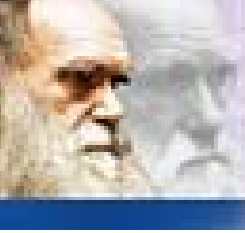
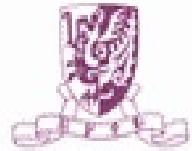


語言工程實驗室
Language Engineering Laboratory



LANGUAGE, *EVOLUTION and the BRAIN*

Nanyang Technological University
March 7 ,2011

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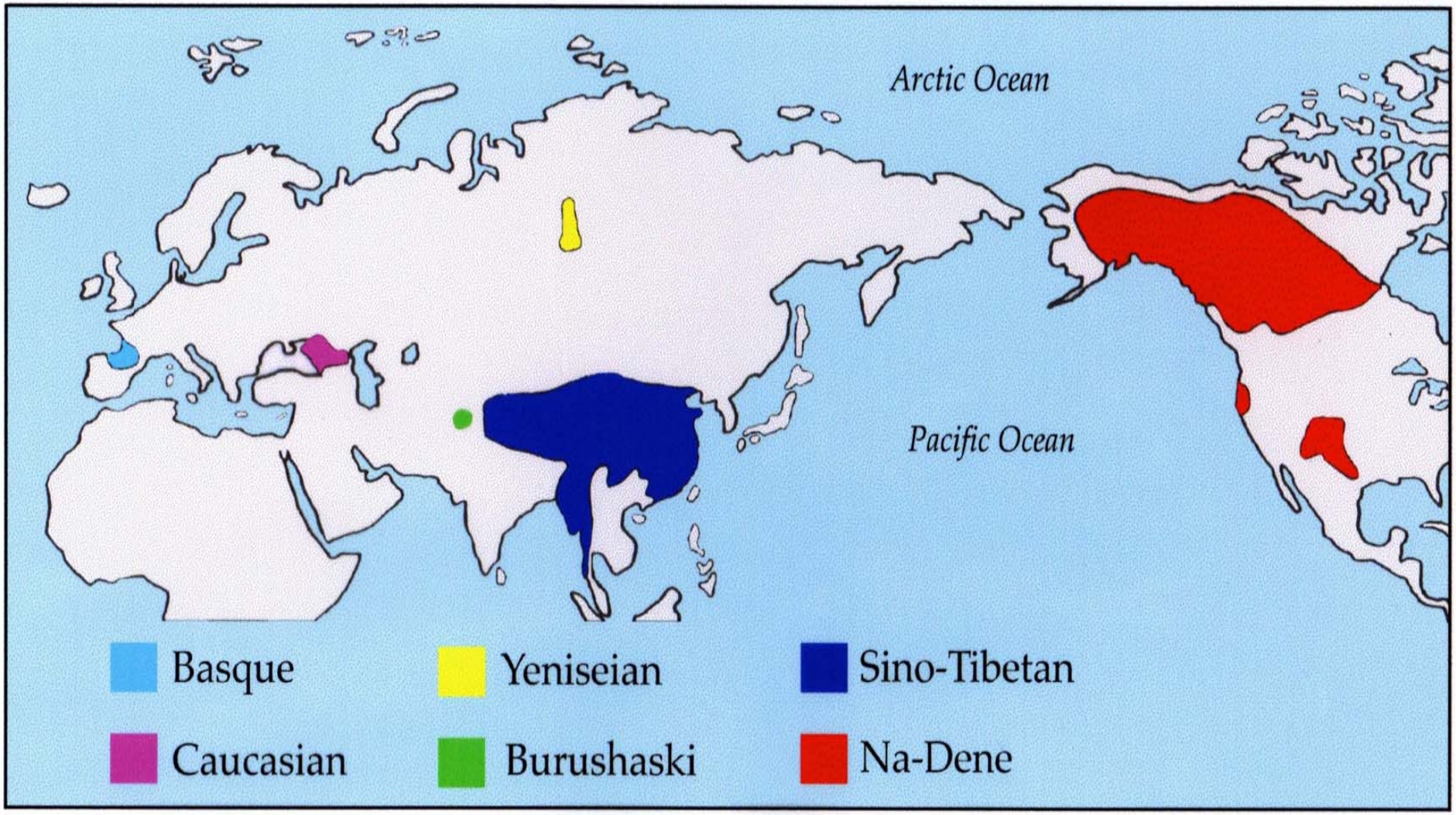
www.ee.cuhk.edu.hk/~lel/public/download/

ntu1w.pdf
ntu2w.pdf
ntu3w.pdf

Comments would be appreciated!

wsywang@ee.cuhk.edu.hk



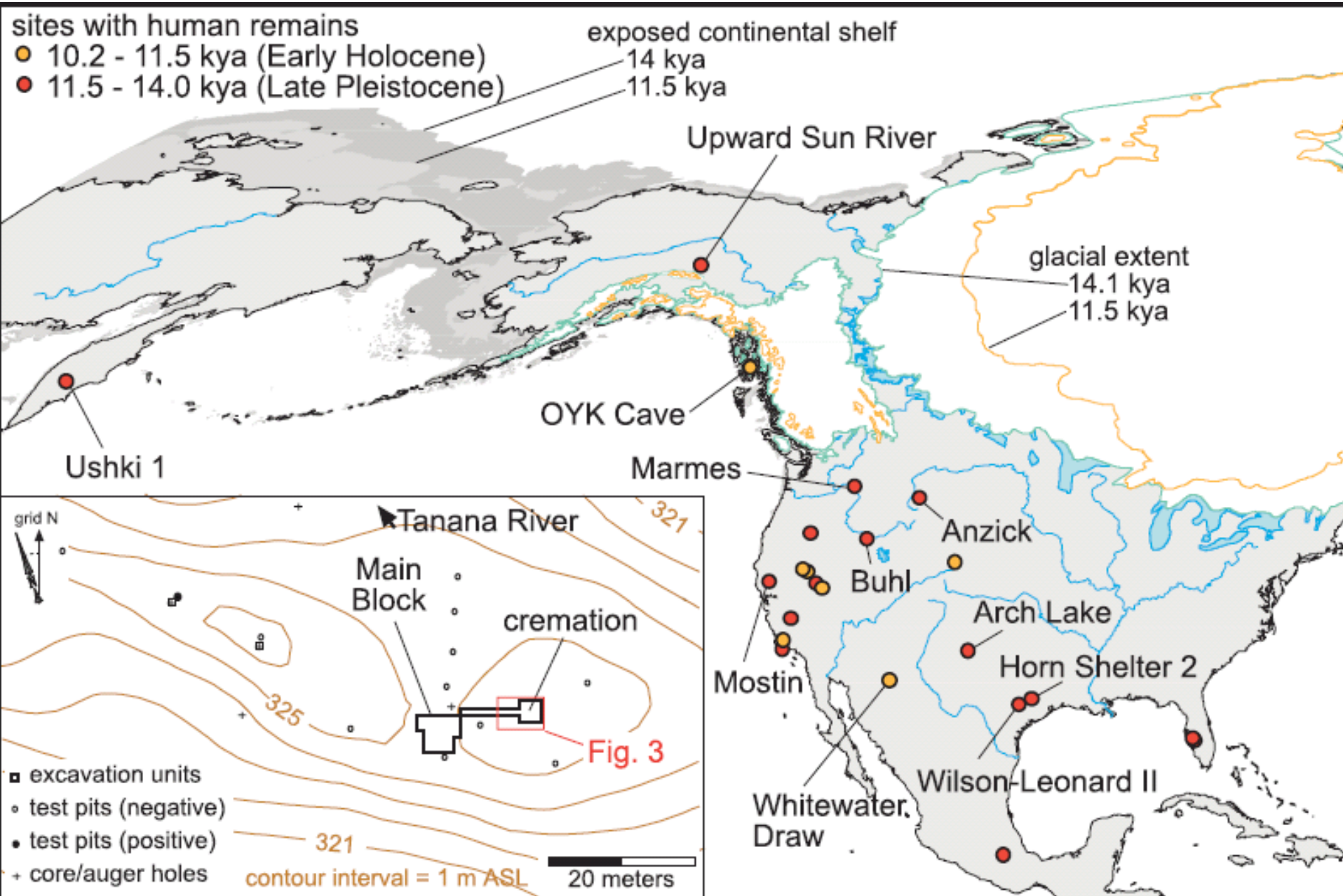
The Dene-Caucasian Family

Ruhlen, Merritt. 1998.
The origin of the Na-Dene. ***Proc.Natl.Acad.Sci.USA 95.13994-13996.***

	Ket	Proto-Athabaskan
birch bark	qɨ'y	
birch tree		*q'əy

Postponement of glottal stop also occurs in the words for *stone, utensil, bow, and foot.*

Potter, et al. 2011. Science 331.1058.



Ben A. Potter, *et al.*

A Terminal Pleistocene Child Cremation and Residential Structure from Eastern Beringia. *Science* **331**, 1058 (2011);

"The remains are from a ~3-year-old child who was cremated in a pit within a semisubterranean house. The burial-cremation and house have exceptional integrity and preservation and exhibit similarities and differences to both Siberian Upper Paleolithic and North American Paleoindian features."
from Abstract

Language
in multi-disciplinary perspective

	19th century	20th century (first half)	20th century (second half)	21st century
Evolution	Darwin, Mendel	Synthetic theory of evolution	Watson-Crick (1962)	Decoding human genome
Neuro-science	Broca, Wernicke	Cajal (1906) Sherrington (1932)	Sperry (1981) Hebb Penfield	Brain imaging
Linguistics	Schleicher Schmidt	Saussure Sapir Jakobson Greenberg	Generative grammar (MIT) Construction grammar (Berkeley)	Evolutionary linguistics

Meltzoff, A. N. & M. K. Moore. 1977.
Imitation of facial and manual gestures by human neonates. Science 198.75-78.

Kuhl, P.K. 2008. Phonetic learning as a pathway to language: new data and native language magnet theory expanded (NLM-e). *Phil. Trans. R. Soc.* B 363.979–1000.

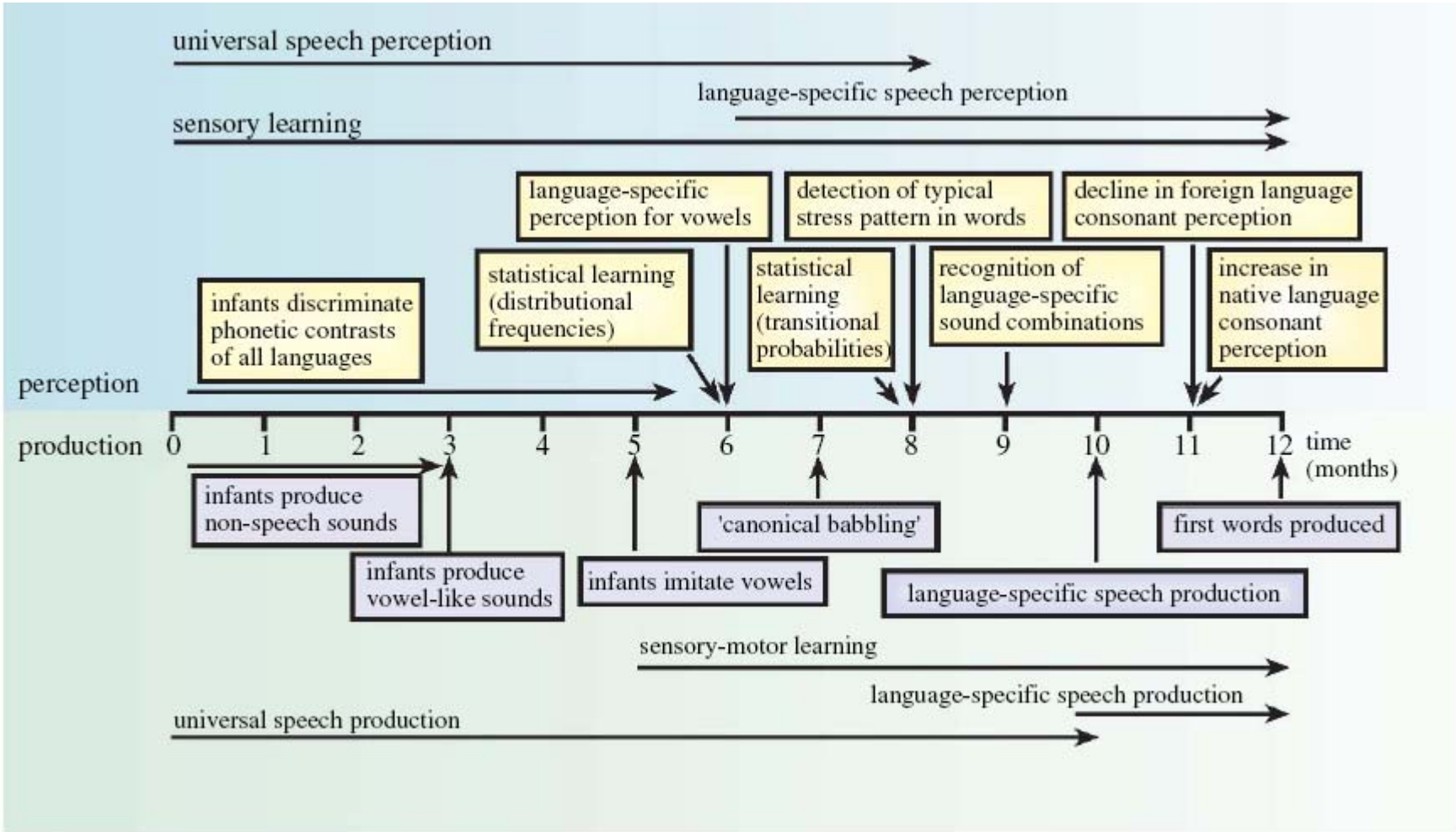


Figure 1. Universal timeline of infants' perception and production of speech in the first year of life. Modified from Kuhl (2004).

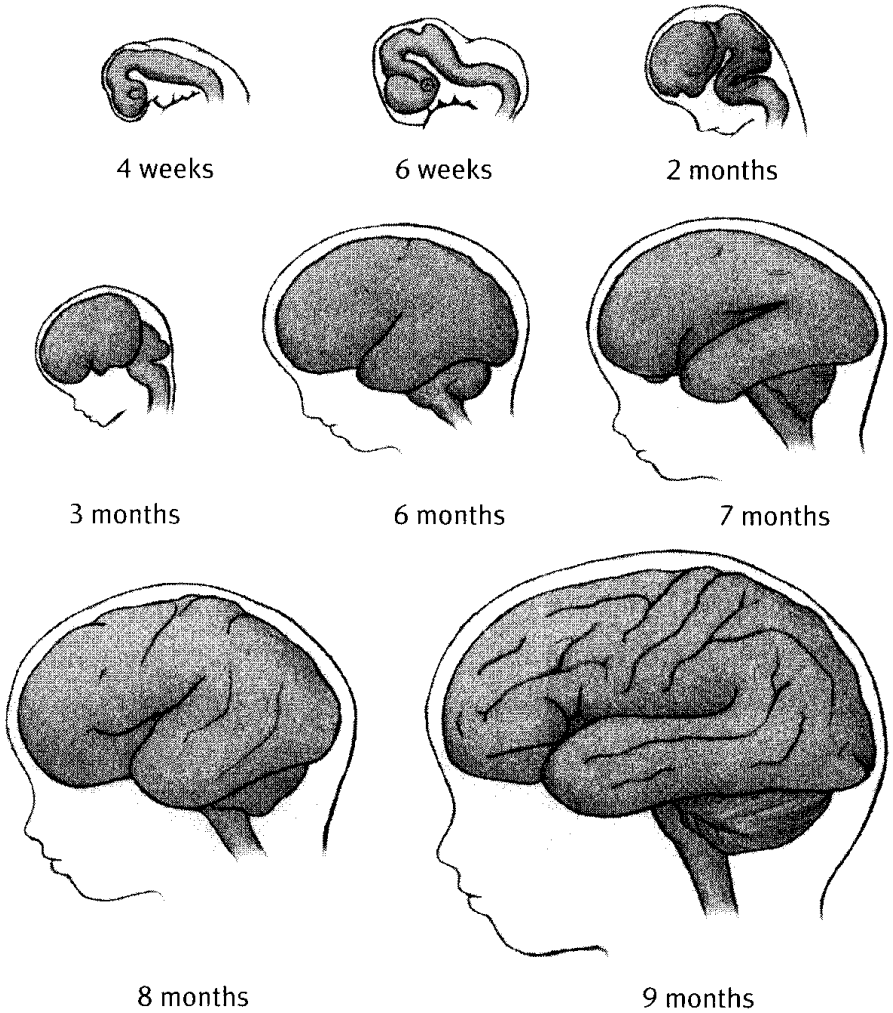
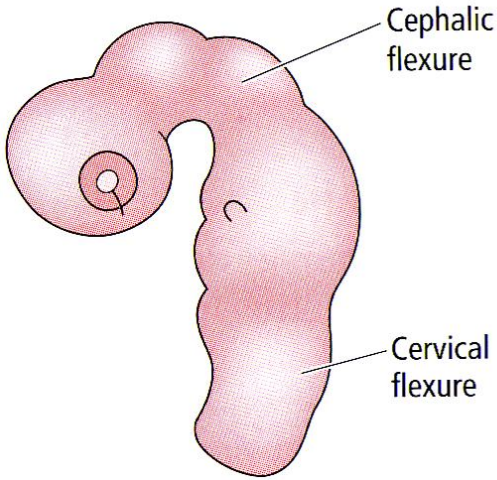
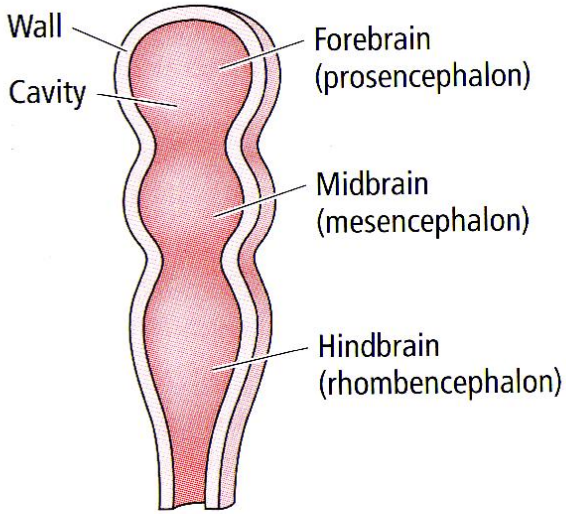


FIGURE 3.3. The development of the brain from 4 weeks after conception, when the neural tube has just formed, through birth. Intermediate stages show the formation of swellings in the neural tube and the expansion and bending of the tube that ultimately give rise to the brain of the newborn. The drawings of the earliest stages are magnified relative to those of the latest stages: the 4-week-old neural tube, for example, is only about 3 millimeters long. Adapted from W. M. Cowan, The development of the brain, *Scientific American* 241:113–133 (1979). *Joan M. K. Tycko, illustrator.*

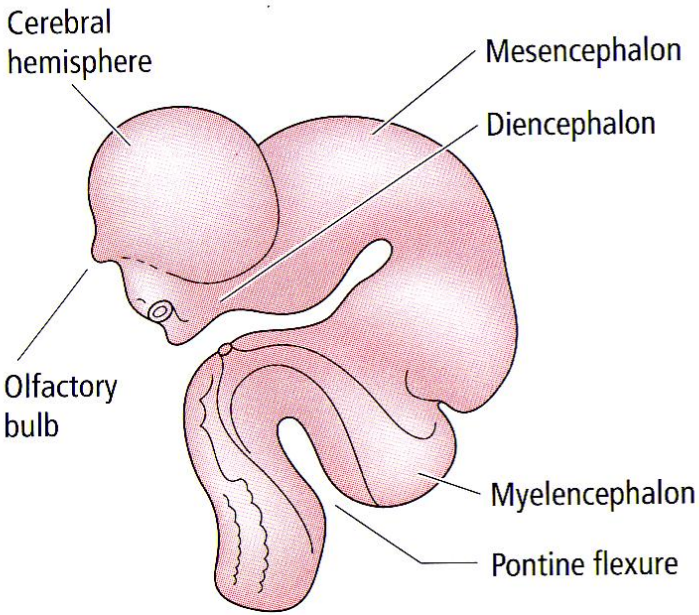
Brain growth in the fetus
胚胎



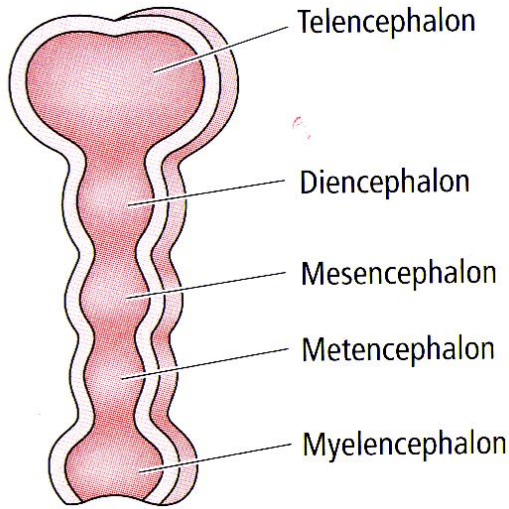
Human brain at 6 mm



Patestas, Maria & Leslie Gartner. 2006. A Textbook of Neuroanatomy: Blackwell.



Human brain at 27 mm



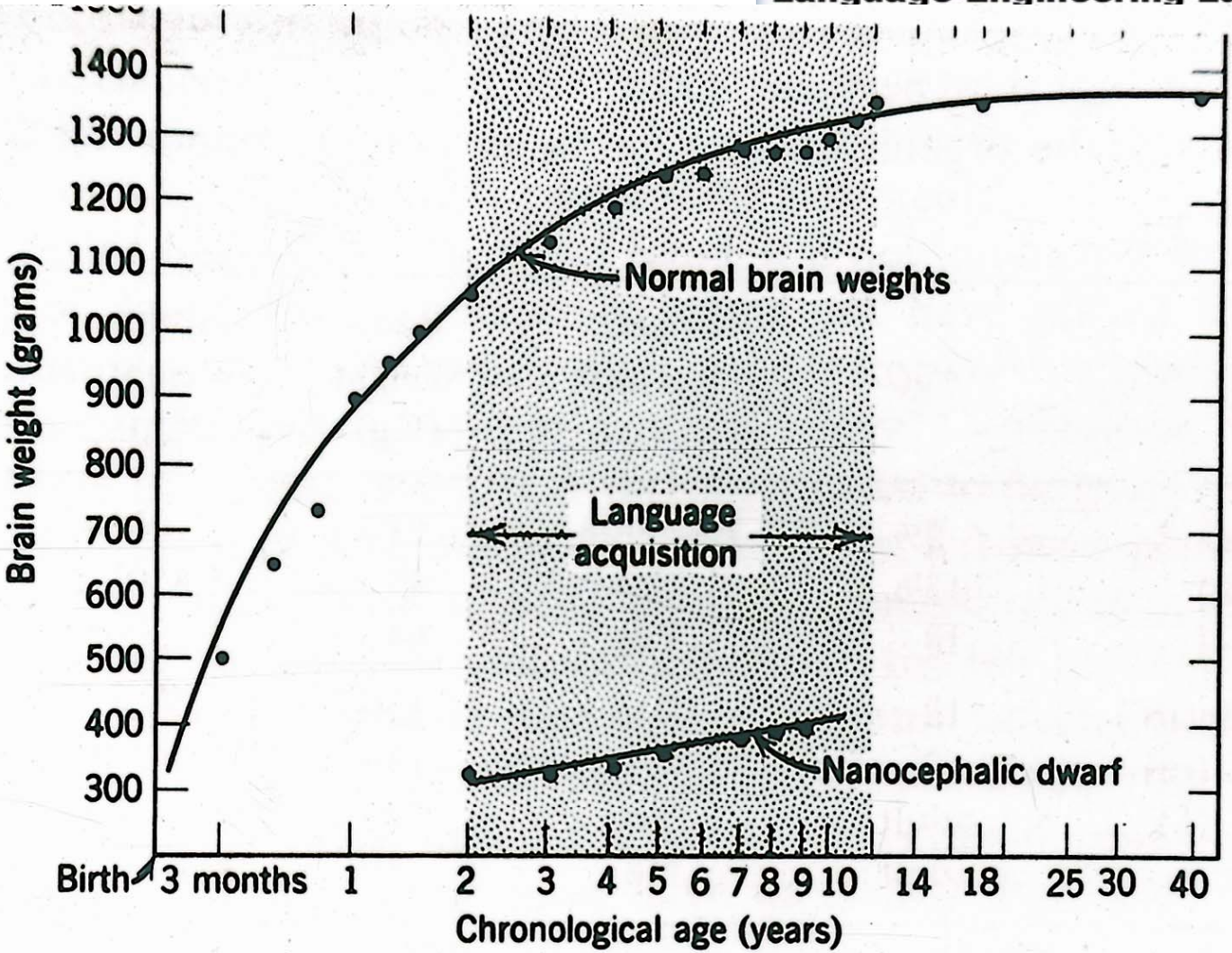
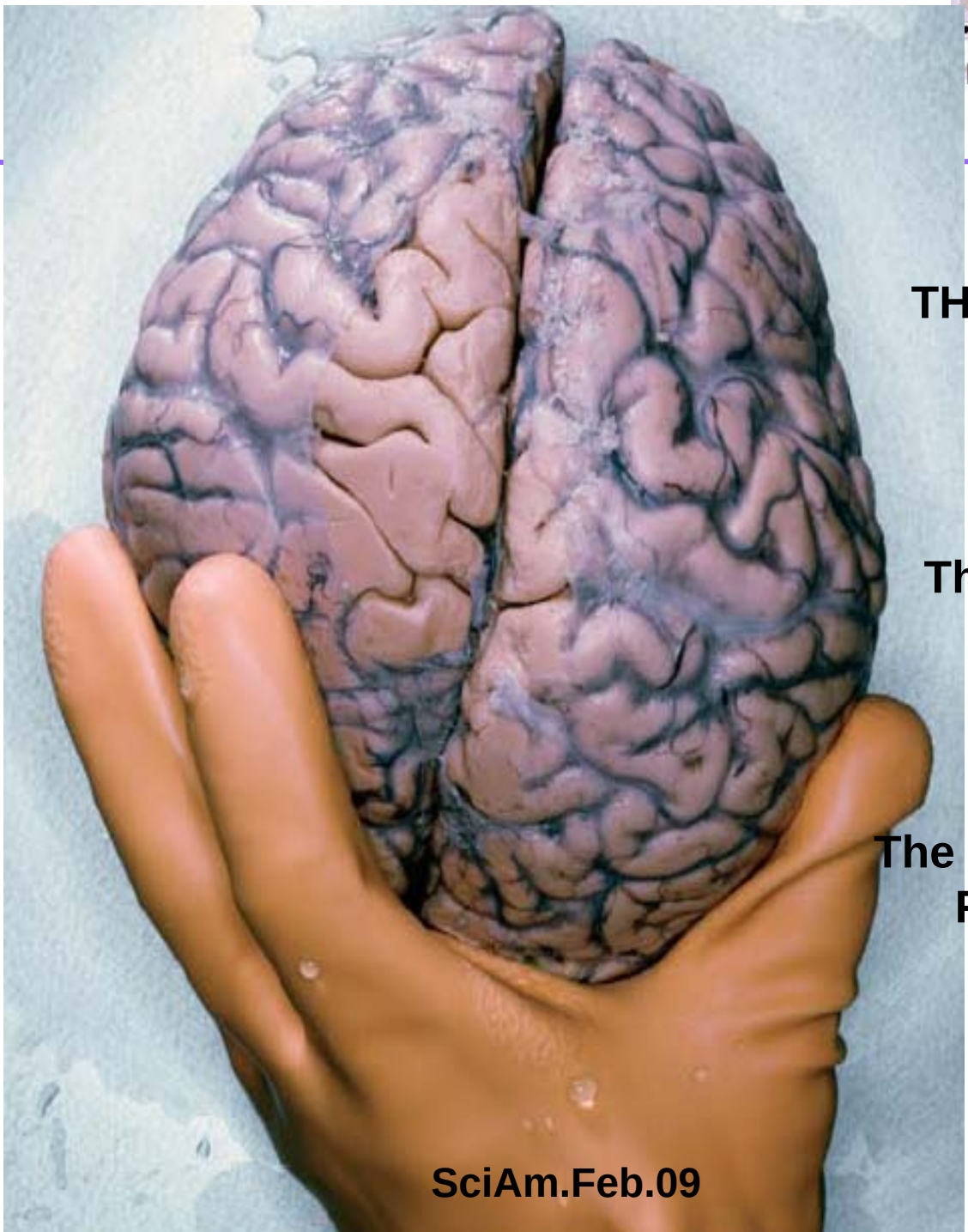


FIG. 2.25. Brain weights determined at autopsy plotted as function of patients' chronological age; data from Coppoletta and Wolbach (1933). *Bottom plot:* various measurements of head-circumference of patient described by Seckel (1960), converted to estimates of brain weight.



THE BRAIN is wider than the sky,
For, put them side by side,
The one the other will include
With ease, and you beside.

The brain is deeper than the sea,
For, hold them, blue to blue,
The one the other will absorb,
As sponges, buckets do.

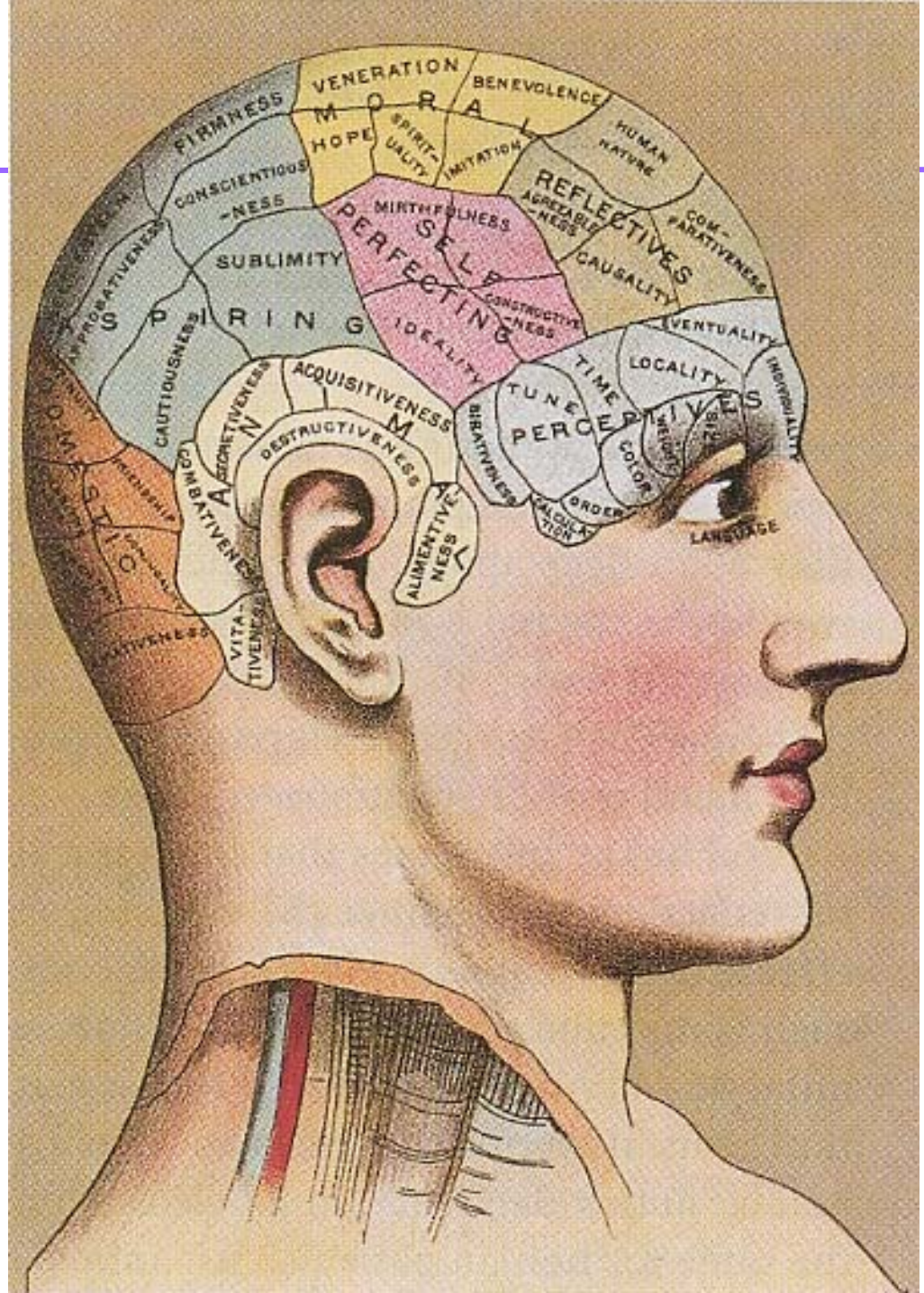
The brain is just the weight of God,
For, lift them, pound for pound,
And they will differ, if they do,
As syllable from sound.

Emily Dickenson 1924: 126.

From p.509 of ***Syntactic Complexity***, T.Givon and M.Shibatani, eds. 2009. John Benjamins.

Hippocrates *(ca. 400 BCE; author of Hippocratic Oath)*:

"Men ought to know that from nothing else but 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 are 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."**



Franz Joseph Gall. 1808.
***Introducion au cours de physiologie du cerveau*,**

~

Phrenology

Locating language in the brain

Paul Pierre Broca 1824-1880

Carl Wernicke 1848-1904

Paul Pierre Broca (1824-1880)

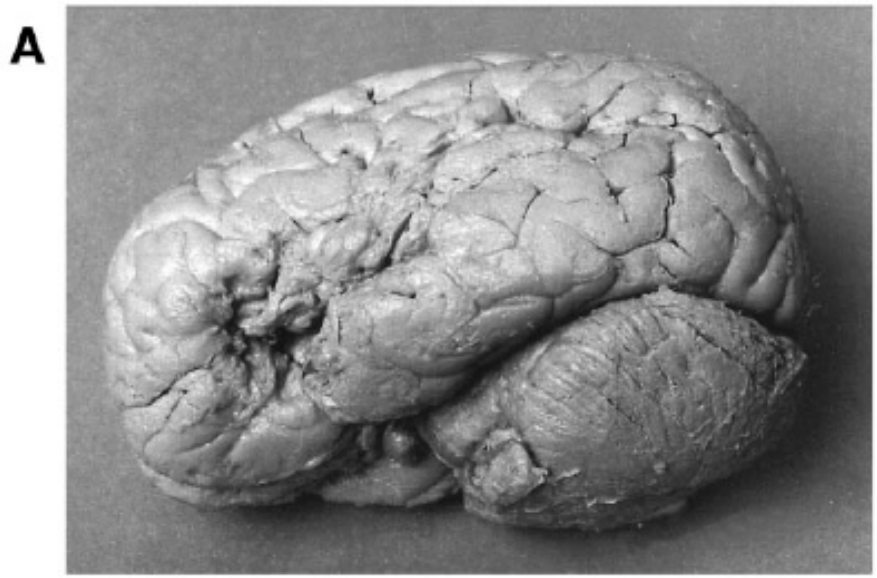
Broca, Paul. 1861. Nouvelle observation d'aphémie produite par une lésion de la moitié postérieure des deuxième et troisième circonvolution frontales gauches. Bulletin de la Société Anatomique 36. 398-407.

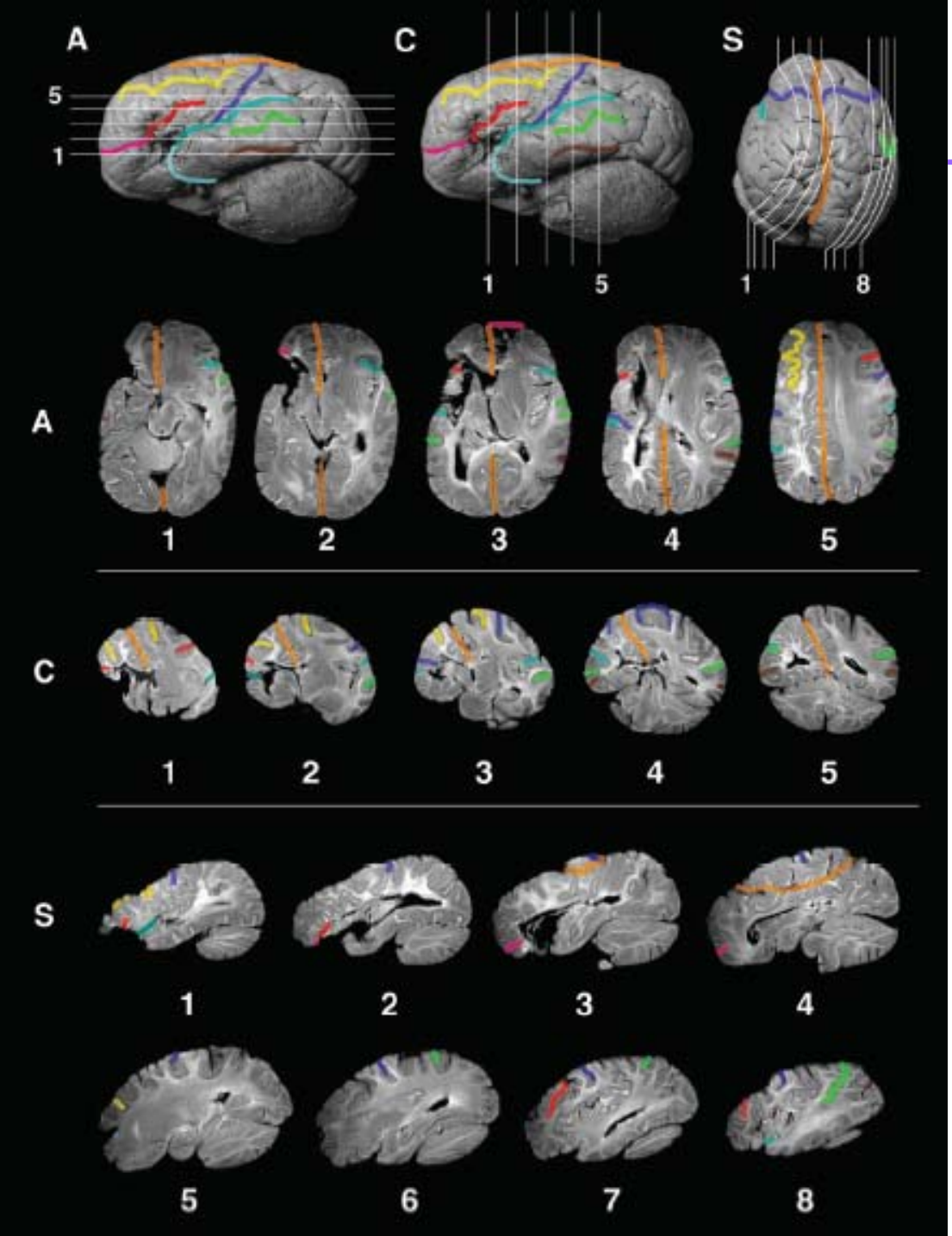
Broca, Paul. 1824-80.

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 (1861).*

"The integrity of the third frontal convolution (and perhaps of the second) seems indispensable to the exercise of the faculty of articulate language ... I found that in my second patient the lesion occupied exactly the same seat as with the first - immediately behind the middle third, opposite the insula and precisely on the same side."

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.

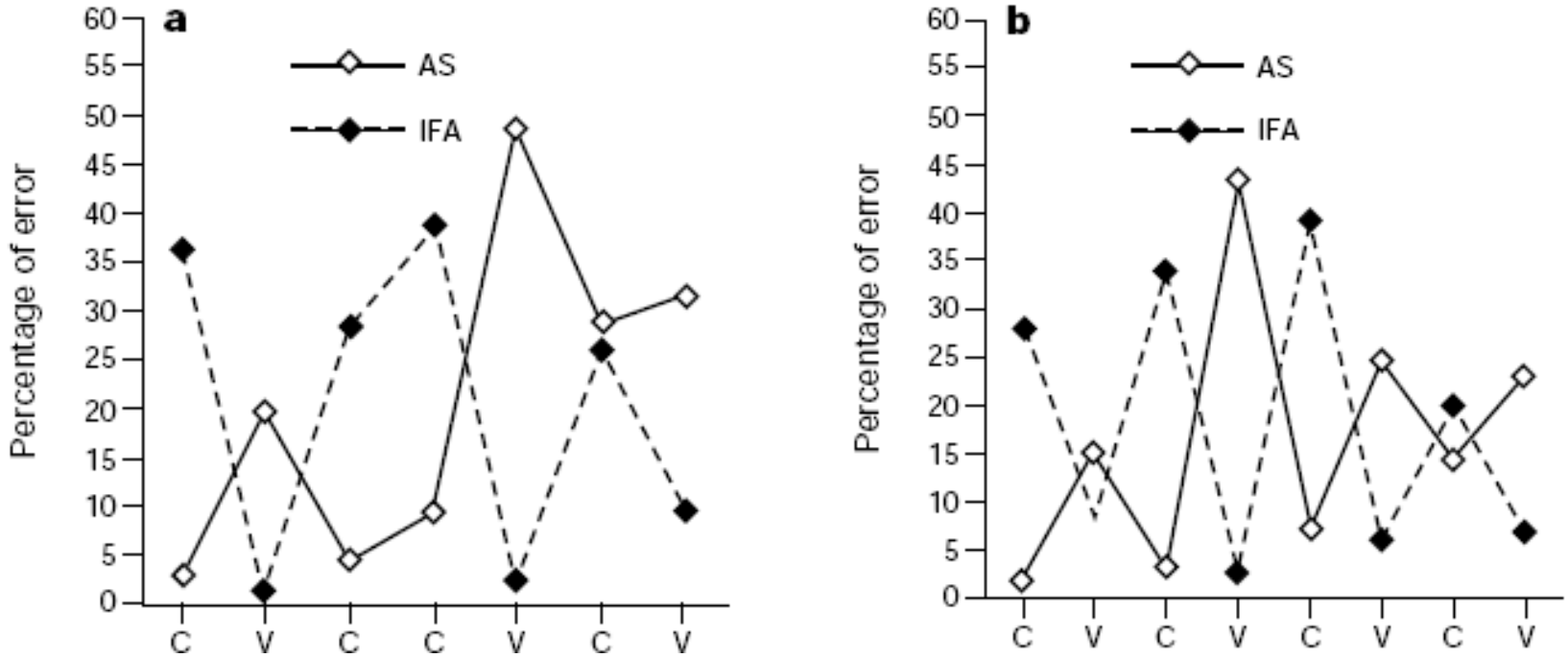




Dronkers, N. et al. 2007. Paul Broca's historic cases: high resolution MR imaging of the brains of Leborgne and Lelong. Fig.4. ***Brain*** 130.1432-41.

"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.*

Caramazza, A., et al. 2000.
Separable processing of consonants and vowels. Nature 403.428-430.



Performance in repetition of a set of words seven or eight phonemes in length. The figure illustrates the complementary performance of the two patients in repetition of items matched for length in number of phonemes and syllable structure. a, The data reported refer to items like 'pastore' (shepherd); b, the data reported refer to items like 'minatore' (miner). Taken after Caramazza et al (2000), *Nature* p.429.

Carl Wernicke (1848-1904)

Wernicke, Karl. 1874.

Der aphasische Symptomencomplex. Eine psychologische Studie auf anatomischer Basis.

Breslau.

Dick, Frederic, 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.

"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." p.761.

- 'Twas brillig, and the slithy toves
- Did gyre and gimble in the wabe;
- All mimsy were the borogoves,
- And the mome raths outgrabe.

- "Beware the Jabberwock, my son!
- The jaws that bite, the claws that catch!
- Beware the Jubjub bird, and shun
- The frumious Bandersnatch!"

- He took his vorpal sword in hand:
- Long time the manxome foe he sought—
- So rested he by the Tumtum tree,
- And stood awhile in thought.

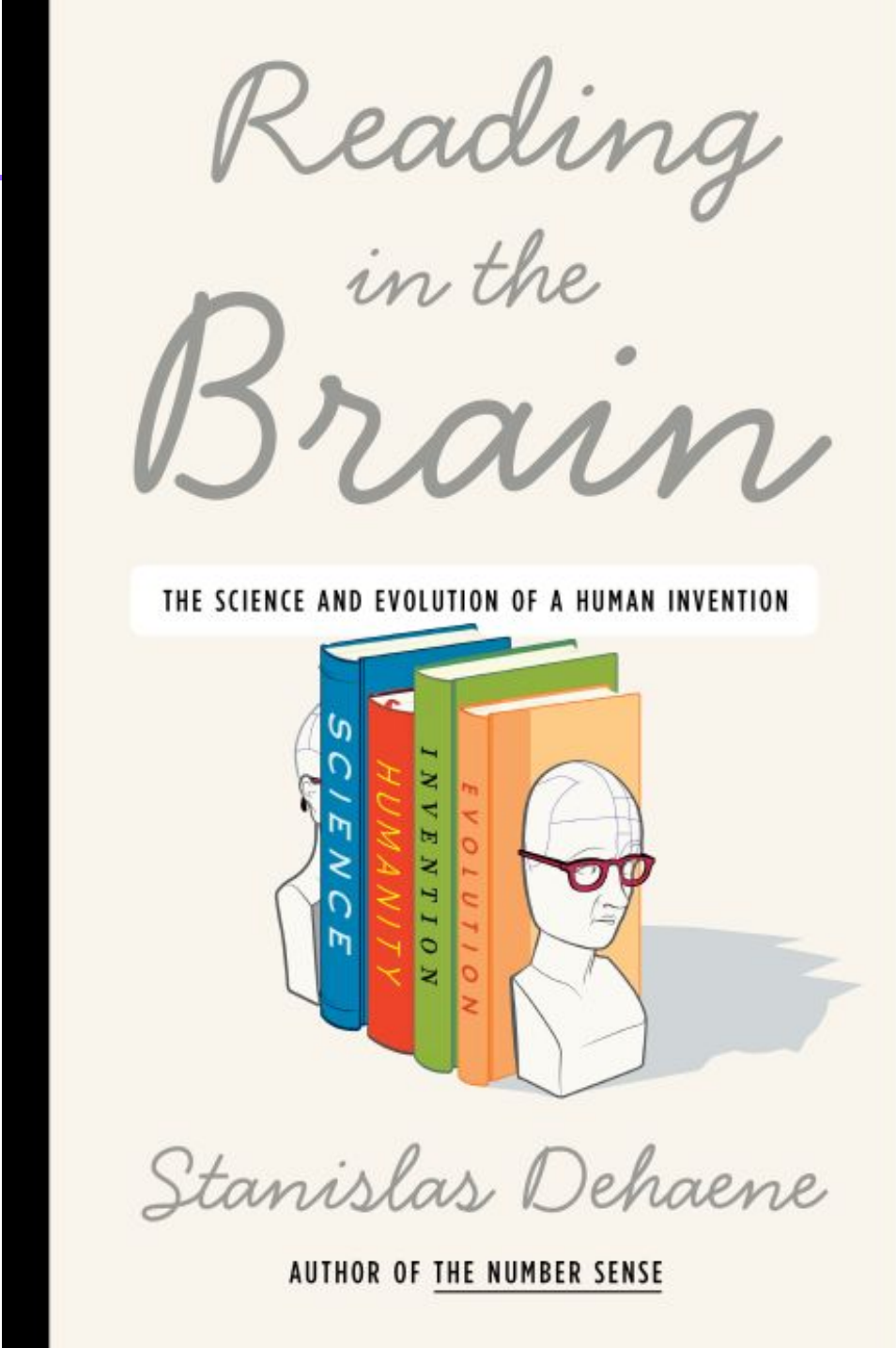
- . . . . .

Carroll, Lewis (1832-98)

Jabberwocky poem.

有(一)天魚裡，那些活濟濟的猶子
在衛邊儘着那麼跼那麼蹐；
好難四啊，那些鶺鴒鴝子，
還有家的猪子慪得格。

(Chao Yuen Ren, 1892-1982)



Déjerine, J. 1892.

Contribution à l'étude anatomo-pathologique et clinique des différentes variétés de cécité verbale.

Mémoires de la Société de Biologie 4.61-90.

1887. Discovery of pure alexia, *alexia sine agraphia.*

Oscar C., a retired businessman who had no problem recognizing people and objects, but who had suddenly become unable to read. Here is the first description of Oscar C.'s situation, included in Dejerine's report:

"Asked to read an eye chart, C is unable to name any letter. However, he claims to see them perfectly. He instinctively sketches the form of the letters with his hand, but he is nevertheless unable to say any of their names. … He compares the A to an easel, the Z to a serpent, and the P to a buckle. His incapacity to express himself frightens him. He thinks he has 'gone mad,' since he is well aware that the signs he cannot name are letters."

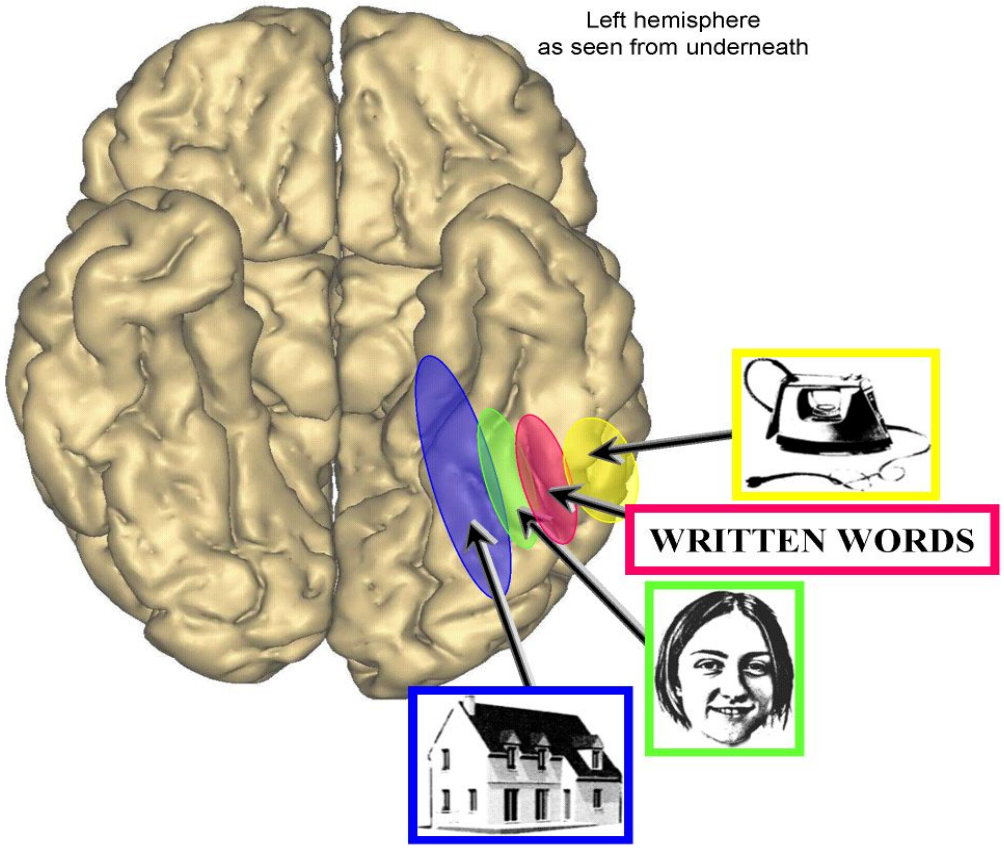


Figure 2.6. A patchwork of specialized visual detectors covers the underside of the brain. Each cortical region preferentially responds to a certain category of objects. This preference pattern occurs in the same order in all individuals, from houses to faces, words and then objects. Reading always activates an area located between the peak responses to faces and to objects (after Ishai et al., 2000; Puce et al., 1996).

Dehaene, Stanislas. 2009.

Reading in the Brain.

Penguin Viking.

Sasanuma, Sumiko. 1974. Impairment of written language in Japanese aphasics: kana versus kanji processing. *Journal of Chinese Linguistics* 2.141-58.

kanji	hiragana	katakana
子供	*このも	
*毛皮		ク
着物	*き	
		*ポー
帽子	*こうち	
時計	*ときい	テレビ
封筒		セーター
太陽		
大根	*たくこう	*トッ
手袋		

* Error words.

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

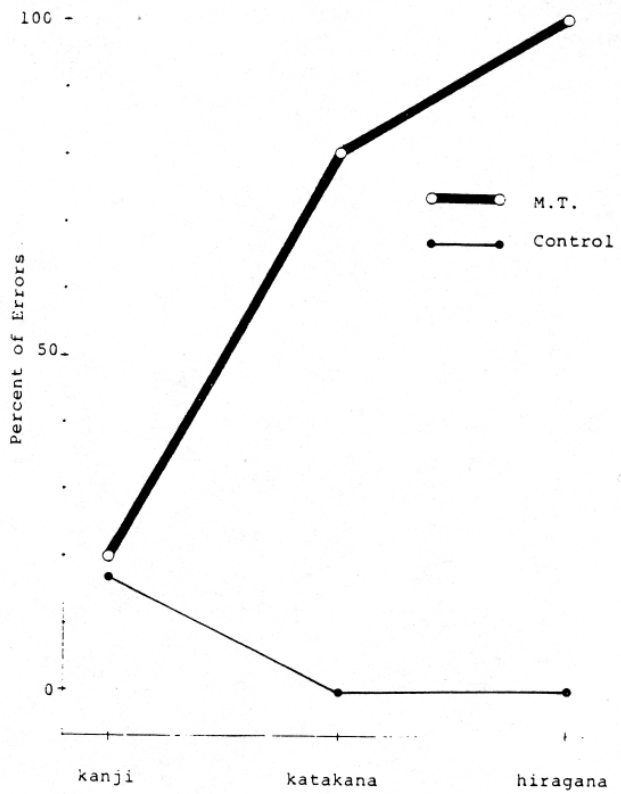
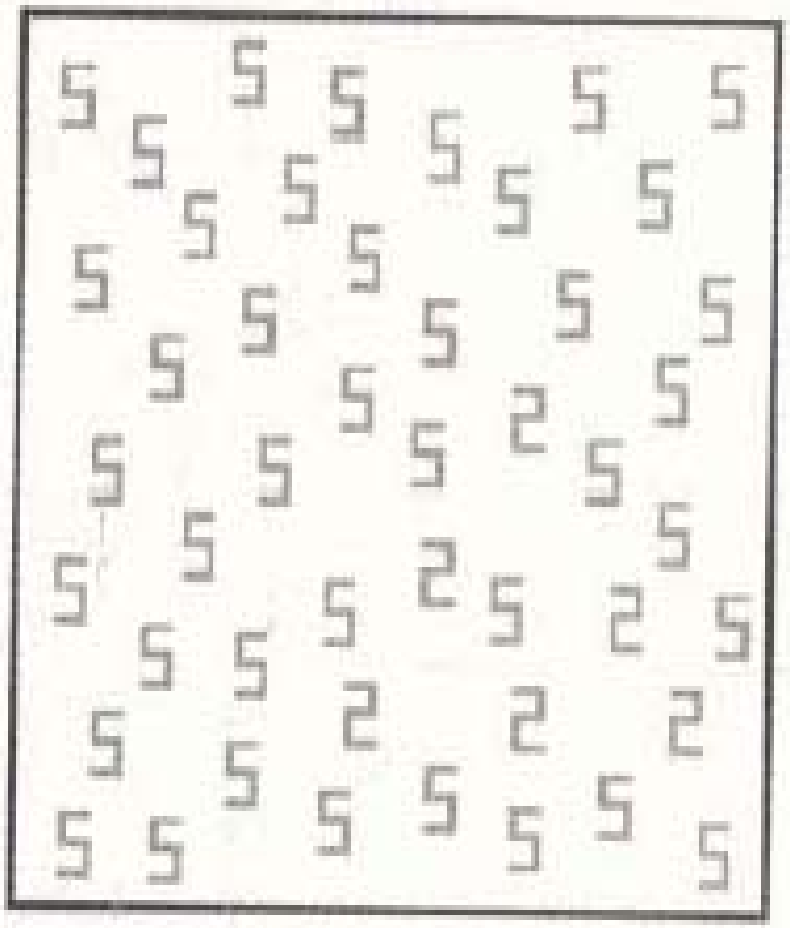


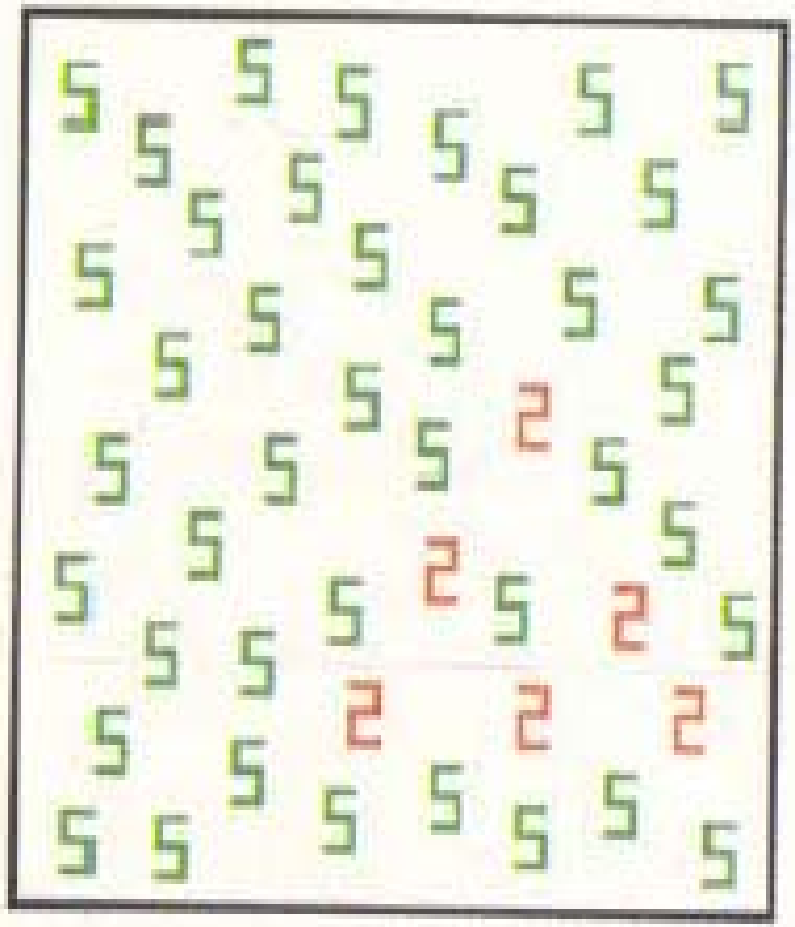
Figure 5. The pattern of errors in writing high-frequency words in *kana* and *kanji* by M.T. (a Type 1 patient) and control group.

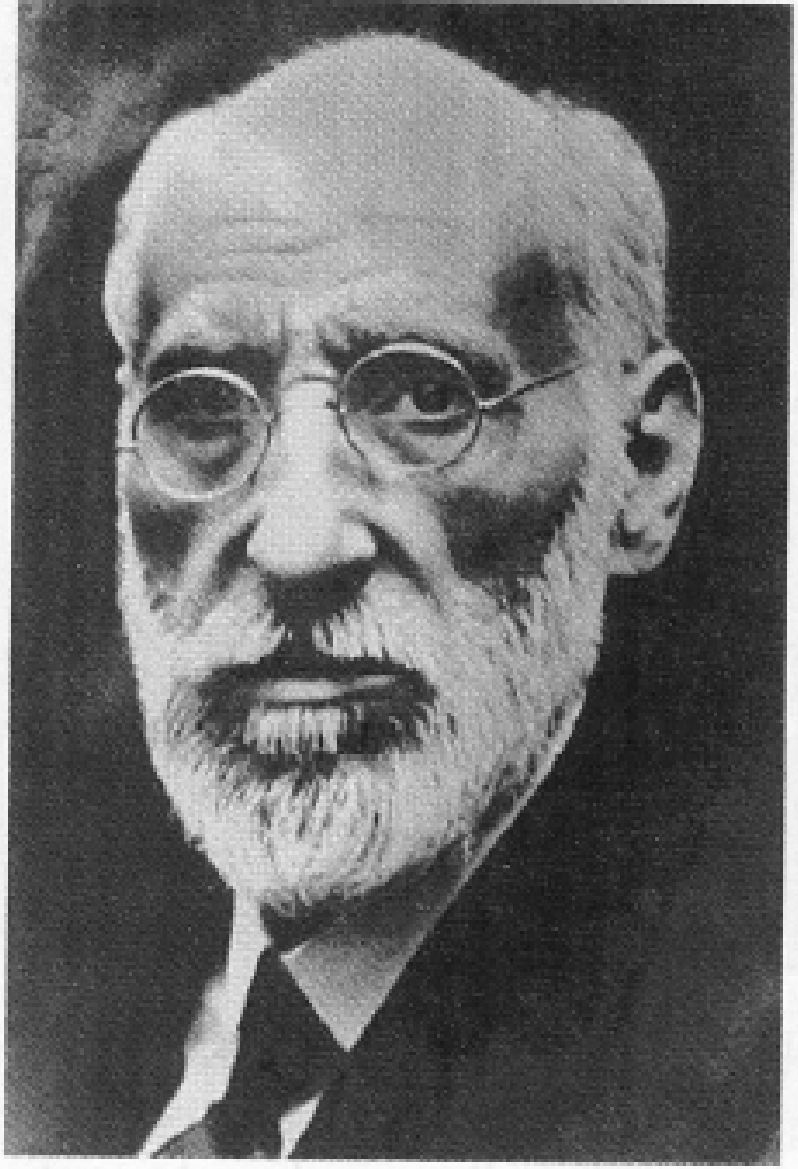
Unusual minds:

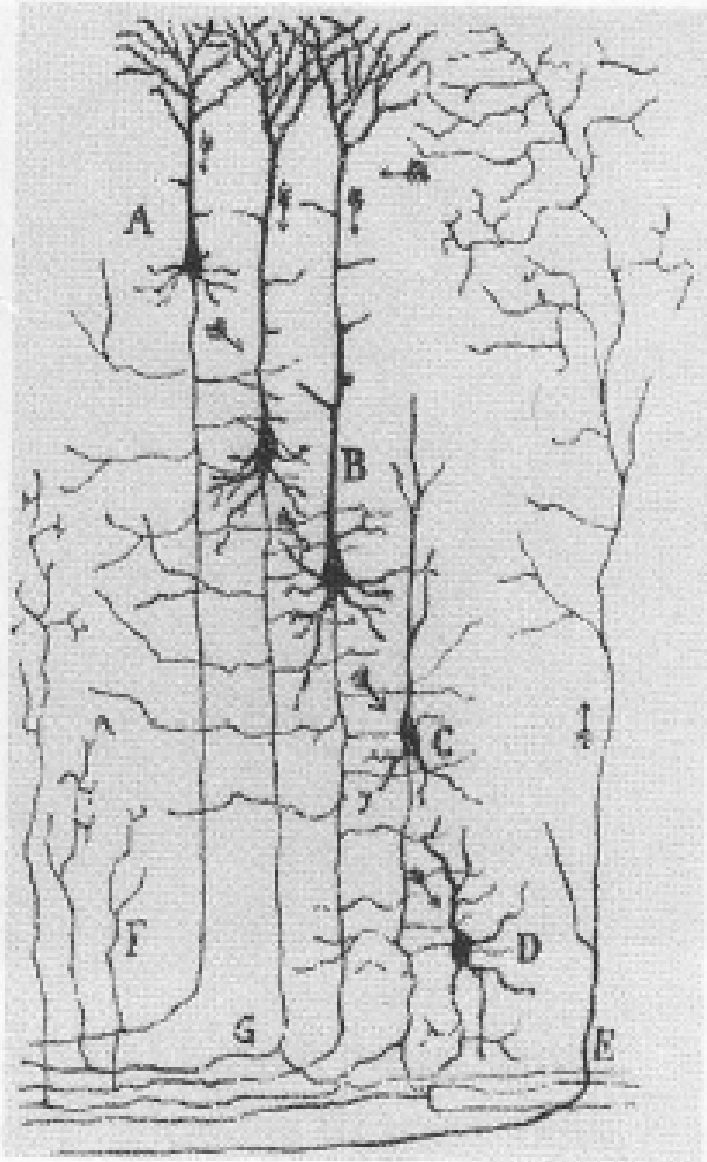
- Luria, A.R. 1968. The Mind of a Mnemonist: a Little Book about a Vast Memory. Basic Books.
- Hilts, Philip J. 1996. Memory's Ghost: the Nature of Memory and the Strange Tale of Mr.M. New York: Touchstone.
- Sacks, Oliver. 2010. The Mind's Eye. Picador.
- Ramachandran, V.S. 2011. The Tell-Tale Brain: Unlocking the Mystery of Human Nature. London: Heinemann.

Ramachandran, V. S. & E. M. Hubbard.
Hearing colors, tasting shapes.
Scientific American 288.42-9. 2003.

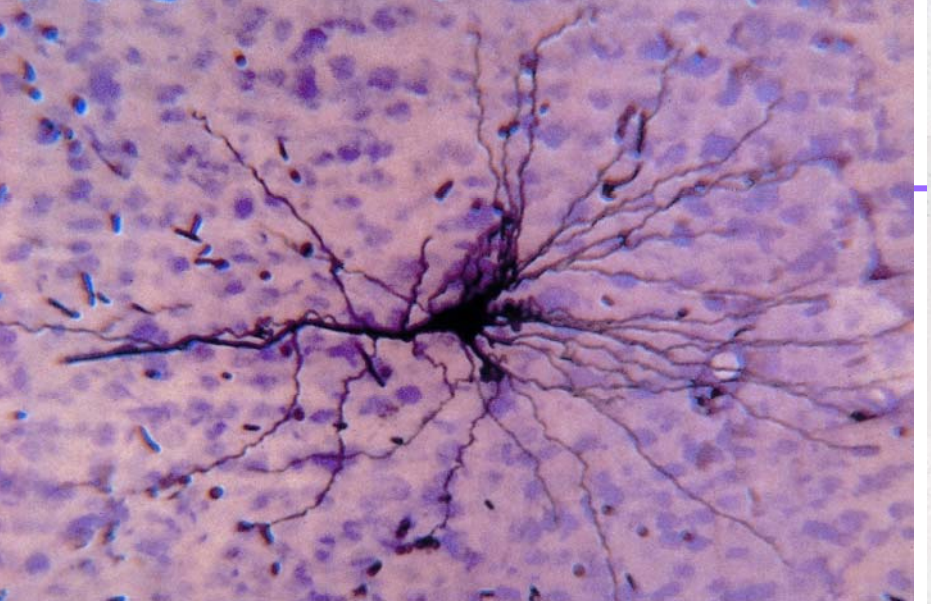


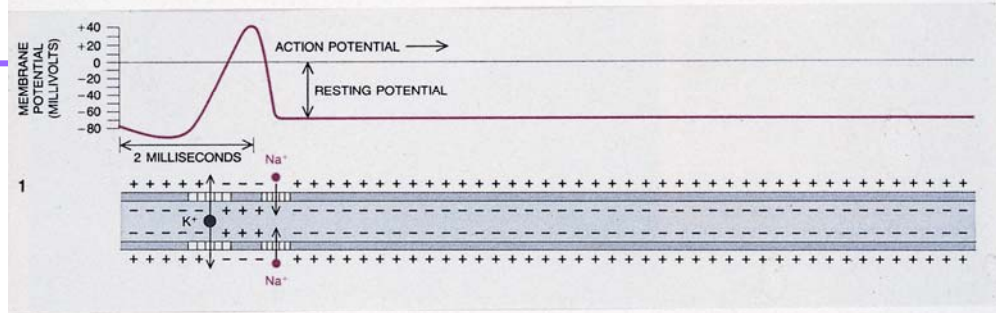


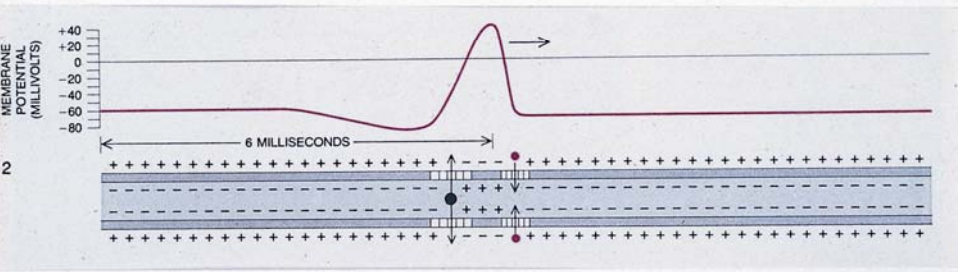


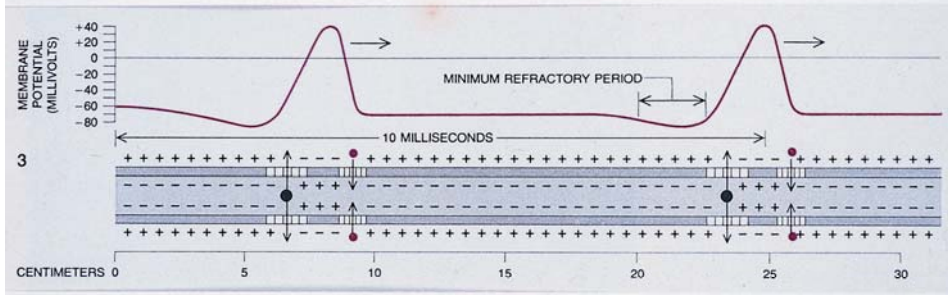


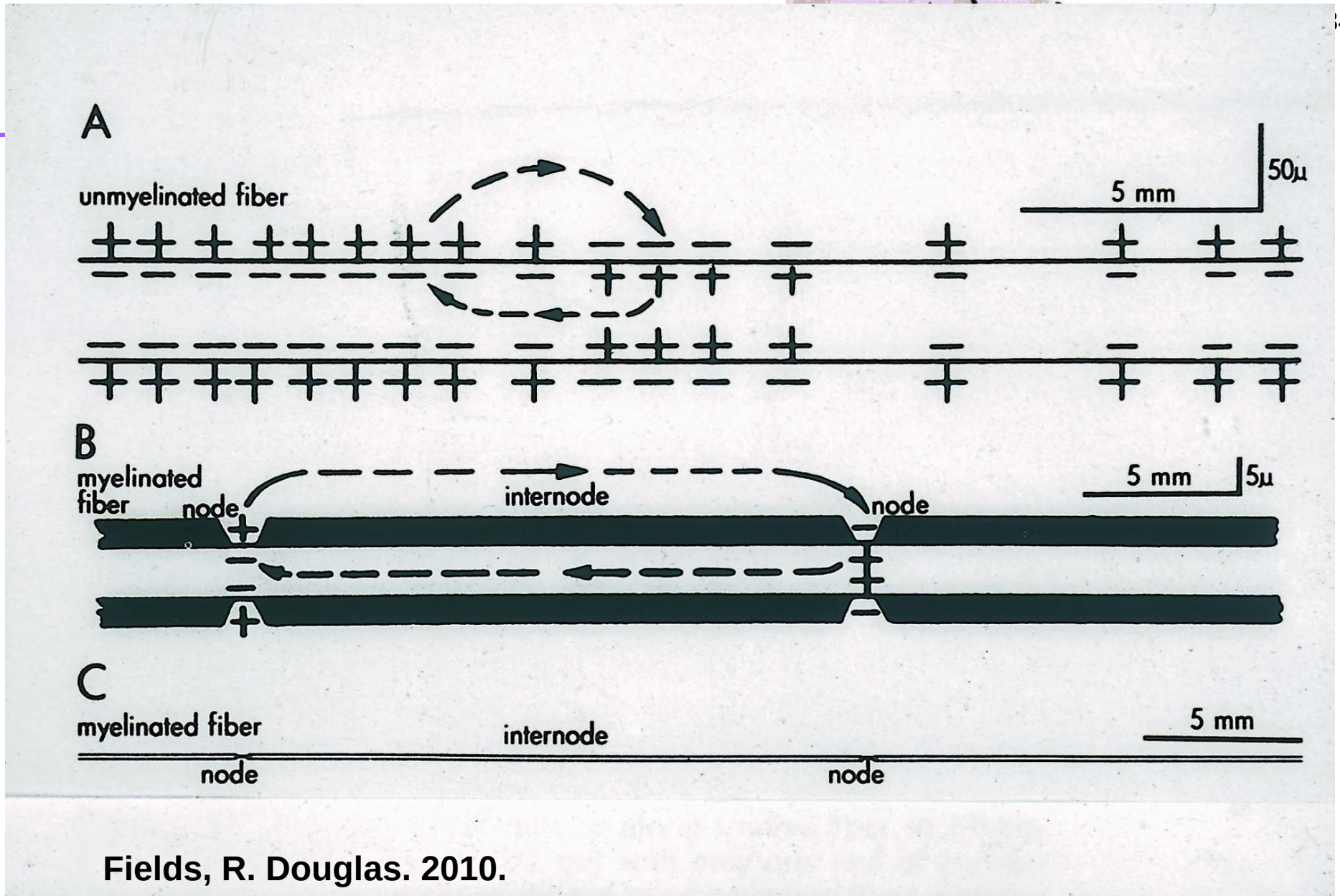
Left: Santiago Ramón y Cajal (1852–1934), co-winner of the Nobel Prize in 1906. **Right:** Cajal's drawing of the afferent inflow to the mammalian cortex.




MEMBRANE POTENTIAL (MILLIVOLTS)
+40
+20
0
−20
−40
−60
−80
ACTION POTENTIAL
RESTING POTENTIAL
2 MILLISECONDS
Na+
1
K+
Na+


MEMBRANE POTENTIAL (MILLIVOLTS)
+40
+20
0
−20
−40
−60
−80
6 MILLISECONDS
2


MEMBRANE POTENTIAL (MILLIVOLTS)
+40
+20
0
−20
−40
−60
−80
MINIMUM REFRACTORY PERIOD
10 MILLISECONDS
3
CENTIMETERS 0
5
10
15
20
25
30



Fields, R. Douglas. 2010.
The Other Brain: from Dementia to Schizophrenia, how New Discoveries about the Brain are Revolutionizing Medicine and Science
New York: Simon & Schuster.

Mind and consciousness

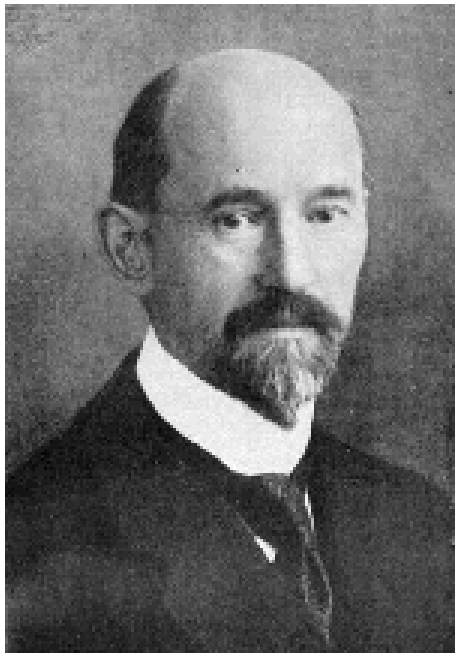
"… an enchanted loom where millions of flashing shuttles weave a dissolving pattern, always a meaningful pattern though never an abiding one; a shifting pattern of subpatterns.

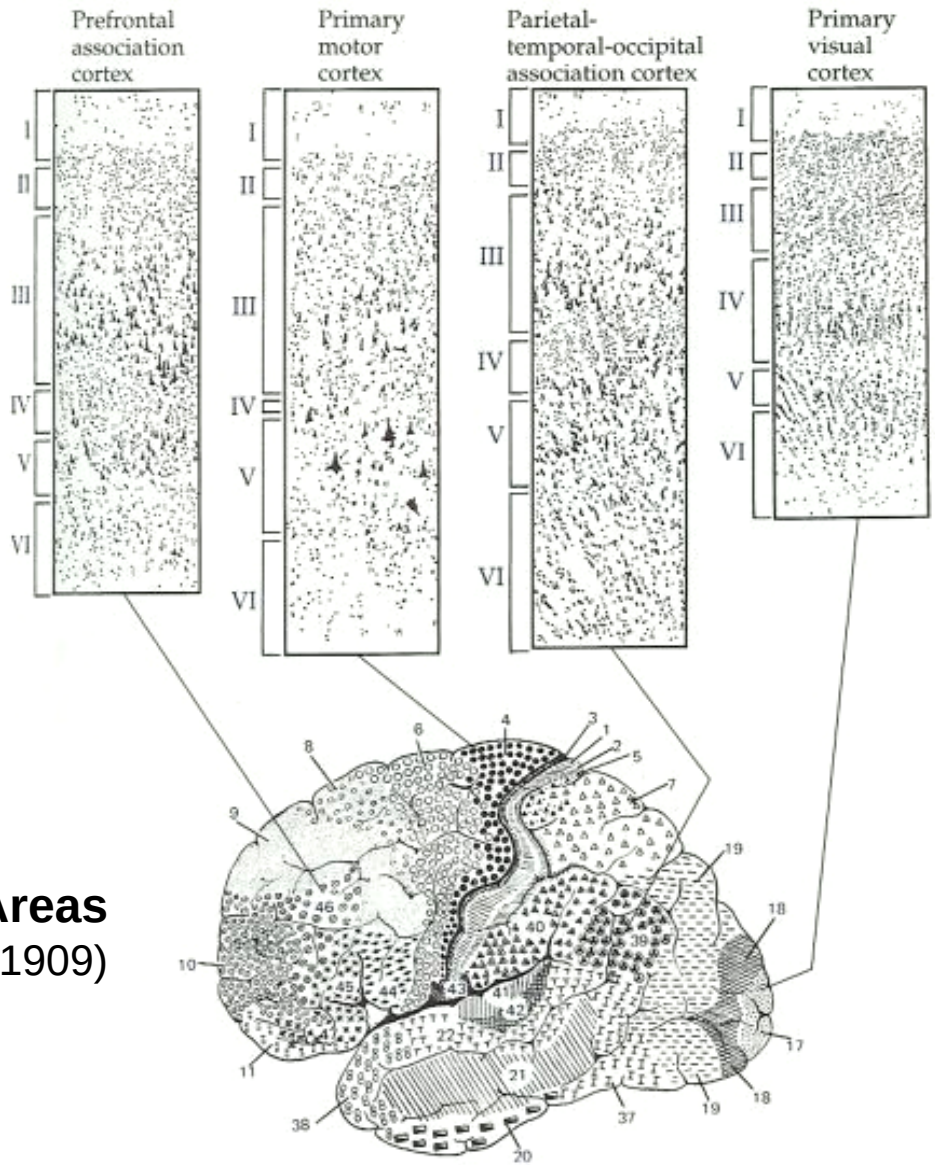
Sherrington, Charles. 1953. The Integrative Action of the Nervous System. 2nd ed.

"Imagine consciousness as a beam of light ... directed around the dark universe of the Mind. We are the beam of light, and we see nothing outside. But there is a great deal around it, and much that is never illuminated. All this is Mind. Present consciousness is what is lit by the patch of light of the beam."

Richard Gregory. Quotes in Restak 2003:84.

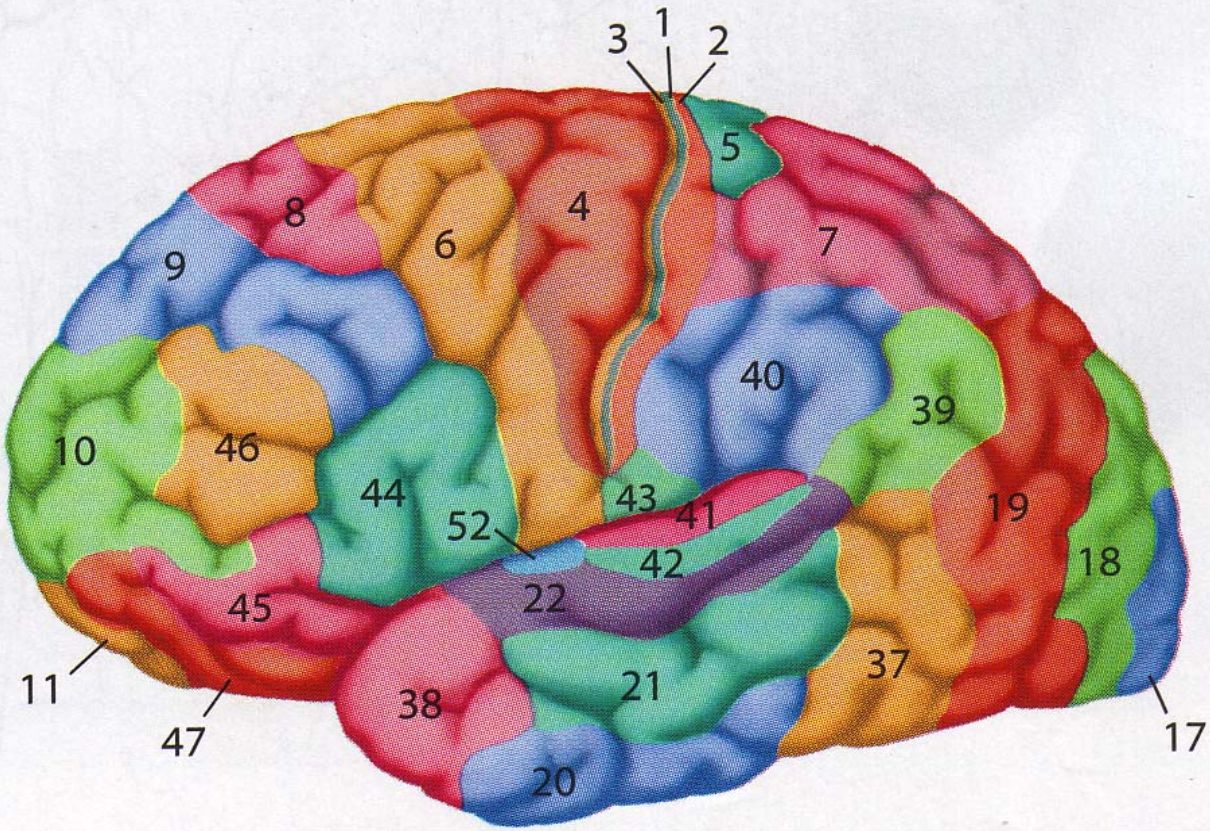
Korbinian Brodmann



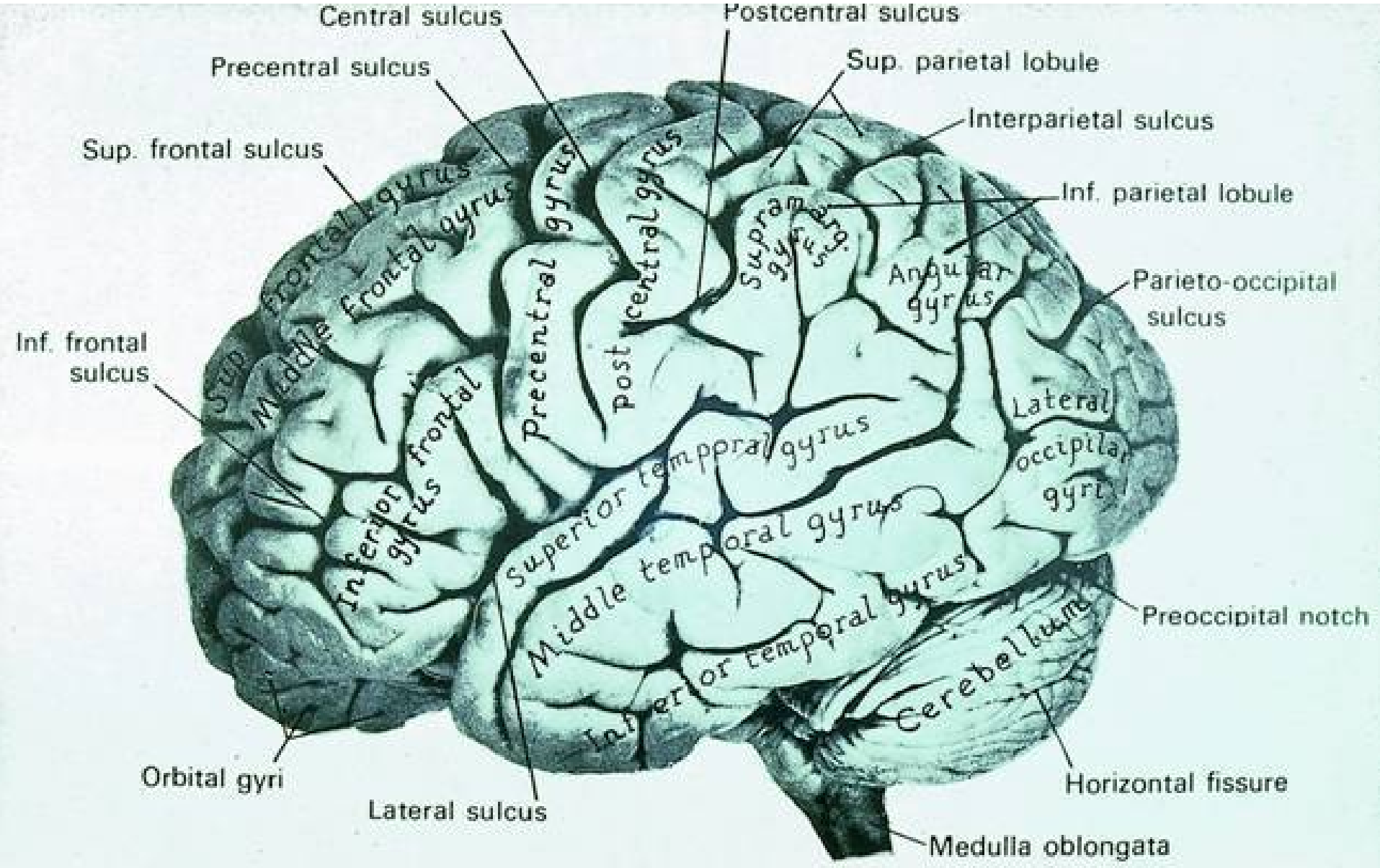


Brodmann's Areas
(Brodmann, 1909)

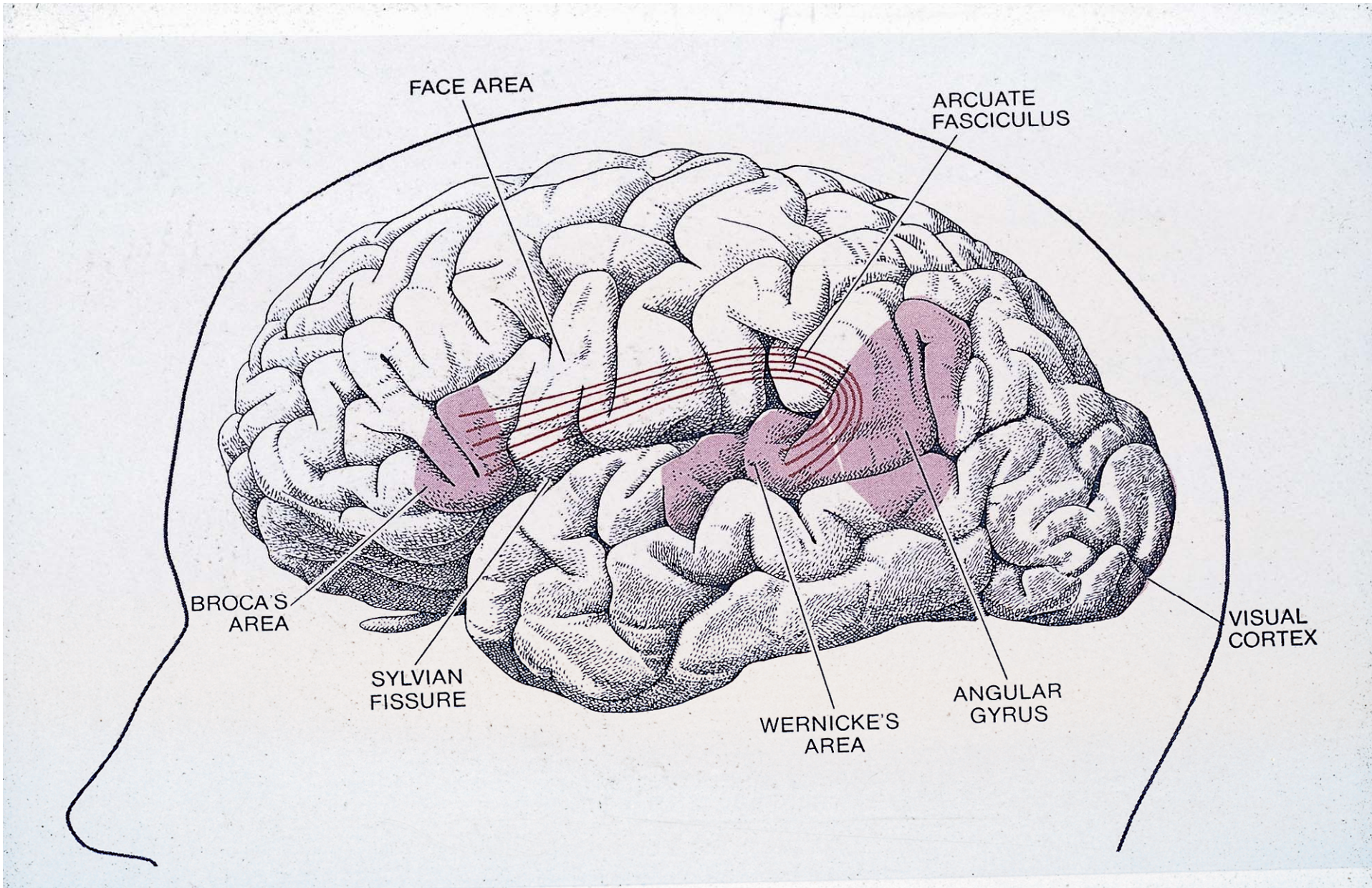
Figure 1.7 The fifty-two distinct areas described by Brodmann based on cell structure and arrangement. Adapted from Brodmann (1909).



Landmarks on left cortex



Geschwind, N. 1976. The development of the brain and the evolution of language. Selected Papers on Language and the Brain.86-104.



Catani, M. et al. 2005. Perisylvian Language Networks of the Human Brain. *Ann Neurol* 2005;57:8–16.

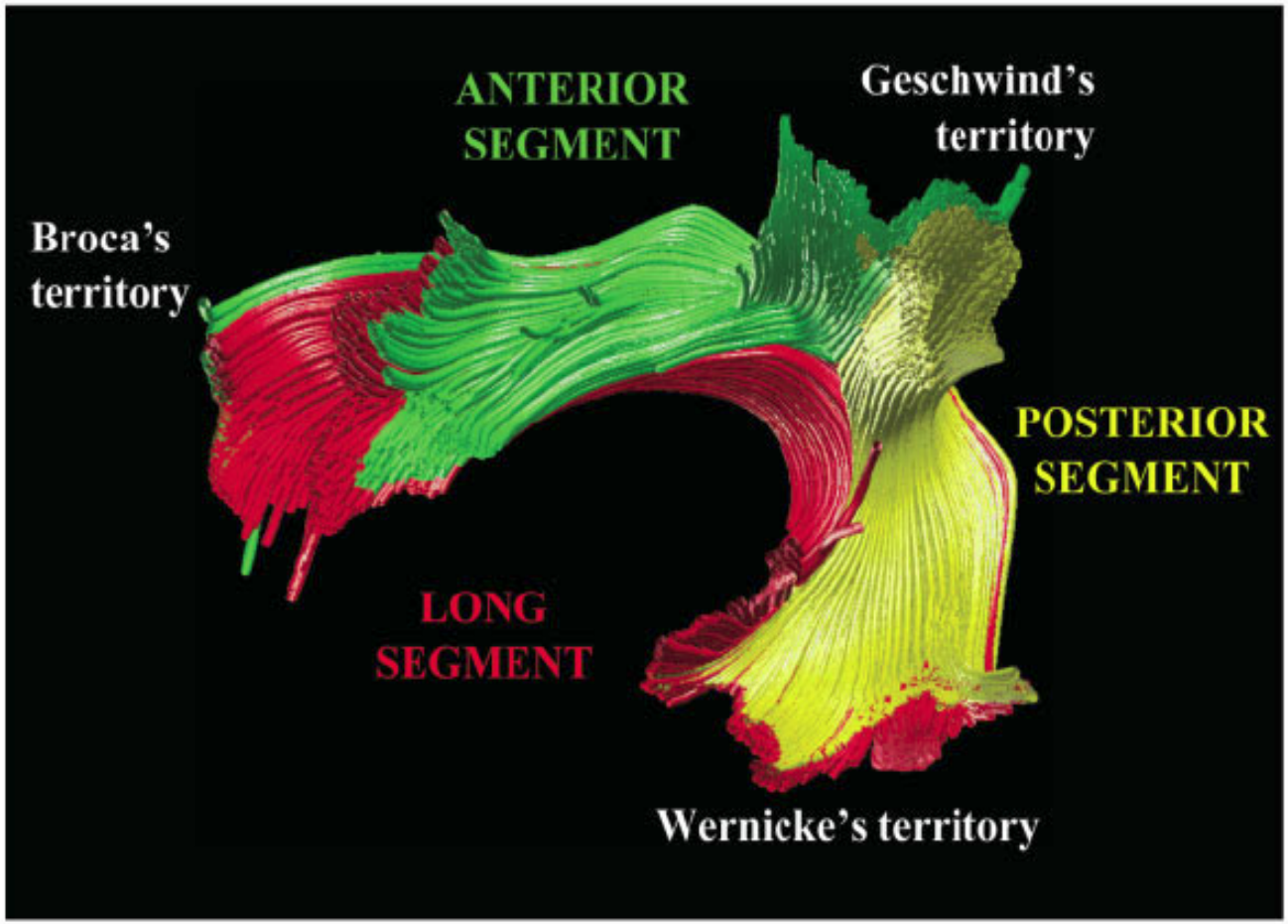
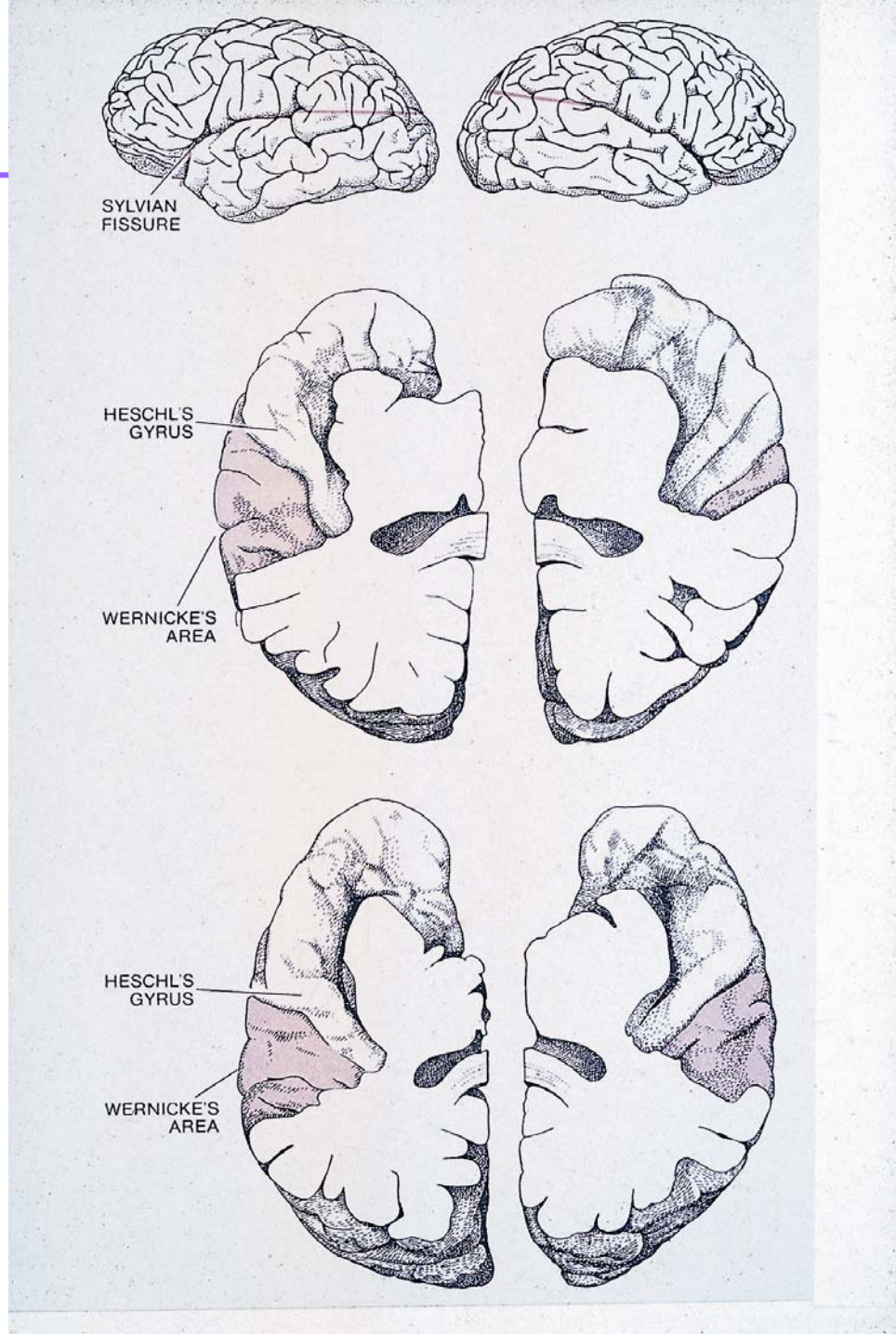
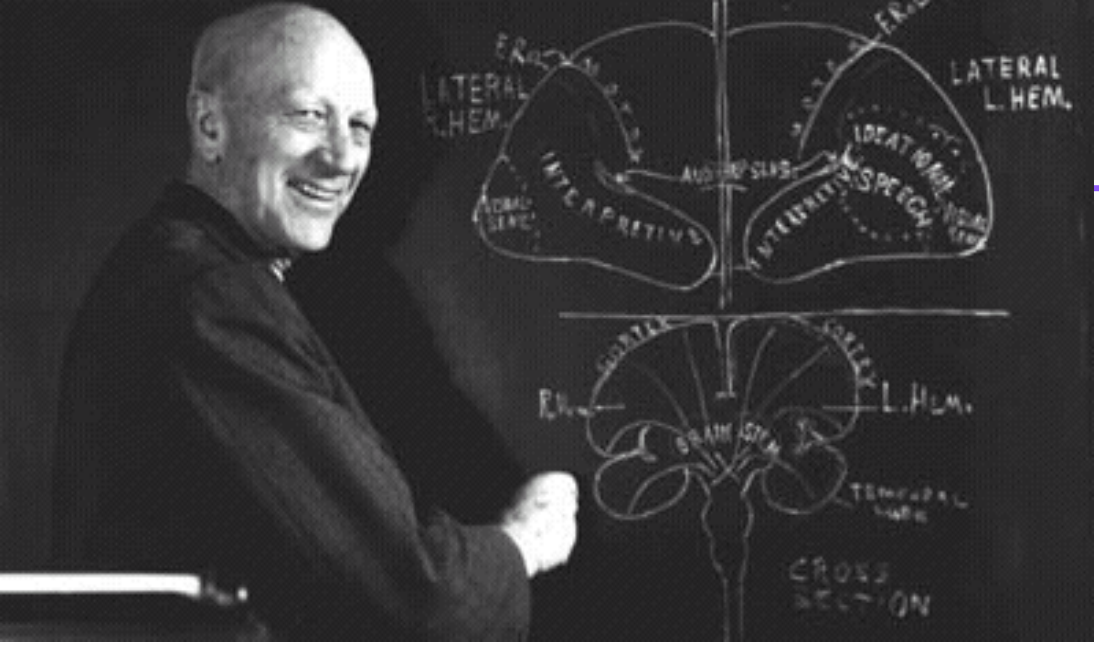


Fig 3. Tractography reconstruction of the arcuate fasciculus using the two-region of interest approach. Broca's and Wernicke' territories are connected through direct and indirect pathways in the average brain. The direct pathway (long segment shown in red) runs medially and corresponds to classical 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.

Asymmetry of human hemispheres

Geschwind, Norman. 1979. Specializations of the human brain. *Scientific American* **241.158-68.**



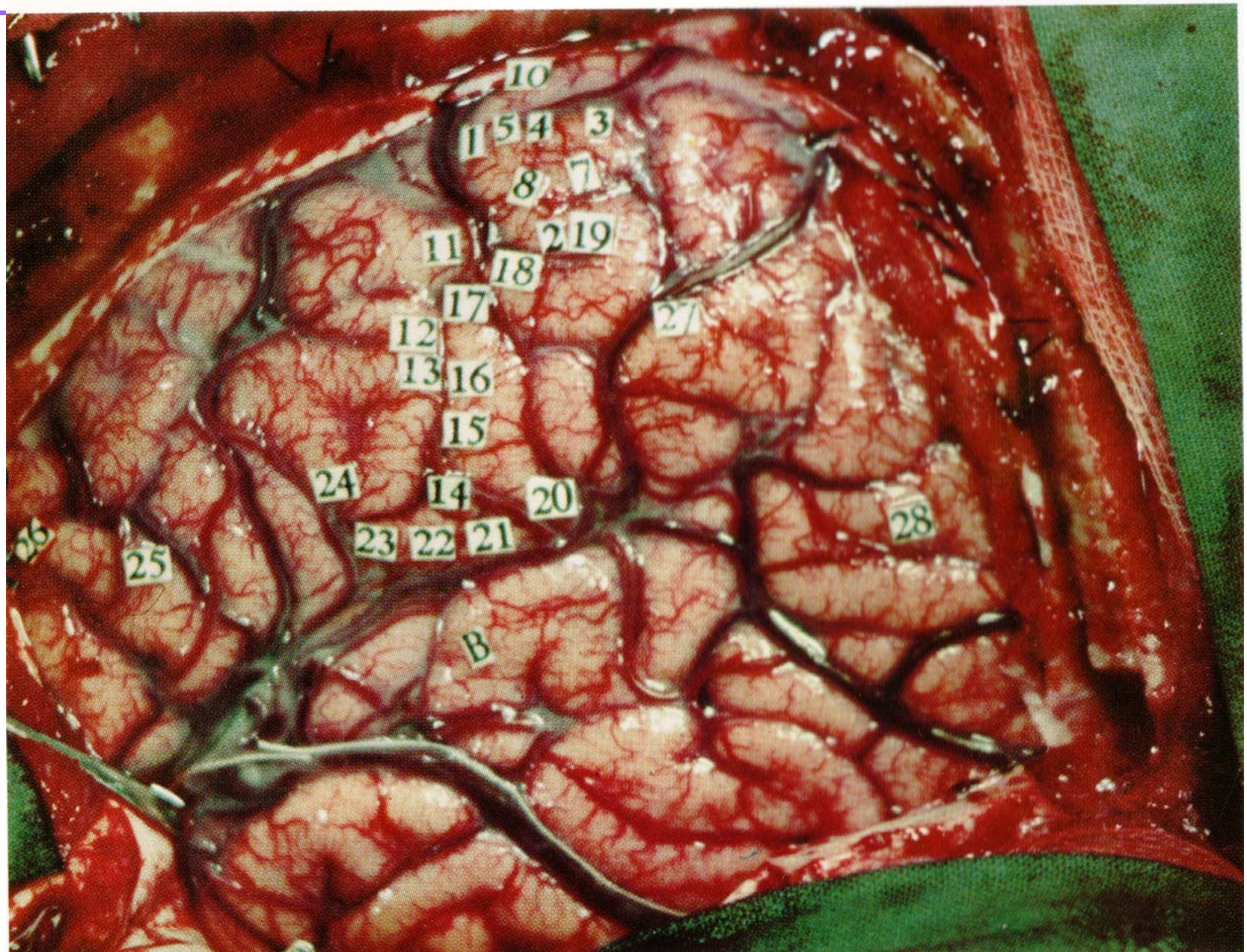


Wilder Penfield 1891-1976.

Penfield, W. & L. Roberts. 1959. Speech and Brain Mechanisms: Princeton University Press

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

Penfield, W. & L. Roberts. 1959.
Speech and Brain Mechanisms. Princeton University Press.

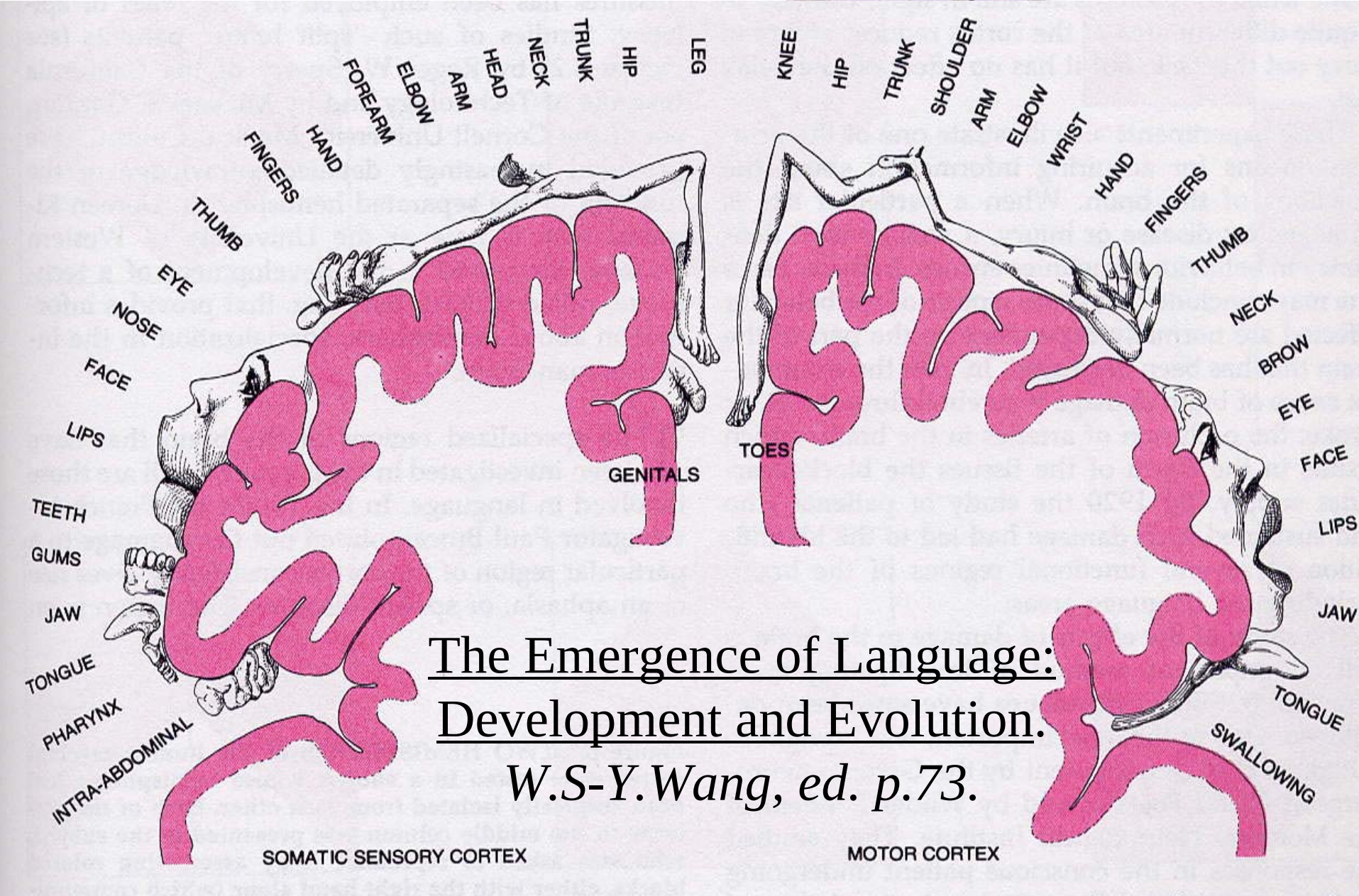


Wilder Penfield 1939

- “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. …”

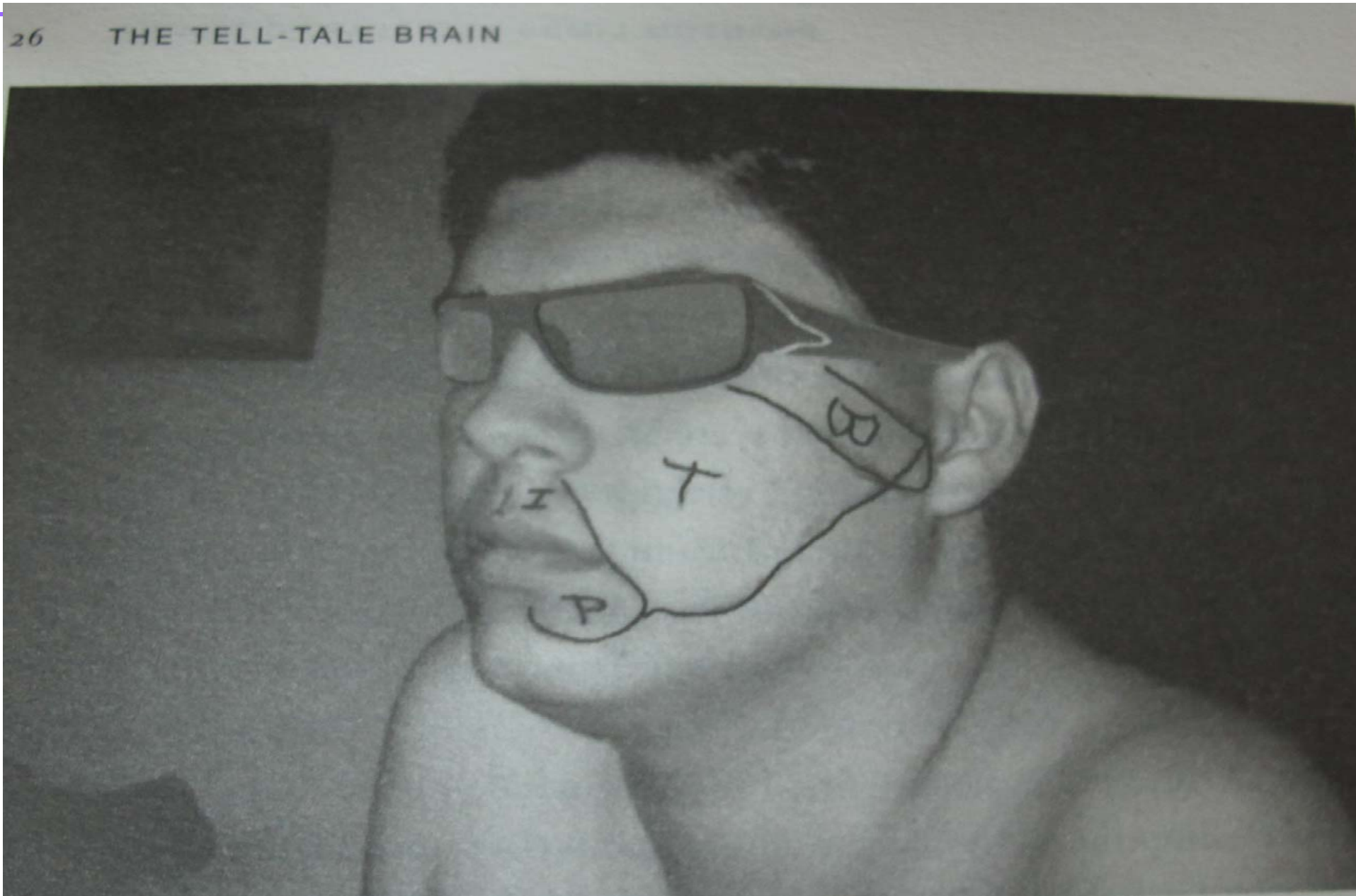
- “… for the purposes of learning languages, the human brain becomes progressively stiff and rigid after the age of nine.”

[1939; reprinted 1959:235.]



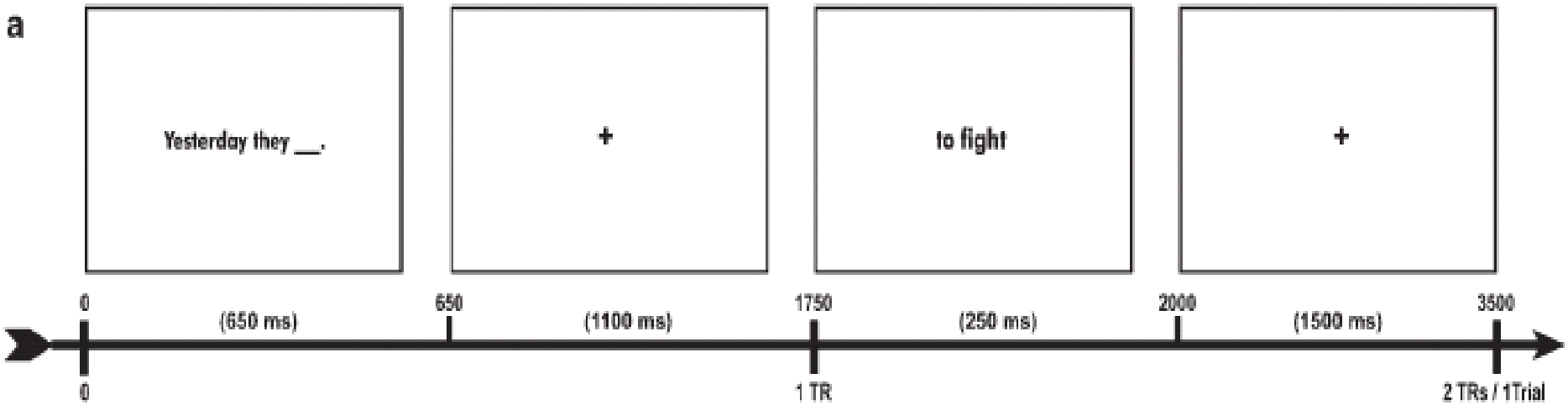
The Emergence of Language: Development and Evolution. *W.S-Y.Wang, ed. p.73.*

Ramachandran 2011:26



Sahin, Ned T., Steven Pinker & **Eric Halgren**. 2006. ABSTRACT GRAMMATICAL PROCESSING OF NOUNS AND VERBS IN BROCA'S AREA: EVIDENCE FROM fMRI. ***Cortex*** 42.540-62.

a



b

Verb Trials

Task	Context Frame	Regularity	Example Target	Correct Response
Read	repeat word: ___.	Regular	to fade	*fade*
		Irregular	to fight	*fight*
Zero-Inflect	Every day they ___.	Regular	to fade	*fade*
		Irregular	to fight	*fight*
Overt-Inflect	Yesterday they ___.	Regular	to fade	*faded*
		Irregular	to fight	*fought*

Noun Trials

Context Frame	Regularity	Example Target	Correct Response
repeat word: ___.	Regular	a fort	*fort*
	Irregular	a foot	*foot*
That is the ___.	Regular	a fort	*fort*
	Irregular	a foot	*foot*
Those are the ___.	Regular	a fort	*forts*
	Irregular	a foot	*feet*

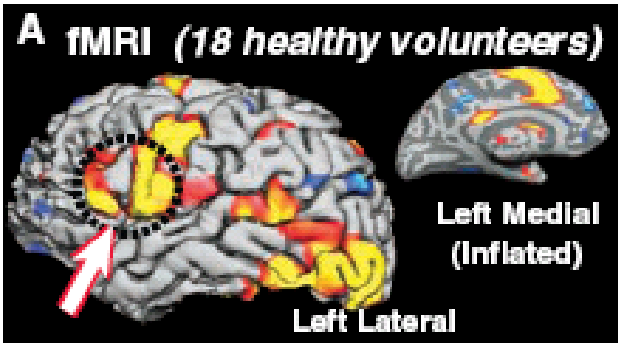
Sahin, Ned T., et al. 2009. Sequential Processing of Lexical, Grammatical, and Phonological Information Within Broca's Area. ***SCIENCE*** 326.445-9. Table S1.

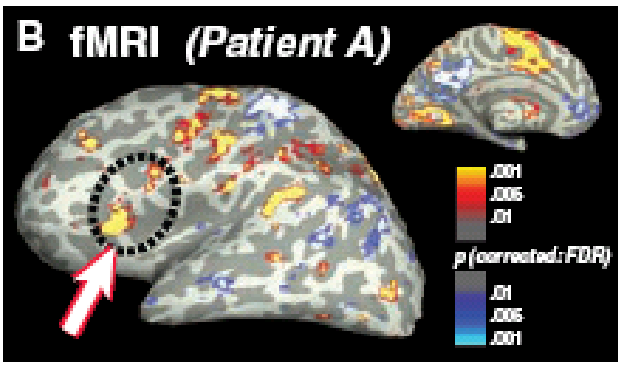
Patient	Sex	Age	Seizure Onset Age	fMRI Performed?	Testing Day	Completed Runs (of 9)
A	F	41	14	Yes	13	6
B	F	51	18	No	16	9
C	F	38	5	Yes	4	7

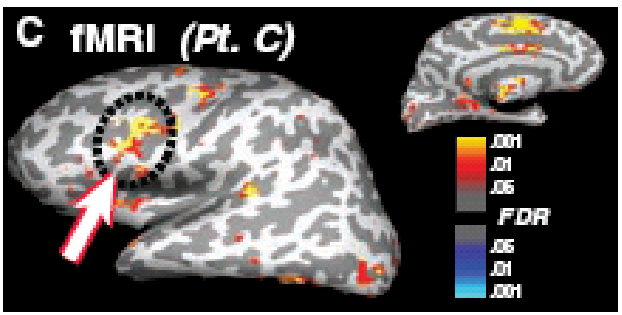
Condition	Examples [Verbs]	Examples [Nouns]	Requires Inflection	Change in Phonology
Read	repeat word: ___. (response = "walk")	repeat word: ___. ("rock")	X	X
Null-Inflect	Every day they ___. ("walk")	That is the ___. ("rock")	✓	X
Overt-Inflect	Yesterday they ___. ("walked")	Those are the ___. ("rocks")	✓	✓

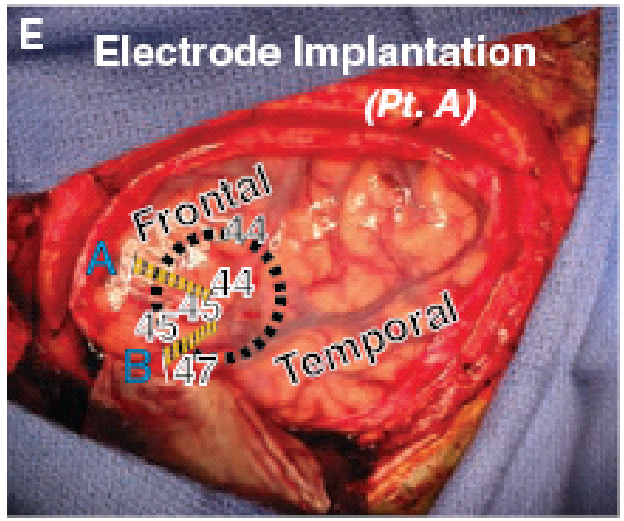
Sahin, Ned T., Steven Pinker, Sydney S. Cash, Donald Schomer, Eric Halgren. 2009. Sequential Processing of Lexical, Grammatical, and Phonological Information Within Broca's Area. ***SCIENCE*** 326.445-9. Fig.1B.

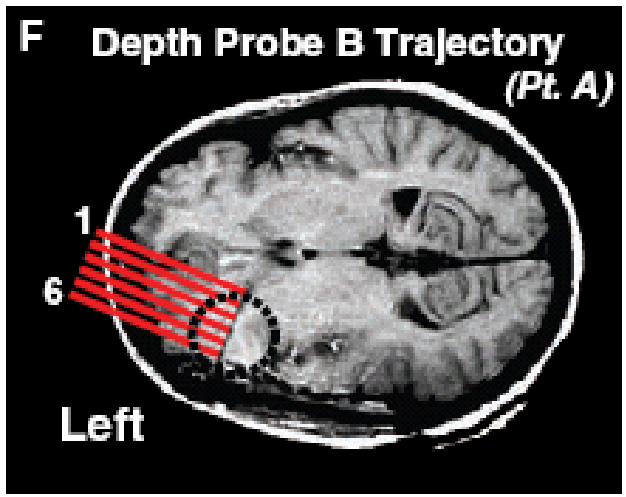
Sahin, Ned T., et al. 2009. Sequential Processing of Lexical, Grammatical, and Phonological Information Within Broca's Area. ***SCIENCE*** 326.445-9. Table S1.

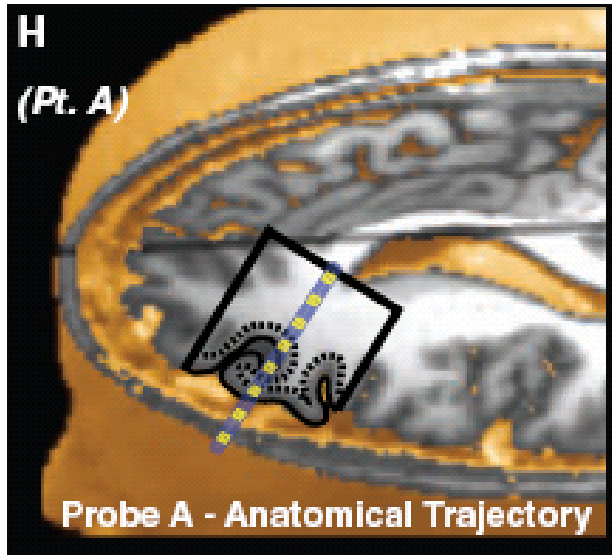


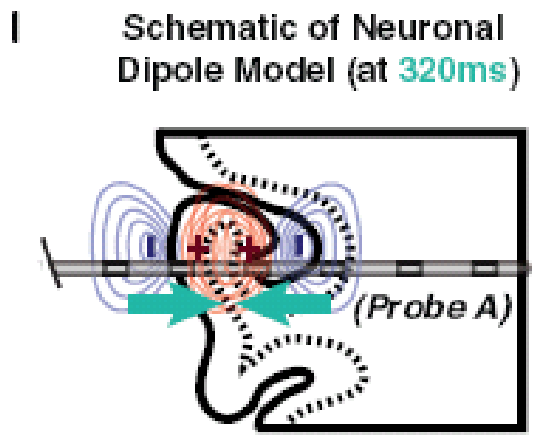


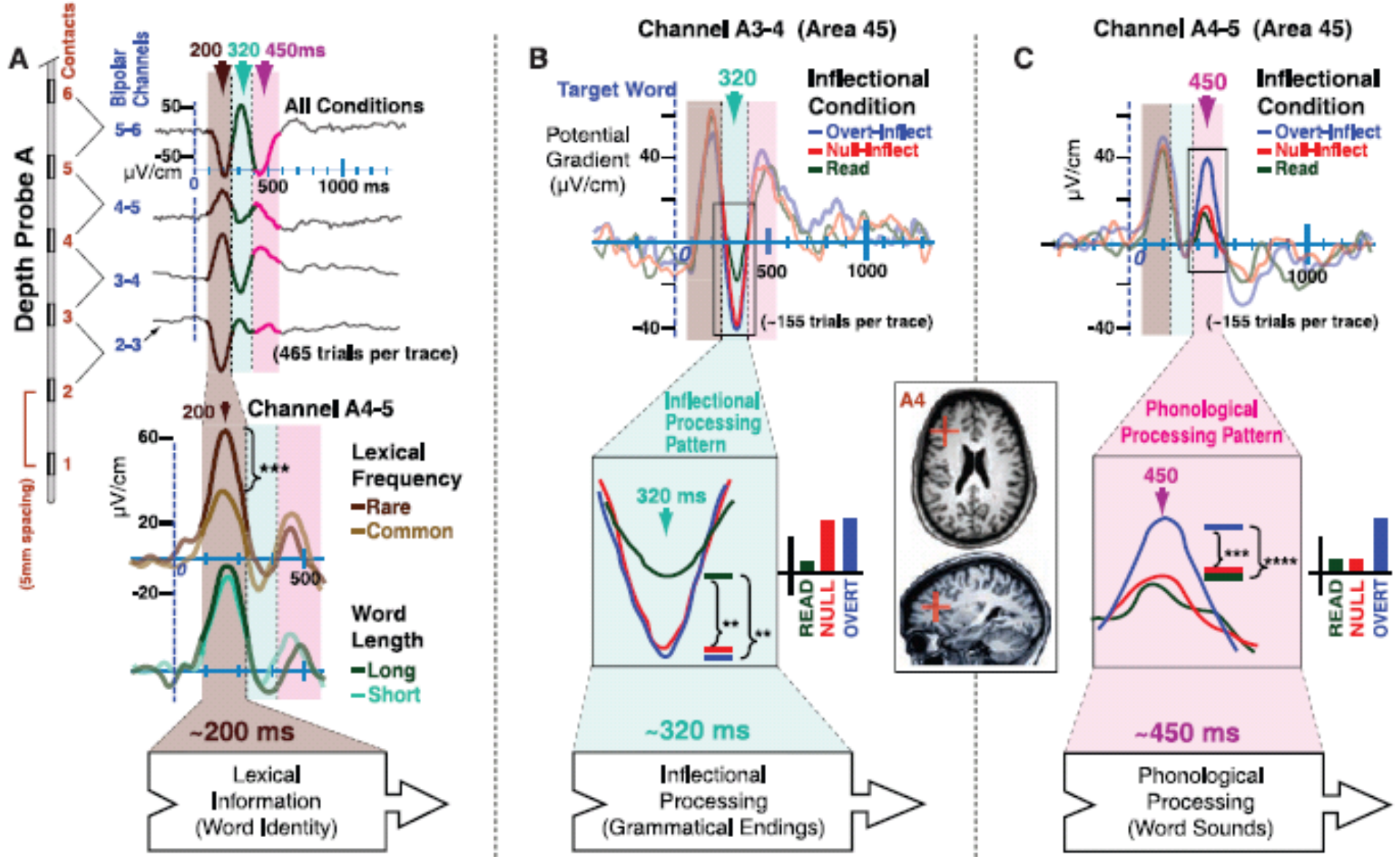




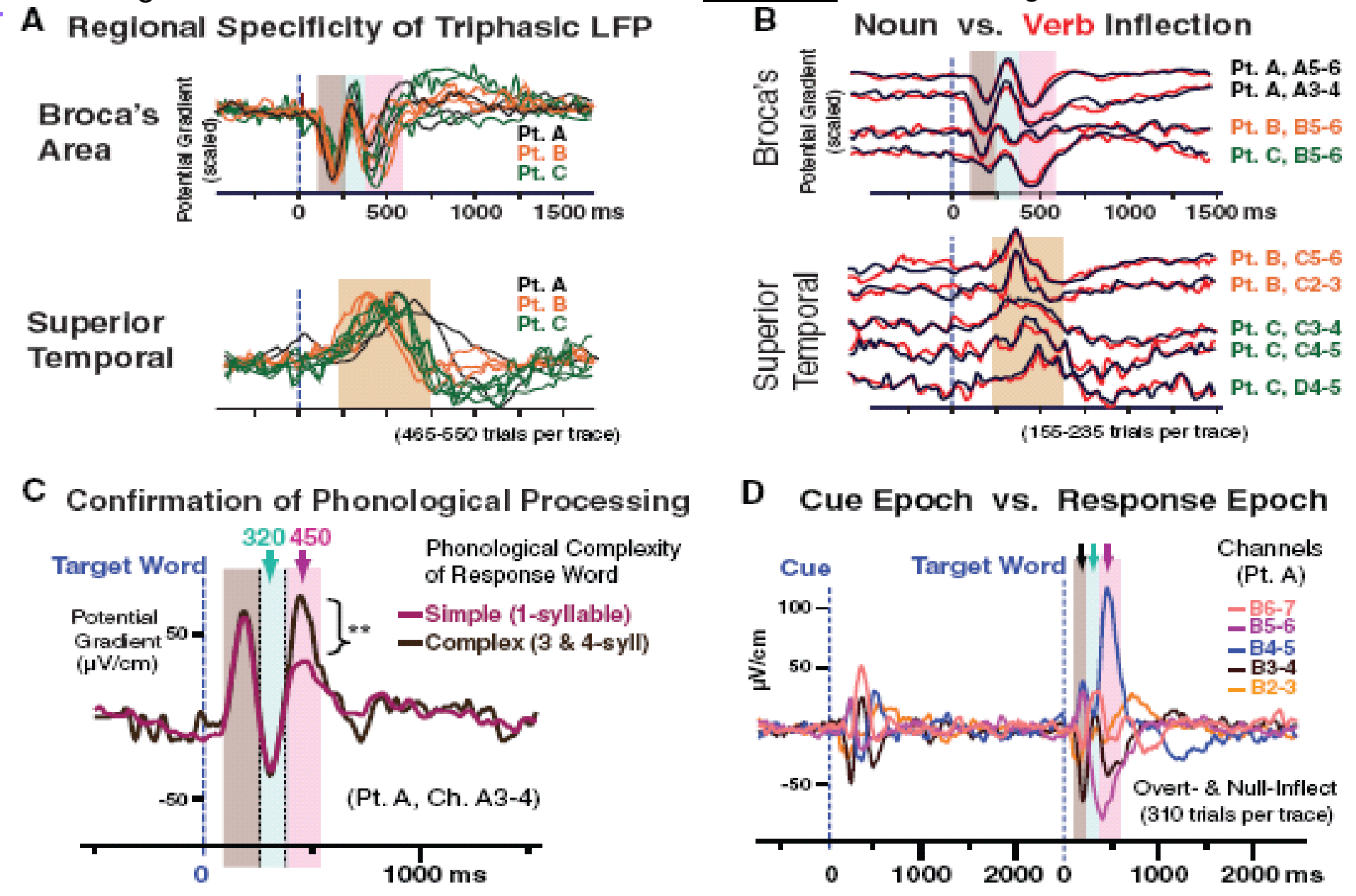






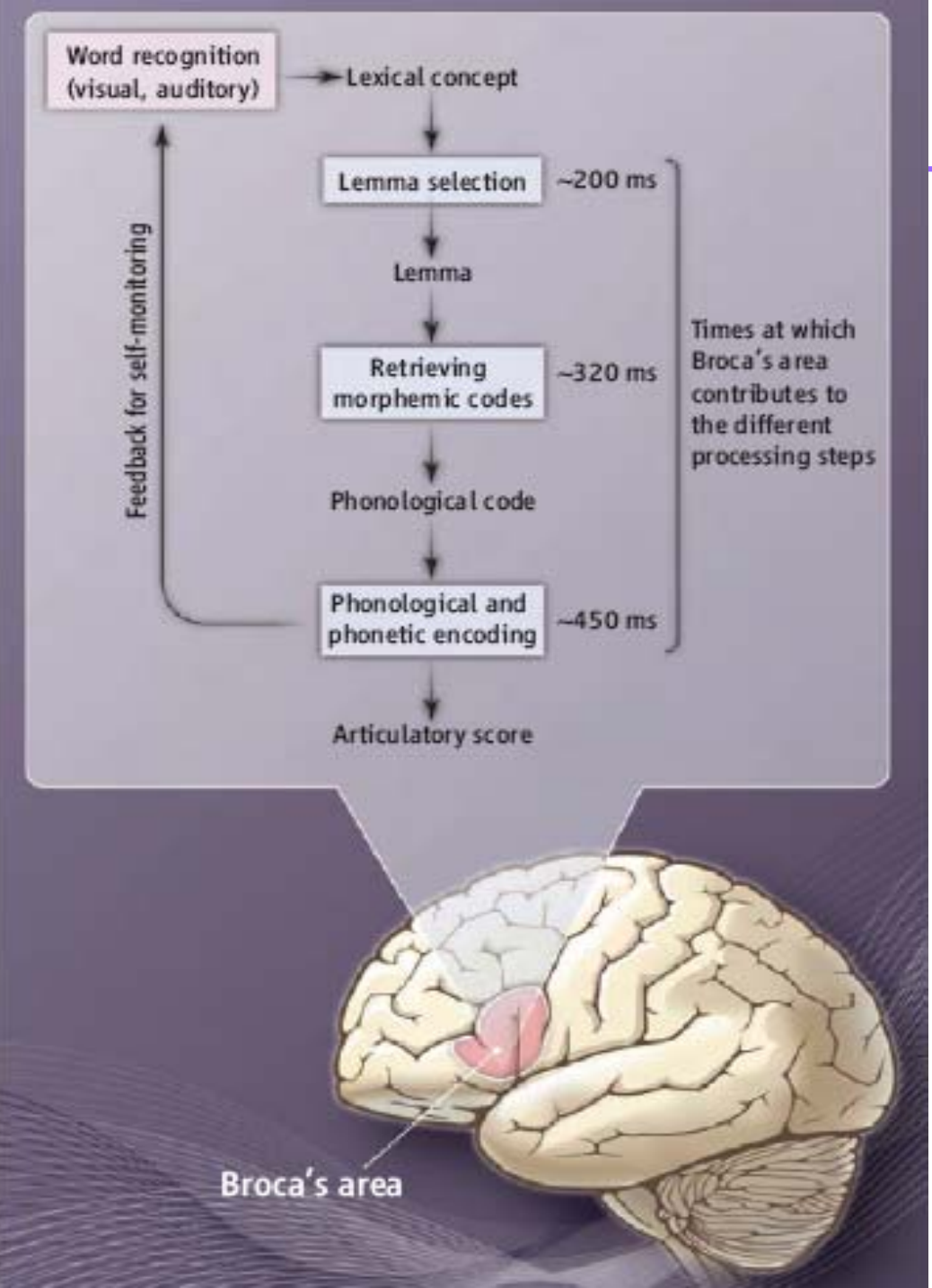

A
Depth Probe A
Contacts
Bipolar Channels
200 320 450ms
All Conditions
μV/cm
500
1000 ms
(465 trials per trace)
Channel A4-5
Lexical Frequency
Rare
Common
Word Length
Long
Short
~200 ms
Lexical Information (Word Identity)
(5mm spacing)
B
Channel A3-4 (Area 45)
Target Word
320
Inflectional Condition
Over-Inflect
Null-Inflect
Read
Potential Gradient (μV/cm)
(~155 trials per trace)
Inflectional Processing Pattern
320 ms
READ
NULL
OVERT
A4
~320 ms
Inflectional Processing (Grammatical Endings)
C
Channel A4-5 (Area 45)
450
Phonological Processing Pattern
~450 ms
Phonological Processing (Word Sounds)

Sahin, Ned T., et al. 2009. Sequential Processing of Lexical, Grammatical, and Phonological Information Within Broca's Area. ***SCIENCE*** 326.445-9. Fig.4.



Sahin, Ned T., et al. 2009. Sequential Processing of Lexical, Grammatical, and Phonological Information Within Broca's Area. ***SCIENCE*** 326.445-9. Figure S1.

"Neighboring probes within Broca's area revealed distinct neuronal activity for **lexical** (~200ms), **grammatical** (~320 ms), and **phonological** (~450 ms) processing, identically for nouns and verbs, in a region activated in the same patients and task in functional magnetic resonance imaging. This suggests that a linguistic processing **sequence** predicted on computational grounds is implemented in the brain in fine-grained spatiotemporally patterned activity."



Peter Hagoort
& Willem J. M. Levelt

The Speaking Brain

SCIENCE 326. 372
OCTOBER 16, 2009.

Hypothesis of Linguistic Relativity

Edward Sapir 1884-1939

Benjamin L. Whorf 1897-1941

Edward Sapir, 1929.

"The fact of the matter is that the 'real world' is to a large extent unconsciously built upon the language habits of the group. No two languages are ever sufficiently similar to be considered as representing the same social reality. The worlds in which different societies live are distinct worlds, not merely the same world with different labels attached... We see and hear and otherwise experience very largely as we do because the language habits of our community predispose certain choices of interpretation."

Quoted in Kay, Paul & W. Kempton. 1984. What is the Sapir-Whorf hypothesis? *American Anthropologist* 86.65-79.

Jacob, François. 1982. *The Possible and the Actual*. University of Washington Press.

"The quality of language that makes it unique does not seem to be so much its role in communicating directives for action as its role in symbolizing, in evoking cognitive images. We mold our 'reality' with our words and our sentences in the same way as we mold it with our vision and our hearing. And the versatility of human language also makes it a unique tool for the development of the imagination."

p.58.

Huxley, Aldous. 1956.
The Doors of Perception. Harper & Row.

"Every individual is at once the beneficiary and the victim of the linguistic tradition into which he has been born – the beneficiary inasmuch as language gives access to the accumulated records of other people's experience, the victim in so far as it confirms him in the belief that reduced awareness is the only awareness and as it bedevils his sense of reality, so that he is all too apt to take his concepts for data, his words for actual things."

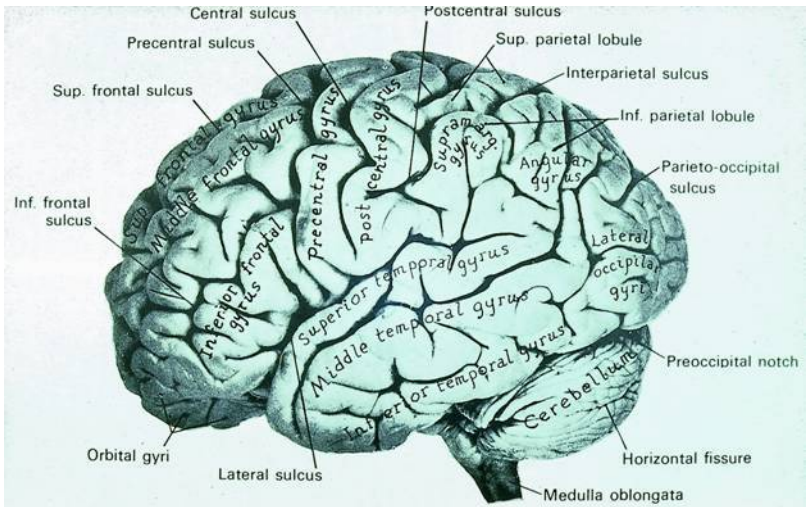
Restak, Richard. 2003. The New Brain: How the Modern Age is Rewiring your Brain London: Rodale.

"Does use and exertion of mental power gradually change the material structure of the brain, just as we see, for example, that much used muscles become stronger? It is not improbable, although the scalpel cannot easily demonstrate this."

Samuel T. Soemmering,. 1791. quoted by Richard Restak.

WHORF HYPOTHESIS

LANGUAGE → **BEHAVIOR**



BRAIN

Different **LANGUAGES** shape different **BRAINS**;
different brains produce different perceptions;
different perceptions produce different **BEHAVIORS**.

Kuhl, P. & M. Rivera-Gaxiola.

Neural Substrates of Language Acquisition.

Annual Review Neuroscience 31.511-34. 2008.

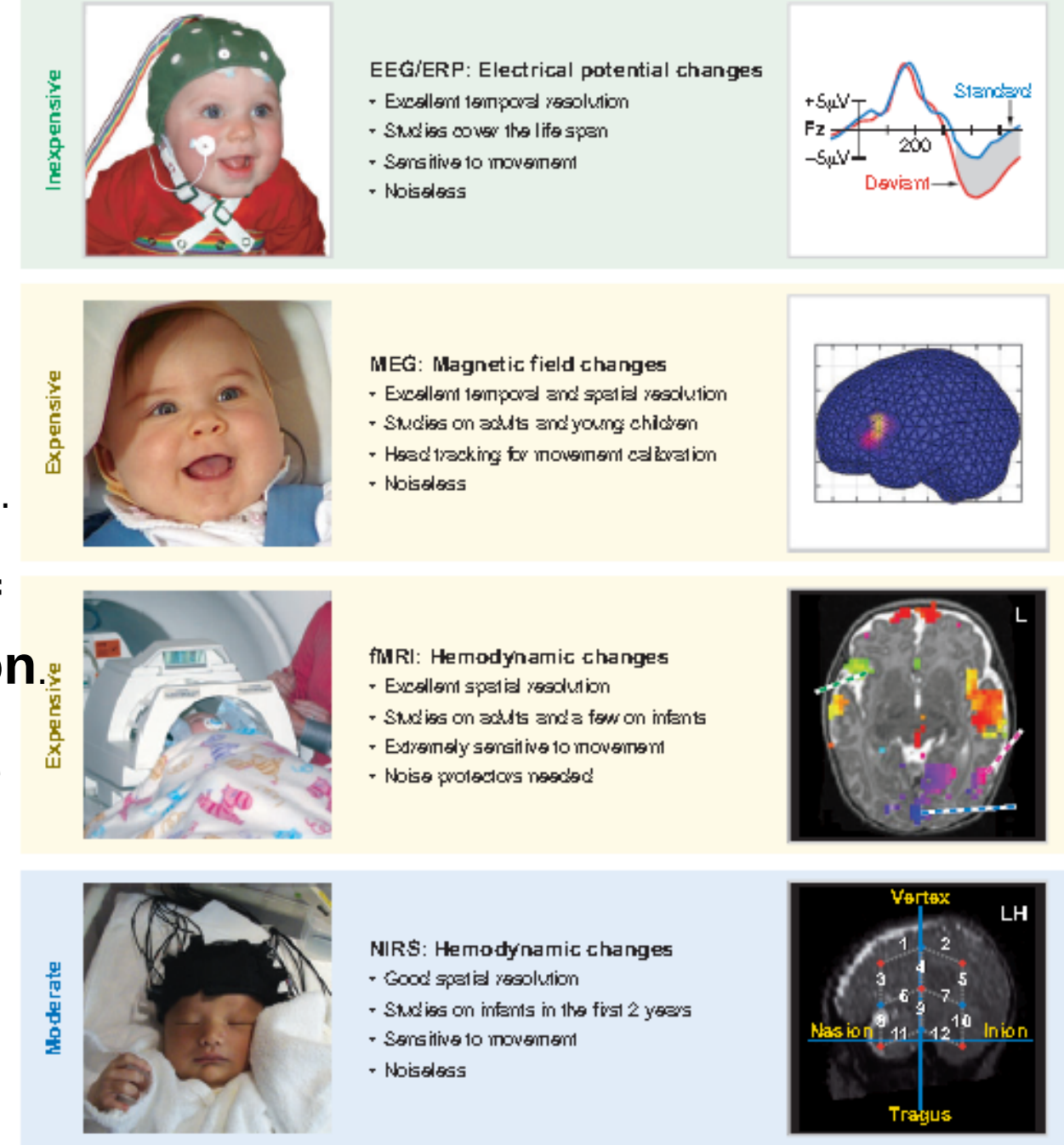
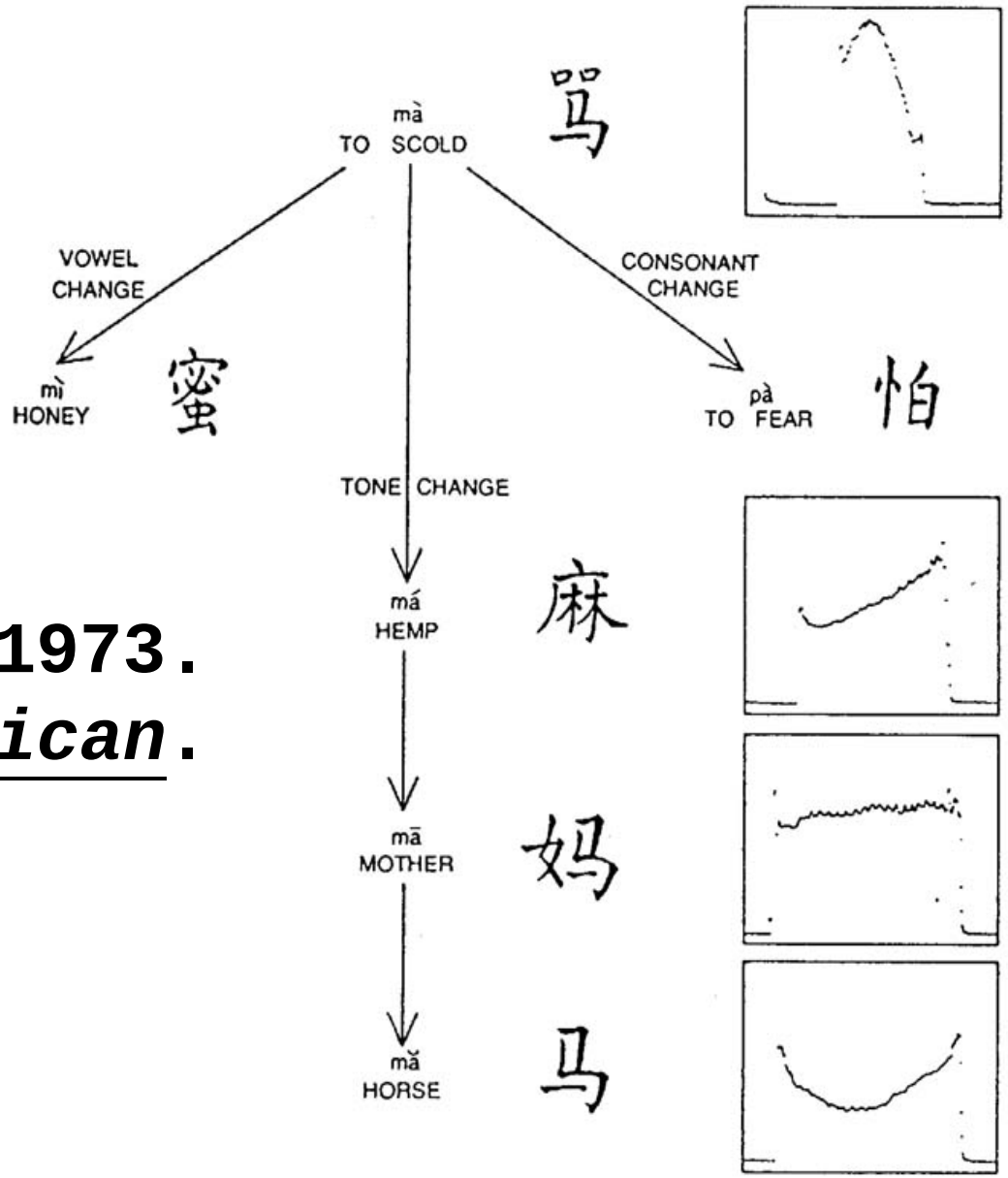


Figure 1

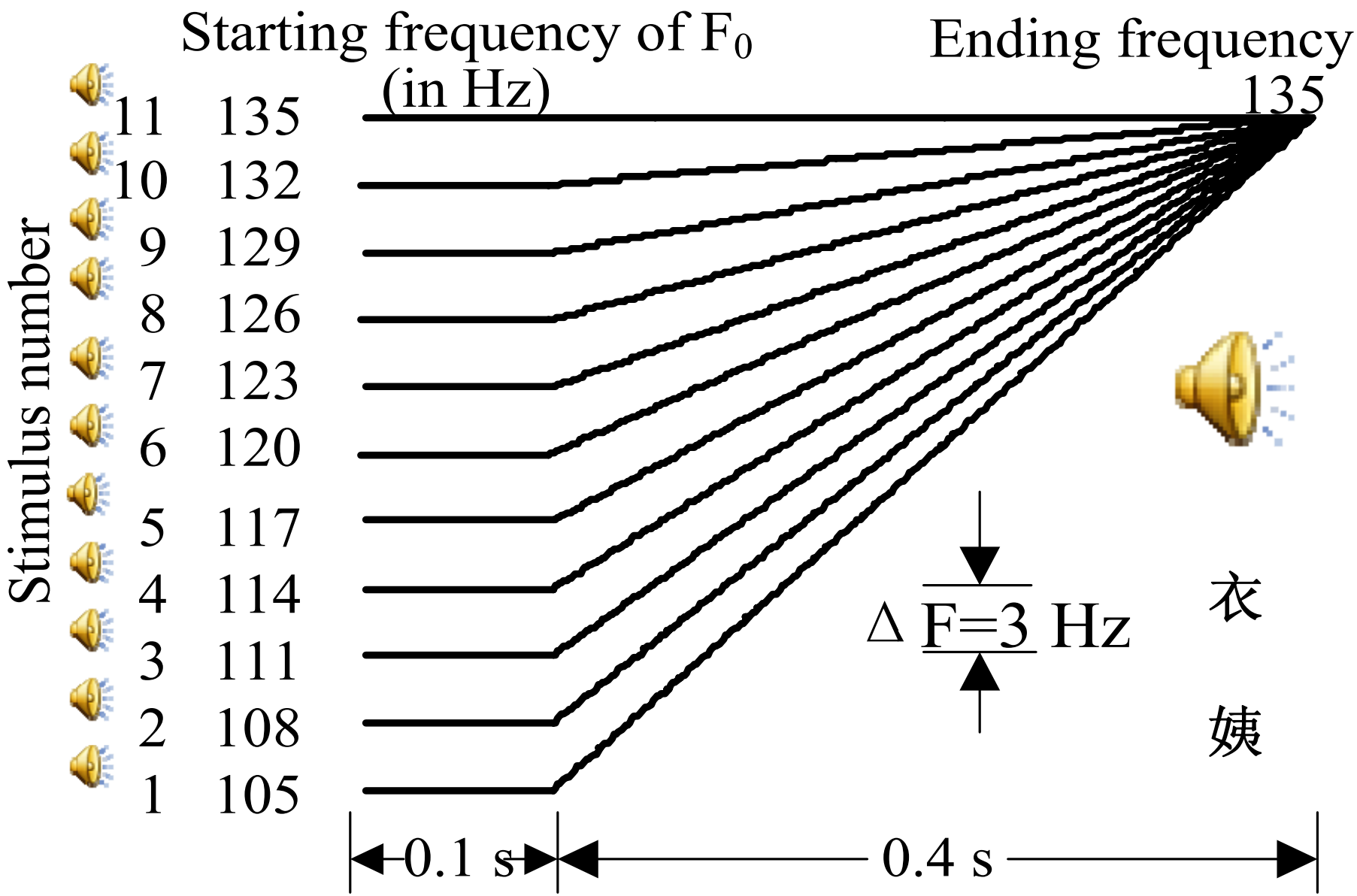
Four neuroscience techniques now used with infants and young children to examine their brain responses to linguistic signals.

Chinese tones

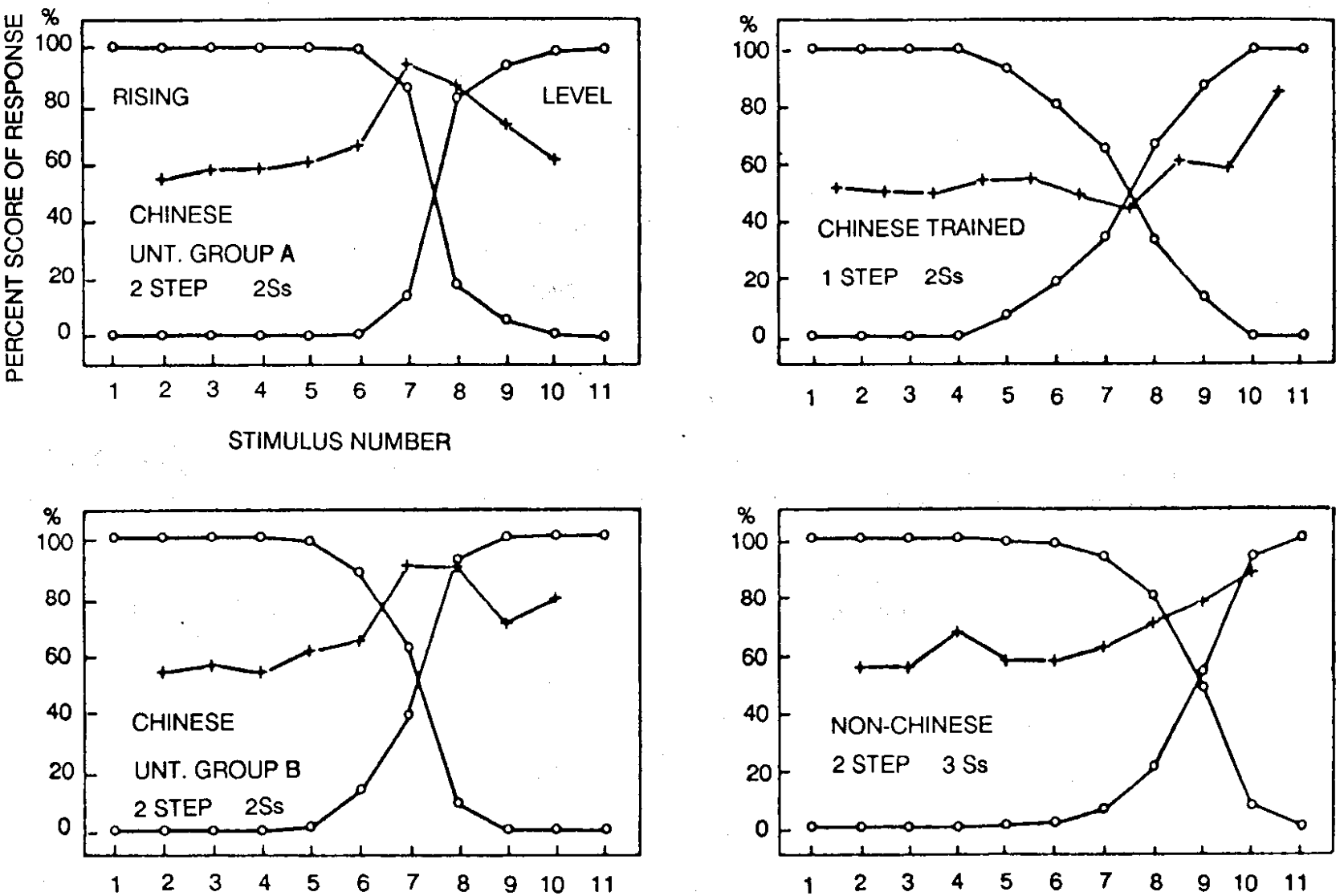


W.S-Y.Wang.Feb.1973.
***Scientific American*.**

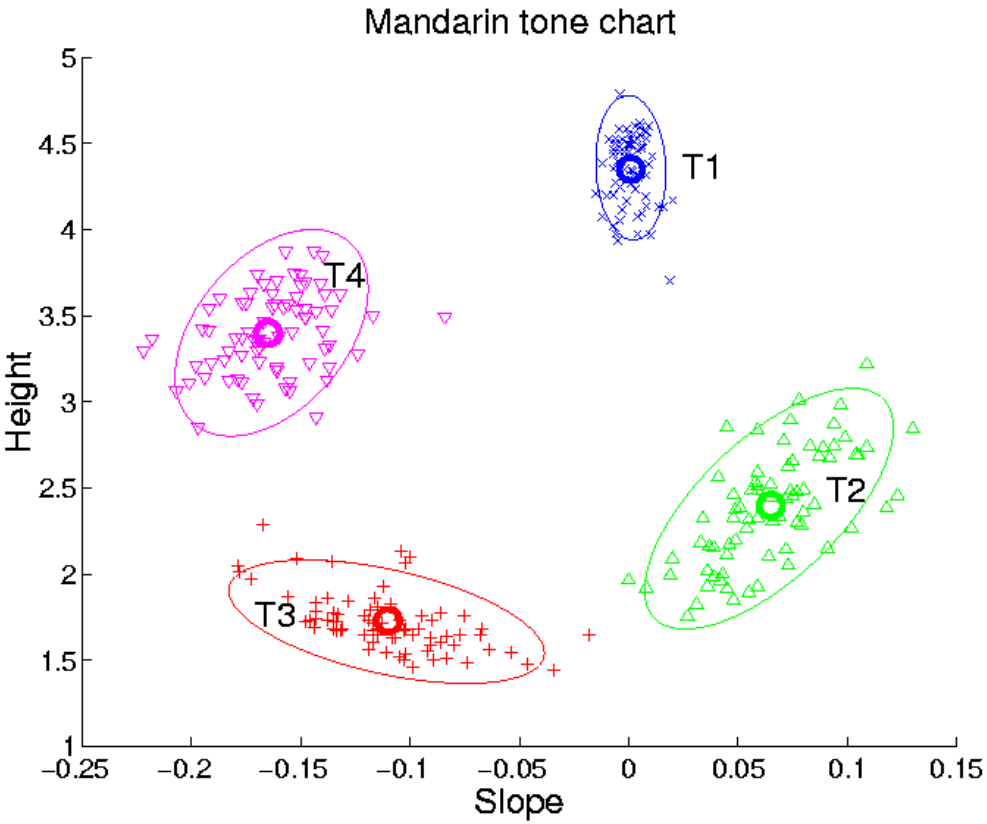
Tone CP 聲調類別感知

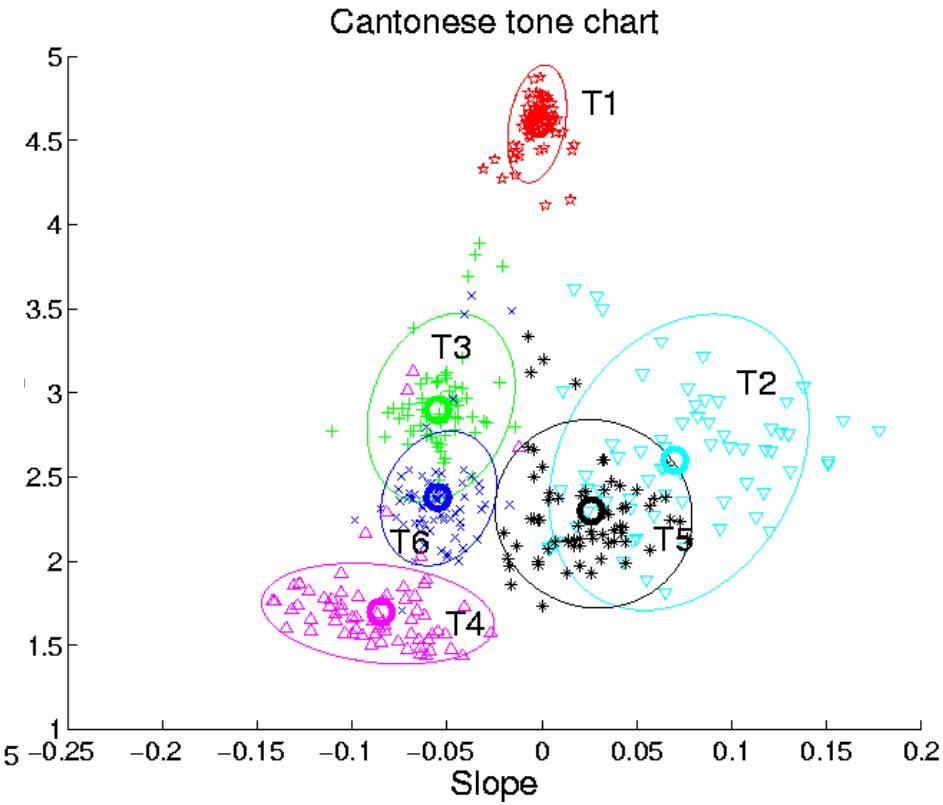


Wang, W.S-Y. 1976. Language change. Annals of the N.Y. Academy of Science 280.61-72.



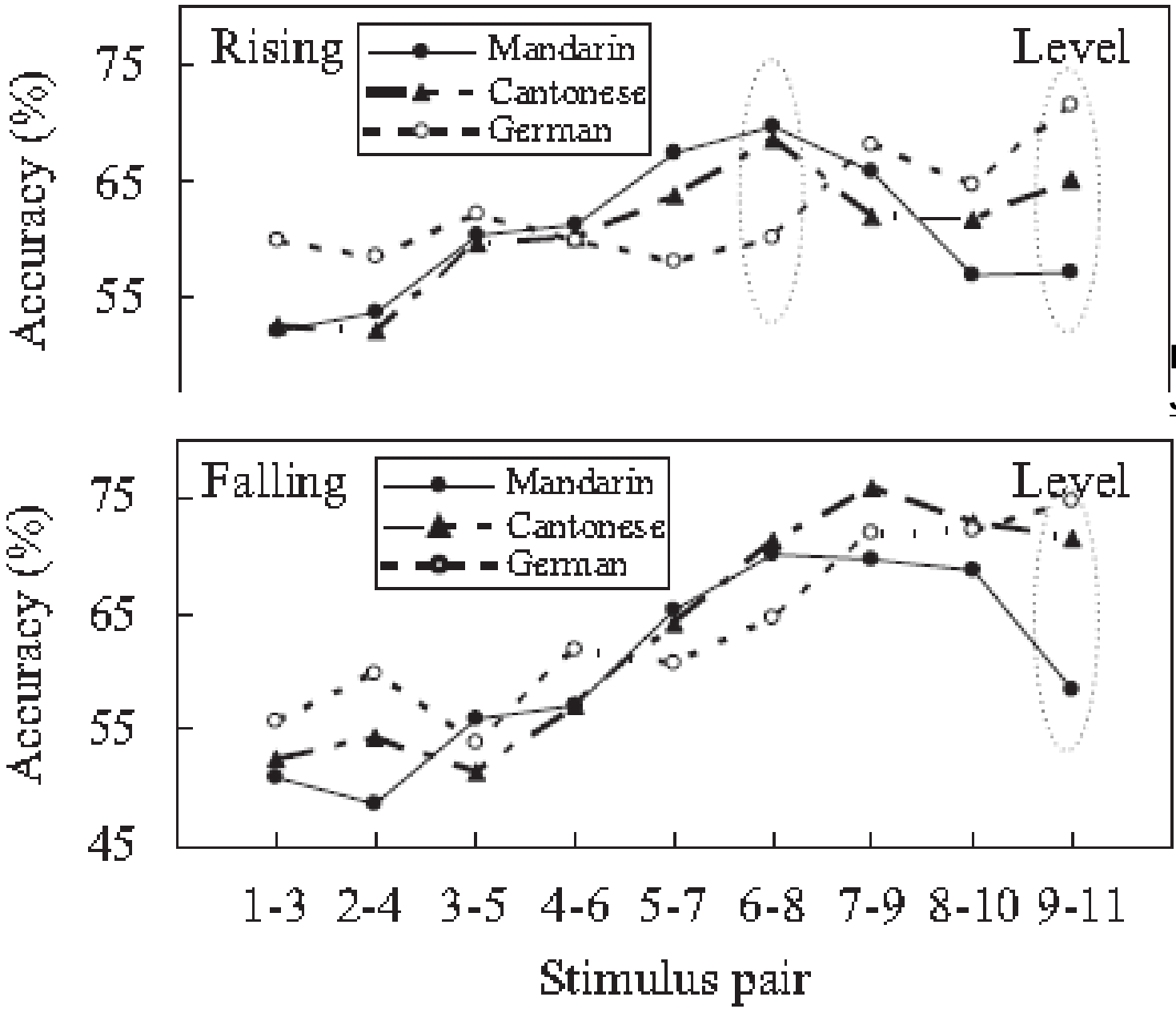
Peng, G.(2006) "Temporal and tonal aspects of Chinese syllables: A corpus-based comparative study of Mandarin and Cantonese." *Journal of Chinese Linguistics* 34.1:134-154.





The Mandarin tones are relatively compact and discretely distributed, which allows for more successful recognition.
In contrast, the Cantonese tones are tightly squeezed into the lower pitch range, suggesting on-going mergers.

The influence of language experience on categorical perception of pitch contours.



Peng, G. et al. 2010. ***Journal of Phonetics.***

Lateralized Whorf

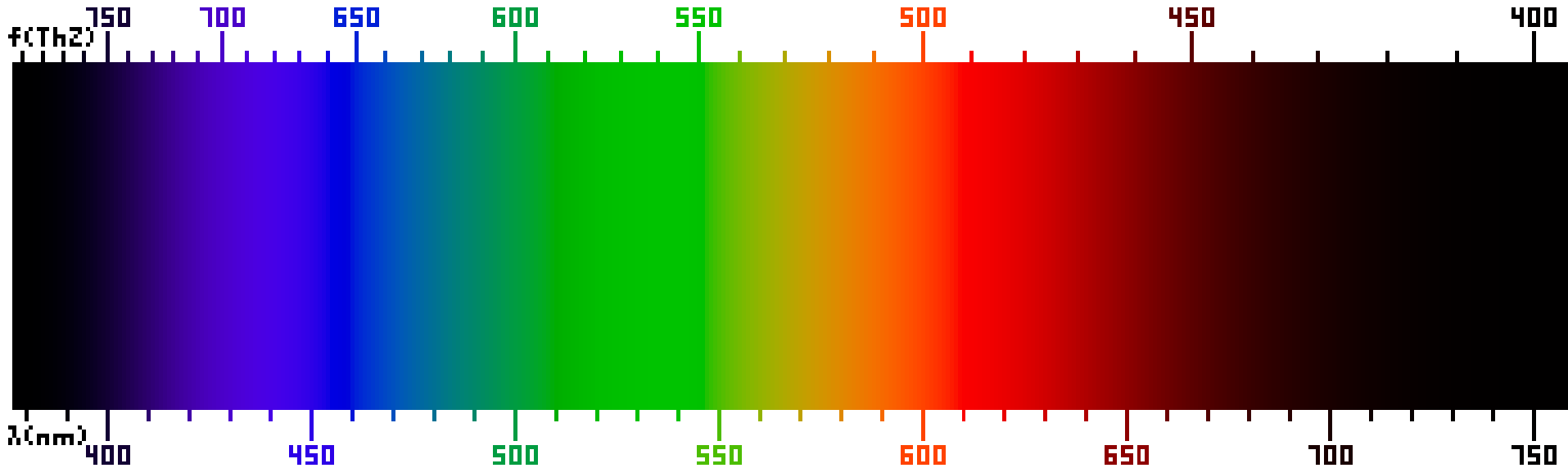
Siok, W.T., C.A. Perfetti, Z.Jin & L.H.Tan. (2004).
Biological abnormality of impaired reading is constrained by culture. *Nature* 431.71-76.

Gilbert, A.L.,Regier,T., Kay.P. & Ivry R.B. (2006).
Whorf hypothesis is supported in the right visual field but not the left.
Proceedings of the National Academy of Sciences *103*, 489–494.

Tan, L.H., A.H.D.Chan, P.Kay, P.L.Khong, L.K.C.Yip & K.K.Luke(2008).
Language affects patterns of brain activation associated with perceptual decision.
Proceedings of the National Academy of Sciences *105*.10.4004-9

Kay, P., T.Regier, A.L.Gilbert & R.B.Ivry. (2009).
Lateralized Whorf: Language influences perceptual decision in the right visual field.
Language, Evolution, & the Brain, ed. by J.W. Minett & W.S-Y. Wang:
City University of Hong Kong Press.

Siok,W.T., P.Kay, W.S-Y.Wang, A.H.D.Chan, L.Chen, K.K. Luke & L.H.Tan. (2009).
Language regions of brain are operative in color perception.
Proceedings of the National Academy of Sciences 106.8140-5.


f(Thz)
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700
650
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400
λ(nm)
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450
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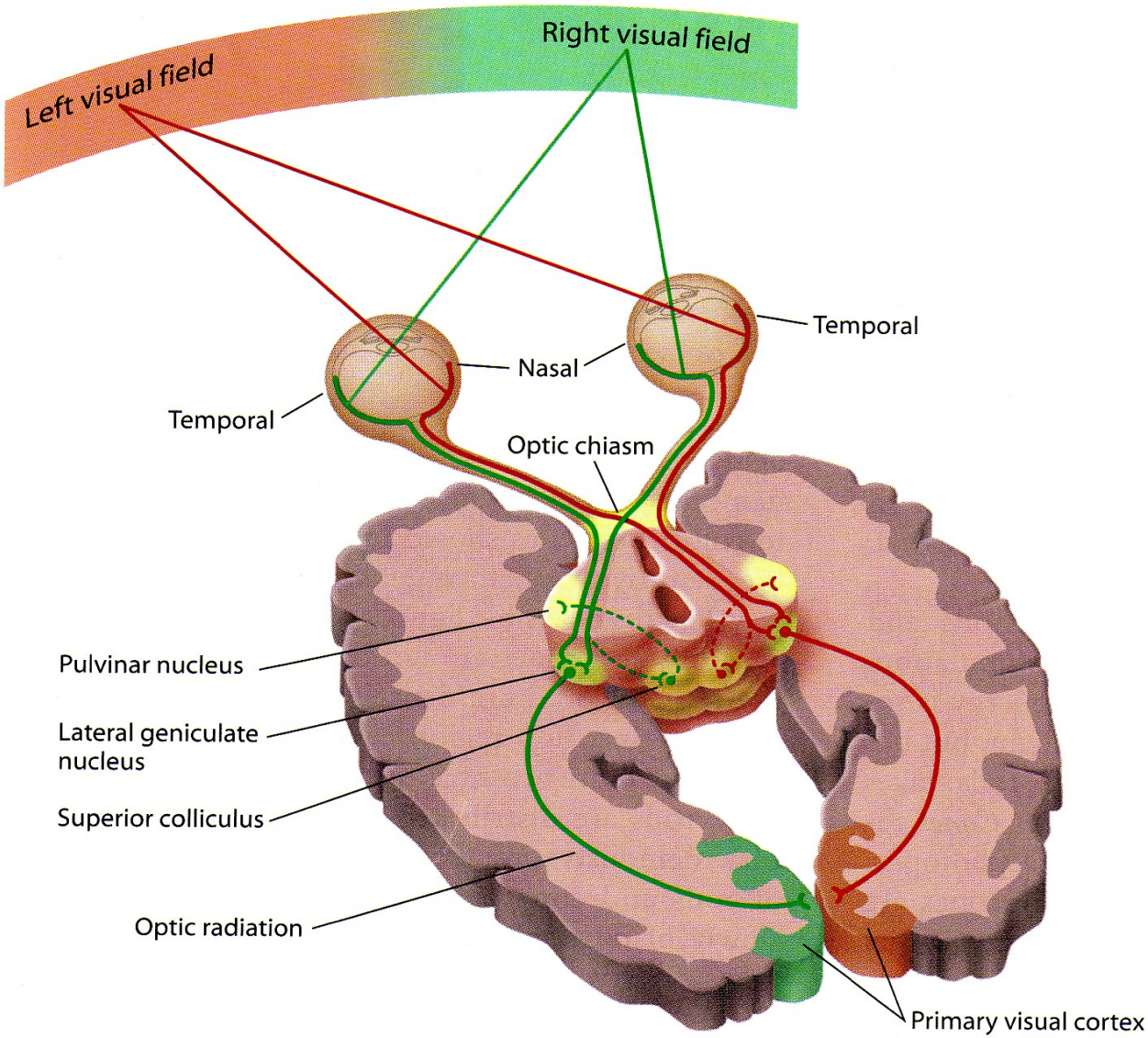
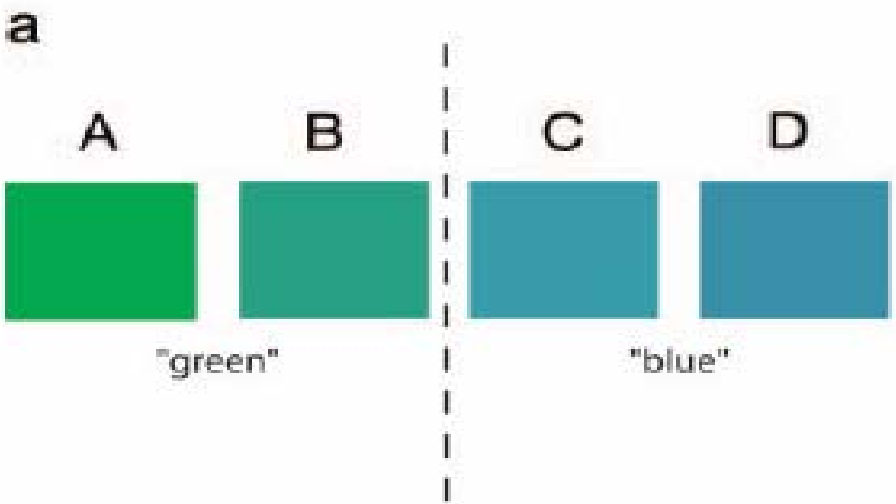
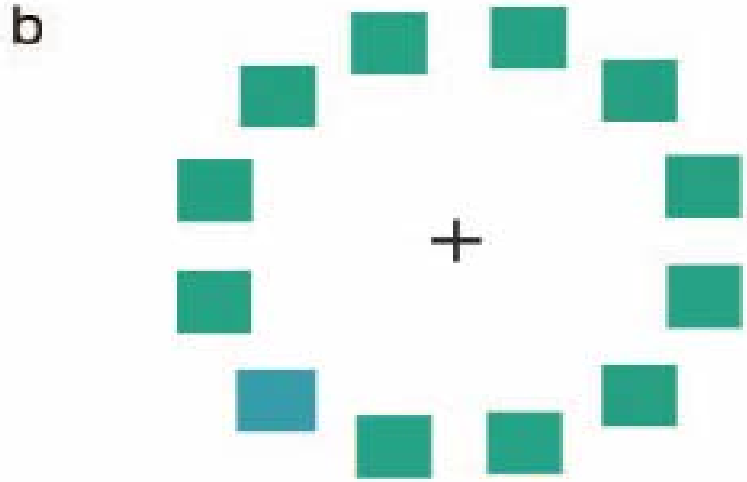


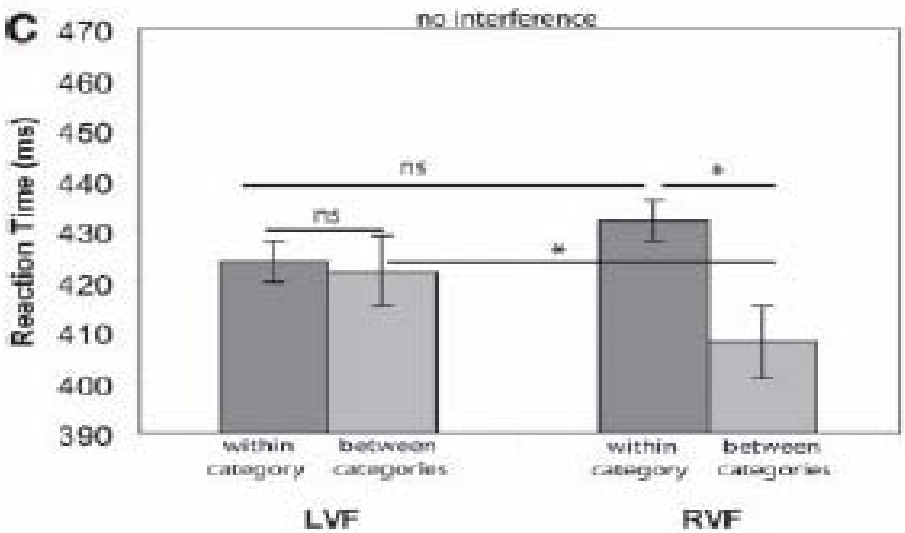
Figure 5.4 The primary projection pathways of the visual system. The optic fibers from the temporal half of the retina project ipsilaterally, while the nasal fibers cross over at the optic chiasm. In this way, the input from each visual field is projected to the primary visual cortex in the contralateral hemisphere after the fibers synapse in the lateral geniculate nucleus (geniculo-cortical pathway). A small percentage of visual fibers of the optic nerve terminate in the superior colliculus and pulvinar nucleus.

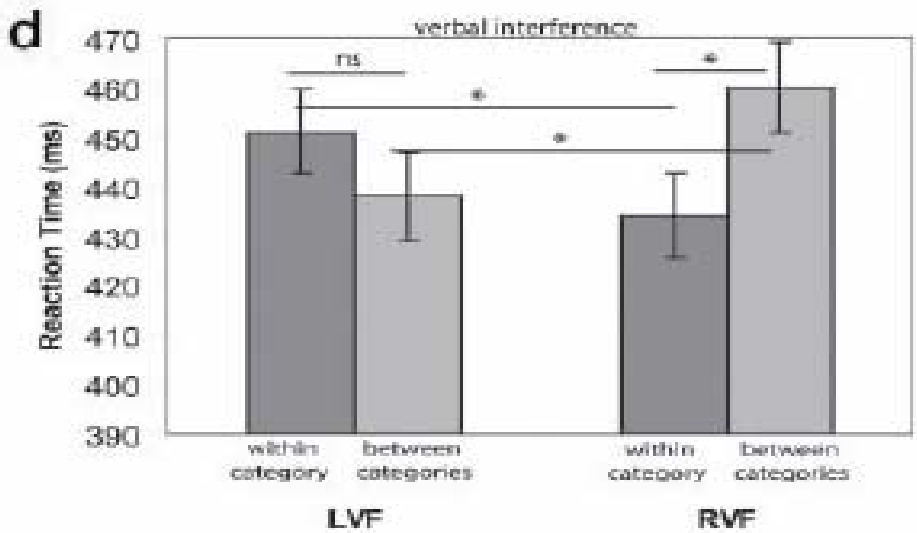
Gazzaniga et al. 2002:152.

Kay, Paul, et al. 2008. **Lateralized Whorf**: Language influences perceptual decision in the right visual field. *Minett & Wang,eds*.

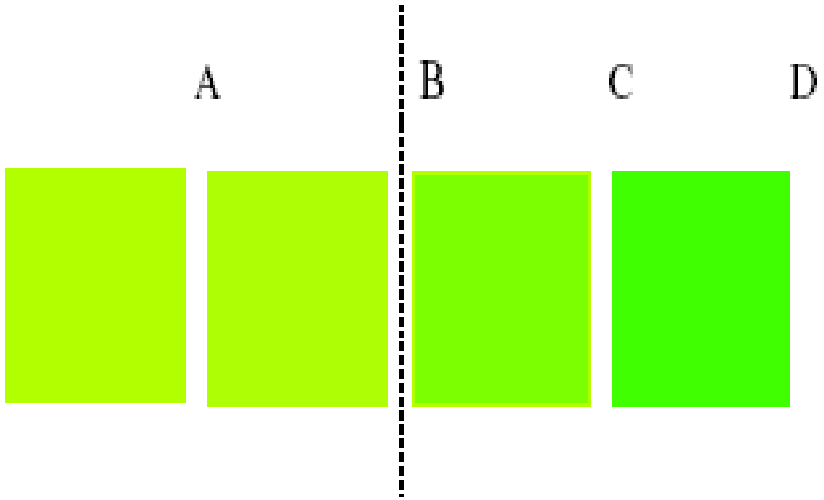








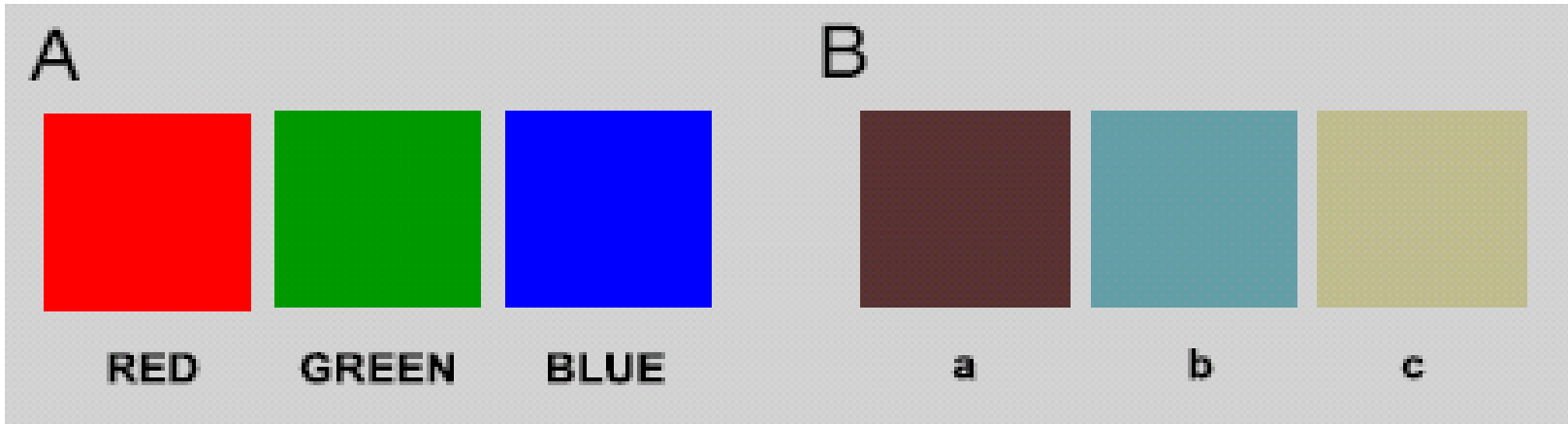
Color words in Korean and Russian.

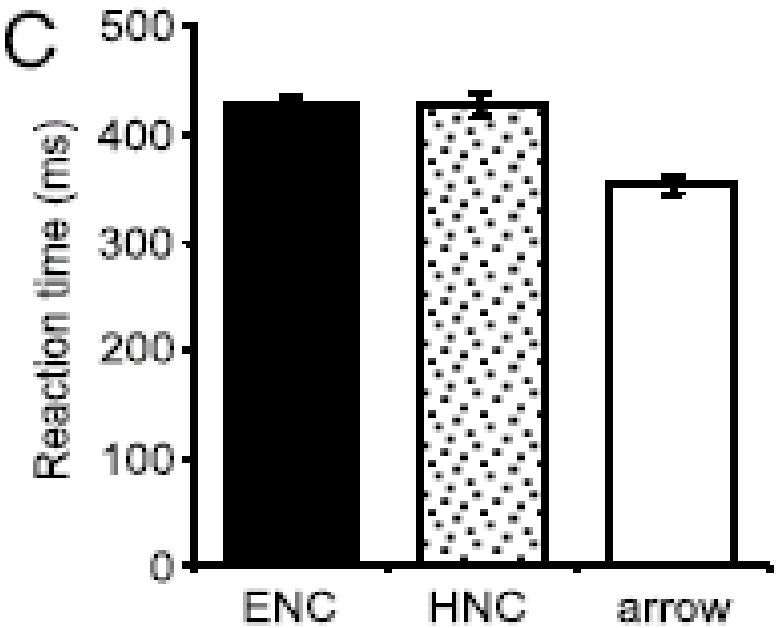


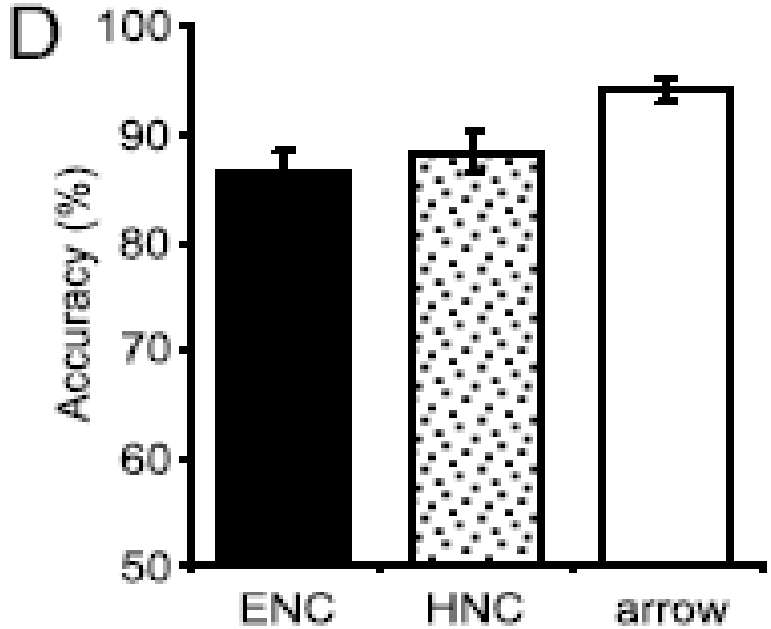
Roberson, Debi, Hyensou Pak & J. Richard Hanley. 2008. **Categorical perception of colour in the left and right visual field is verbally mediated: Evidence from Korean**. *Cognition* 107.752-62.
[yeondu vs. chorok]

Winawer, Jonathan et al. 2007. [goluboy vs. siniy]
Russian blues reveal effects of language on color discrimination. *Proceedings of the National Academy of Sciences* 104.7780-85.

Tan, L.H., A.H.D.Chan, P.Kay, P.L.Khong, L.K.C.Yip & K.K.Luke. (2008). Language affects patterns of brain activation associated with perceptual decision. *PNAS* *105*.10.4004-9







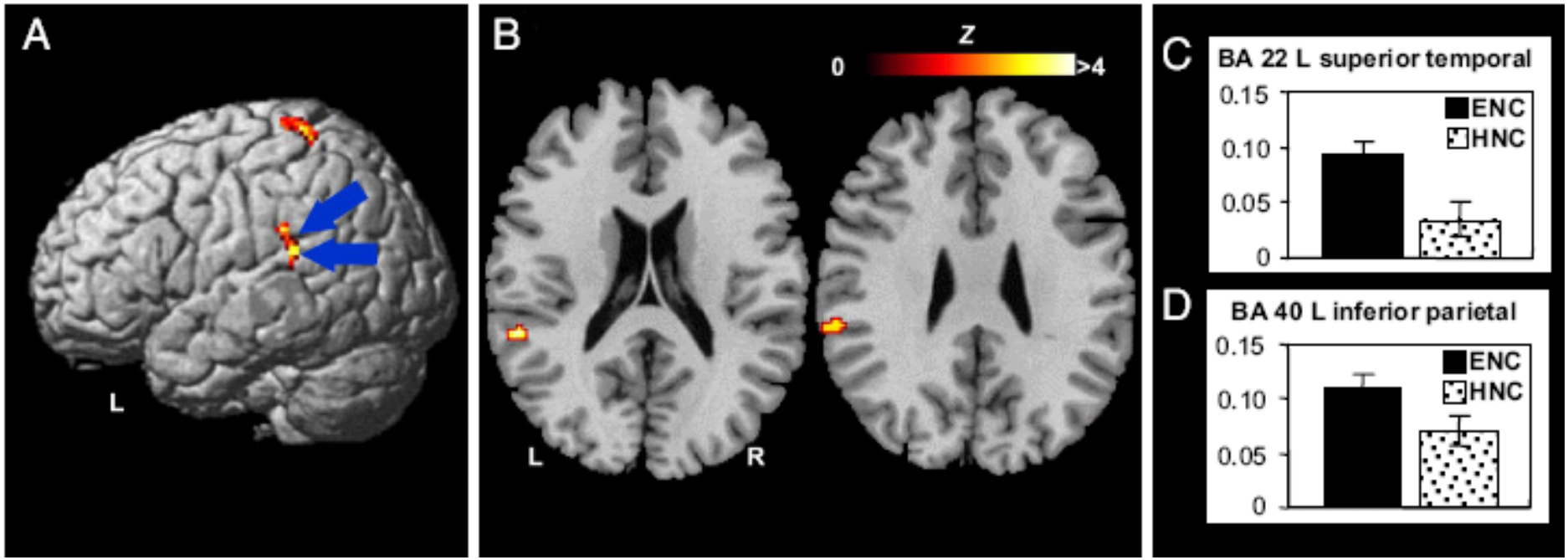


Fig. 3. Brain activations elicited by color perception and explicit color naming. (*A* and *B*) Areas showing significant activation during perceptual discrimination of easy-to-name colors in comparison with perceptual discrimination of hard-to-name colors. *A* and *B* are lateral view and axial sections, respectively. Two regions of greatest interest are the left posterior superior temporal gyrus (BA 22; *x*57, *y*38, *z* 18) and the left inferior parietal lobule (BA 40; *x*61, *y* 32, *z* 27). (*C* and *D*) Percentage BOLD signal change (SEM) at voxels of maximal difference between the two color-discrimination conditions in the two regions of interest.

Chinese language, Chinese brain

- Wang, W. S.-Y. (1973). The Chinese language. *Scientific American*, 228, 50–63.
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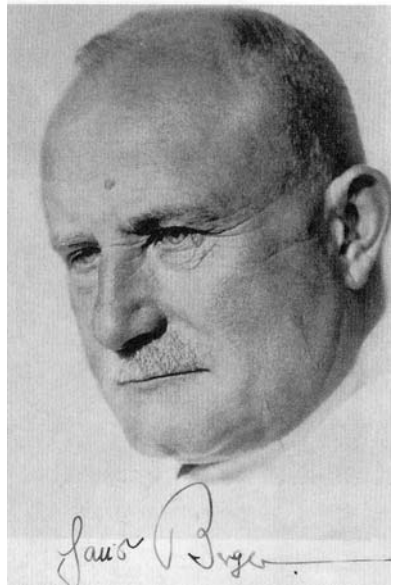
- In 1924, Hans Berger made the first recording of electrical activity generated by the human brain. He observed waves in distinct frequency bands:



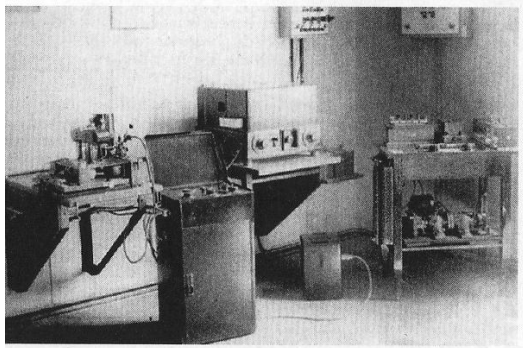
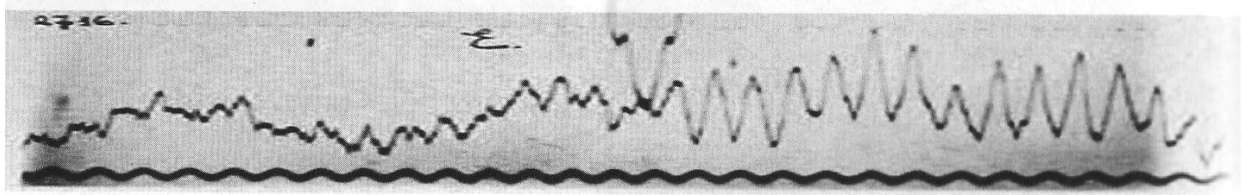
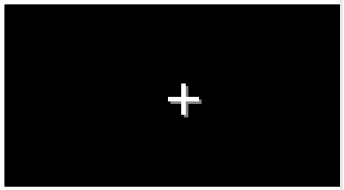
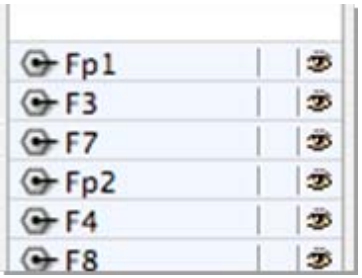


FIGURE 37. Equipment used by Berger to record human brain waves.

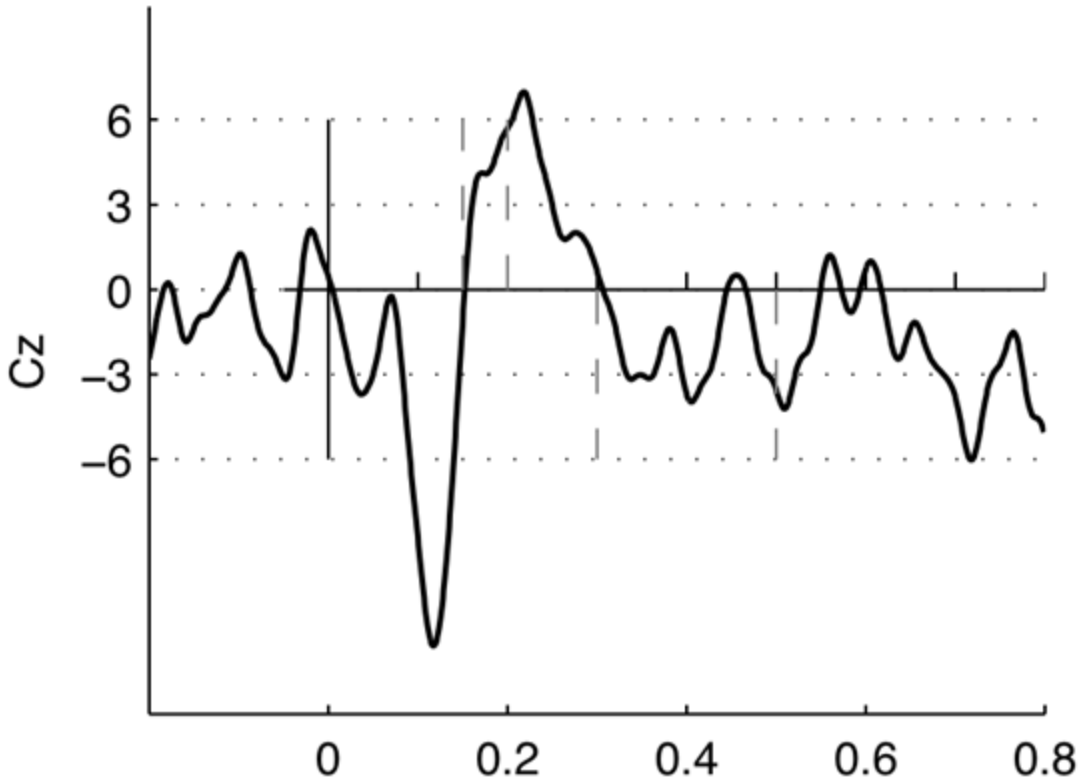
FIGURE 38. An early EEG recording by Berger.





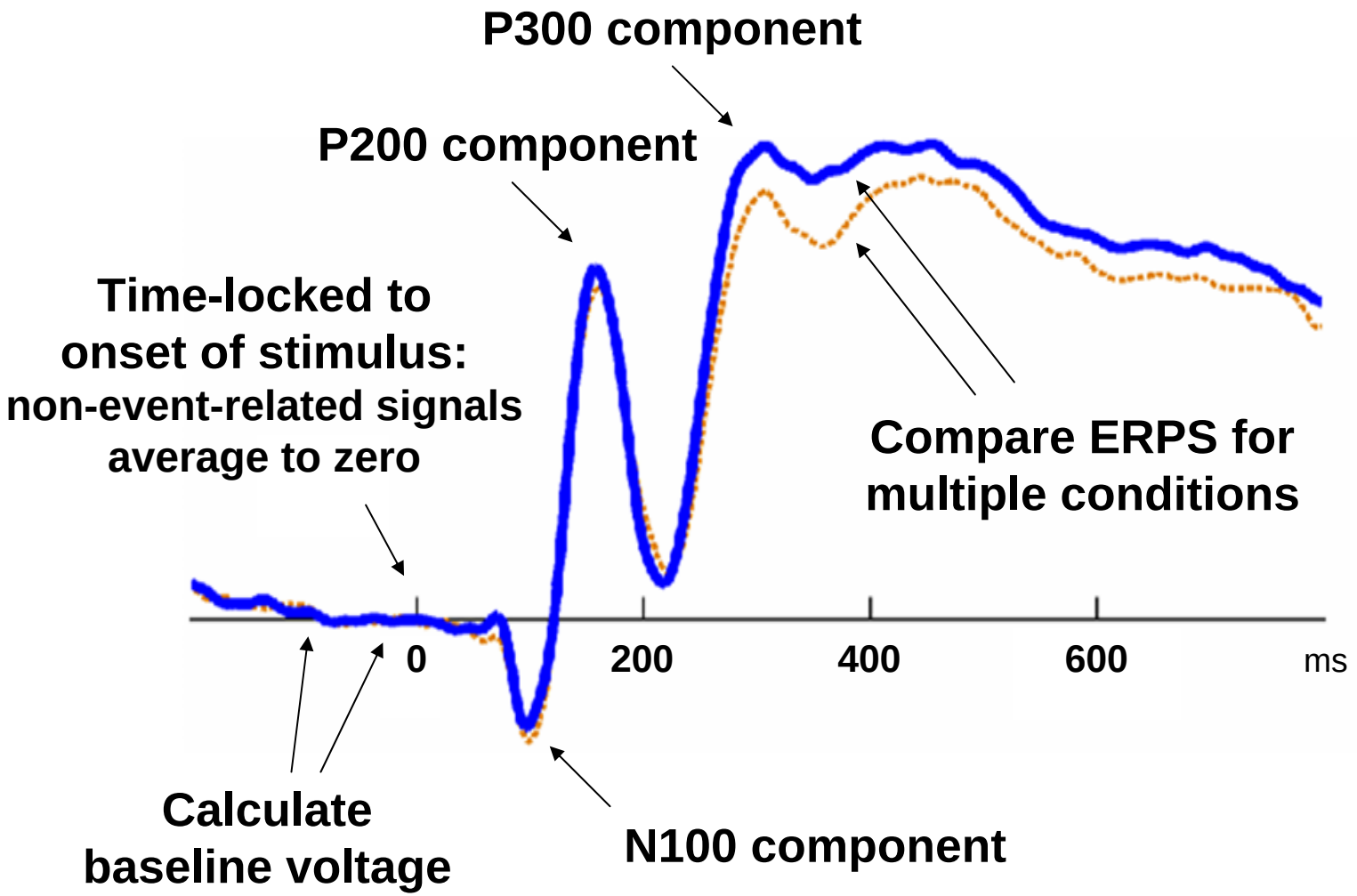

Fp1
F3
F7
Fp2
F4
F8

Reducing intra-subject variations



From EEG to single subject ERP:
Averaging over: 1, 2, 3, ... 10, 15, 20, 25 trials.
Thanks to Dr. Francis Wong for this illustration.

Event-related Potentials (ERP)



PENG, G. J. W. MINETT, W. S-Y. WANG. 2009. Cultural Background Influences the Liminal Perception of Chinese Characters: An ERP Study.

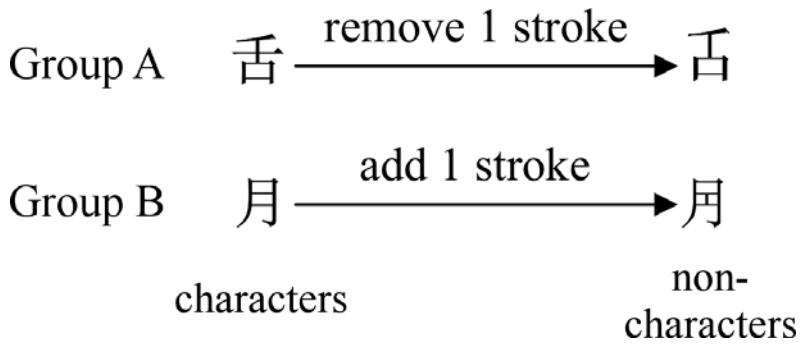
Table 1. Sociolinguistic differences between native Putonghua and Hong Kong Cantonese speakers.

	Mother tongue	Character set	Language used in Primary schools		Language used in Secondary schools	
			Spoken	Written	Spoken	Written
PTH speakers	Putonghua	Simplified	Putonghua	Chinese	Putonghua	Chinese
HKC speakers	Cantonese	Traditional	Cantonese	Chinese	Partially English	Mainly English

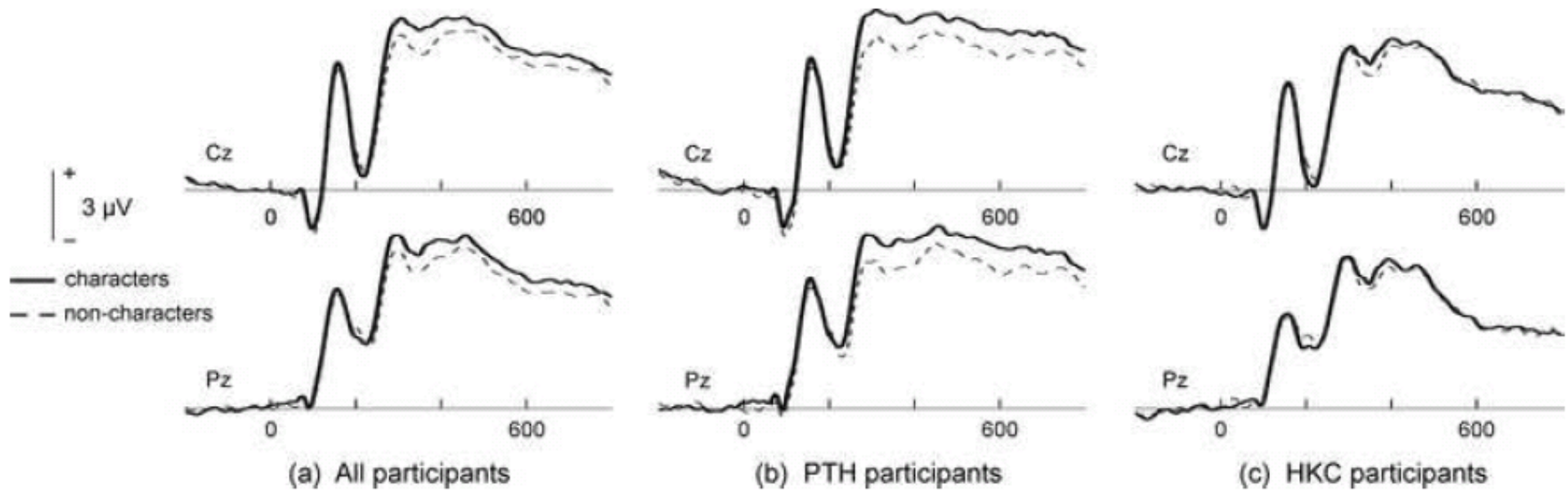
Experimental Materials

	Group A		Group B	
	character	non-character	character	non-character
1	舌	舌	人	人
2	牙	于	井	开
3	心	心	水	水
4	米	米	石	石
5	冬	冬	尺	反
6	屯	屯	月	月
7	民	民	田	田
8	式	式	豆	豆
9	史	史	女	女
10	西	西	子	子
11	卡	卡	夫	夫
12	内	内	王	王
13	右	右	户	户
14	左	左	方	方
15	令	令	包	包
16	央	央	本	本
17	五	五	支	支
18	甩	甩	升	升
19	立	立	上	上
20	老	老	走	走
21	吉	占	古	古
22	更	更	又	又
23	勿	勿	未	未
24	且	且	全	全
25	由	由	乍	乍

Characters and non-characters differ by a single stroke:



HKC – PTH 脑电波的不同



"The **diversity of language is**, from a biological point of view, **its most remarkable property** ... It presupposes an extraordinary plasticity and powerful learning abilities able to cope with variation at every level of the language system. This has to be the central explicandum for a theory of human communication."

Evans, N. & S. Levinson. 2009. **The Myth of Language Universals: Language diversity and its importance for cognitive science.** BEHAVIORAL AND BRAIN SCIENCES.

WEIRD = Western, Educated, Industrialized, Rich, and Democratic

"A recent analysis of the top journals … from 2003-2007 revealed that … a full 96% of subjects were from Western industrialized countries, specifically North America, Europe, Australia, and Israel. … **This means that 96% of psychological samples come from countries with only 12% of the world's population."**

Henrich, Joseph, Steven J. Heine & Ara Norenzayan. 2010. Most people are not WEIRD. *Nature* 466.29.

---. 2010. The Weirdest People in the World? ***BEHAVIORAL AND BRAIN SCIENCES*** 33.61-135.

Recapitulation - 1

- To answer focal question: **What is language?** concepts & methods from many disciplines are essential, especially linguistics, & cognitive neuroscience.
- Language is possible because of our powerful brain. Both brain & language are products of millions of years of evolution.
- The human line separated from other primates 6 million years ago. Bipedalism brought major bodily changes, freeing hands for intricate activities, and mouth for refined communication.

Recapitulation - 2

- We share numerous aspects of cognition with other primates, *e.g.,* structured social living, imitation & theory of mind, etc., though some aspects are much fuller developed in us.
- Anatomically Modern Humans left Africa 100kya. Evidence comes from fossil records & genetic analysis. Success to colonize entire planet due to power of language unique to our species.
- Linguistics as a science started with IE studies & comparative method. Languages diversify due to vertical & horizontal transmission, portrayed as trees and waves by 19th century linguists. Illustrated with English & Tok Pisin (New Guinea), & with Chinese & Donggan (Kirzhistan).

Recapitulation - 3

- Study of language & brain started with localizing language disorders to brain regions by inferring from autopsies, *e.g.,* speaking, comprehension, & reading.
- Neuroscience started with Neuron Doctrine. Neurosurgery for epilepsy provided valuable data on language via electrical stimulation, commissurotomy, & intracranial electrophysiology.
- With brain imaging technology recently developed, we can now monitor non-invasively online linguistic activities in the normal intact brain. Sapir-Whorf hypothesis may be studied by examining how different languages shape different brains, which in turn underlie different cultures.

The road ahead

- Convergence of linguistics, cognitive neuroscience, & evolution theory is exciting new area, attracting talent from many scientific fields, & already producing significant research.
- The area is moving forward swiftly; basic concepts still fluid, *e.g.,* neural plasticity, mirror neurons, glia cells.
- Crucial that the area builds upon not only WEIRD languages, but be fully informed on language diversity as well as multilingualism.

爲學要如金字塔，要能廣大才能高,

… building our pyramid of Linguistic Theory.

***Language** is the foundation of our species. We must understand it as individuals and as a society. For effective progress, we must **work locally** but **think globally**.*

谢谢！

Terima Kasih !

Thank you !

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