Lecture X. Higher Functions

Bio 3411

Wednesday

September 30, 2009

Readings

NEUROSCIENCE 4th ed Chapter 26, pp. 637–657

Page	Figure	Feature
700	27.4	R & L Auditory cortices differ
703	27.6	Activity with language

THE BRAIN ATLAS 3rd ed

Page	*Figure*	*Feature*
12	*7*	*Brodmann's areas*
20-23		*Cerebral hemisphere & blood supply*
122-123		*Blood supply in axial slices*
196-197		*Auditory pathways*

Principal References

Posner MI, Raichle ME (1994) *Images of Mind.* Freeman: New York, 257 p.

Ross ED (1993) Nonverbal aspects of language. Neurological Clinics 11: 9–23.

† Shaywitz BA, Shaywitz SE,Pugh KR, Constable RT, Skudlaski P, Fulbright RK, Bronen RA, Fletcher JM, Shankweller DP, Katz L, Gore JC (1995) Sex differences in the functional organization of the brain for language. Nature 373:607-609.

†Schlaug G, Jäncke L, Huang Y, Steinmetz H (1995) In vivo evidence of structural brain asymmetry in musicians. Science 267:699-700.

† Witelson SF, Kigar DL, Harvey T (1999) The exceptional brain of Albert Einstein. The Lancet 353:2149-2153.

†Articles/Abstracts posted on website.

Additional References

††Baxter LC, Saykin AJ, Flashman LA, Johnson SC, Guerin SJ, Babcock DR, Wishart HA (2003) Sex differences in semantic language processing: a functional MRI study. Brain Lang 84:264-272.

††Bell EC, Willson MC, Wilman AH, Dave S, Silverstone PH (2006) Males and females differ in brain activation during cognitive tasks. Neuroimage 30:529-538.

††Clements AM, Rimrodt SL, Abel JR, Blankner JG, Mostofsky SH, Pekar JJ, Denckla MB, Cutting LE (2006) Sex differences in cerebral laterality of language and visuospatial processing.Brain Lang 98:150-158.

††Keenan JP, Thangaraj V, Halpern AR, Schlaug G (2001) Absolute pitch and planum temporale. Neuroimage 14:1402-1408.

†† Embellishing information posted on the website.

What this lecture is about:

- Methods for study of human brain function/structure
- Auditory pathways
- Language
- Hemispheric specialization
- Special talents and genius

Methods to Study Brain Activity in Awake Humans

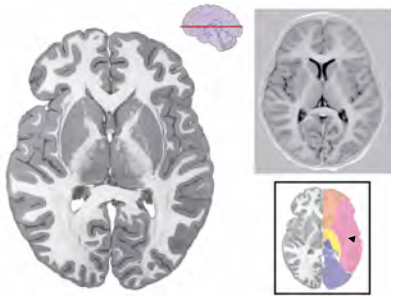
- **Lesions**: changes in function and behavior
- **"Electrophysiology": Stimulation/recording** directly from the brain; **ECoG** (electrocorticography); **EEG** (electroencphalography); **MEG** (magnetoencephalography)
- **Blood flow:** changes with activity - **PET** (positron emission tomography with isotopes); **fMRI** (functional magnetic resonance imaging for O_2 hemoglobin); **fcMRI** (correlated – connected – loci)

THE BRAIN ATLAS, 3rd ed, p 22

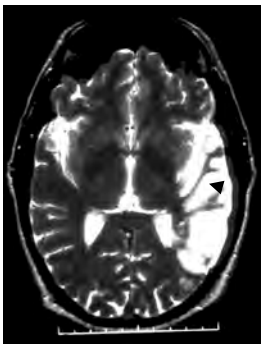
Arteries of the brain from the lateral aspect (side view). The sources and destinations of these vessels are hidden by the convolutions of the cerebral cortex.

THE BRAIN ATLAS, 3rd ed, pp 121-123

Axial slice of the brain, MRI at the same level and a map of the vessel territories. The **arrow** indicates the region supplied by the middle cerebral artery.

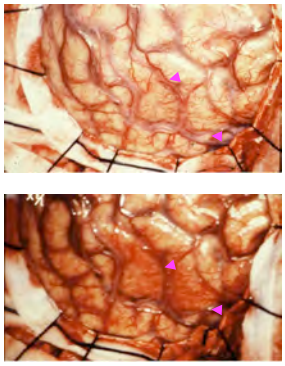


Magnetic Resonance Image (MRI) after a stroke (blocked blood vessel) in the territory of the middle cerebral artery (**arrow**).



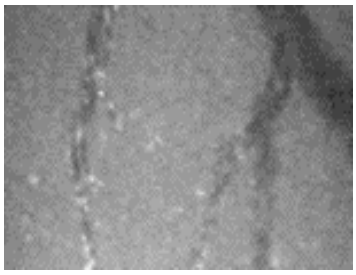
Sensors for recording the EEG from an awake normal volunteer.

During an operation for treatment of seizures the patient is awake. This patient had a seizure which is a burst of abnormal action potentials in the right lateral postcentral gyrus. The active cortex got redder when blood flow increased .



Video clip of the brain surface under a fluorescence microscope showing movement of labeled red blood cells through the vessels. When the brain is stimulated the numbers and velocity of these cells increase.

Play the movie - **RBCs.mov**

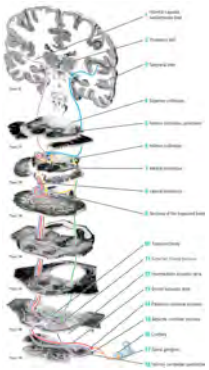


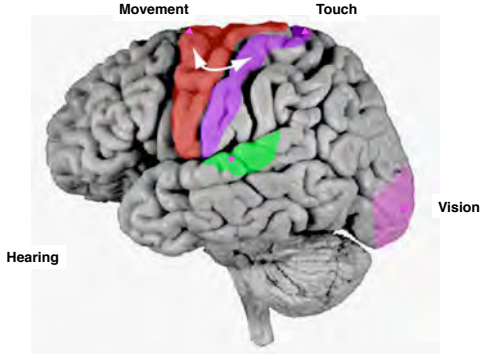
Dr. Marcus Raichle (here in his youth) and colleagues at Washington University pioneered the use of positron emission tomography (PET also developed here) to study complex behaviors such as language. Here he injects tracers into a volunteer. The volunteer's head is in an early device to monitor regional changes in radioactivity.

Auditory Pathways:

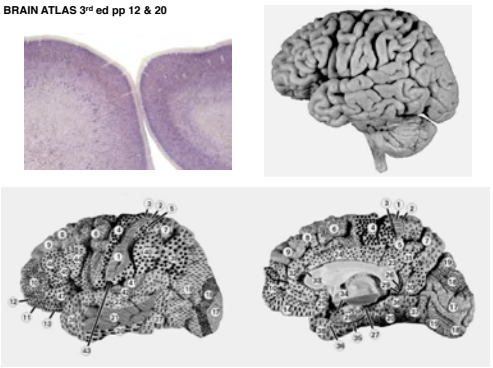
Sound information for localization, discrimination, and speech is carried through a series of ipsilateral and contralateral pathways

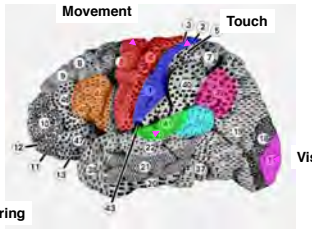
THE BRAIN ATLAS 3rd ed p. 197





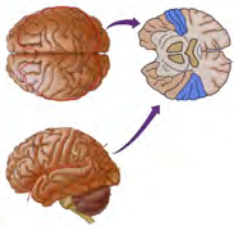
THE BRAIN ATLAS 3rd ed pp 12 & 20





NEUROSICIENCE, fig 27.4 (p 700)

The auditory cortex of humans (plamum temporale) is asymmetrical. Usually left > right.



Planum temporale measurements of 100 adult and 100 infant brains

	Left	Right
Infant	20.7	11.7
Adult	37.0	18.4

Definitions

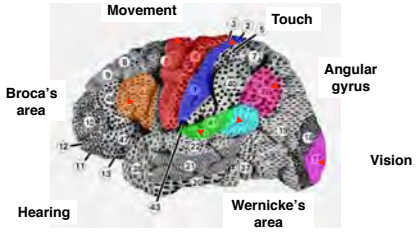
- -phasia: to speak
- aphasias: disorders of speech "content"
- prosody: stress, intonation, patterns of utterances in speech
- aprosodias: disorders of speech "affect"

THE BRAIN ATLAS 3rd ed, p 23

Different branches of the middle cerebral artery supply cortex around the lateral fissure

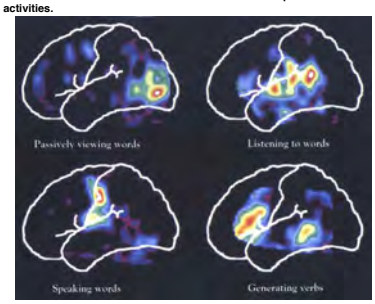
Strokes from blocking different branches of the middle cerebral artery have different effects on language function (aphasias).

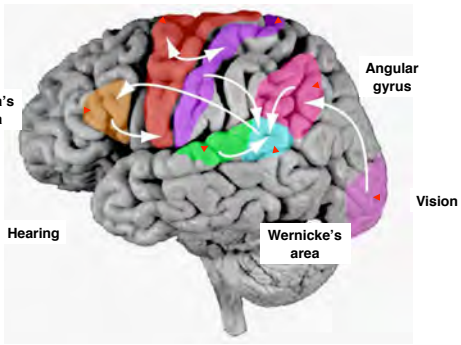
Type	Verbal Out	Sentence Repeat	Compre-hension	Naming	Lesion
Broca's	↓	↓	-	↓±	
Wernicke's	Fluent	↓	↓	↓	
Conduction	Fluent	↓	-	↓	
Global	↓	↓	↓	↓	
Anomic	Fluent	-	-	↓	
Trans-cortical Motor	↓	-	-	↓	
Sensory	Fluent	-	↓	↓	



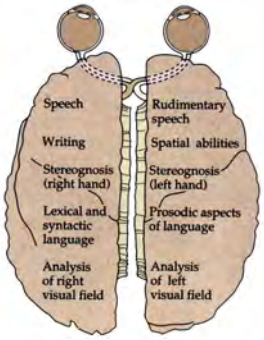
NEUROSCIENCE fig 27.6 (p 653)

PET scans show activation of different areas with different "speech" related activities.



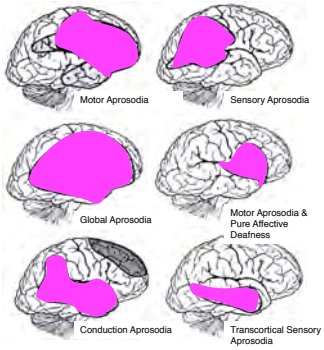


Left Hemisphere



Right Hemisphere

Right sided strokes affect expressive aspects of language.



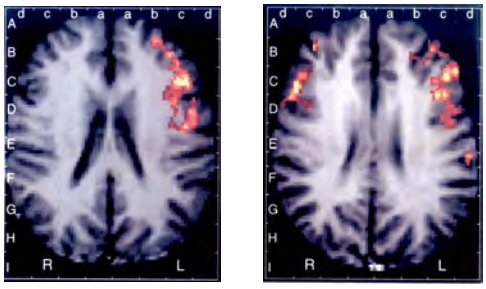
Pathways for Prosody: Expression in response to a written or spoken question.

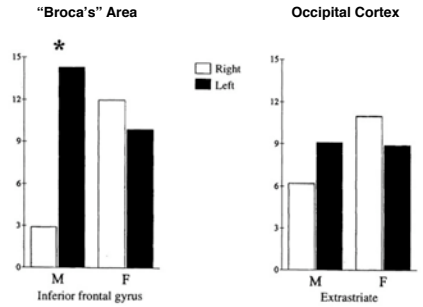
Type	Area	Aphasias	Aprosodias
Global	MCA	Comprehension Speech Production	Comprehension Gesture Production
Sensory	Wernicke's	Speech Comprehension	Gesture Comprehension
Conduction	Angular Gyrus	Word Repetition	Gesture Repetition
Motor	Broca's	Speech Production	Gesture Production

Language/Gender

- Subjects – 19 right-handed males (mean age 28.5 y); 19 right-handed females (mean age 24 y).
- Tasks – performance (bulb squeezing – yes/no) in line judgement (letter-case patterns); rhyme and semantic categorization.
- fMRI with statistics and subtractive task isolation.

Males Females





During phonological tasks, brain activation in males is lateralized to the left inferior frontal gyrus regions; in females the pattern of activation is very different, engaging more diffuse neural systems that involve both the left and right inferior frontal gyrus.

Music

- Subjects – 30 musicians (19 without perfect pitch; 11 with) & 30 non-musicians
- "Structural" MRI with measurements of the superior temporal plane (auditory cortex) on both sides.

Musician with perfect pitch

Musician without perfect pitch

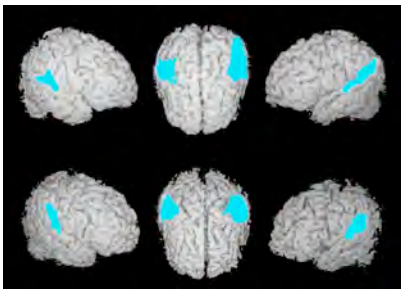


Table 1. Means (±SD) for age, degree of anatomical planum temporale asymmetry (PT), and size of left and right PT determined with in vivo magnetic resonance morphometry in healthy, right-handed musicians and nonmusicians.

Subjects	Age	PT†	PT size (mm²)	
			Left	Right
Musicians (n = 30)	26 (4)	−0.36 (0.25)*	1063 (189)	750 (187)
Perfect pitch (n = 11)	27 (5)	−0.57 (0.21)**	1097 (202)	611 (105)
No perfect pitch (n = 19)	26 (4)	−0.23 (0.17)	1043 (183)	830 (178)
Nonmusicians (n = 30)	26 (3)	−0.23 (0.24)	896 (236)	736 (283)

†Negative values indicate leftward asymmetry of the PT (16). *P = 0.028 compared to nonmusicians. **P < 0.001 compared to musicians without perfect pitch (21).

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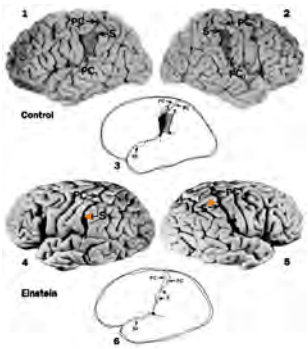
Musicians with perfect pitch revealed stronger leftward planum temporale asymmetry than nonmusicians or musicians without perfect pitch. The results indicate that outstanding musical ability is associated with increased leftward asymmetry of cortex subserving music-related functions.

Genius

Albert Einstein –
"for my scientific thinking"
…"words do not seem to play any role"
… but there is "associative play" of "more or less clear images" of a "visual and muscular type."



"Einstein's brain weight was not different from that of controls and the gross anatomy of his brain was within normal limits with the exception of his parietal lobes. In each hemisphere, morphology of the Sylvian fissure was unique compared with 182 hemispheres from the 35 control male and 56 female brains: the posterior end of the Sylvian fissure had a relatively anterior position, associated with no parietal operculum. In this same region, Einstein's brain was 15% wider than controls. These two features suggest that, in Einstein's brain, extensive development of the posterior parietal lobes occurred early, in both longitudinal and breadth dimensions, thereby constraining the posterior expansion of the Sylvian fissure and the development of the parietal operculum, but resulting in a larger expanse of the inferior parietal lobule. A further consequence of this morphology is that the full supramarginal gyrus lies behind the Sylvian fissure, undivided by a major sulcus as is usually the case."

What this lecture was about:

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With TAs

- What are the principal merits and drawbacks of direct electrical recording and fMRI for studies of human brain function?
- What areas are involved in interpreting language? In speech production?
- Compare and contrast aphasias and aprosodias. On what side of the brain do the underlying functions exist?
- How do the brains of musicians with perfect pitch differ structurally from brains of other musicians? That of Einstein from other mortals?

End