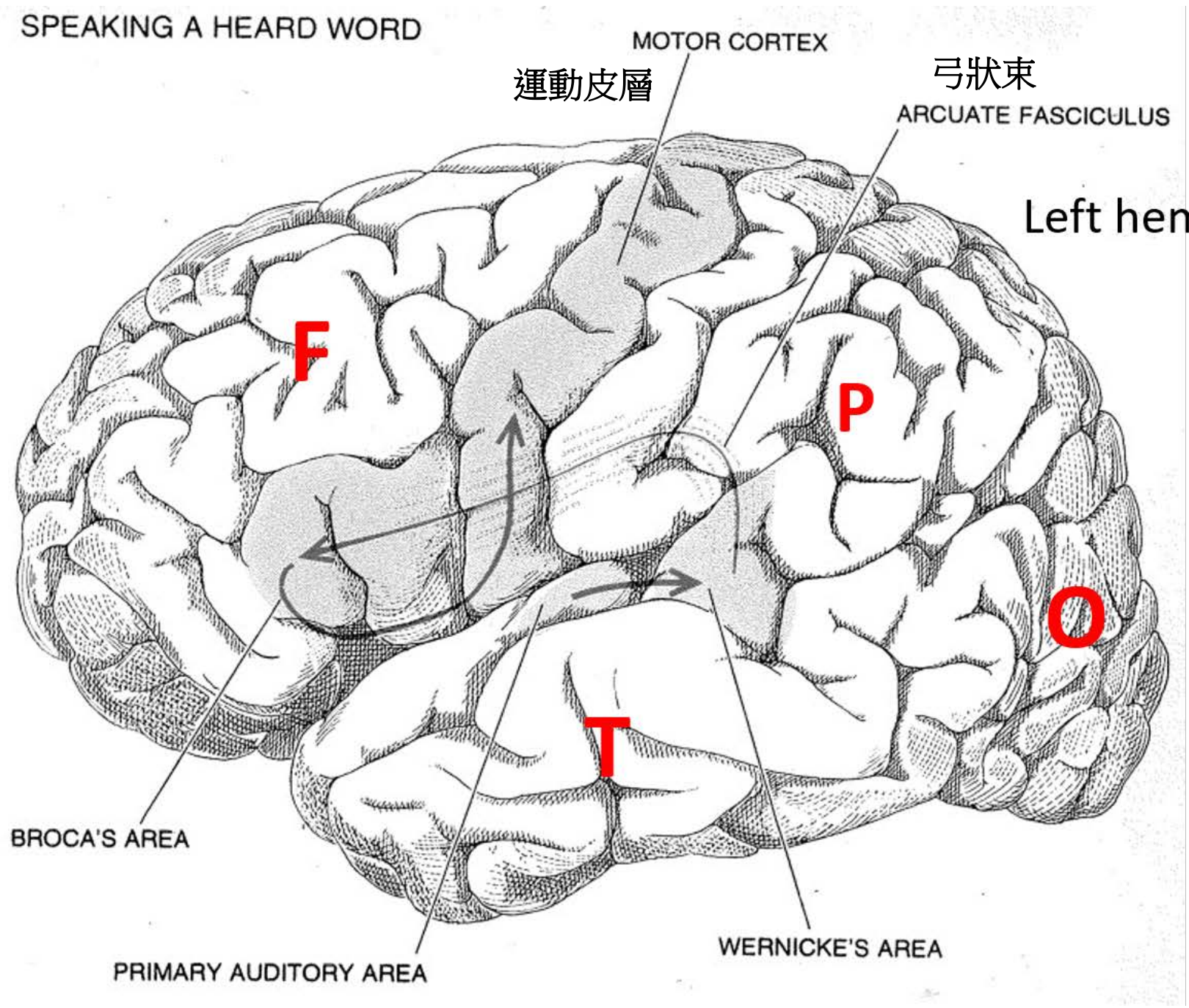
3. Temporal Lobe

Auditory Area
Wernicke's Area

4. Occipital Lobe

Visual Area

Cerebellum



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:

Frontal, 額葉
Parietal, 頂葉
Temporal, 顳葉
Occipital. 枕葉

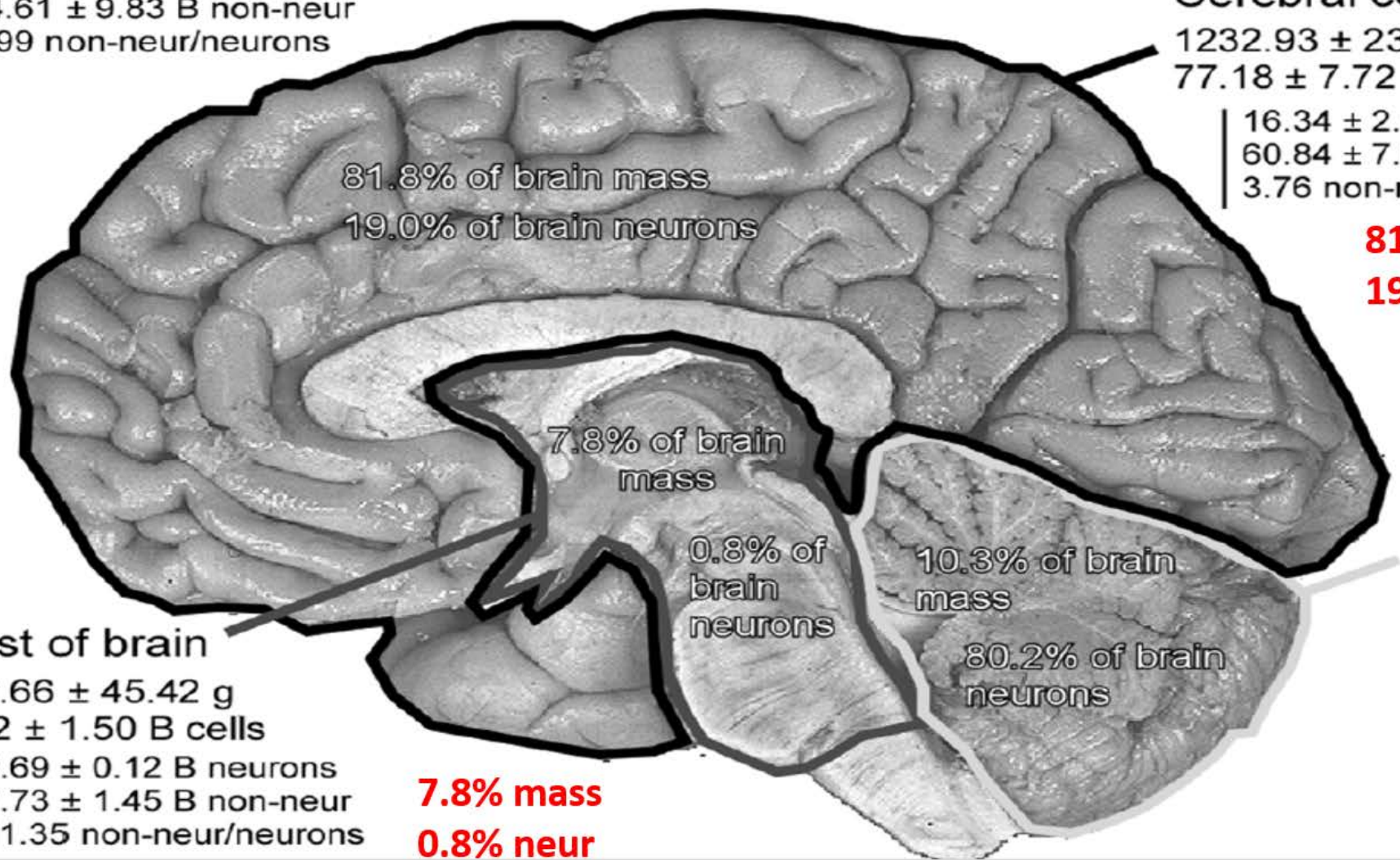
Geschwind, Norman. 1979.

Specializations of the human brain.

Scientific American 241.158-68.

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

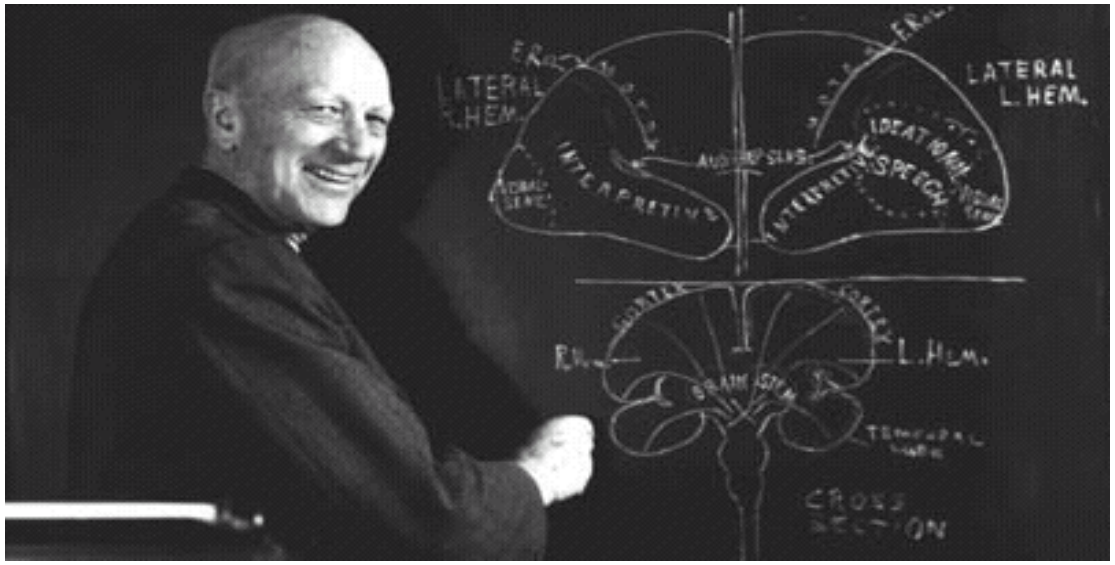
81.8% mass
19.0% neur

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

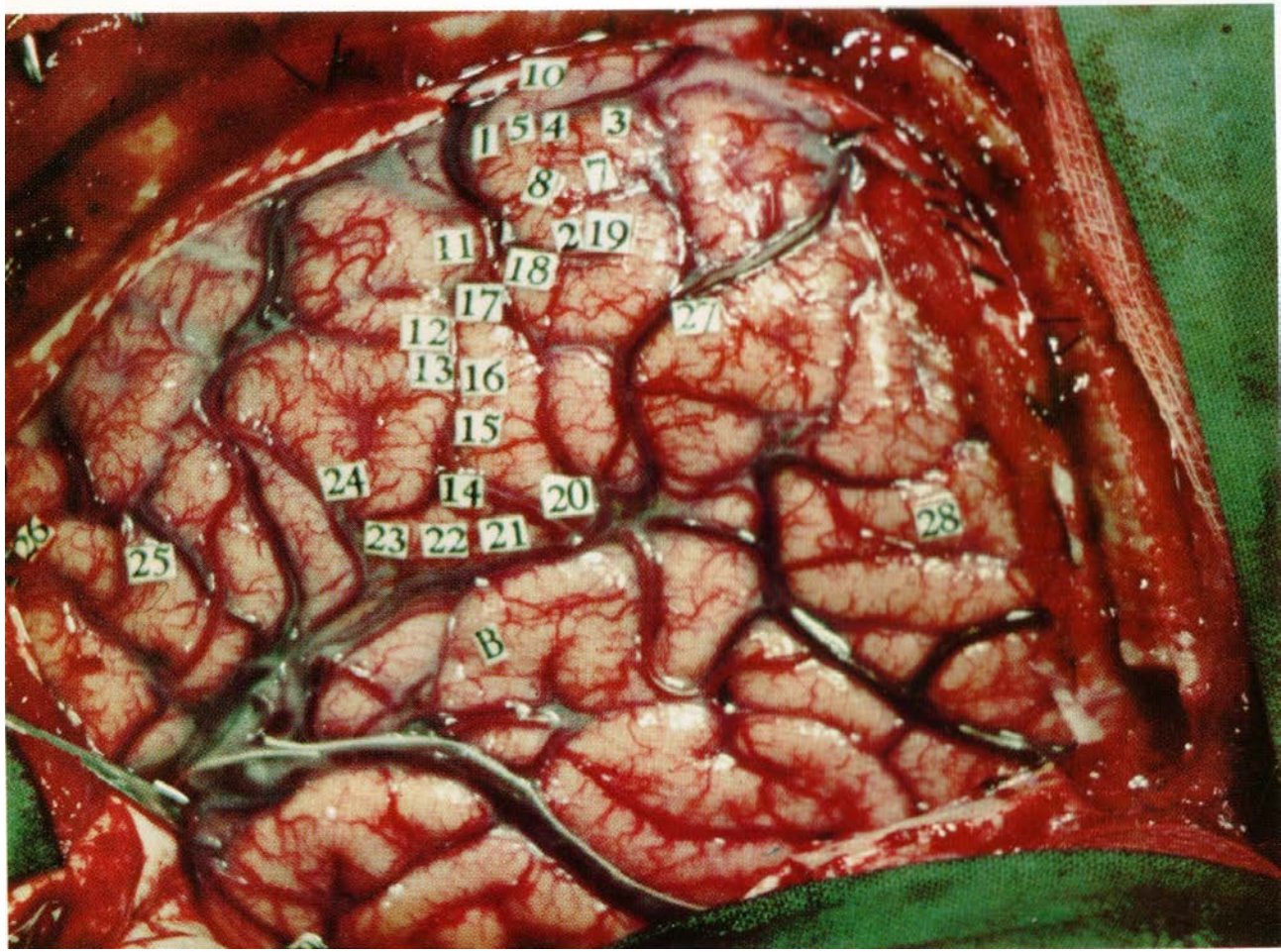
10.3% mass; 80.2% neur



Wilder Penfield 1891-1976.

Before the **age of nine to twelve**, a child is a specialist in learning to speak. At that age he can learn two or three languages as easily as one. …

… for the purposes of learning languages, the human brain becomes progressively stiff and rigid after the age of nine. [**1939**; reprinted 1959:235.]



Penfield, W. & L. Roberts. **1959**. *Speech & Brain Mechanisms*. Princeton U.P.

Penfield, Wilder. **1965**. Conditioning the uncommitted cortex for language learning ***Brain*** 88.787-98.

赵元任，语言问题。1980：149

施氏食狮史

石室诗士施氏，嗜狮，誓食十狮。氏时时适市视狮。十时，适十狮适市。是时，适施氏适市。氏视是十狮，恃矢势，使是十狮逝世。氏拾是十狮尸，适石室。石室湿，氏使侍拭石室。石室拭，氏始试食十狮尸。食时，始识是十狮尸，实十石狮尸。试释是事。

林思華. 施氏食獅史. 信報另類. P. 40. Hong Kong. October 22, 2007

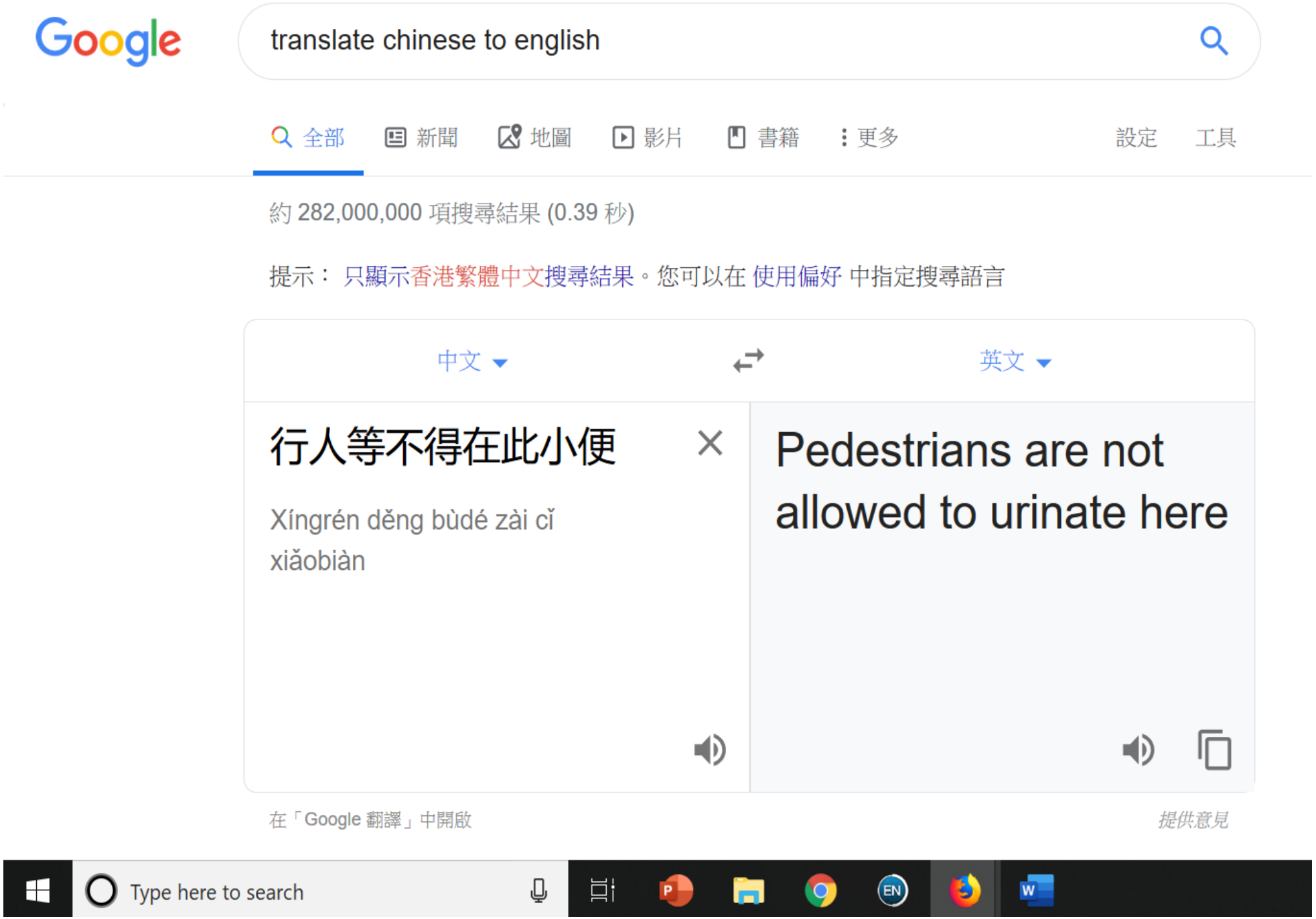
赵元任，语言问题。1980：149

施氏食狮史

石室诗士施氏，嗜狮，誓食十狮。氏时时适市视狮。十时，适十狮适市。是时，适施氏适市。氏视是十狮，恃矢势，使是十狮逝世。氏拾是十狮尸，适石室。石室湿，氏使侍拭石室。石室拭，氏始试食十狮尸。食时，始识是十狮尸，实十石狮尸。试释是事。

Failure of Google to translate Resultative Constructions.

2019.09.17.



Failure of Google to translate Resultative Constructions.

2019.09.17.

Failure of Google to translate Resultative Constructions.

2019.09.17.

Where are we going?

We should recognize that we are constantly being shaped by our own inventions. Thanks to impressive advances in science and technology, we have doubled our life span over the past century – centennarians are becoming increasingly numerous in many parts of the world. However, since natural selection essentially stops to favor people past their reproductive years, many ageing-related diseases have surfaced that pose increasingly severe challenges to families and societies in the years to come. In spite of the fabulous progress in medical sciences, we are still powerless when the brain is attached by Alzheimer's, Parkinson's, and a host of other diseases caused by neurological degeneration. Wherever we are going, these are urgent problems which must be solved by an integrated and balanced approach based on STEM and HASS.

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)

Dick, F. et al. 2001. Language Deficits, Localization, and Grammar: Evidence for a Distributive Model of Language Breakdown in Aphasic Patients and Neurologically Intact Individuals. *Psychological Review* 108.759-88.

Broca's aphasia:

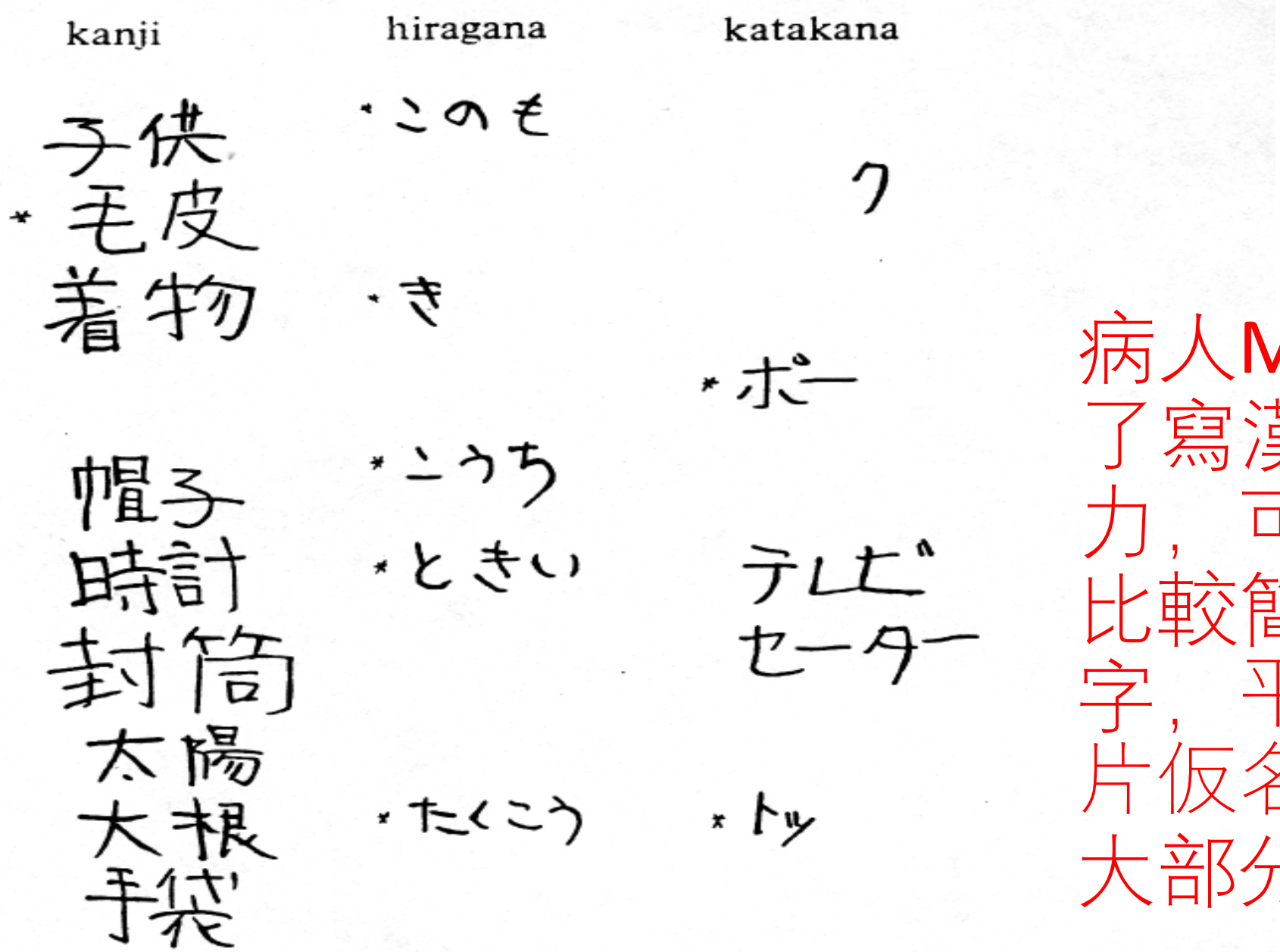
"Alright. . . . Uh ... stroke and uh ... I . . . huh tawanna guy . . . h ... h ... hot tub and.... And the ... two days when uh . . . Hos . . . uh ... huh hospital and uh . . . amet... am ... ambulance."

Broca, P. (1861). "Nouvelle observation d'aphémie produite par une lésion de la moitié postérieure des deuxième et troisième circonvolution frontales gauches." Bulletin de la Société Anatomique **36**: 398-407.

Wernicke's aphasia.

"It just suddenly had a feffort and all the feffort had gone with it. It even stepped my horn. They took them from earth you know. They make my favorite nine to severed and now I'm a been habed by the uh stam of fortment of my annulment which is now forever."

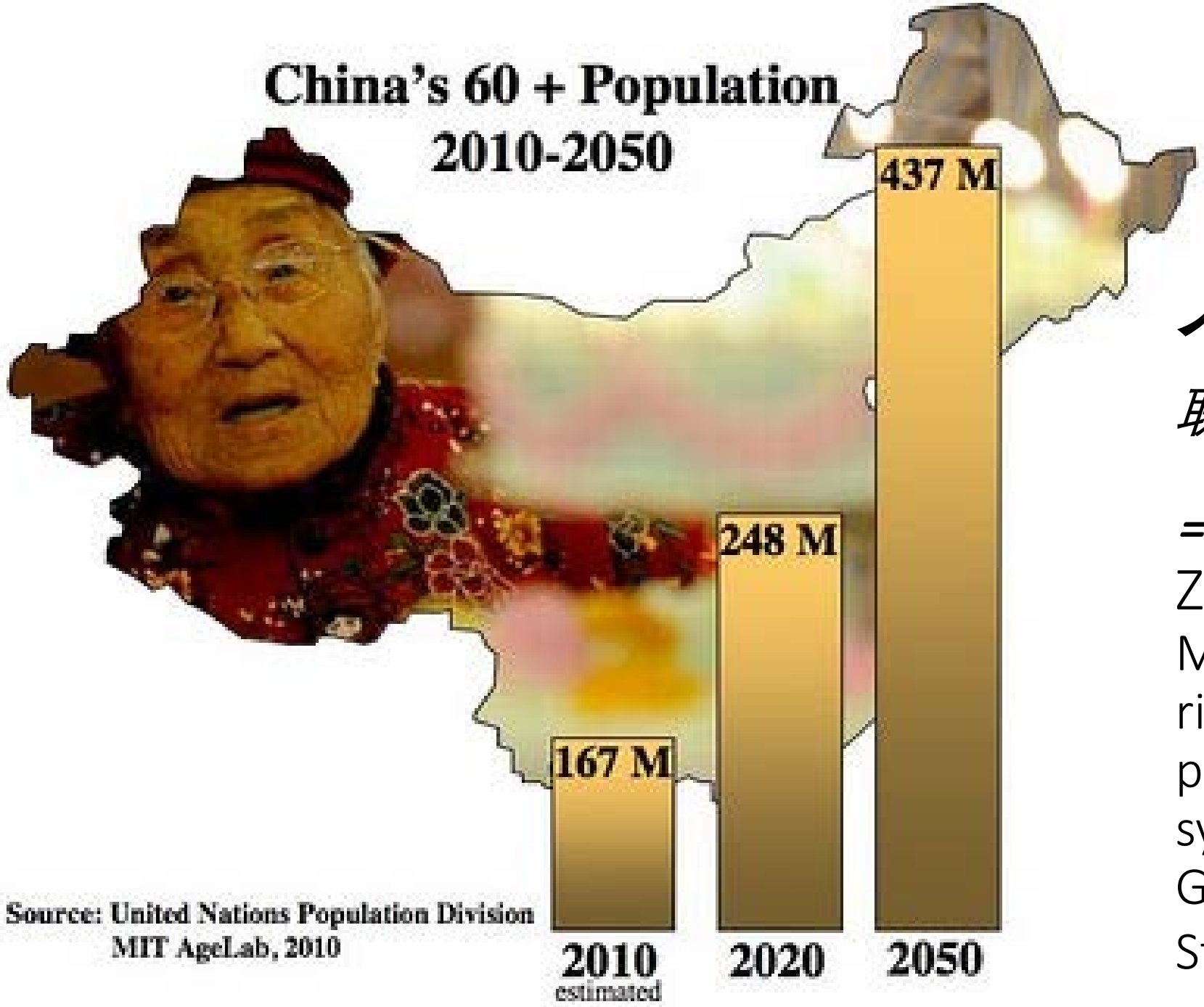
Dick, F. et al. 2001. Language Deficits, Localization, and Grammar: Evidence for a Distributive Model of Language Breakdown in Aphasic Patients and Neurologically Intact Individuals. *Psychological Review* 108.759-88.



* Error words.

Figure 4. Performance of M.T. (a Type 1 patient) on the task of writing high-frequency words in *kana* and *kanji*.

病人M.T.保留了寫漢字的能力，可是兩种比較簡單的文字，平仮名及片仮名，卻已大部分受損。



中国老人人口增长。

联合国人口部数据

==========

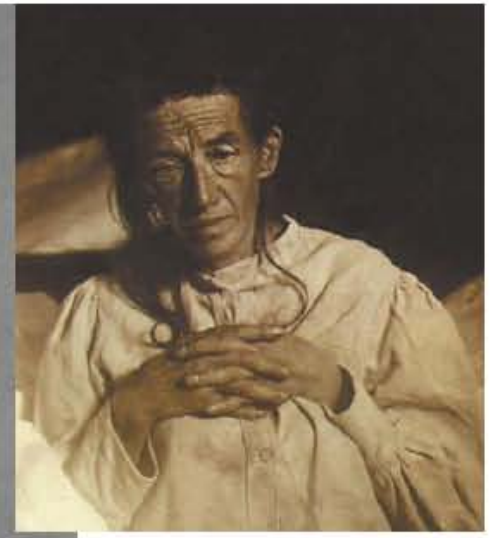
Zhou, M., et al 2019. Mortality, morbidity, and risk factors in China and its provinces, 1990–2017: a systematic analysis for the Global Burden of Disease Study. *Lancet.*

Enjoying the sunset years
and staying active ...

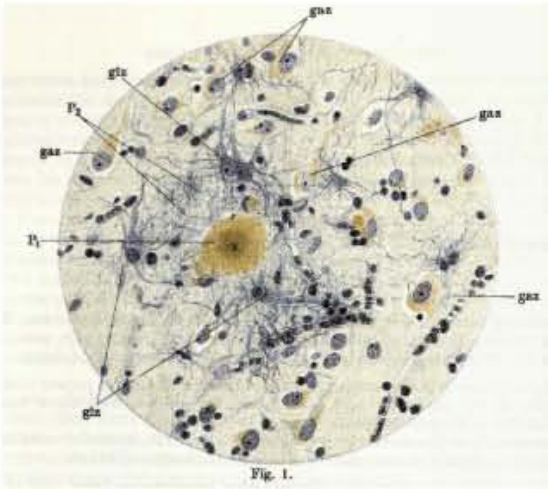
Zhou Youguang,
周有光,
1906 – 2017.
Advocate of
Hanyu Pinyin.

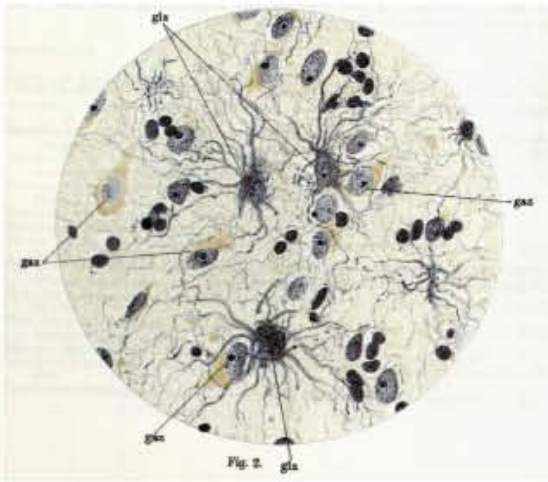
The longest human lifespan is that of **Jeanne Calment** of France (1875–1997), who lived to the age of 122 years, 164 days.

Alois Alzheimer



Auguste Deter





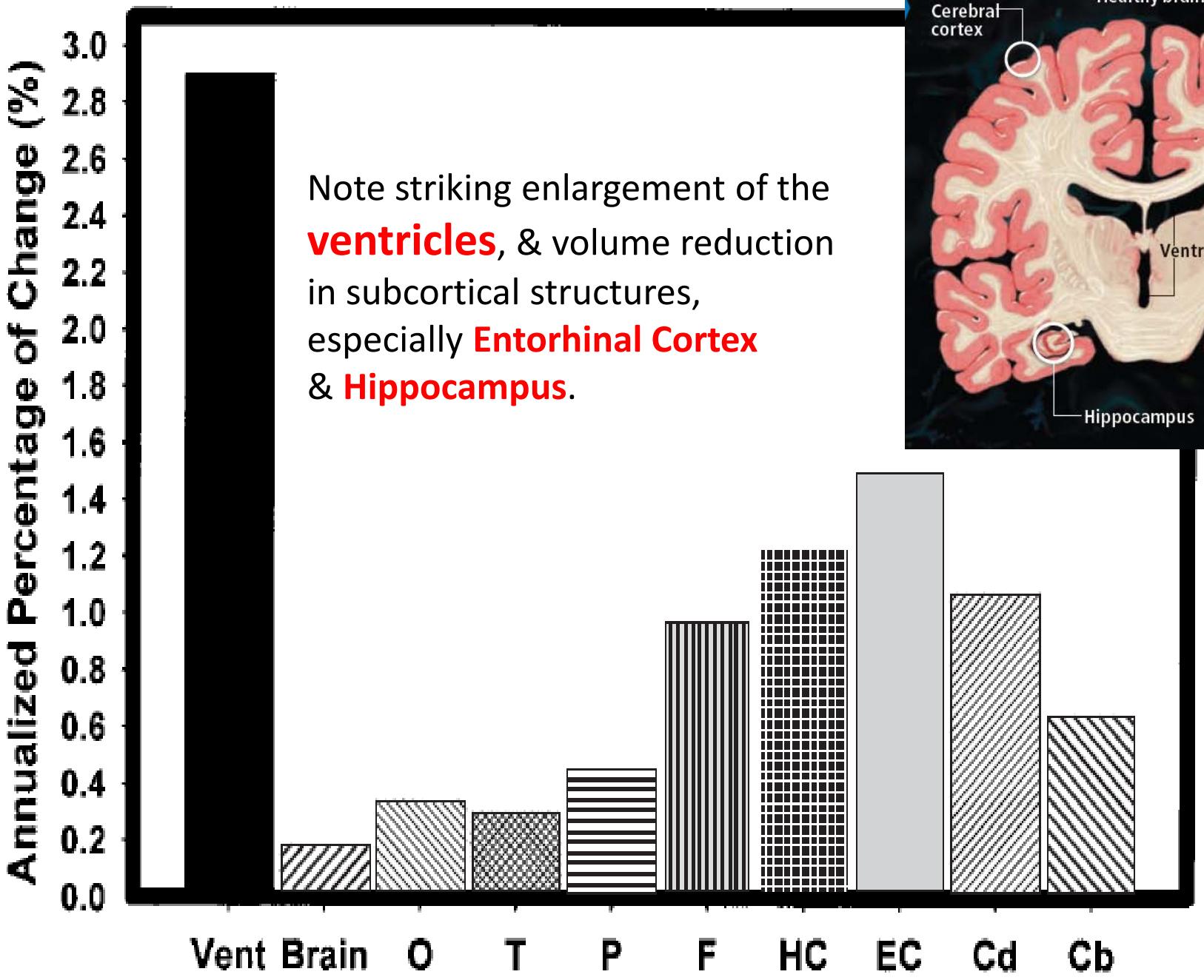
first observations of

beta amyloid & tau tangles.

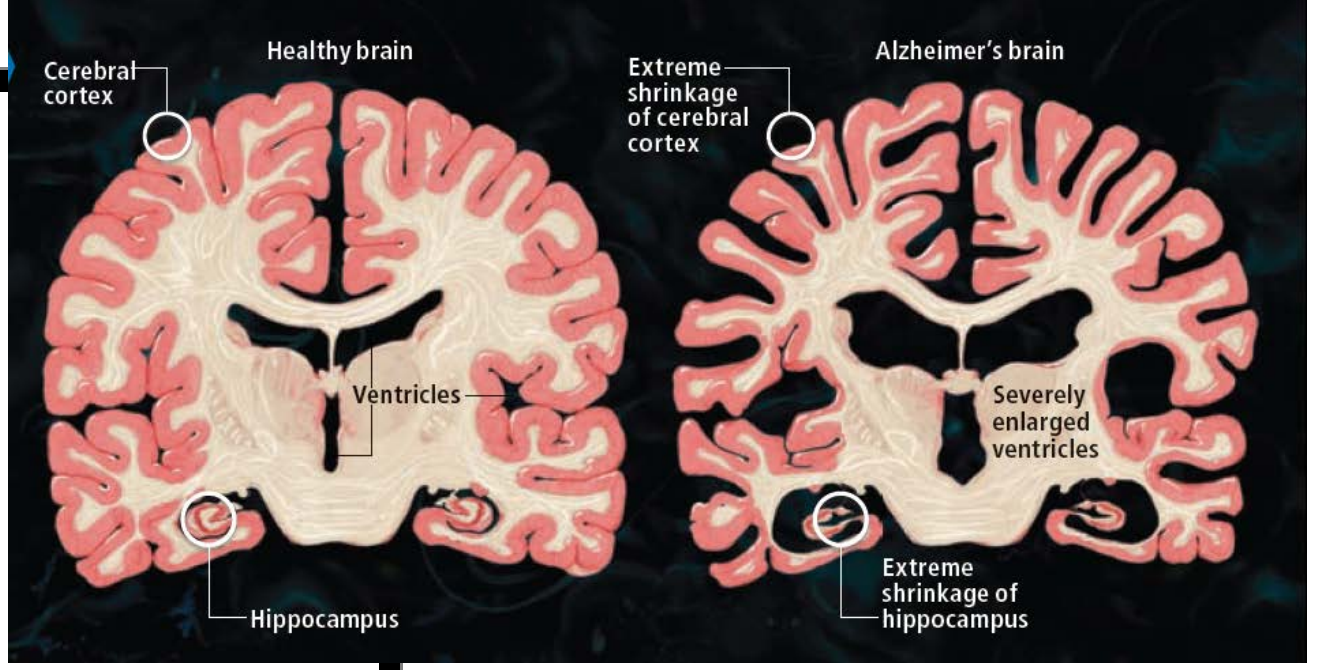
1911.

Uber eigenartige Krankheitsfalle des spateren Alters (On certain peculiar diseases of old age).

Hist Psychiatry **74-99.**

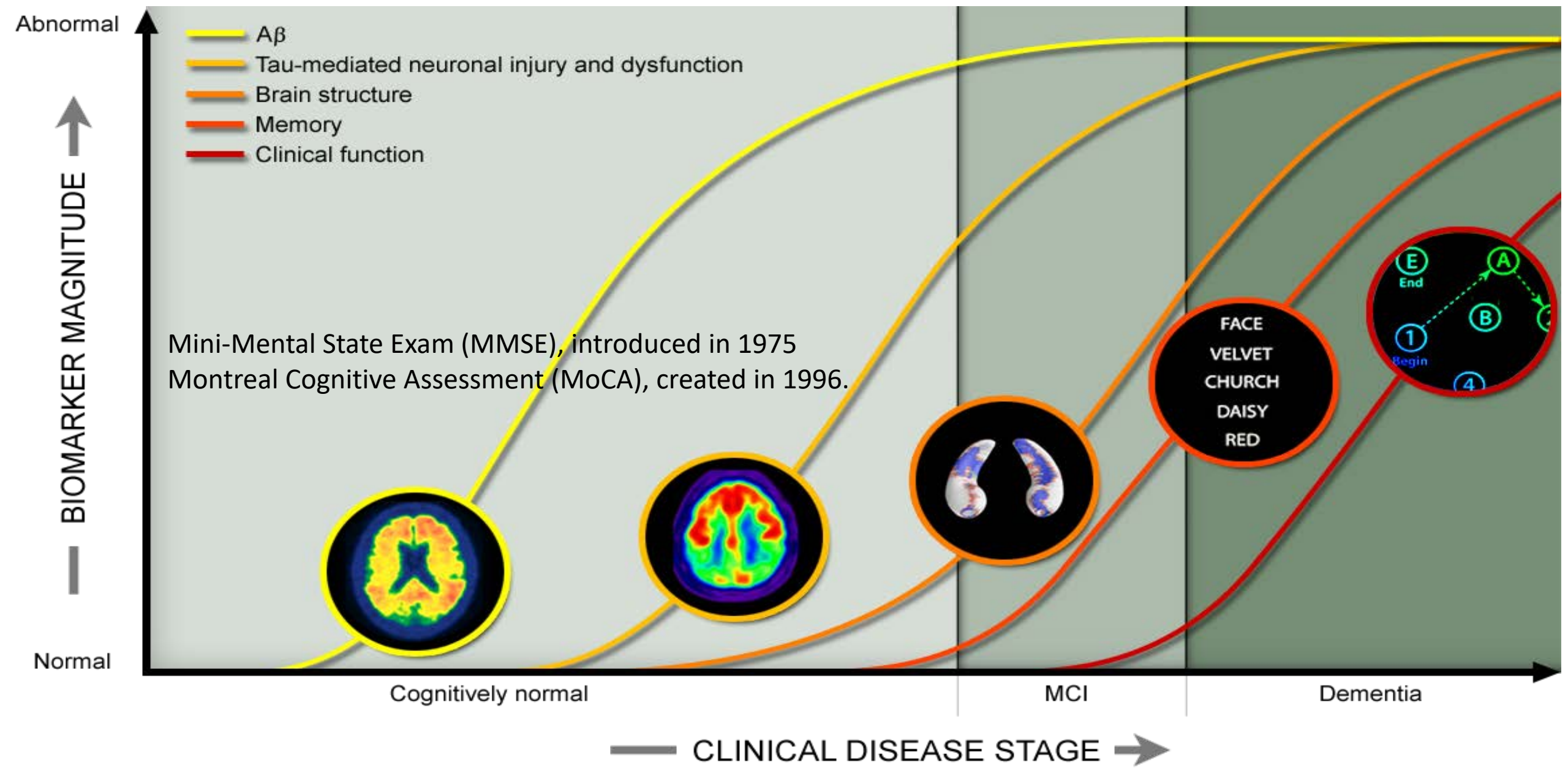


Note striking enlargement of the **ventricles**, & volume reduction in subcortical structures, especially **Entorhinal Cortex** & **Hippocampus**.

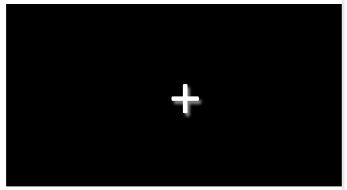


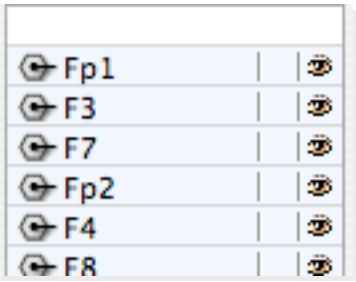
Cabeza, R.et al. eds. 2005:41. *Cognitive Neuroscience of Aging: Linking Cognitive and Cerebral Aging*: Oxford University Press.

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



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.

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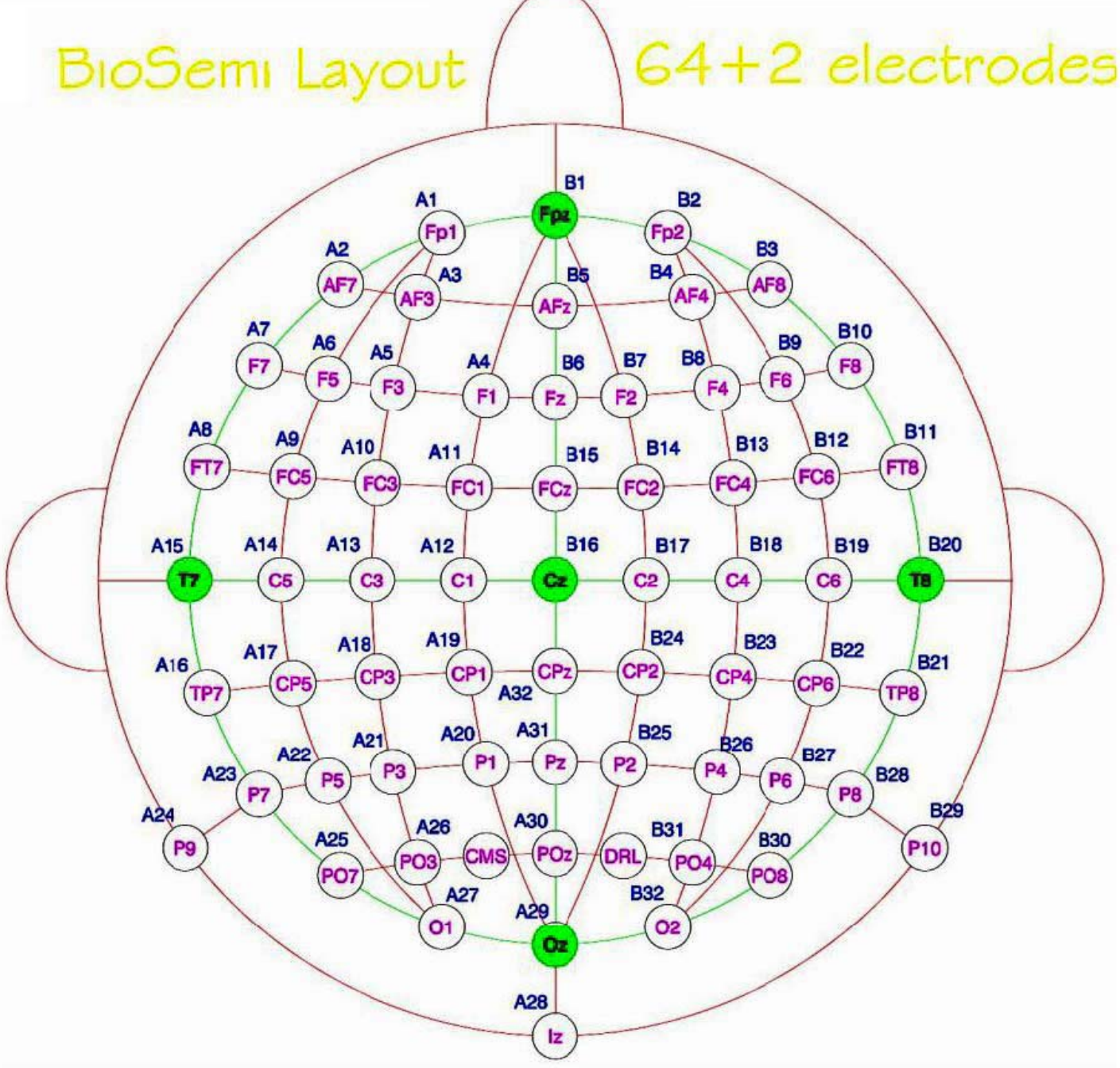
F4
F8



Subject A. BioSemi 32 channel. 20160414 @ GH146 HKPU

T1 MP-RAGE

TE = 2.29 ms TR = 2000 ms TI = 900 ms

Video produced by Manson Fong, 2017.

Young

Old

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 GREEN

PURPLE BLUE

GREEN RED

RED PURPLE

紅 藍

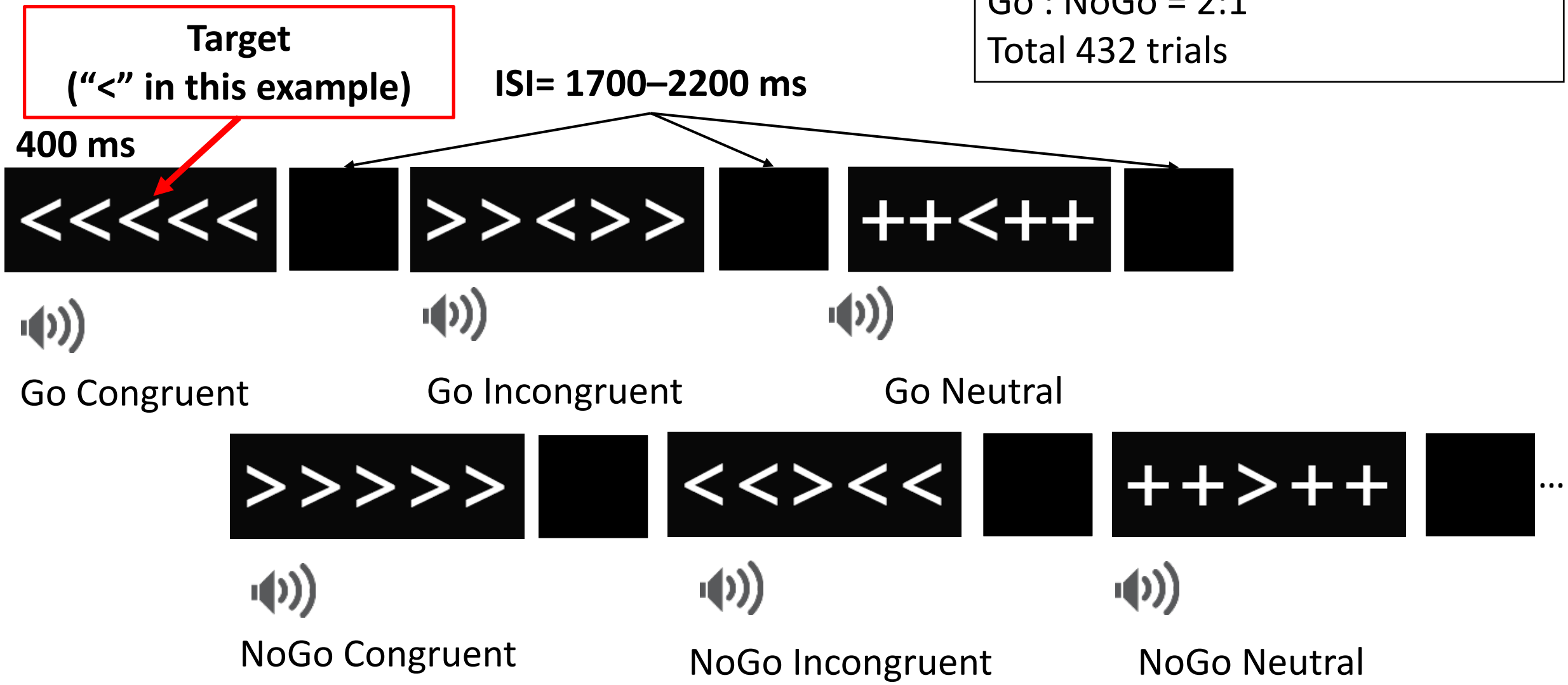
紫 綠

綠 紅

藍 紫

Audiovisual flanker task

Congruent : Incongruent : Neutral = 1:1:1
Go : NoGo = 2:1
Total 432 trials



Research at CBS, Hong Kong Polytechnic University. Manson C.M.Fong, Roza N.Y.Hui, & W.S-Y.Wang. 2017. GRF 14611615.

Recapitulation and Conclusion – 1.

Where do we come from?

We are members of the biological order of Primates, which arose some 60 million years ago. Our taxonomic family of Hominids includes four genera, exemplified by the Orang Utan, the Gorilla, and the Chimpanzee, our closest relative, and ourselves. We separated from the Chimpanzee and went on an independent evolutionary path some 6 million years ago. In brief, our species evolved in Africa, and then colonized our entire planet.

Recapitulation and Conclusion – 2.

What are we?

The first step toward making us unique was taken some 3 million years ago when our remote ancestors changed from walking on all fours to a bipedal posture. This allowed our hands to develop dexterity, to start inventing and making tools of ever increasing complexity, which in turn stimulated the remarkable growth of our powerful brain. A large and well connected brain enabled us to invent language, first spoken language some 200,000 years ago, then written language no later than 6,000 years ago.

Language is by far the most important tool humans invented that made possible the cumulative sharing of information among numerous individuals across vast spans of space and time, giving rise to science and technology in the 16th century. Recently, an acronym has been invented, STEM, Science, Technology, Engineering, and Mathematics, in contrast with HASS, Humanities, Arts, and Social Sciences. In brief, we are the primate defined by our STEM and HASS, both parts absolutely essential.

Recapitulation and Conclusion – 3.

Where are we going?

We should recognize that we are constantly being shaped by our own inventions. Thanks to impressive advances in science and technology, we have doubled our life span over the past century – centennarians are becoming increasingly numerous in many parts of the world. However, since natural selection essentially stops to favor people past their reproductive years, many ageing-related diseases have surfaced that pose increasingly severe challenges to families and societies in the years to come. In spite of the fabulous progress in medical sciences, we are still powerless when the brain is attached by Alzheimer's, Parkinson's, and a host of other diseases caused by neurological degeneration. Wherever we are going, these are urgent problems which must be solved by an integrated and balanced approach based on STEM and HASS.

Thank you!

謝謝！

3q!

For PDF file, email:

wsywang@polyu.edu.hk