THE HONG KONG POLYTECHNIC UNIVERSITY
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Language, Cognition, & Neuroscience.

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IACL 29 神户 2019.05.

PDF available upon request.

Language, Cognition, & Neuroscience has 4 parts:

1. Language is the driving force for cultural evolution, which has largely displaced biological evolution for life on our planet. It is an exaptation, a mosaic tinkered together from many old parts which evolved originally for cognition.

2. First to recognize importance of brain was Hippocrates. Early research on language & brain by 19th century pioneers. Remarkable advances have been made in imaging the brain. Two methods that have been widely used in recent decades: EEG for temporal resolution and MRI for spatial resolution.

. . . . .

My discussion of Language, Cognition, & Neuroscience has 4 parts:

3. Language changes the most at the two ends: acquisition during infancy and disintegration during senescence. Acquisition begins in the womb with hearing the native language in the mother's voice, and practice of orofacial movements for feeding and for vocalizations. EEG reveals that 8 months old infants distinguish speech sounds which are native and nonnative.

4. At the senescence end much less is known, though the epidemic of neurodegenerative diseases is becoming more critical each day as populations age rapidly worldwide. Typically the brain has been degenerating for decades by the time one is diagnosed as having MCI. While biologists are looking for biomarkers , linguists can help significantly by identifying impairments in language which may help predict the onset of these diseases. Research in this urgent area can contribute both to the biological and language sciences, as well as help meet a terrible challenge society is facing.

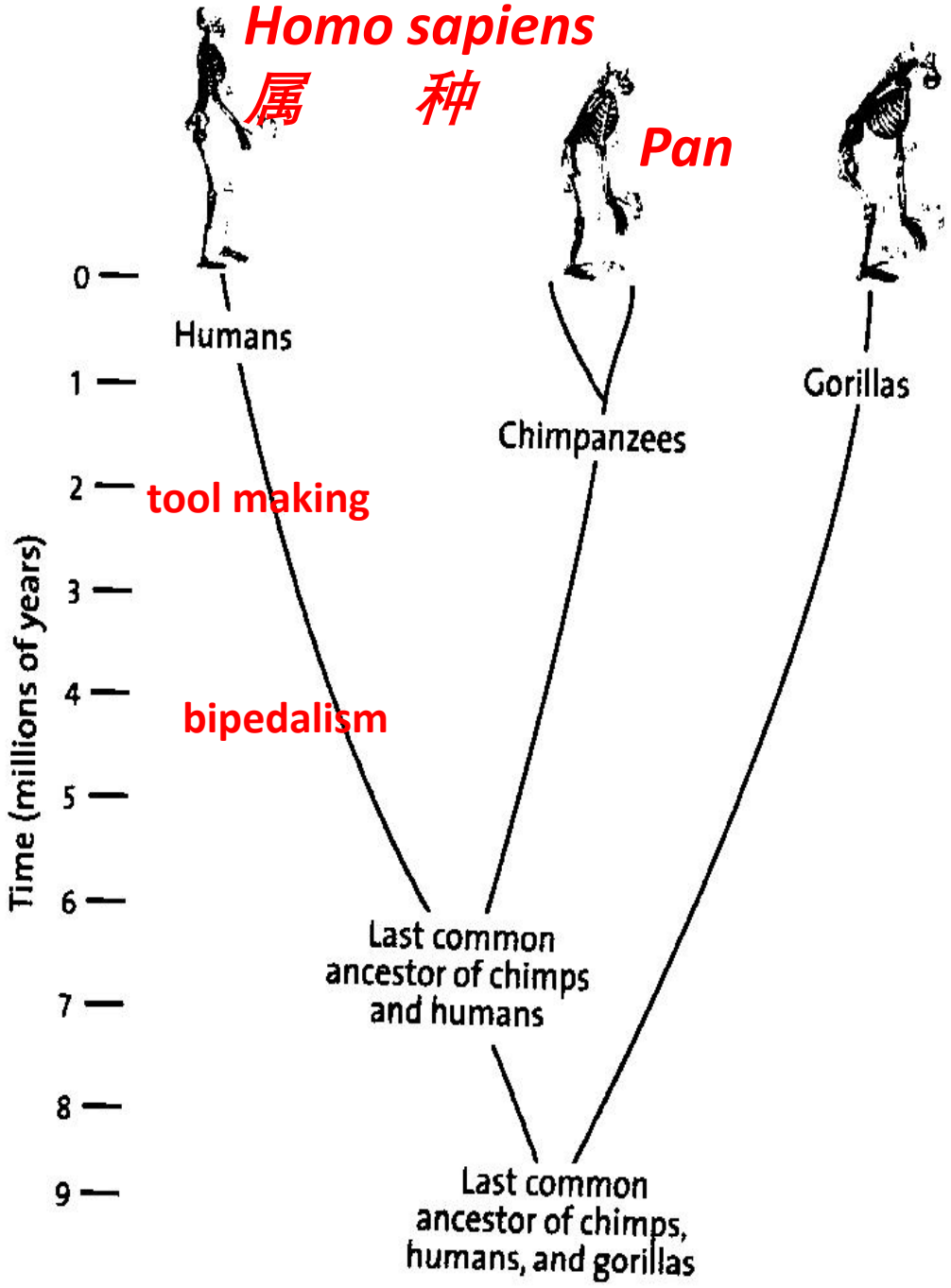
Lieberman, Daniel E. 2013:29.

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

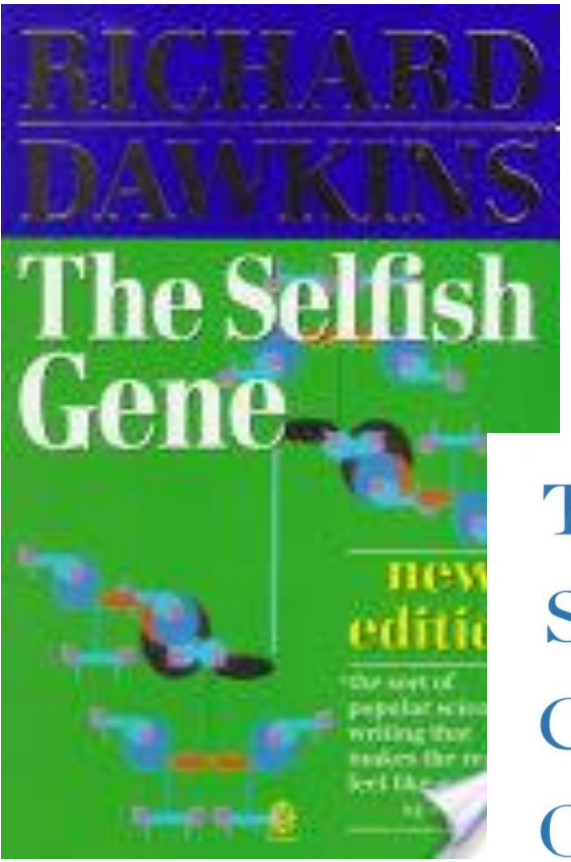
Pantheon.

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.



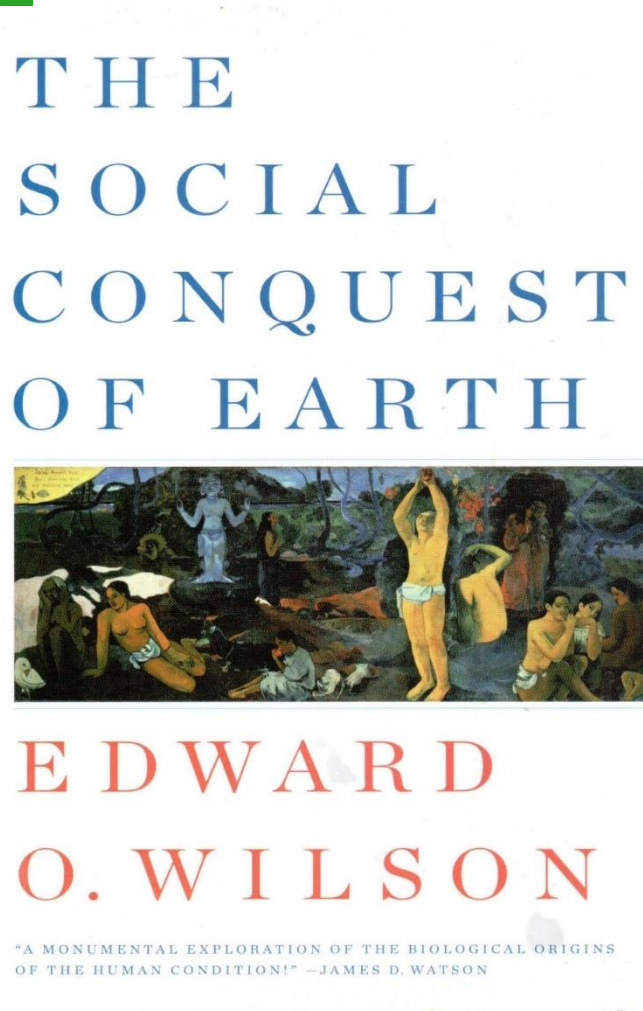
很多种动物都有合作行为。可是因为人类有**语言**来表达复杂微妙的思想及协助配合动，所以人类合作的群体大小、合作的本质方式，就与其他动物有天壤之别。



Dawkins 1976

Nowak 2012

Wilson 2012



“物竞天择，
适者生存”

“Nature, red in tooth & claw …”

**演化并不只基于竞争，
合作也能让群体
更具有生存优势。**

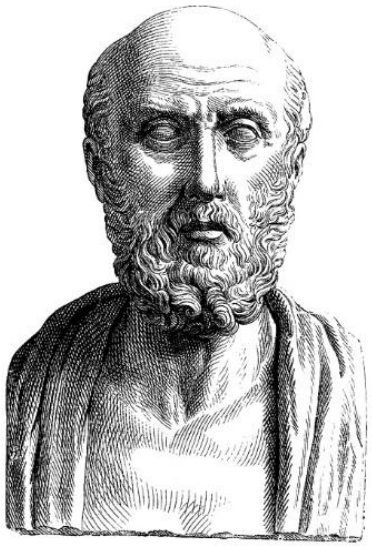
*"[Language] evolved in a **mosaic** fashion, with the emergence of semantics, phonology, morphology and syntax all at different times and according to different schedules ... language is regarded as a kind of '**interface**' among a variety of more basic abilities. These abilities underlie nonlinguistic processes as well and involve the **perception** of patterns in the frequency and temporal domains, the coding and storage of events and objects at different levels of **memory**, the manipulation of various **hierarchical mental structures**. Many of these abilities are present to different degrees in other animals ... Most of them probably emerged much earlier than language in hominid evolution. gradually and piece by piece, these pieces were increasingly made accessible for use in the elaboration of language, much as **adding pieces to a mosaic**. In parallel fashion, these abilities have also been made accessible to several other elaborate human institutions, most notably **mathematics** and **music**."*

Wang, W. S.-Y. Explorations in Language Evolution.
Diamond Jubilee Lecture, Osmania University, February 1979.

It was several years later that I saw the important paper by the French geneticist, Francois Jacob, published in 1977, two years earlier than my lecture. Jacob vividly portrayed the forces of evolution as "**tinkering**" when environment affords the need and opportunity for the forces to operate. By tinkering, "… *evolution makes a wing from a leg or a part of an ear from a piece of jaw. … To make a lung with a piece of esophagus sounds very much like tinkering*." This idea of adapting old parts for new uses in evolutionary change was also stressed by the biologists Gould and Vrba several years later, in 1982, when they introduced the new term "**exaptation**" to refer to "*features that now enhance fitness but were not built by natural selection for their current role*."

Jacob, F. 1977. Evolution and Tinkering. Science **196**: 1161-6.
Gould, S. J. & E. S. Vrba 1982. Exaptation - a missing term in the science of form. Paleobiology **8**: 4-15.

*"And men ought to know that **from nothing else … but from the brain** come joys, delights, laughter and sports, and sorrows, griefs, despondency, and lamentations. And by this, in an especial manner, we acquire wisdom and knowledge, and see and hear, and know what are foul and what are fair, what are bad and what are good, what are sweet, and what unsavory… And by the same organ we become mad and delirious, and fears and terrors assail us… All these things we endure from the brain, when it is not healthy … **In these ways I am of the opinion that the brain exercises the greatest power in the man**.*



***This is the interpreter to us of those things which emanate from the air, when it [the brain] happens to be in a sound state**."*

Hippocrates *quoted on p.509 of Syntactic Complexity. Givon & Shibatani, eds.2009. Emphasis added.*

Three pioneers in studies of Language Disorders & Brain.

研究語言障礙的三位先驅。

Paul Pierre Broca
(1824-1880)

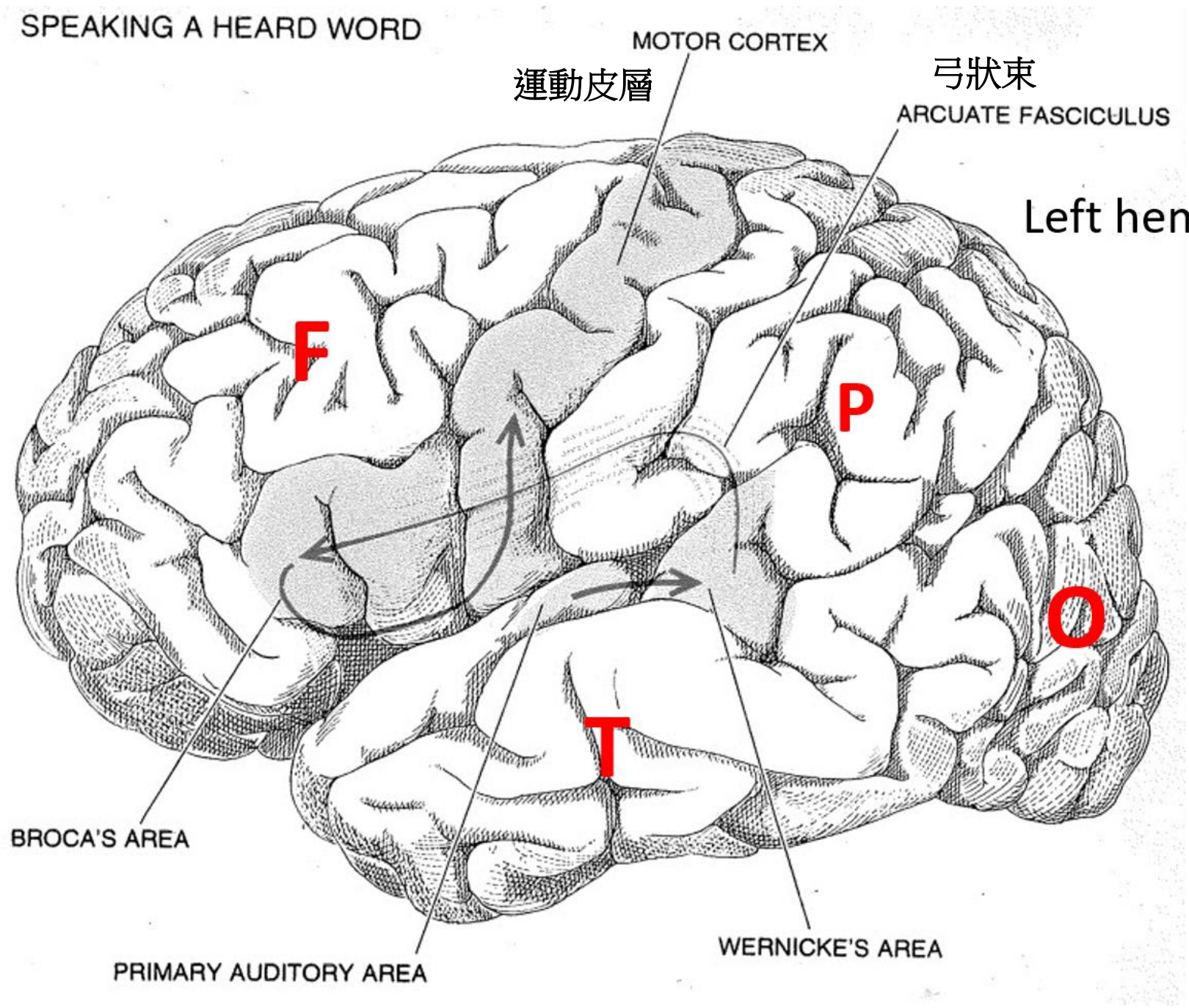
Carl Wernicke
(1848-1904)

Jules Dejerine
(1849-1917)

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



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

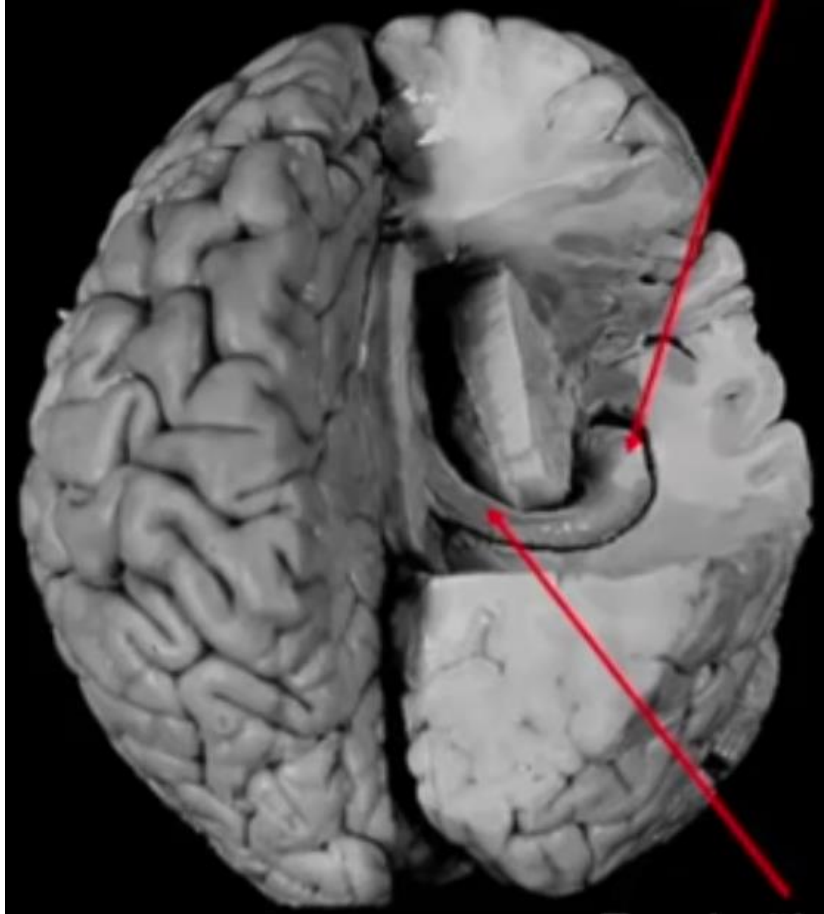
Geschwind, Norman. 1979.

Specializations of the human brain.

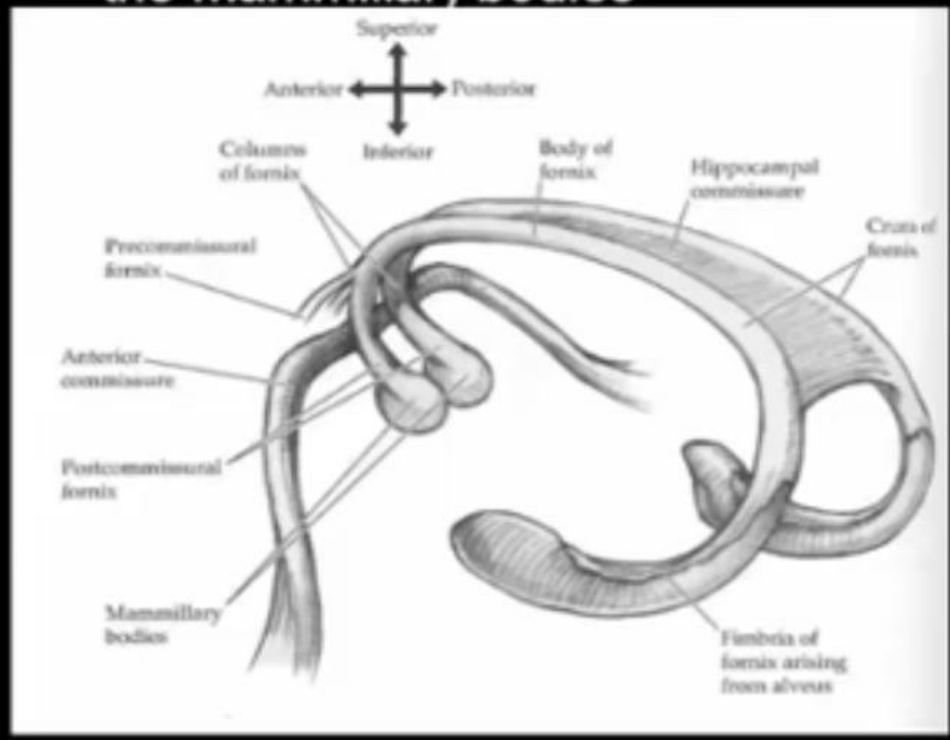
Scientific American 241.158-68.

Hippocampus

Hippocampus



The fornix connects the hippocampus to the mammillary bodies



Fornix (the axons of the hippocampal neurons)

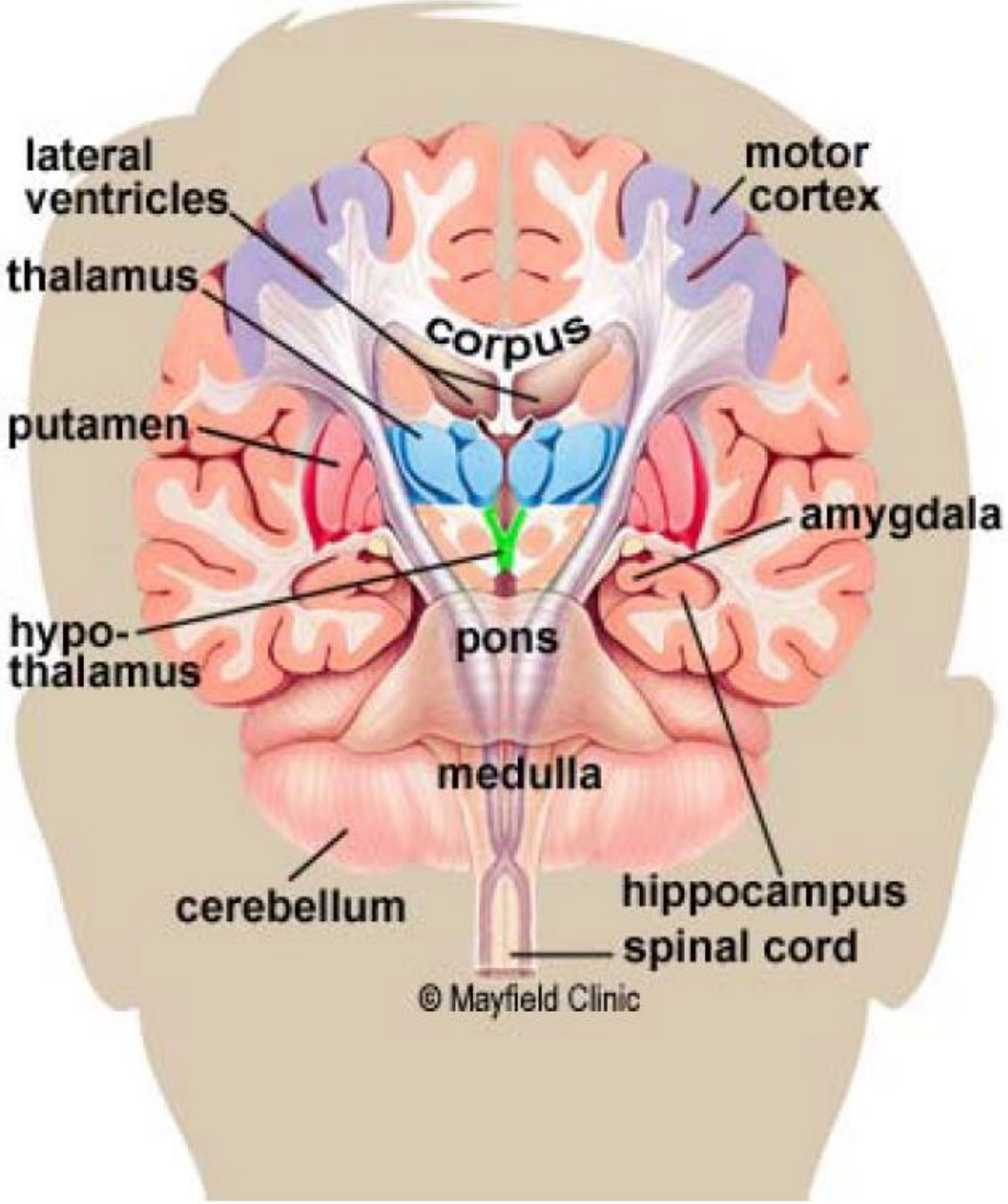
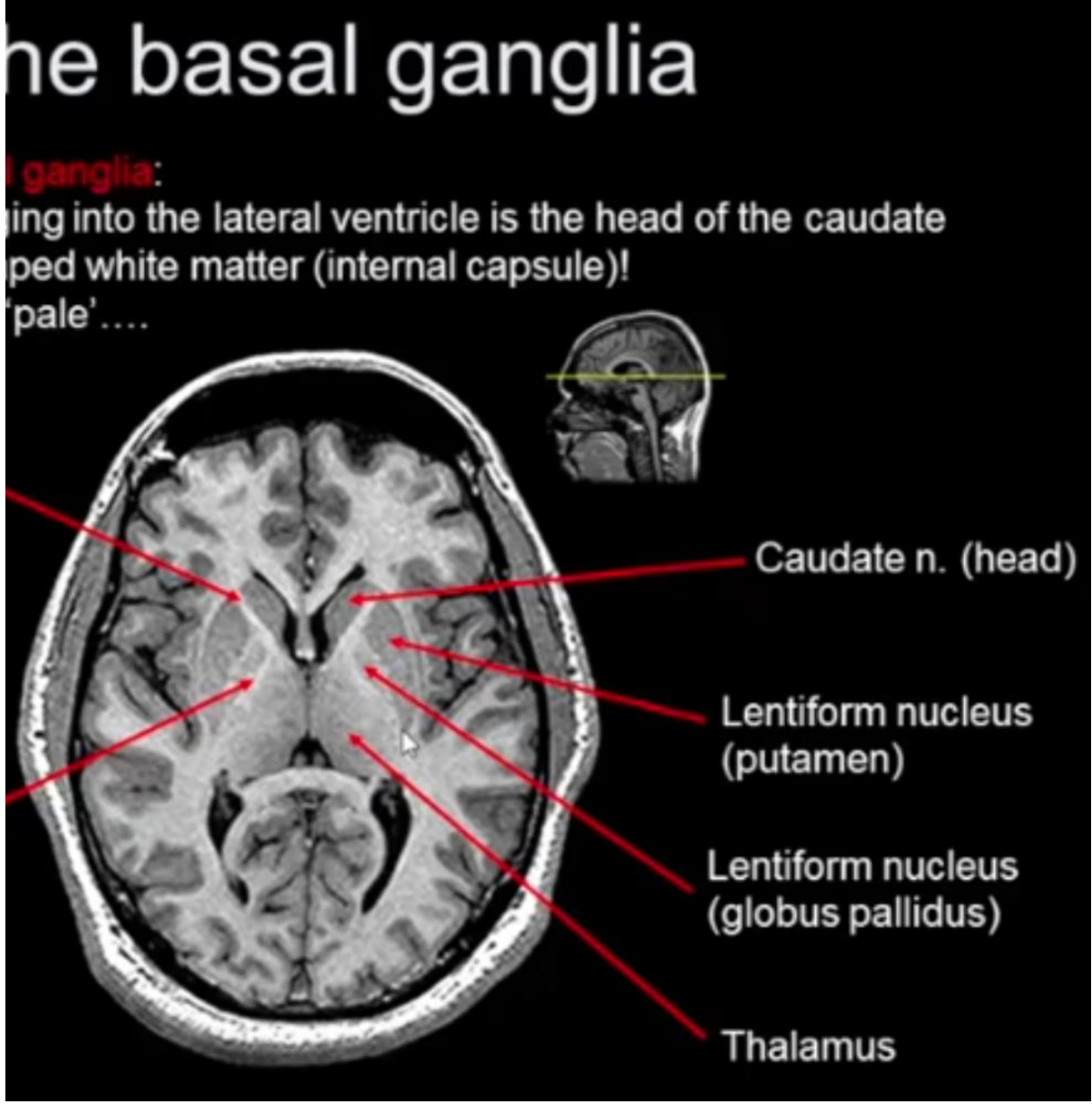
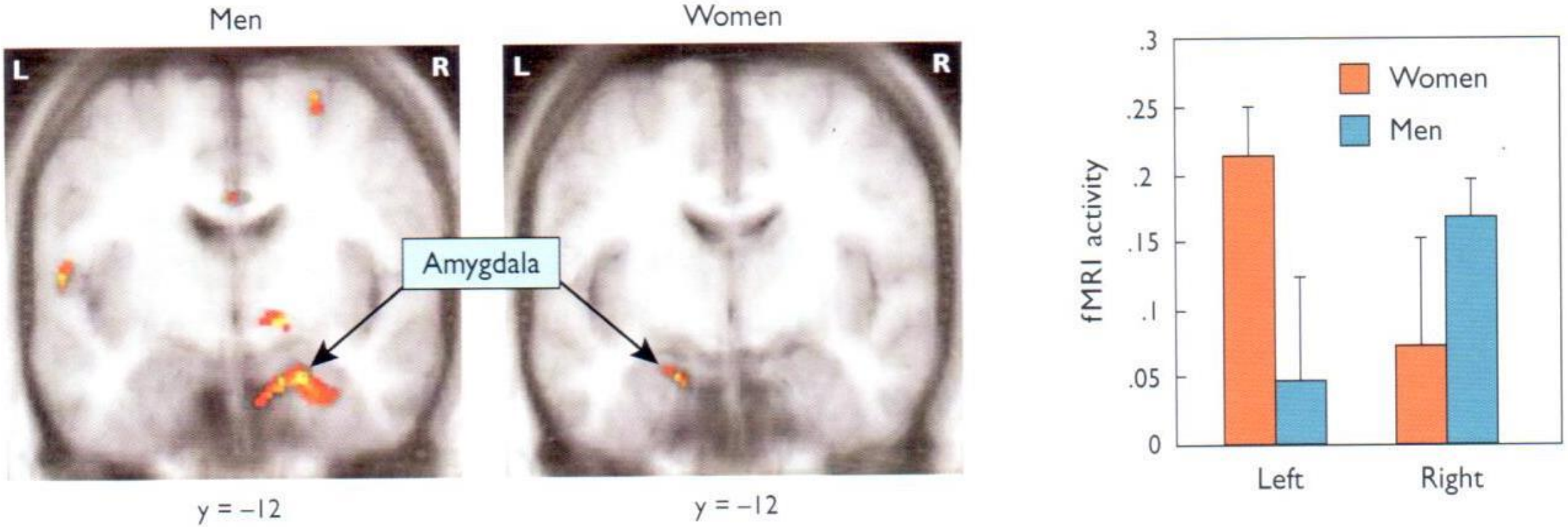


Figure 5. Coronal cross-section showing the basal ganglia.



2 views of the basal ganglia.



The amygdala and emotional memory. Fifteen volunteers (8 men, 7 women) viewed neutral or emotionally arousing scenes while their brains were scanned by functional magnetic resonance imaging (fMRI). In women, left amygdala activity strongly correlated with the ability to subsequently remember emotionally arousing scenes. For men, the same association was found in the right amygdala.

Squire & Kandel 2009:190.

Current knowledge on brain & behaviour is often heavily biased toward men, & toward WEIRD peoples.

Vol 466|1 July 2010 nature

OPINION

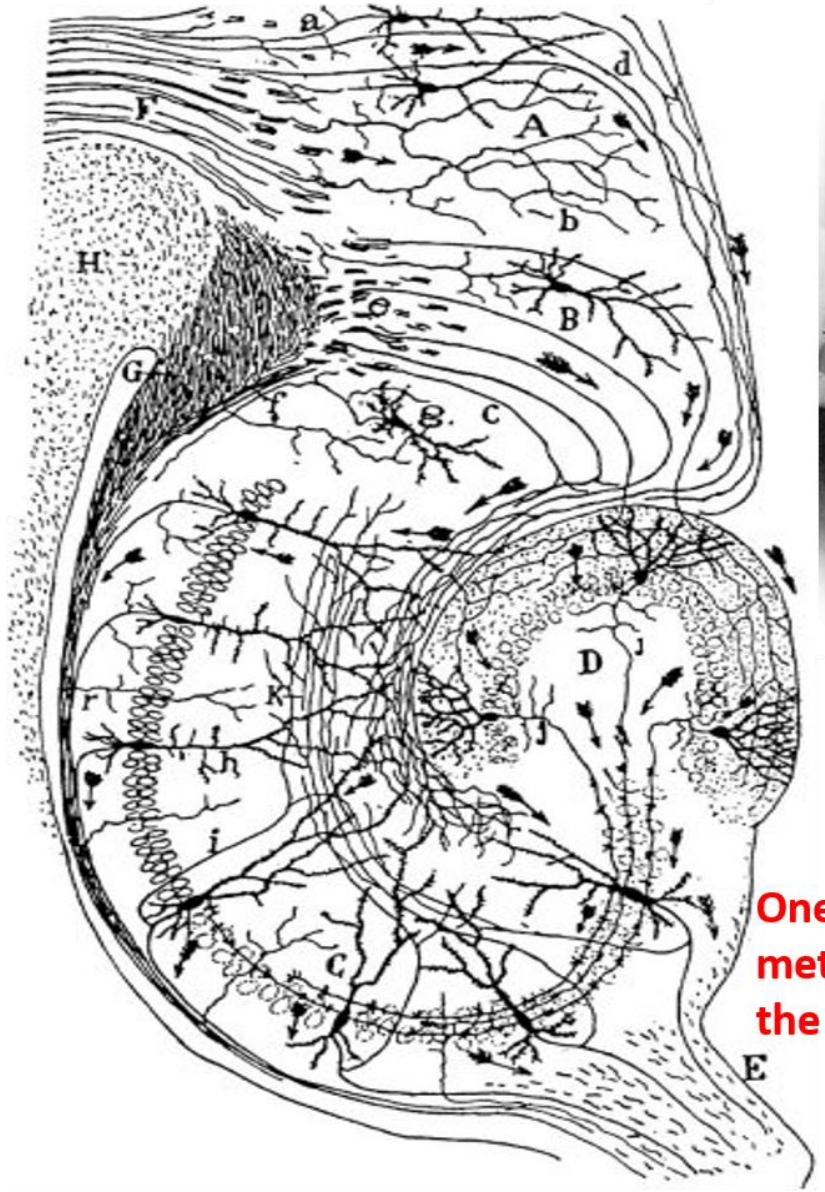
Most people are not WEIRD

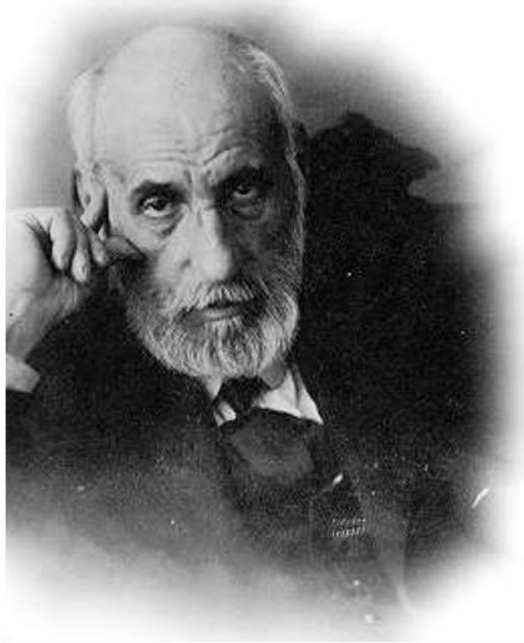
To understand human psychology, behavioural scientists must stop doing most of their experiments on Westerners, argue **Joseph Henrich**, **Steven J. Heine** and **Ara Norenzayan**.

"… Experimental findings from several disciplines indicate considerable variation among human populations in diverse domains, such as visual perception, analytic reasoning, fairness, cooperation, memory and the heritability of IQ. This is in line with what anthropologists have long suggested: that people from Western, educated, industrialized, rich and democratic (WEIRD) societies — and particularly American undergraduates — are some of the most psychologically unusual people on Earth. So the fact that the vast majority of studies use WEIRD participants presents a challenge to the understanding of human psychology and behaviour. A 2008 survey of the top psychology journals found that 96% of subjects were from Western industrialized countries — which house just 12% of the world's population. Strange, then, that research articles routinely assume that their results are broadly representative, rarely adding even a cautionary footnote on how far their findings can be generalized. … "

Ramon Santiago y Cajal

1852-1934. Nobel Prize 1906.





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

Poeppel, David and A.Marantz. 2000:33.
Cognitive Neuroscience of Speech Processing.

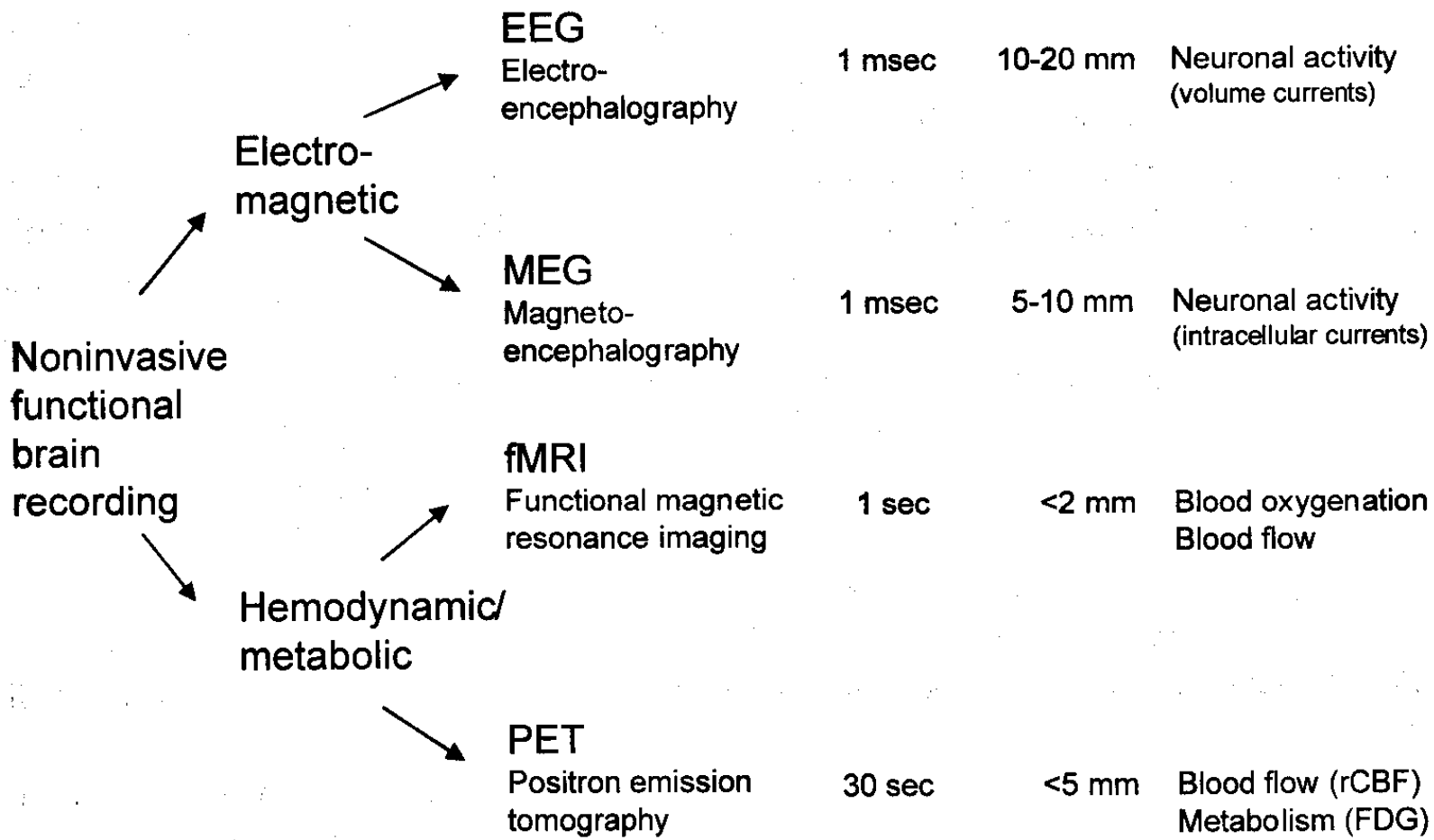
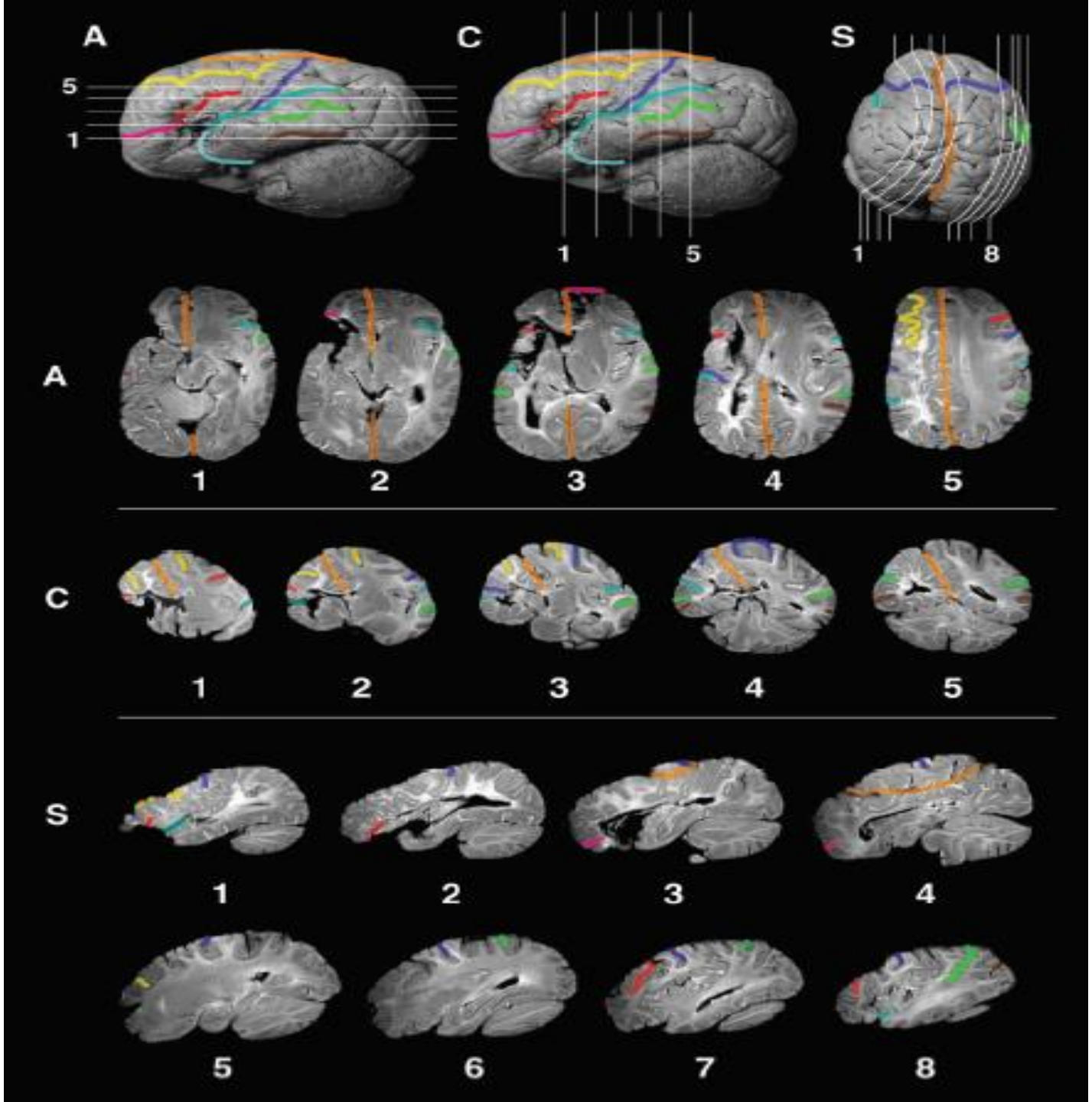


Figure 2.1
Summary of imaging methods.



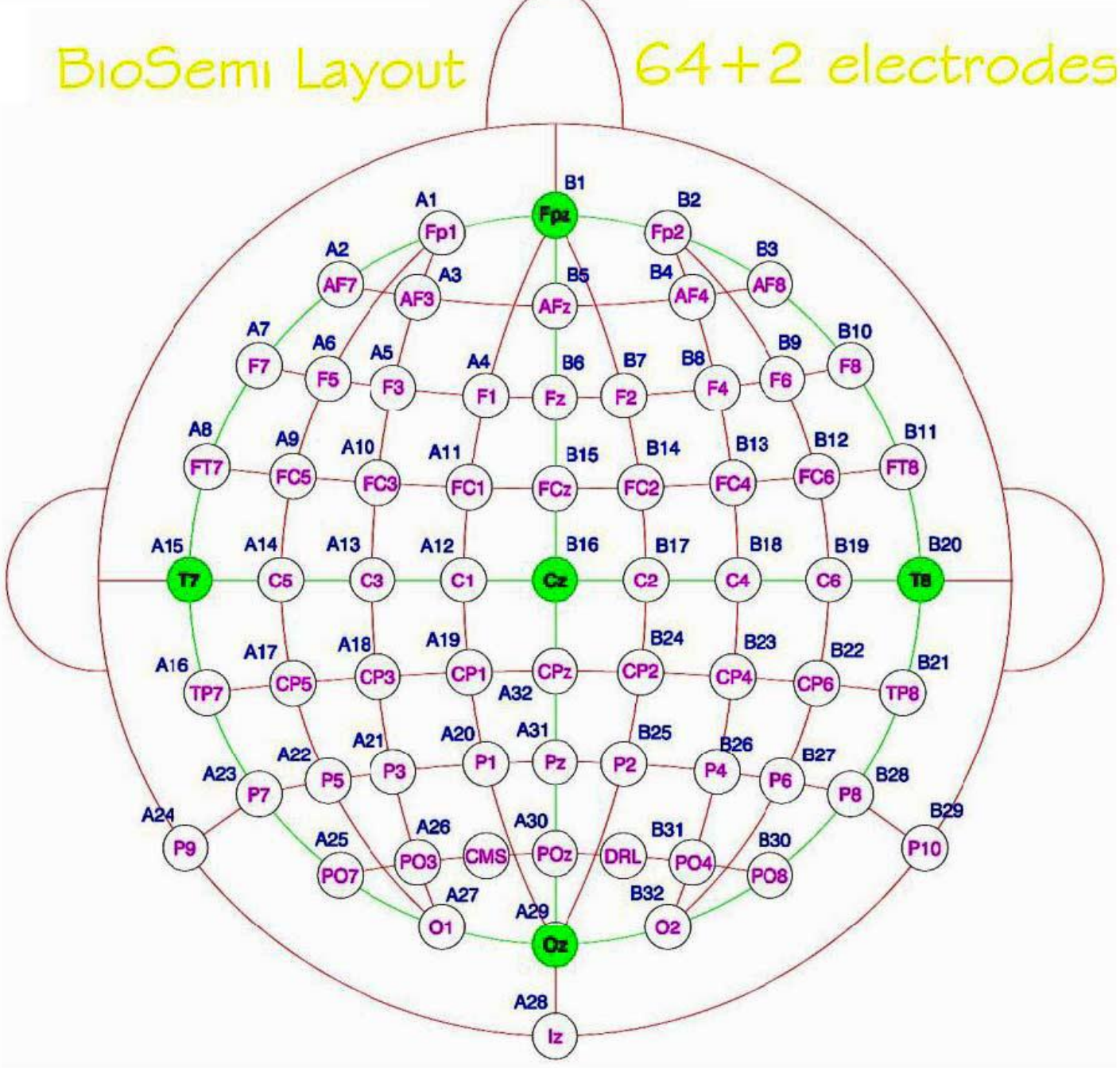
Dronkers, N. et al. 2007.

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.*

Subject: WSYW.
2017.10.10.
@ S.I.A.T.
Experimenter:
MCMF.



Subject A. BioSemi 32 channel. 20160414 @ GH146 HKPU

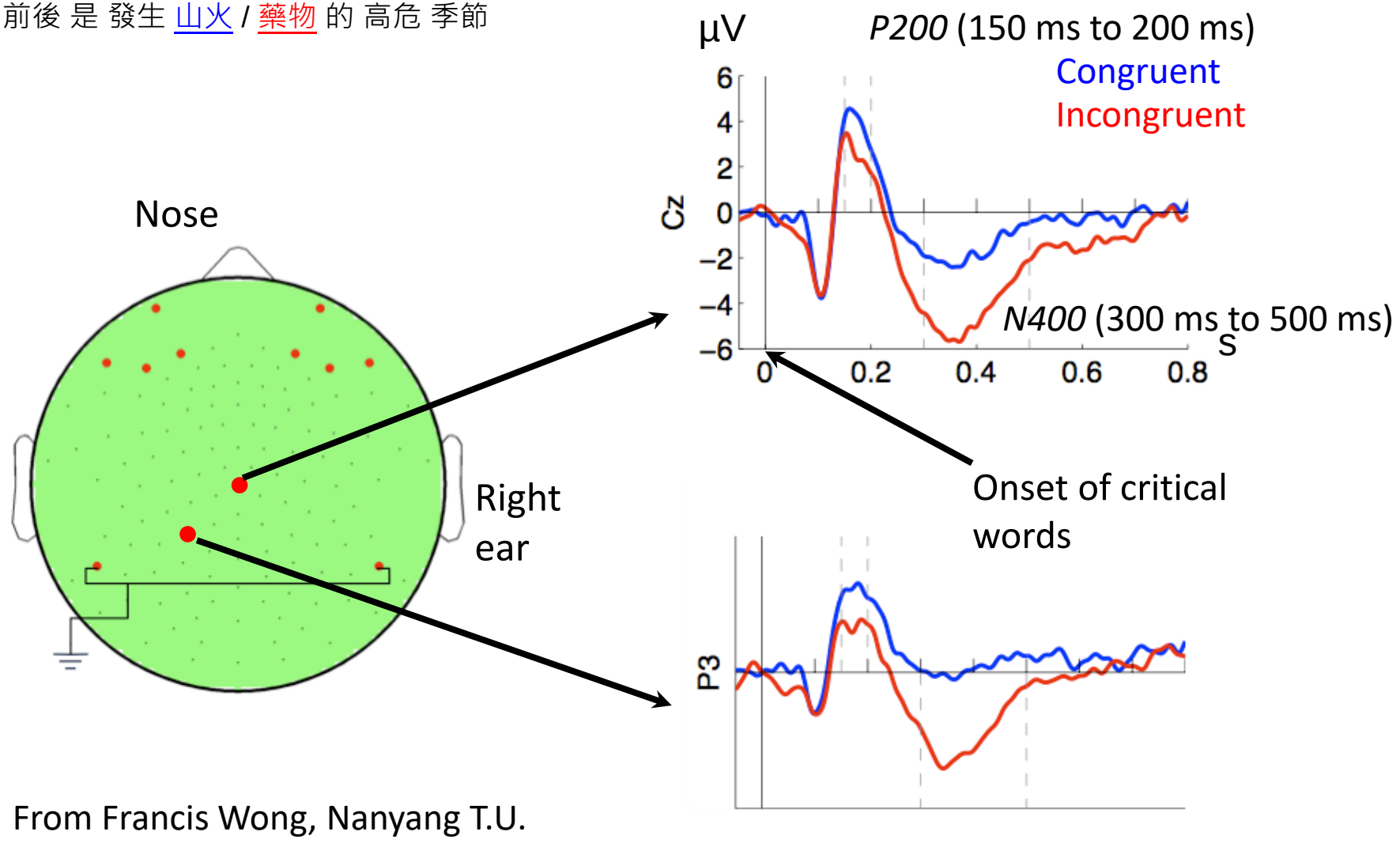
Fp1
F3
F7
Fp2
F4
F8

Congruent/Incongruent sentences in English:

The time of the year around Chung Yeung Festival is traditionally a high-risk period for hill fires / drugs

Congruent/Incongruent sentences in Chinese:

重陽節 前後 是 發生 山火 / 藥物 的 高危 季節



From Francis Wong, Nanyang T.U.

Foreign phonetic test:

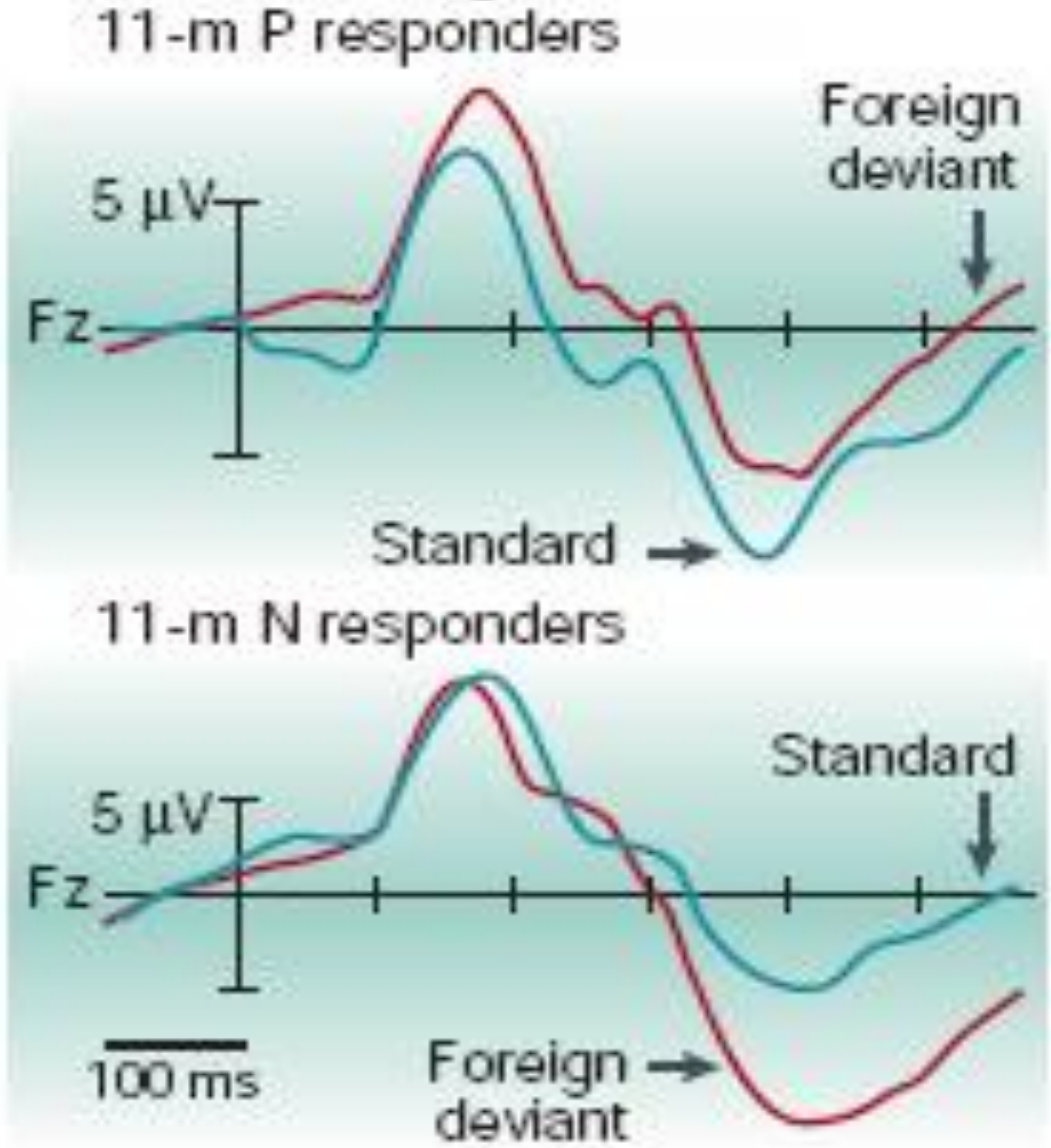
'ta-ta-ta-DA' (Spanish)

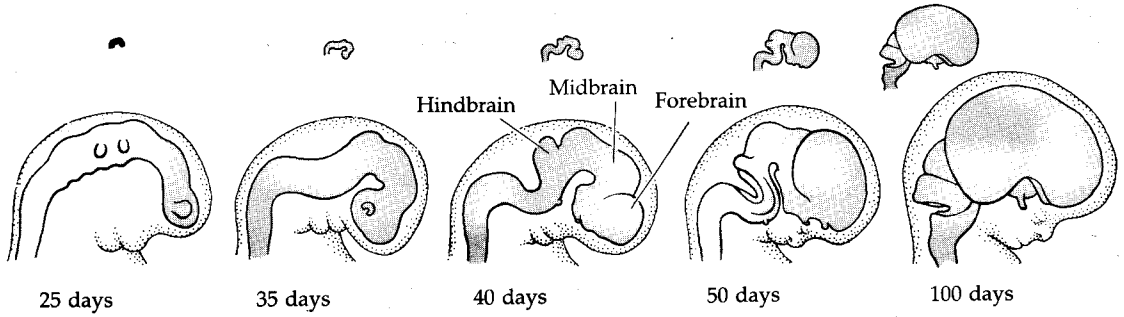
English listeners hear the Spanish syllable 'ta' as 'da'

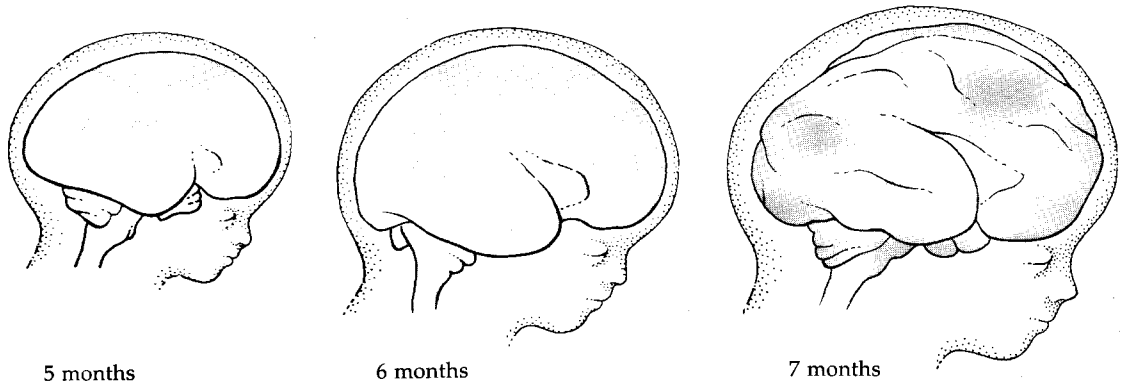
Native contrast:

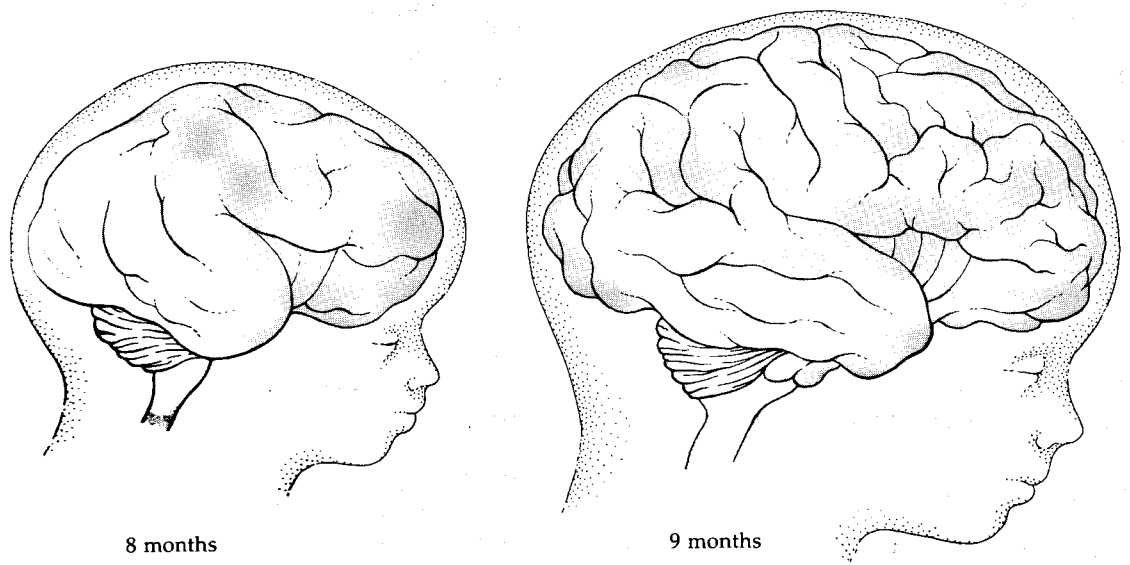
'da-da-da-T^{H}A' (English)

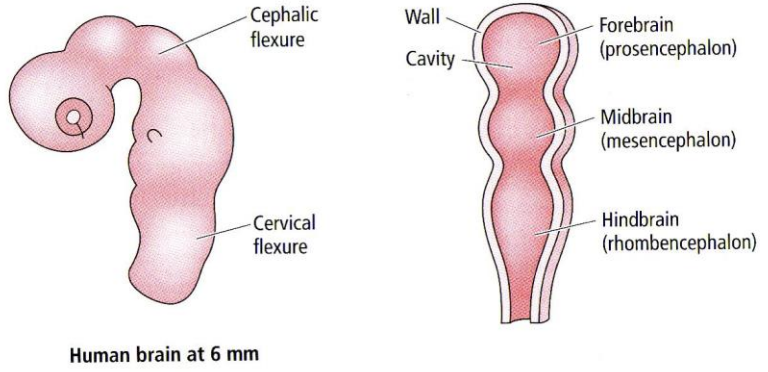
Reponses to foreign contrast at 11 months of age



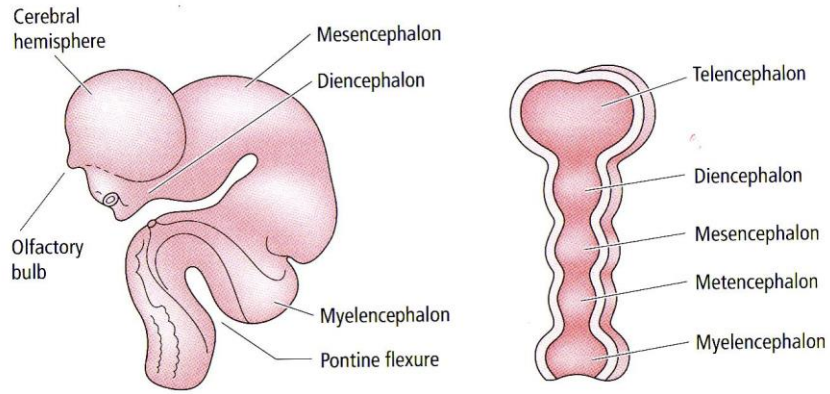








Human brain at 6 mm



Human brain at 27 mm

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

Principles of Cognitive Neuroscience.

“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. ”

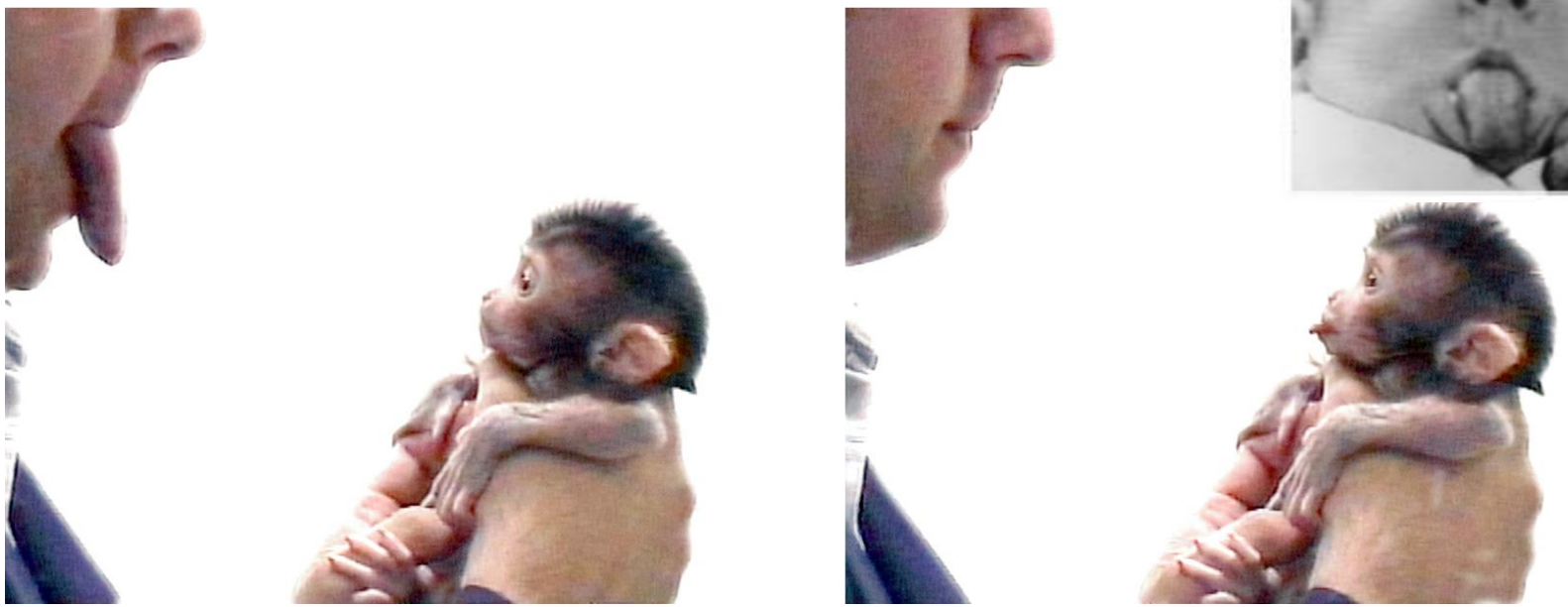
Keven, N. & K.Akins. 2016.

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

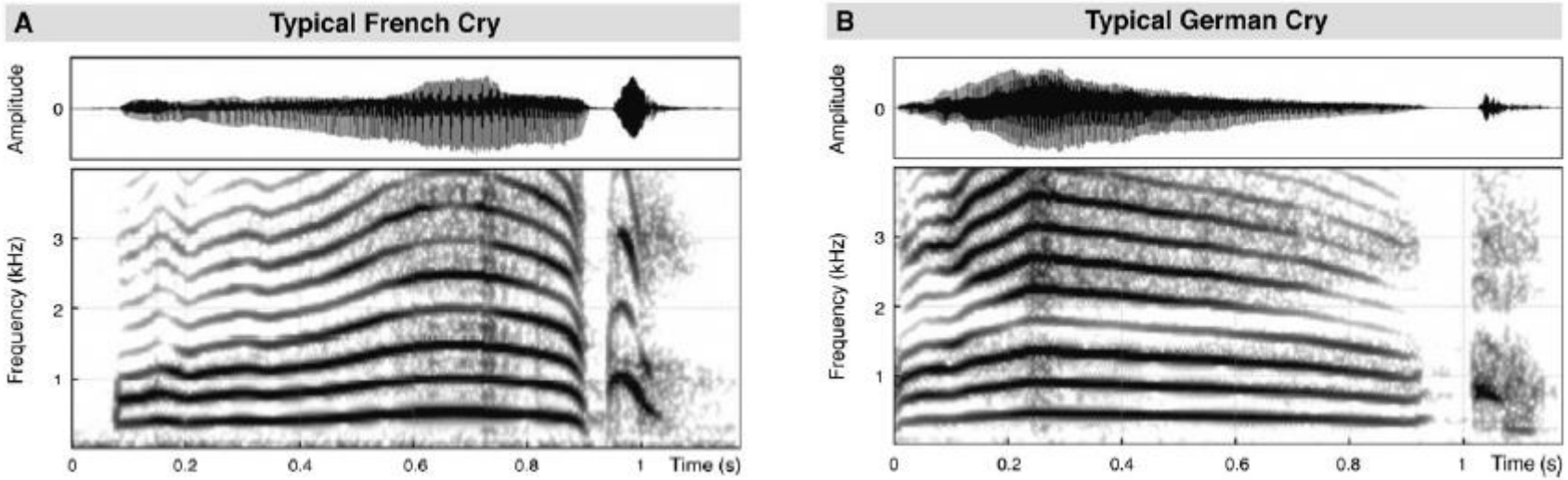
Behavioral and Brain Sciences Fig.2.

Imitation by primates & mirror neurons.

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



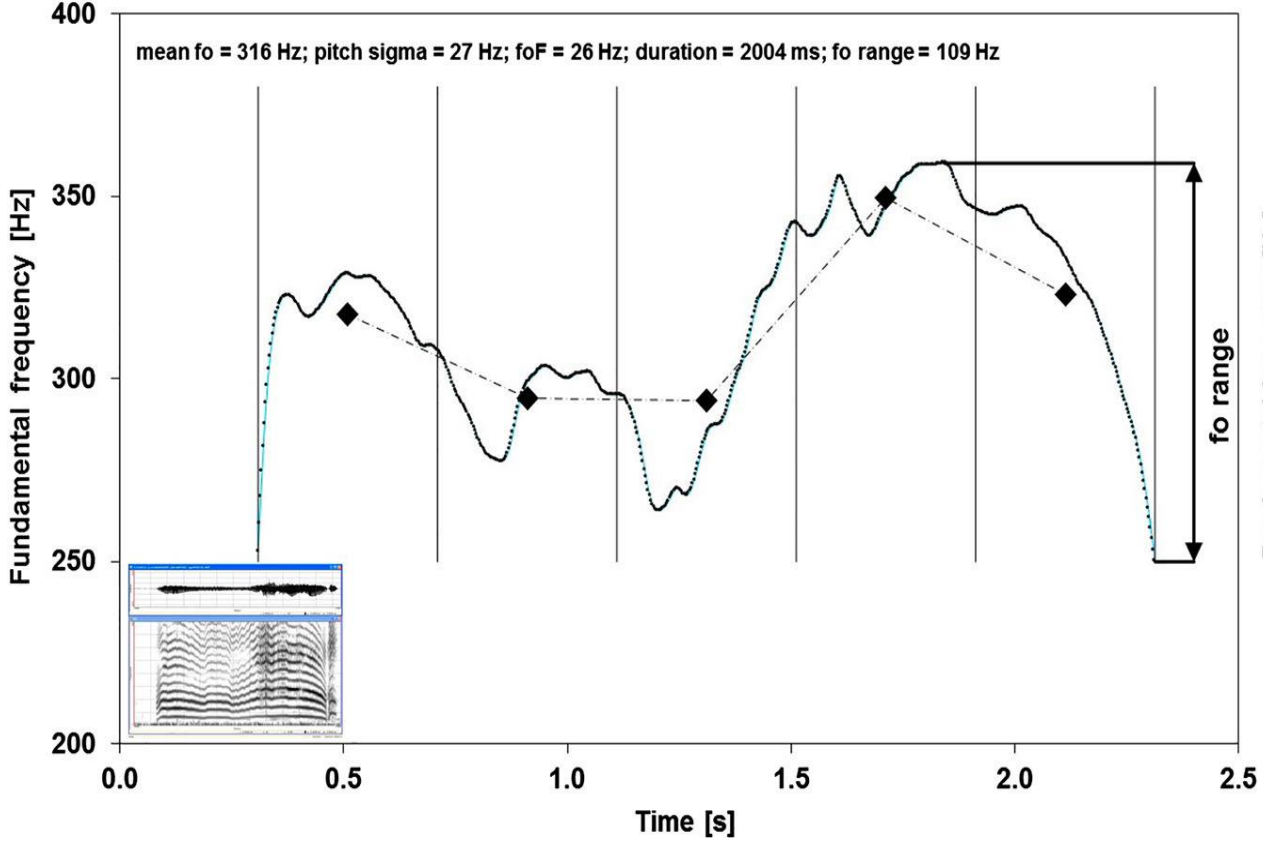
Meltzoff, A.N. & Moore, M.K. 1977.
Imitation of facial & manual gestures
by human neonates.
Science 198, 75–78.

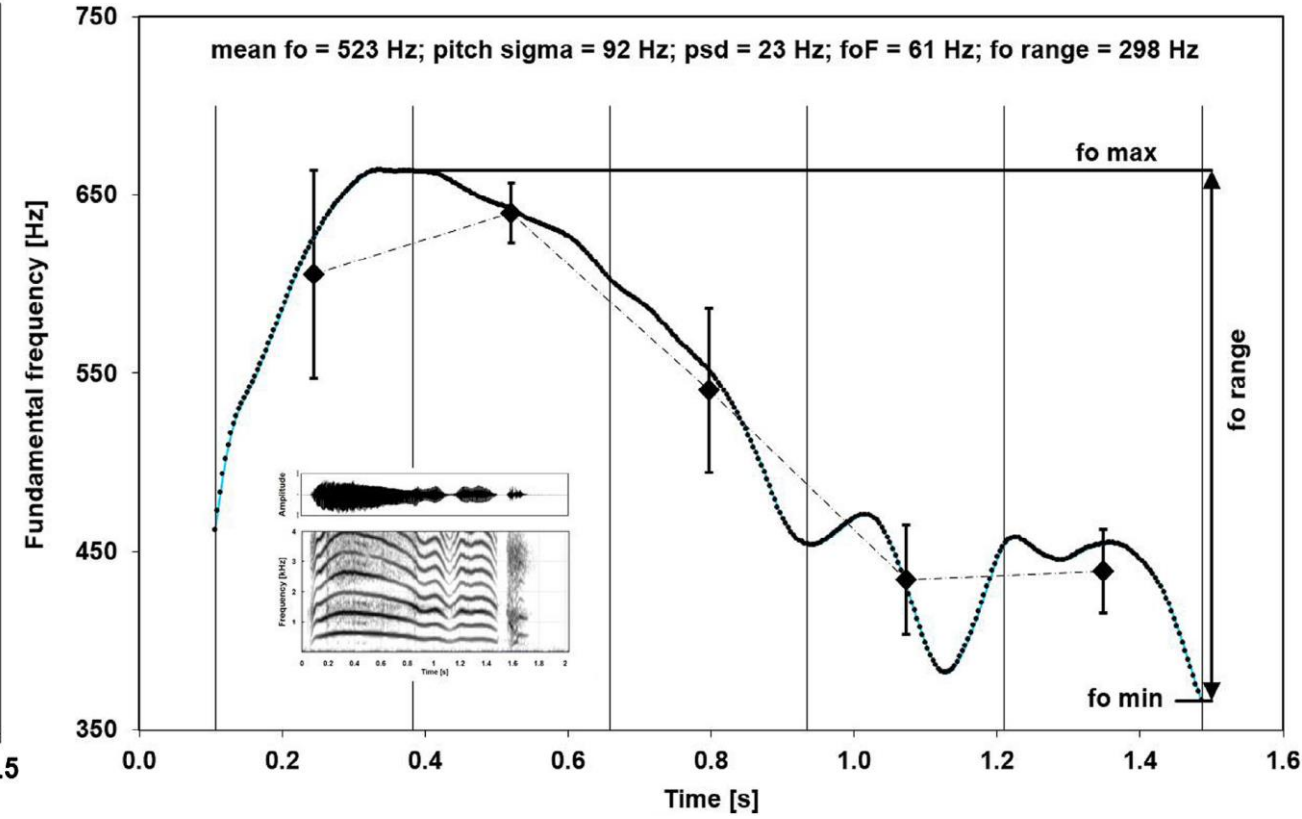


Time Waveform and Narrow-Band Spectrograms of a Typical French Cry and a Typical German Cry.

Mampe, B., et al. (2009). "Newborns' Cry Melody Is Shaped by Their Native Language." Current Biology **19**: 1994-1997.

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





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.*

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

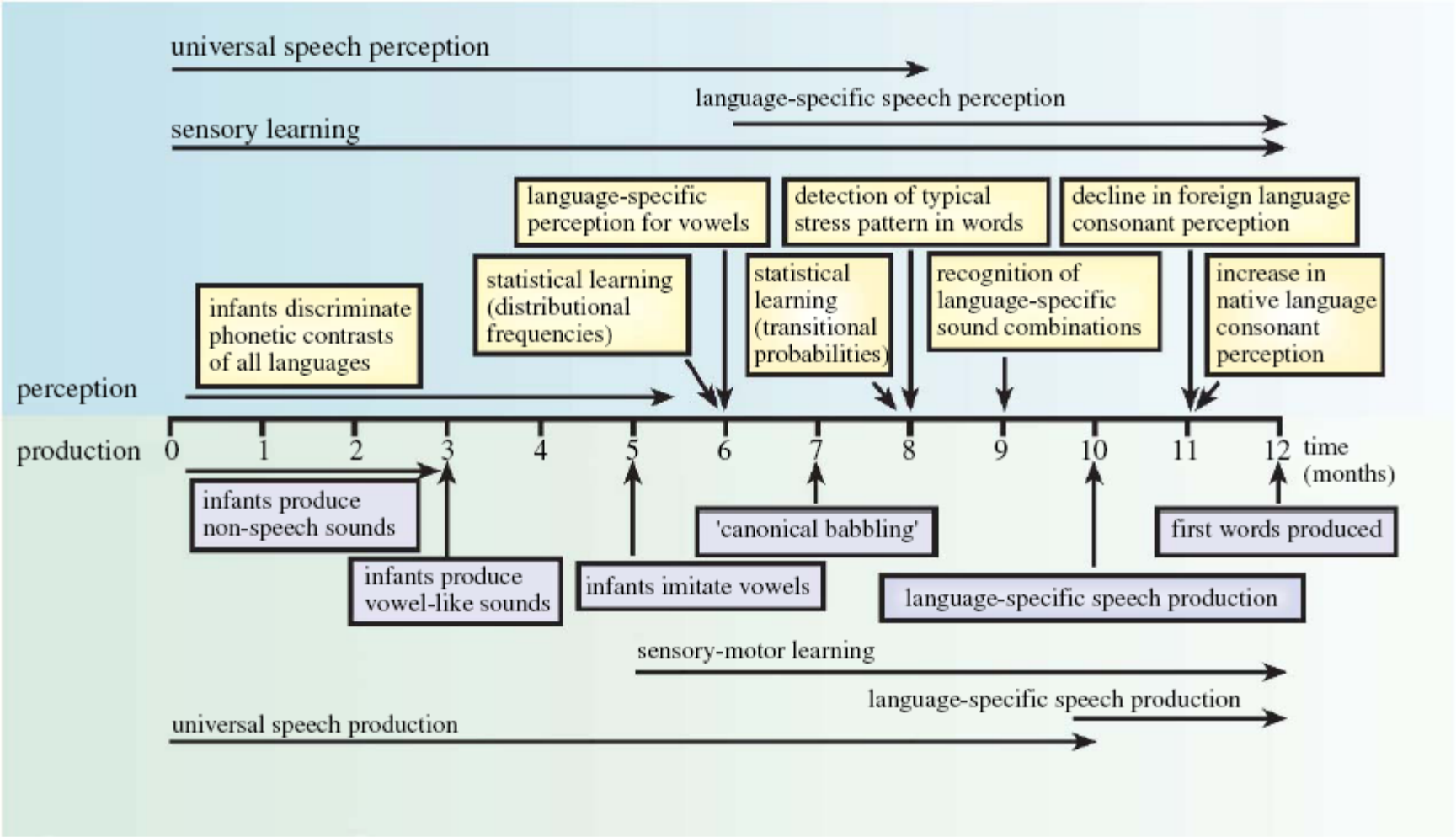


Figure 1. Universal timeline of infants' perception and production of speech in the first year of life. Modified from Kuhl (2004).

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

tupirogolabubidakupadoti

padotibidakutupirotupiro

golabubidakupadotigolabu

bidakutupirogolabupadoti

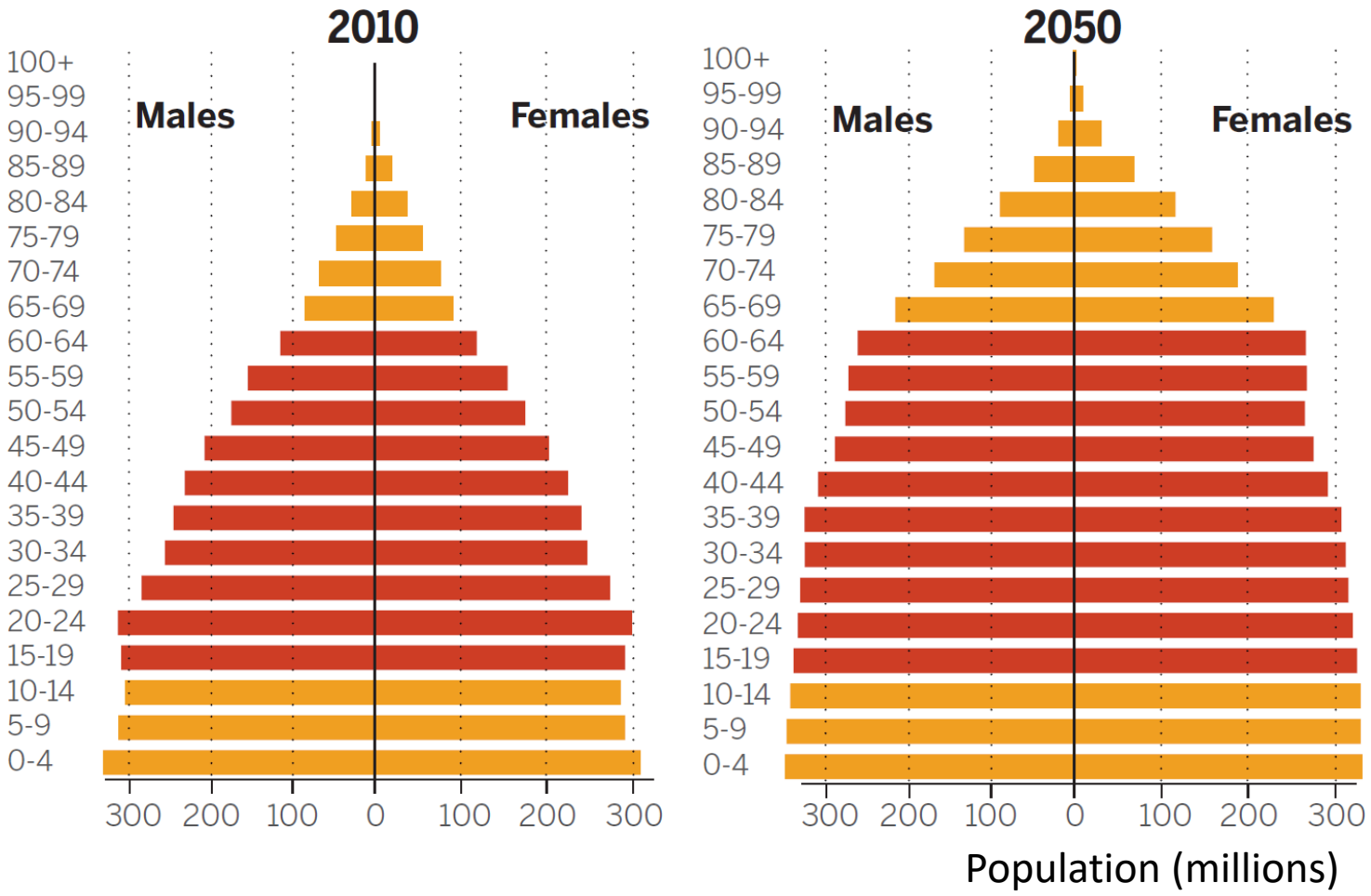
Saffran, J.R., et al. 1996. Statistical Learning by 8-Month-Old Infants. *Science* 274.1926-28.

tupirogolabubidakupadoti

padotibidakutupirotupiro

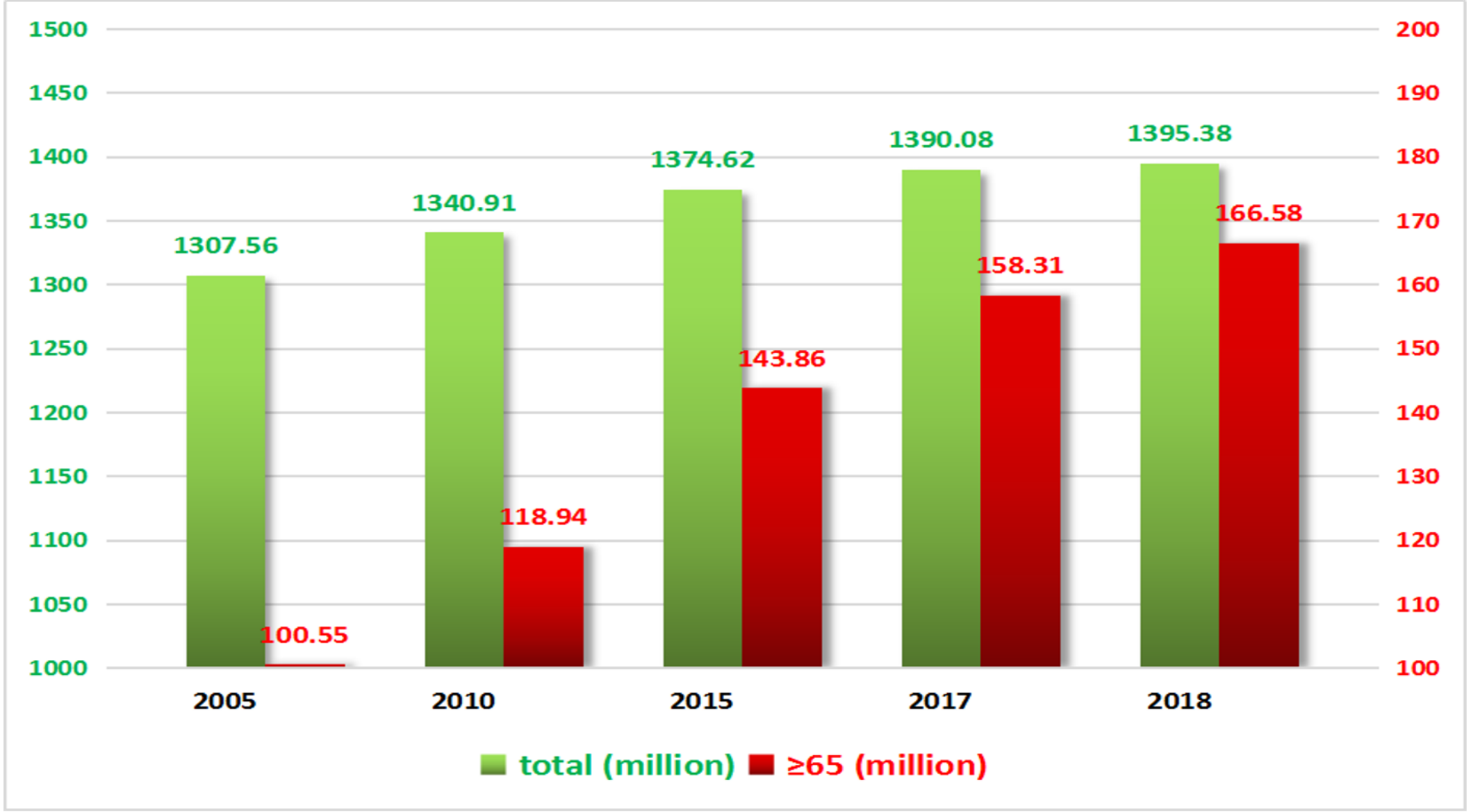
golabubidakupadotigolabu

bidakutupirogolabupadoti



Harper, S 2014. Economic and social implications of aging societies. ***Science*** 346: 587-91.

"In terms of absolute numbers, the Asian/Pacific region is already the oldest, & by the middle of the century will hold two-thirds of the world's then 2 billion elders (aged 60 years or over). The world wide numbers of those aged 80 & above will show an even greater rate of increase, rising from 69 million to 379 million by 2050,when nearly 10% of the developed world will be over 80."

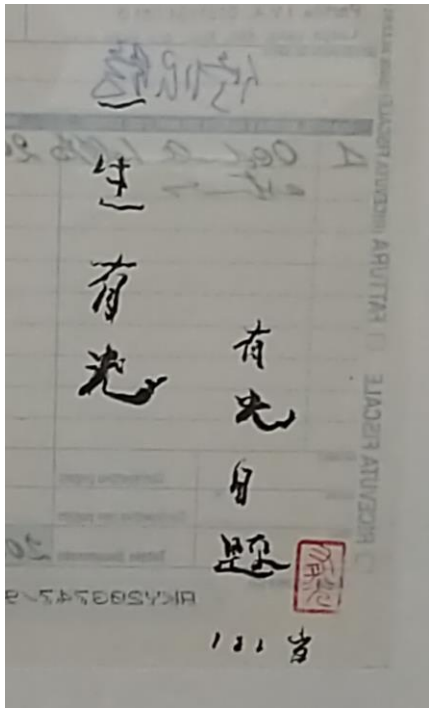


POPULATION AGEING in CHINA

GREEN: Total population in millions.

RED: Elders ≥ 65 population in millions.

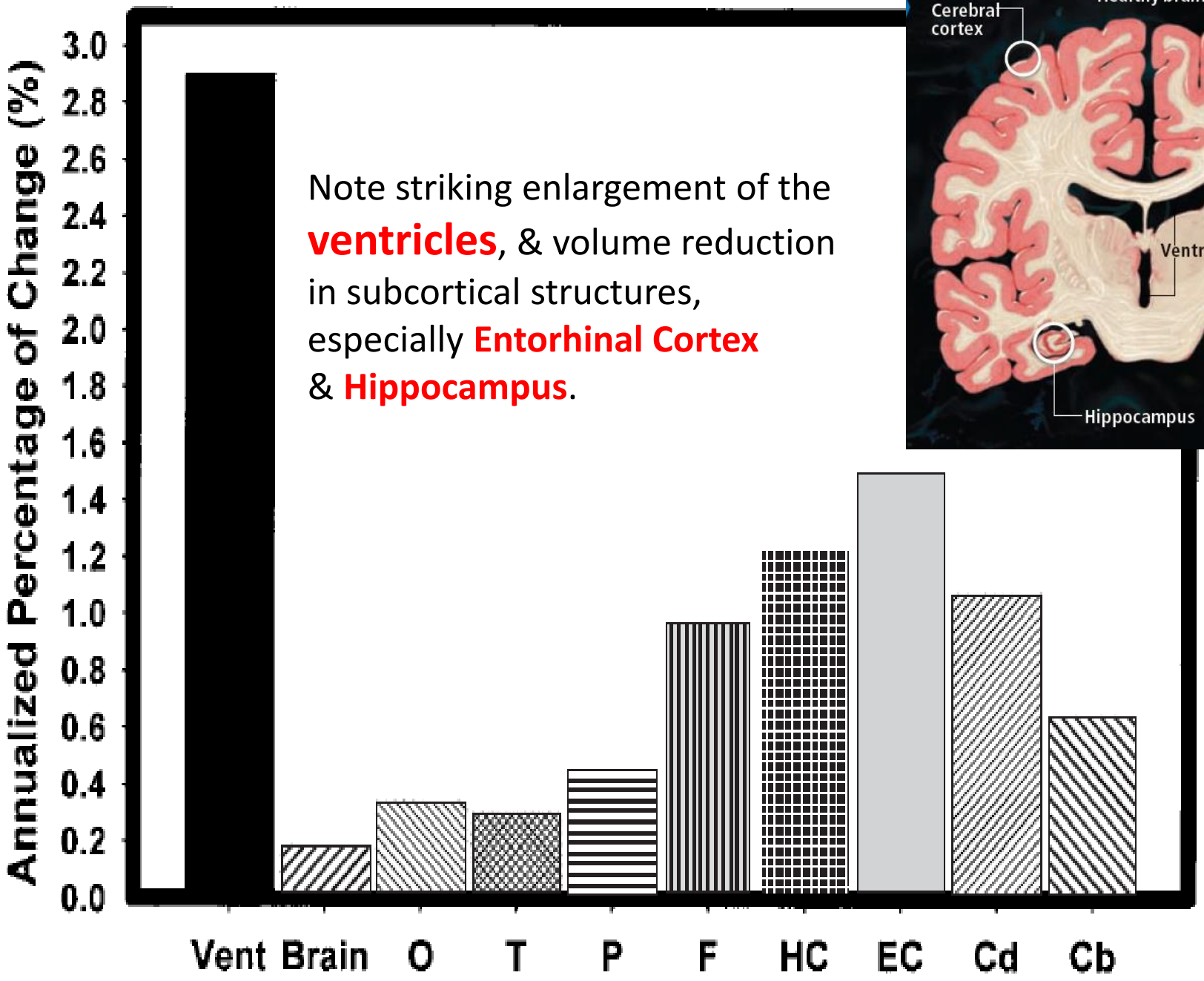
In 2005, elders ≥ 65 were **8%** of the total population; in 2018 they have risen to **12%**.
Over this period, the total population has risen by **7%**; the elders have risen by **66%**.
Government survey: http://data.stats.gov.cn/easyquery.htm?cn=C01&zb=A0305&sj=2017.



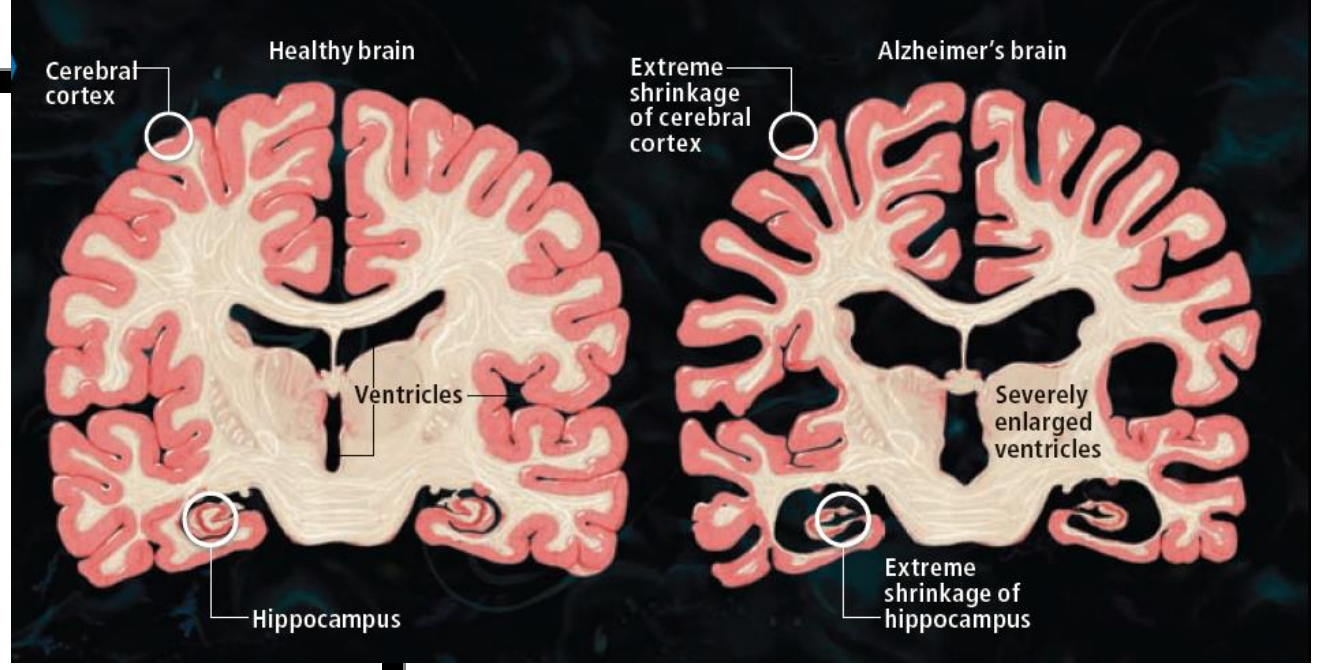
Zhou Youguang,
周有光,
1906 – 2017.
Advocate of
Hanyu Pinyin.

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

Professor Charles Kuen Kao (高錕) (1933-2018), was the recipient of a Nobel Prize in Physics in 2009, & was known as the
"Father of Fibre Optics".
He had Alzheimer's Disease, as did his father.



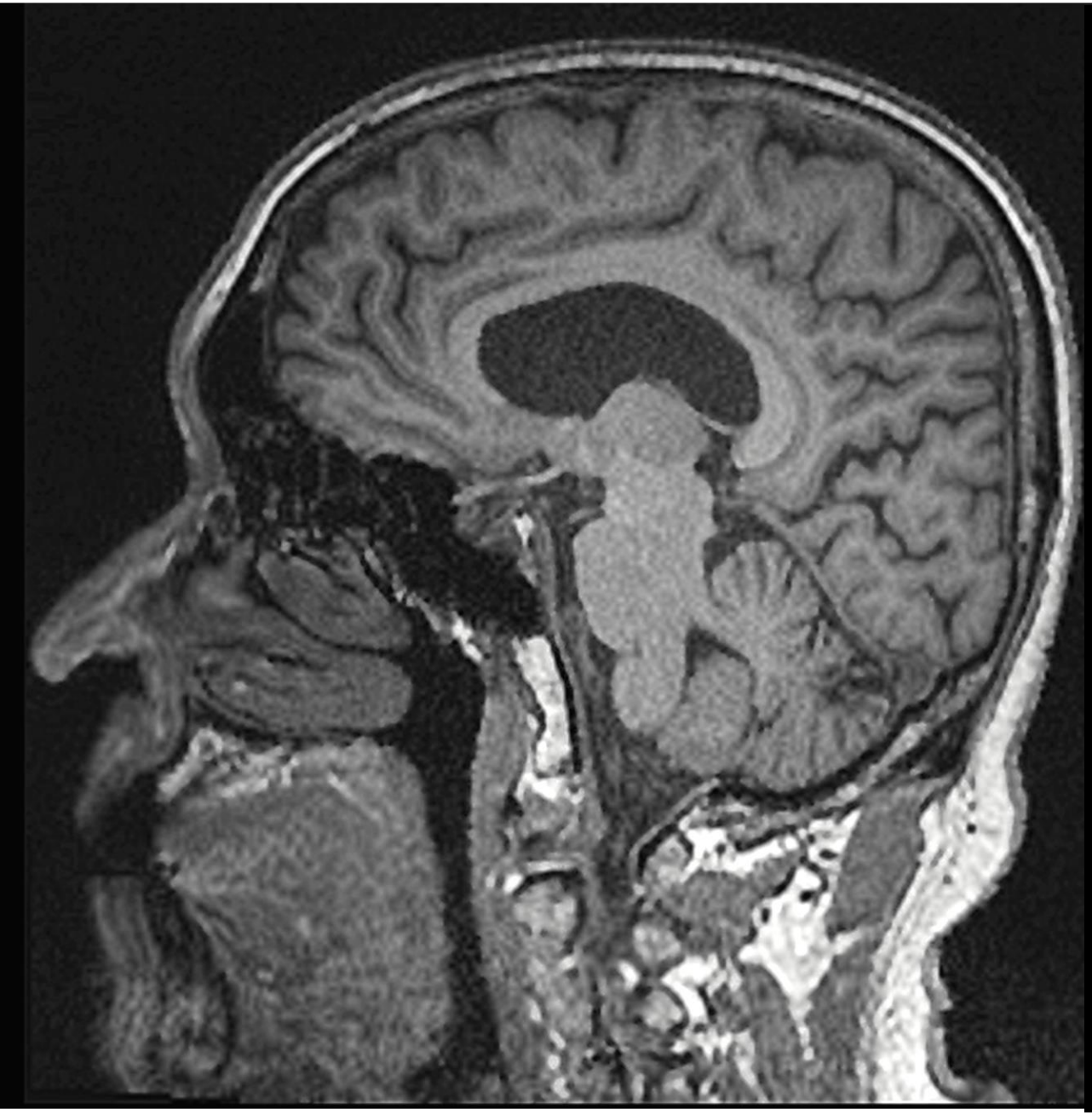
Note striking enlargement of the **ventricles**, & volume reduction in subcortical structures, especially **Entorhinal Cortex** & **Hippocampus**.



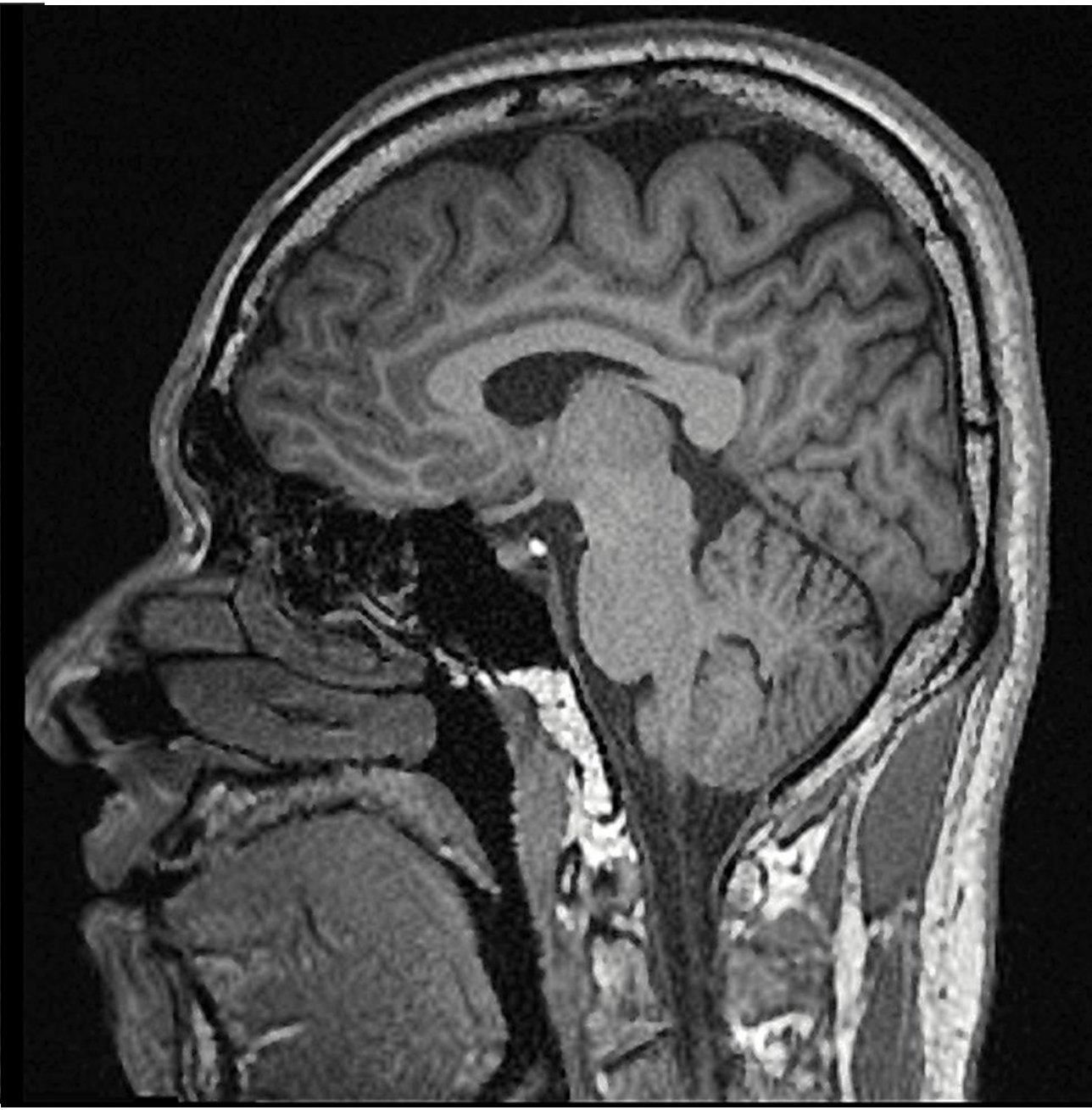
Cabeza, R.et al. eds. 2005:41. *Cognitive Neuroscience of Aging: Linking Cognitive and Cerebral Aging*: Oxford University Press.

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

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

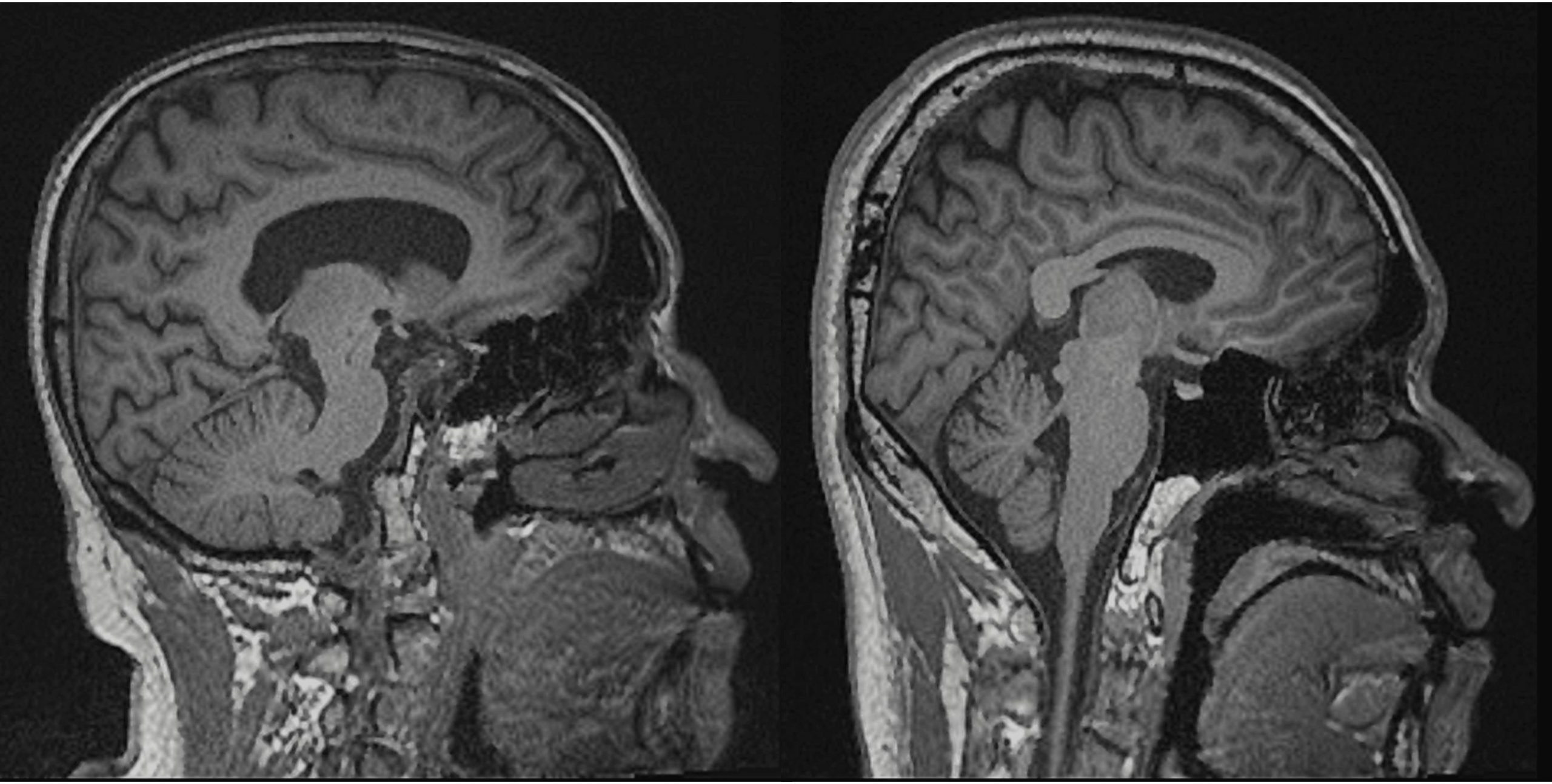


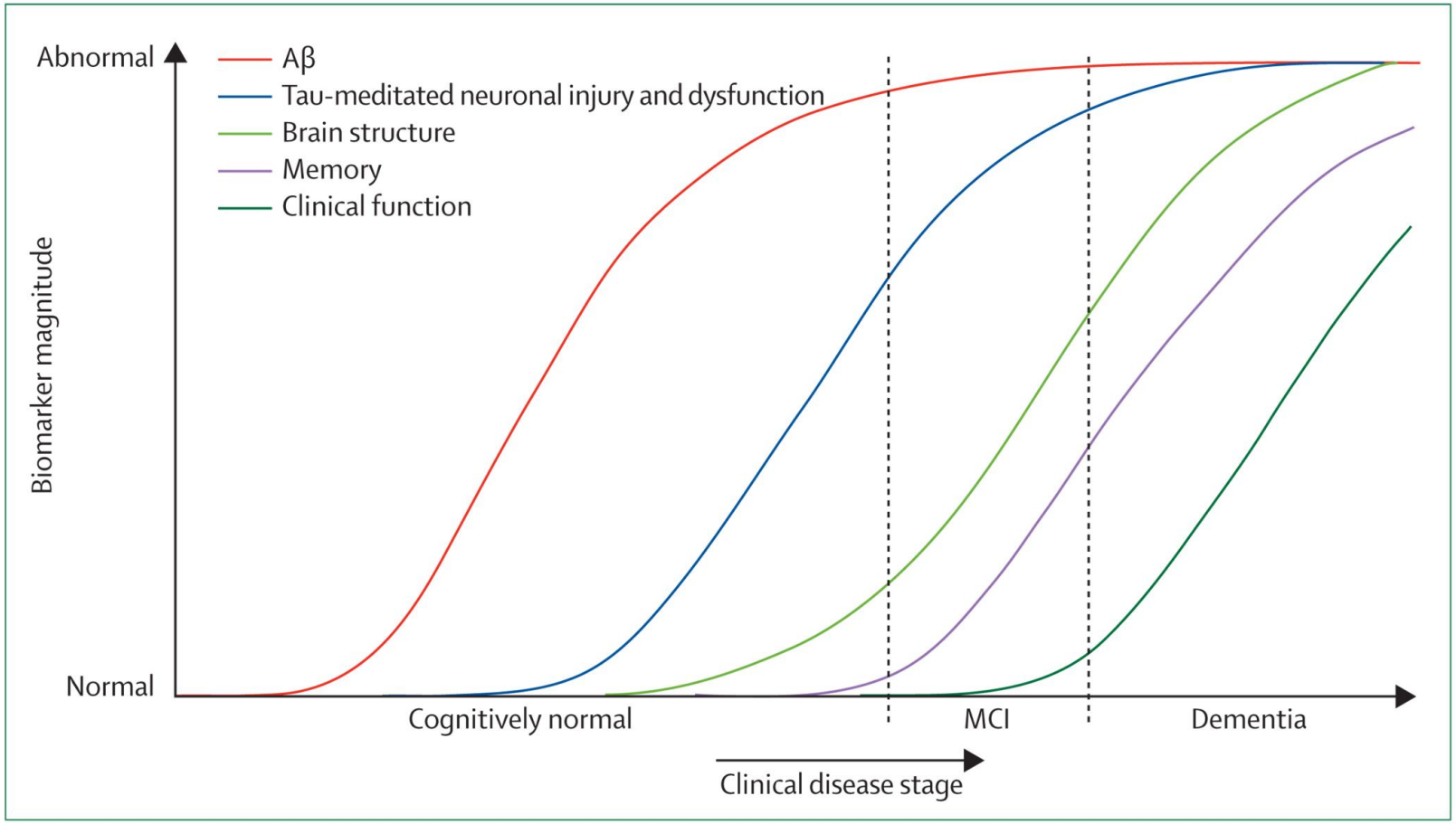
Frame number = 91 5,256 c.m.



Right ventricle Frame number = 107 31,484 c.m.

Frame number = 103 4,624 c.m.





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It is crucial for us to know how much of current knowledge, derived primarily from WEIRD studies, is applicable to Chinese language and culture.

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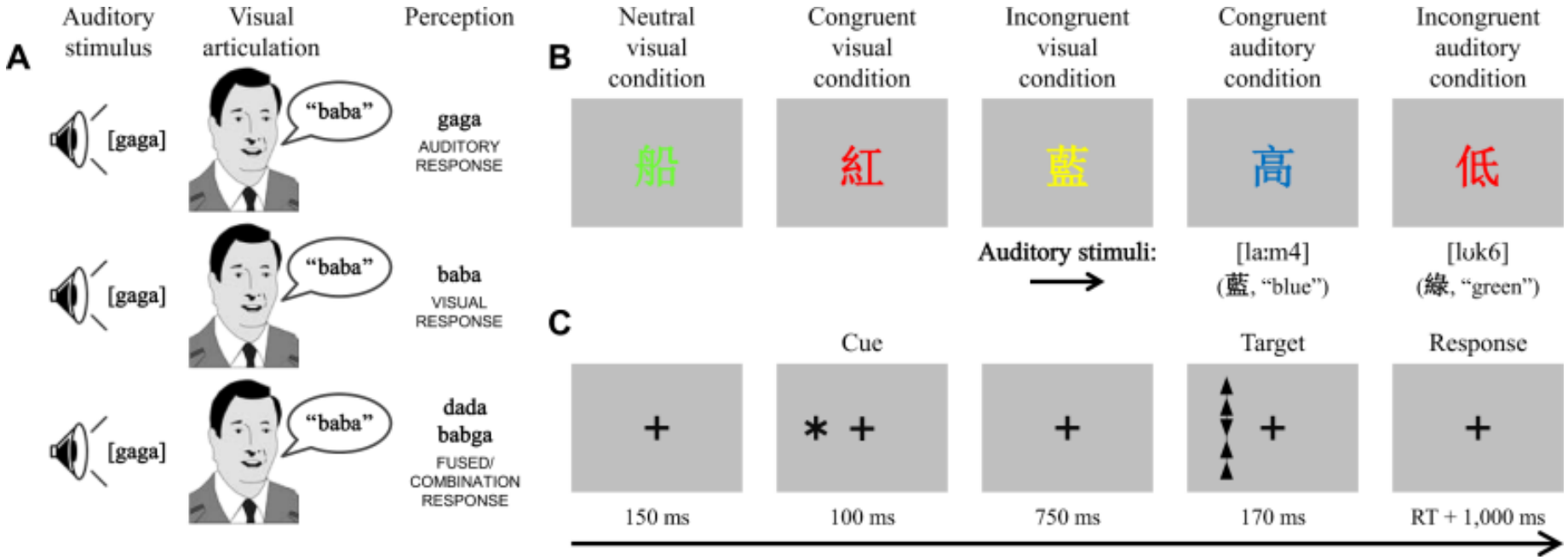
Since lexical tones have much in common with music, will Melodic Intonation Therapy be more effective for speakers of tone language?

Multi-sensory Integration:
Stroop, McGurk, Eriksen Flanker Tasks



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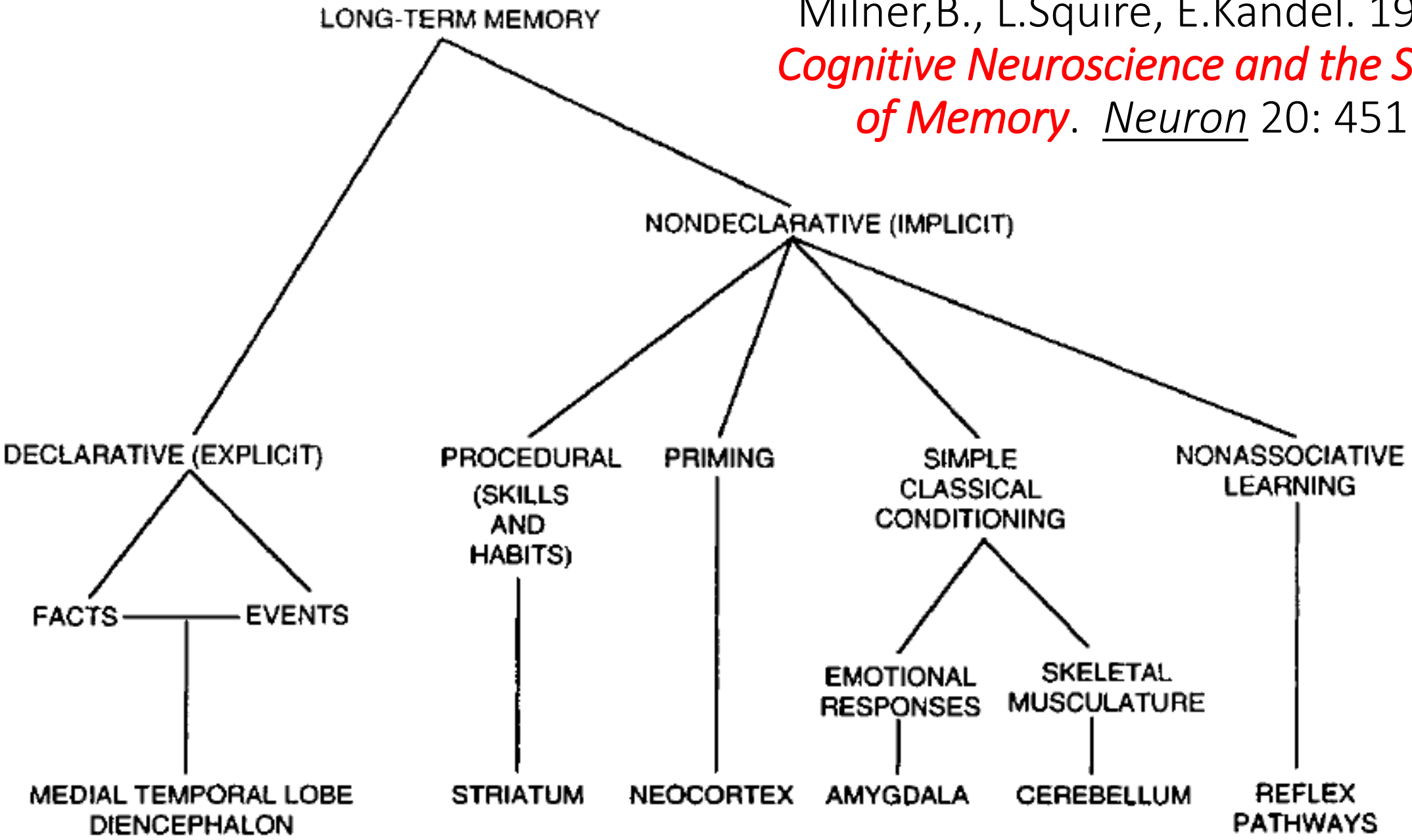

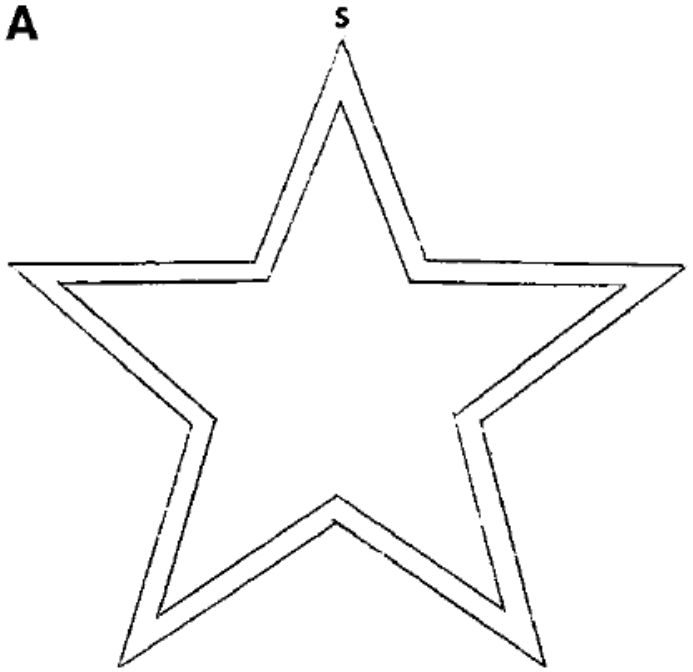

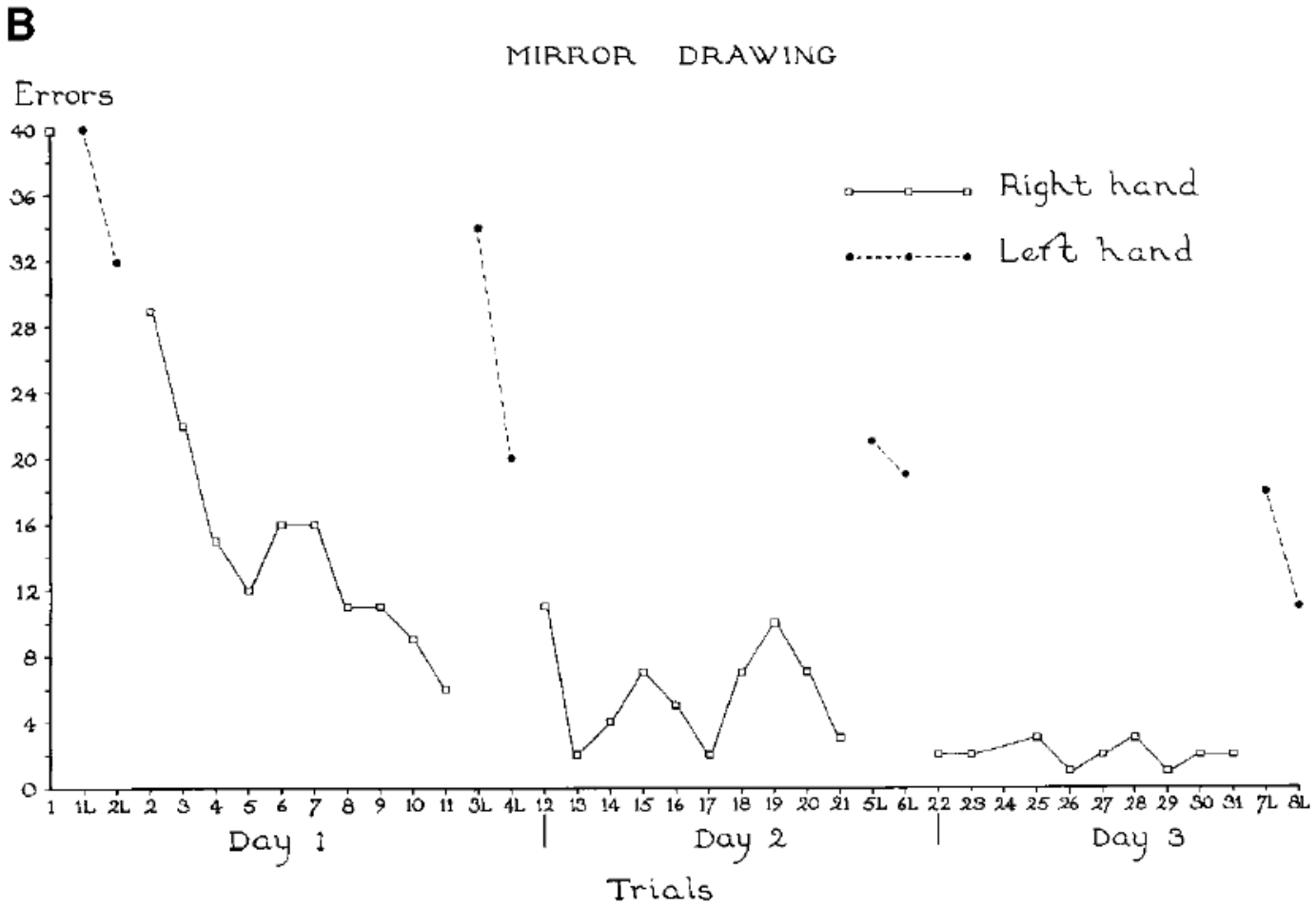

Figure 2. H. M. Showed Improvement in a Task Involving Learning Skilled Movements

In this test, he was taught to trace a line between the two outlines of a star, starting from the point S (Figure 2A), while viewing his hand and the star in a mirror. He showed steady improvement over the 3 days of testing, although he had no idea that he had ever done the task before.

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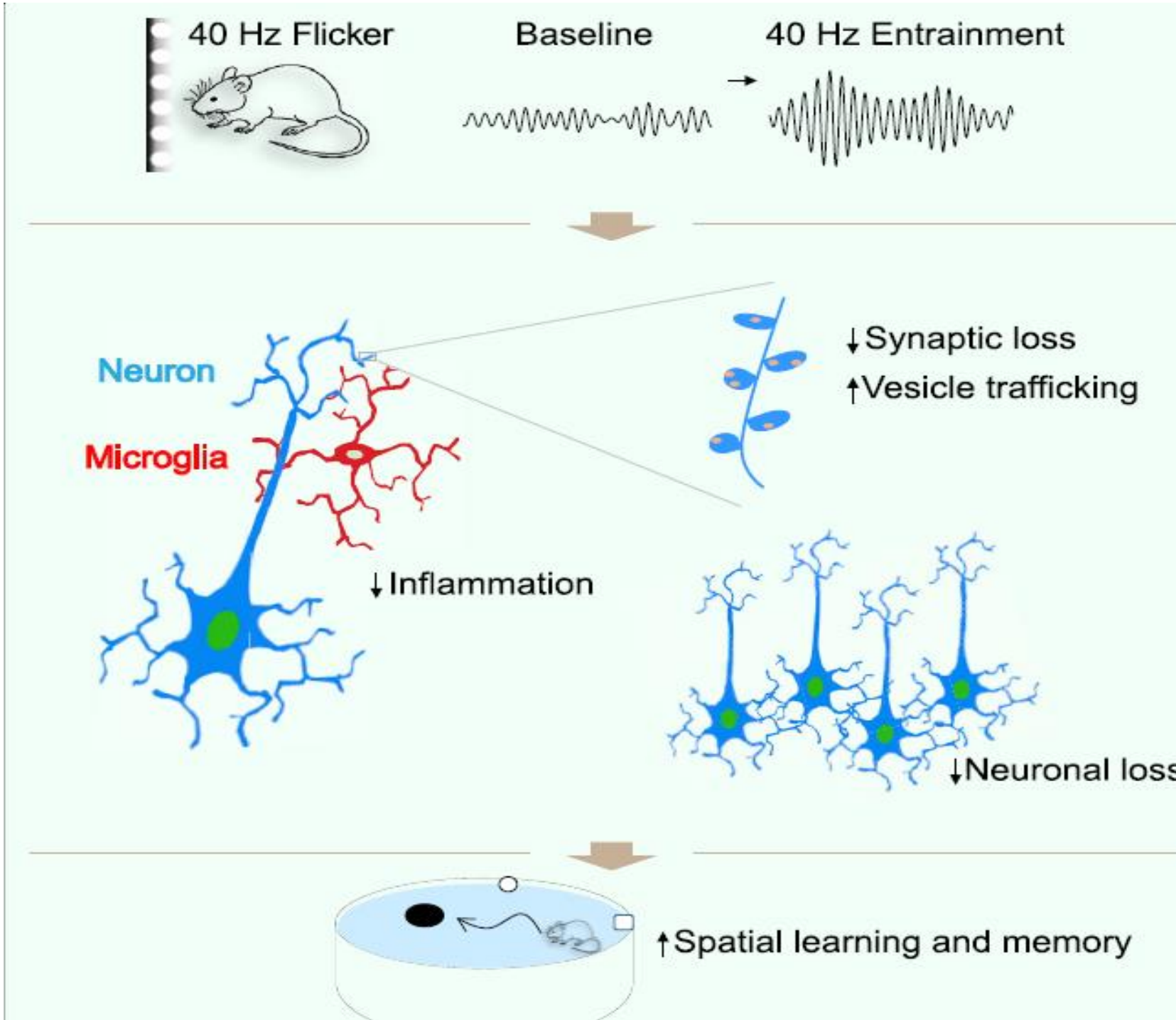


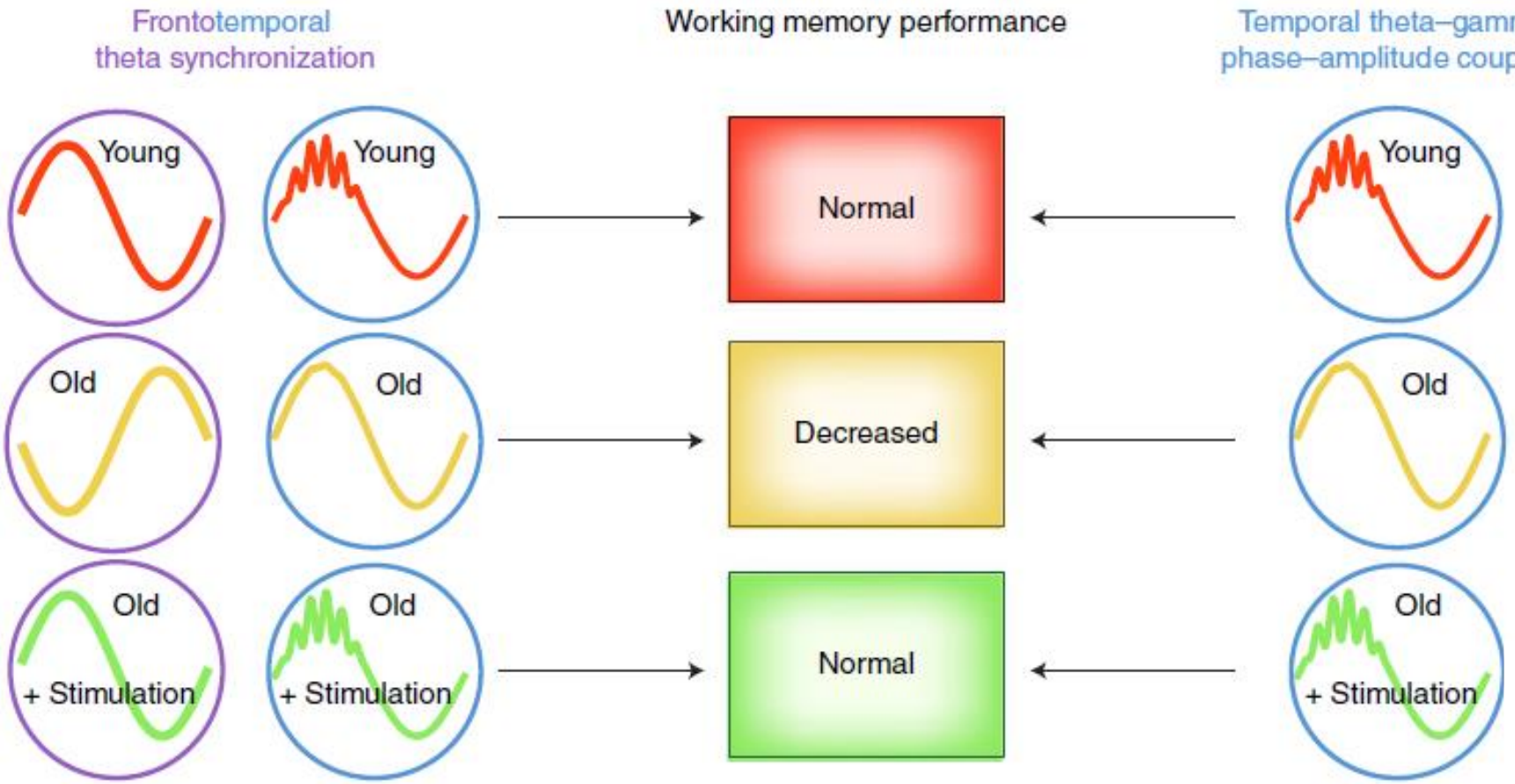
ARTICLES
https://doi.org/10.1038/s41593-019-0371-x
nature neuroscience

Working memory revived in older adults by synchronizing rhythmic brain circuits

Nature Neuroscience
22: 820-827, May 2019.

Robert M. G. Reinhart * and John A. Nguyen

Understanding normal brain aging and developing methods to maintain or improve cognition in older adults are major goals of fundamental and translational neuroscience. Here we show a core feature of cognitive decline—working-memory deficits—emerges from disconnected local and long-range circuits instantiated by theta–gamma phase–amplitude coupling in temporal cortex and theta phase synchronization across frontotemporal cortex. We developed a noninvasive stimulation procedure for modulating long-range theta interactions in adults aged 60–76 years. After 25 min of stimulation, frequency-tuned to individual brain network dynamics, we observed a preferential increase in neural synchronization patterns and the return of sender–receiver relationships of information flow within and between frontotemporal regions. The end result was rapid improvement in working-memory performance that outlasted a 50 min post-stimulation period. The results provide insight into the physiological foundations of age-related cognitive impairment and contribute to groundwork for future non-pharmacological interventions targeting aspects of cognitive decline.



Quentin, R. and L. G. Cohen (2019). Reversing working memory decline in the elderly. *Nature Neuroscience* **22**: 686-688.

"China already has a population of elderly of around 178 million (surpassing that of the number of elderly in all the European countries put together). It is estimated that by 2040 people aged 60 and older will make up about 28% of the population - in absolute numbers 397 million people … **Worries about the impact that the growing ranks of elderly will have on the economy and on individual families have been dubbed in China as the 4-2-1 problem because… a single person in China will soon be expected to support two parents and four grandparents.** The media are only now beginning to expose the ignorance and stigma long associated with dementia in China …"

Lock, M. 2013. The Alzheimer Conundrum: Entanglements of Dementia and Aging. Princeton University Press. p.16.

Since the International Association of Chinese Linguistics was founded 27 years ago, we have made great **contributions to scholarship**, building upon our rich heritage in languages, dialects, & texts. Now there is a precious opportunity for Chinese Linguistics to make important **contributions to society** as well, by exploring how language impairments reveal trajectories of brain decline, and how we can use language to minimize the damage to the individual, family, & society, so that elders can remain comfortable & productive.

I hope many members of IACL will join in with other disciplines to meet this **urgent challenge** worldwide. Please let me know if I can help in any way.

どうもありがとうございました！

謝謝！

Thank you!

3q!

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