Brain and Behaviour – S2

PSYC 304 921

T/TH 6 – 8:50 pm

Buch A104

Announcements

- ***FINAL EXAM – August 15, 7pm, SWING floor 1, room 121***

Outline

1. Left vs right hemispheres
2. Right hemisphere damage, prosopagnosia

-break-

1. Left hemisphere damage
2. Language

-Midterm 3 review-

- 8:00-8:40 pm – in-person only

Learning Objectives

Hemispheric Lateralization

1. Distinguish between communication and language.
2. Describe experimental techniques for studying the left and right hemispheres independently of one another.
3. Summarize the apparent cognitive specializations of each hemisphere as revealed by behavioral testing.
4. Speculate about the evolutionary origins of handedness, and discuss the relationship of handedness to cerebral lateralization
5. Itemize the types of deficits seen after right-hemisphere lesions, relating the deficits to specific anatomical locations within the hemisphere.
6. Describe prosopagnosia and summarize the brain's face-processing network.
7. Discuss the anatomy and specialized functions of the fusiform system

Brainstorm

What do you know about hemispheric specialization or lateralization?

Do the left and right hemispheres of the brain do the same jobs – are they responsible for different skills?

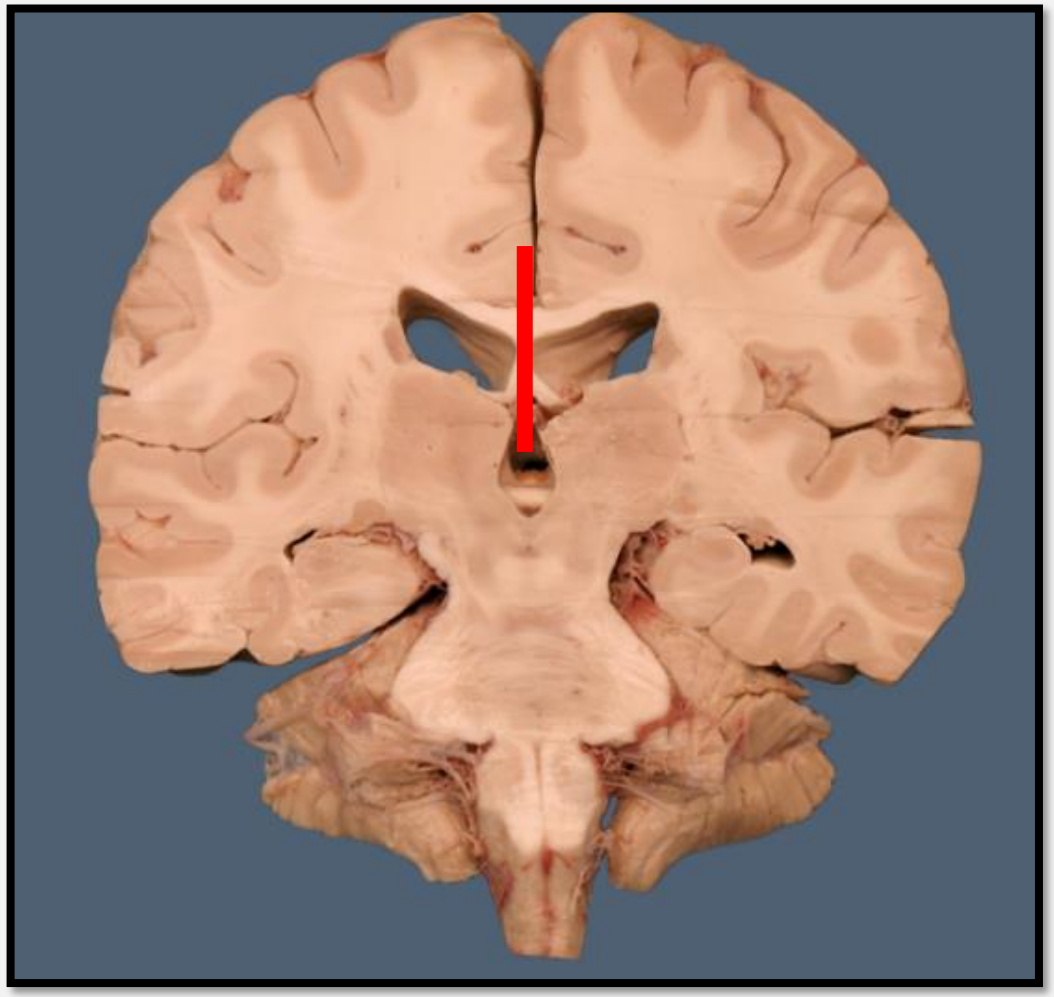
What myths/common assumptions have you heard about the L/R sides of the brain

Lateralization

- Verbal abilities are associated with the left hemisphere of the brain; the right hemisphere plays a role in spatial cognition.
- **Lateralization:** hemisphere specialization

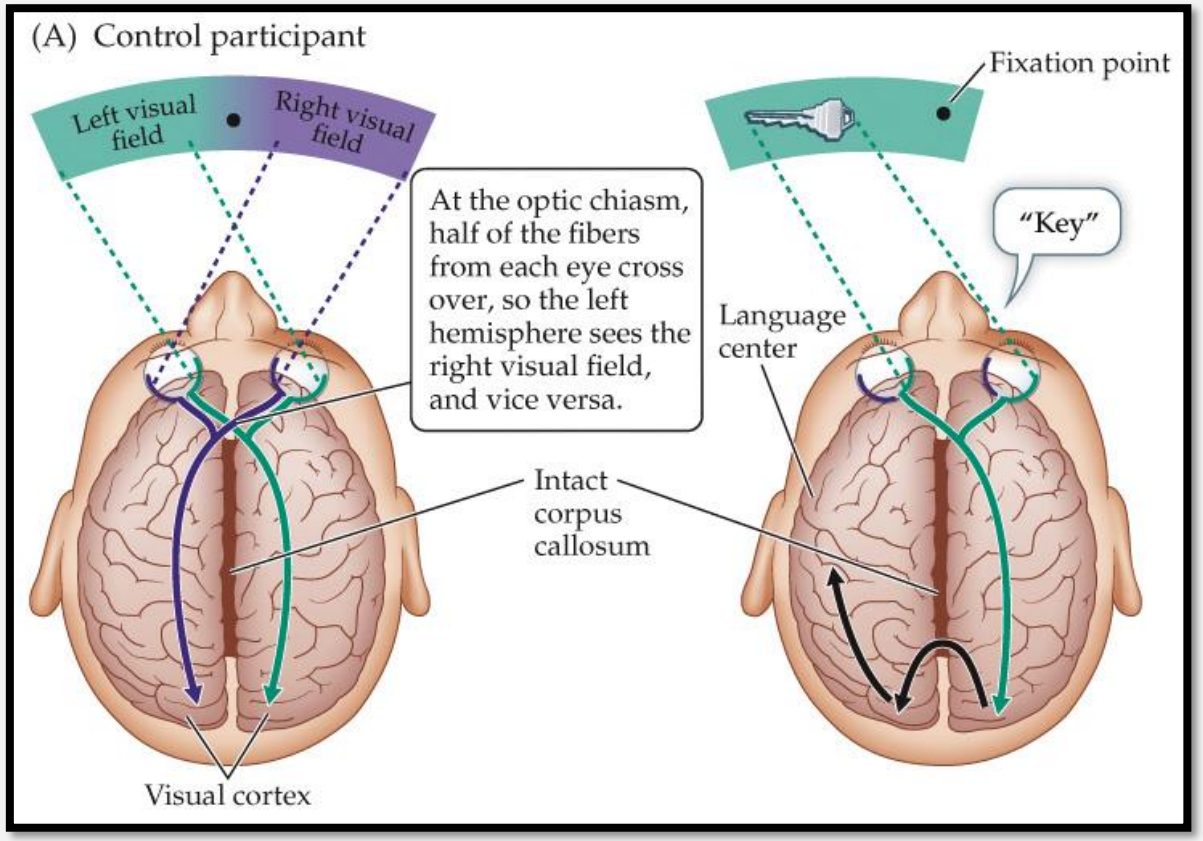
Hemispheric lateralization

- The brain hemispheres communicate with each other so quickly, lateralization of function is masked.
- **Split-brain individuals'** hemispheres are disconnected by surgical severing of the corpus callosum to alleviate seizures.
- In the 1960s, Roger Sperry applied techniques he had perfected in split-brain cats to the study of split-brain humans.



Hemispheric lateralization

- Sperry's studies tested language function in each hemisphere of split-brain individuals.
- Words presented to either visual field showed language ability only if the information reached the left hemisphere.
- The right hemisphere is specialized for processing emotional tone of language, controlling attention, and spatial processing, including face perception.



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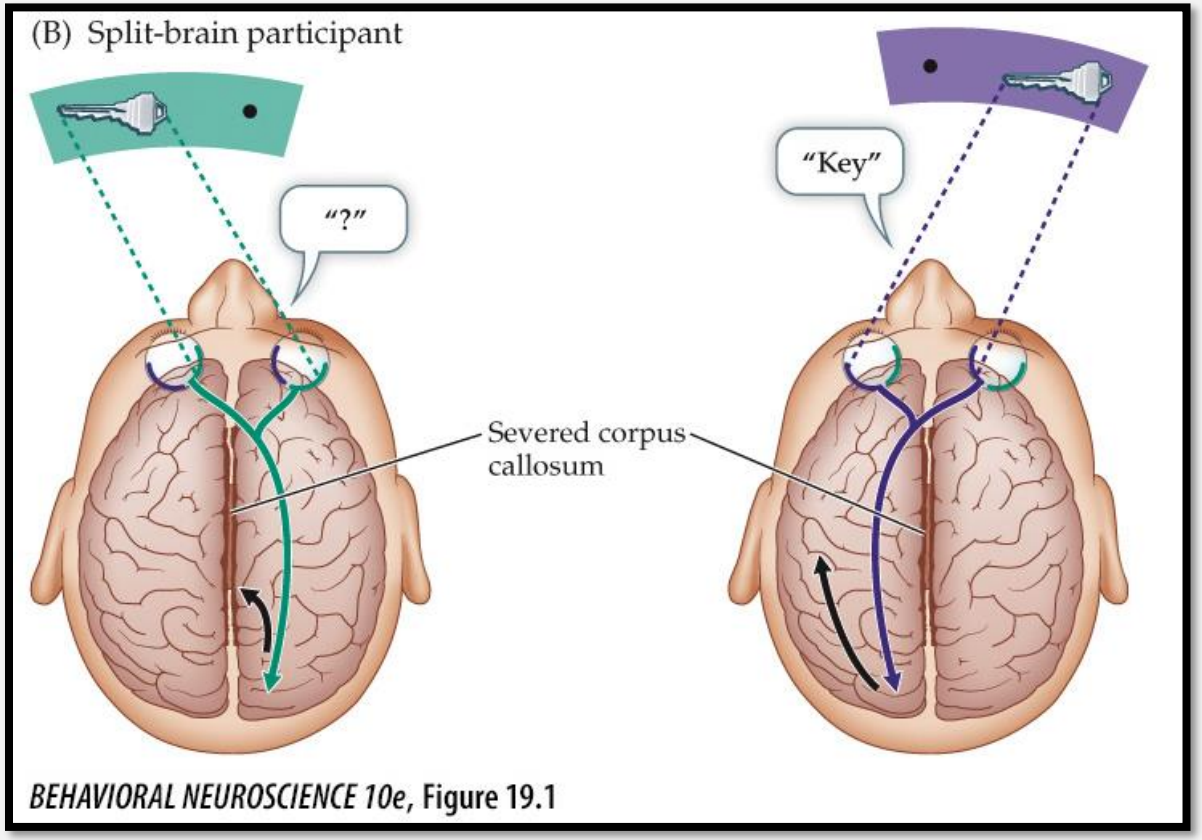
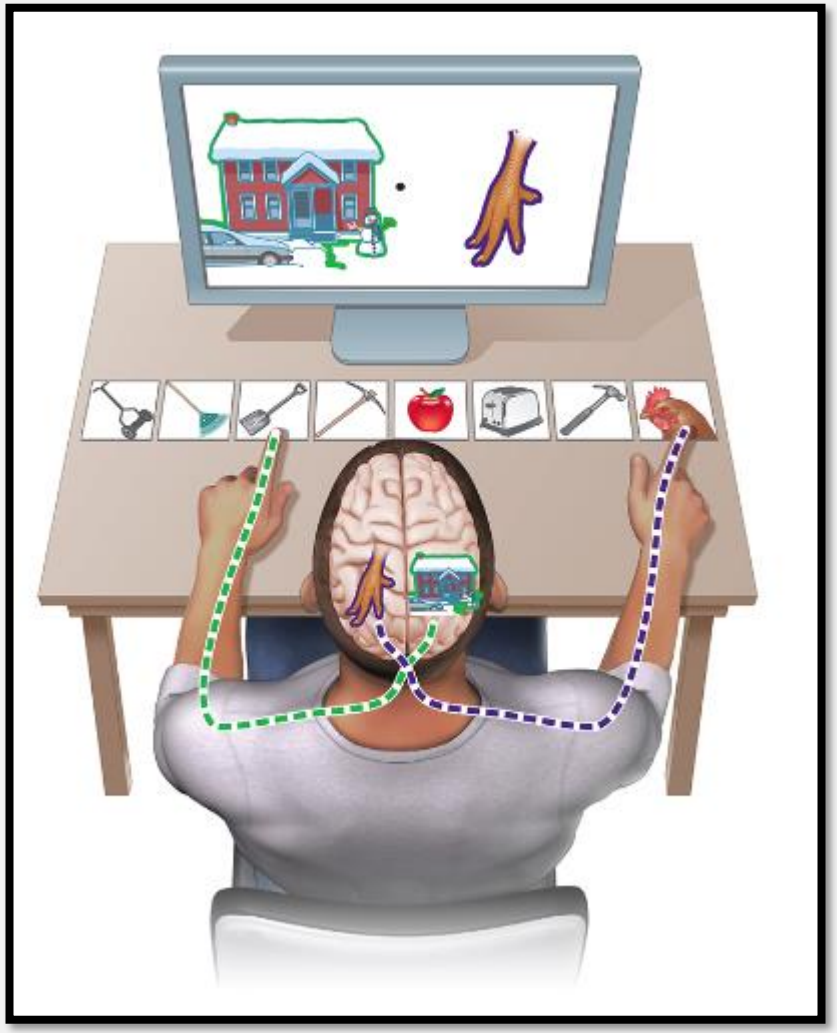


Split – brain – split tasks

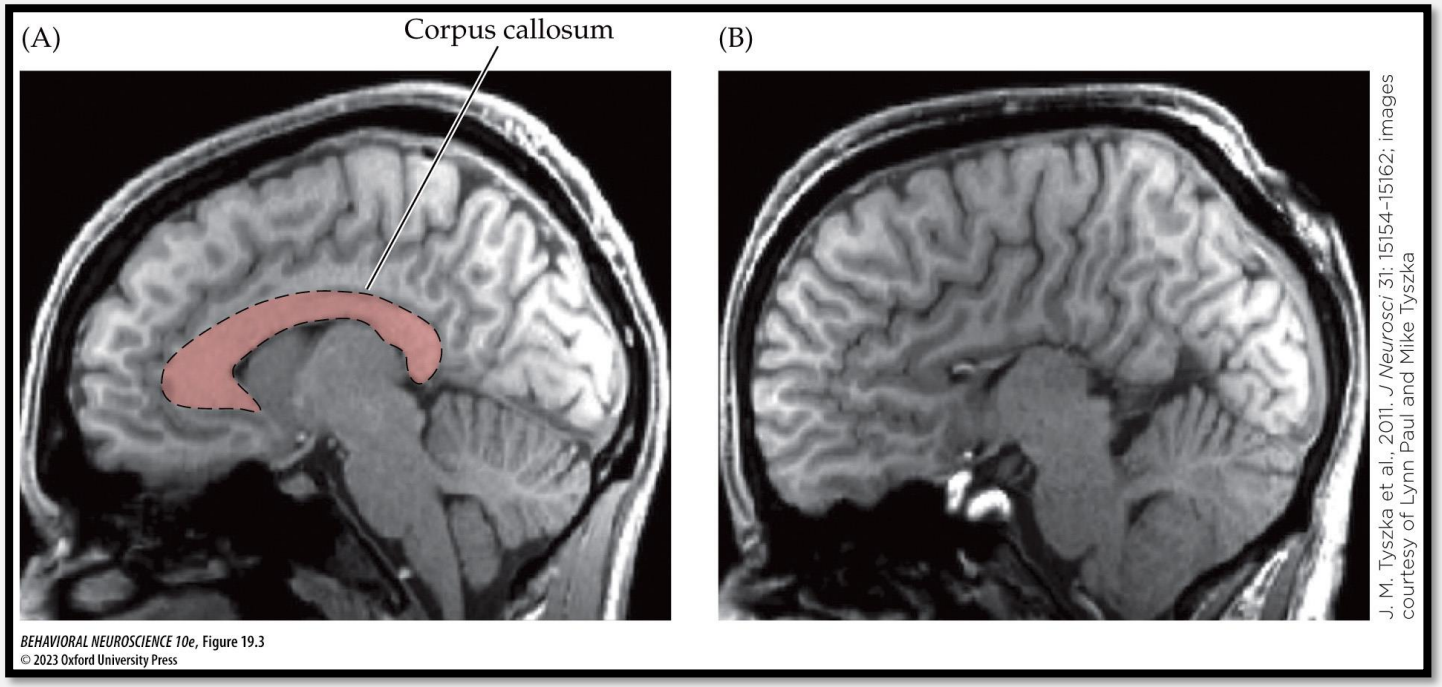
Dual consciousness

- Both hemispheres get the task correct, individually
- But.. Ask the participant why they chose the shovel – the right brain can't explain (no language)
- The left brain would create an answer that has to do with what it saw
- **Confabulation –** filling in gaps in memory with fabrication believed to be true



Hemispheric lateralization

- One in 4000 people is born either partially or totally lacking a corpus callosum (*callosal agenesis*).
- They generally lack the neuropsychological limitations of surgical split-brain patients.
- The developing nervous system compensates for the absence of the main connection between the hemispheres.

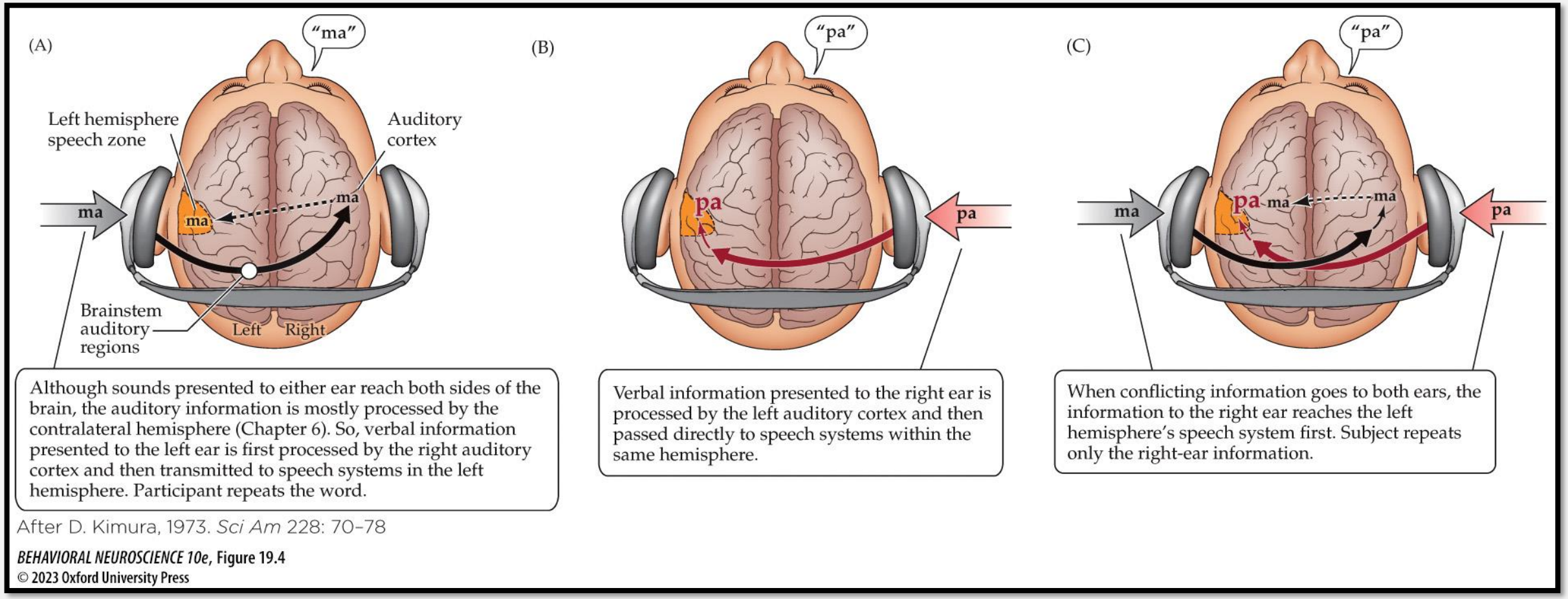


Hemispheric lateralization

Research on healthy people's brains

- A **dichotic presentation** delivers different stimuli to each ear at the same time.
- Right-handed persons identify verbal stimuli delivered to the right ear more accurately than verbal stimuli delivered to the left—a *right ear advantage*.
- 50% of left-handed individuals have a left-ear advantage.

Hemispheric lateralization



Although sounds presented to either ear reach both sides of the brain, the auditory information is mostly processed by the contralateral hemisphere (Chapter 6). So, verbal information presented to the left ear is first processed by the right auditory cortex and then transmitted to speech systems in the left hemisphere. Participant repeats the word.

Verbal information presented to the right ear is processed by the left auditory cortex and then passed directly to speech systems within the same hemisphere.

When conflicting information goes to both ears, the information to the right ear reaches the left hemisphere's speech system first. Subject repeats only the right-ear information.

After D. Kimura, 1973. *Sci Am* 228: 70–78

BEHAVIORAL NEUROSCIENCE 10e, Figure 19.4

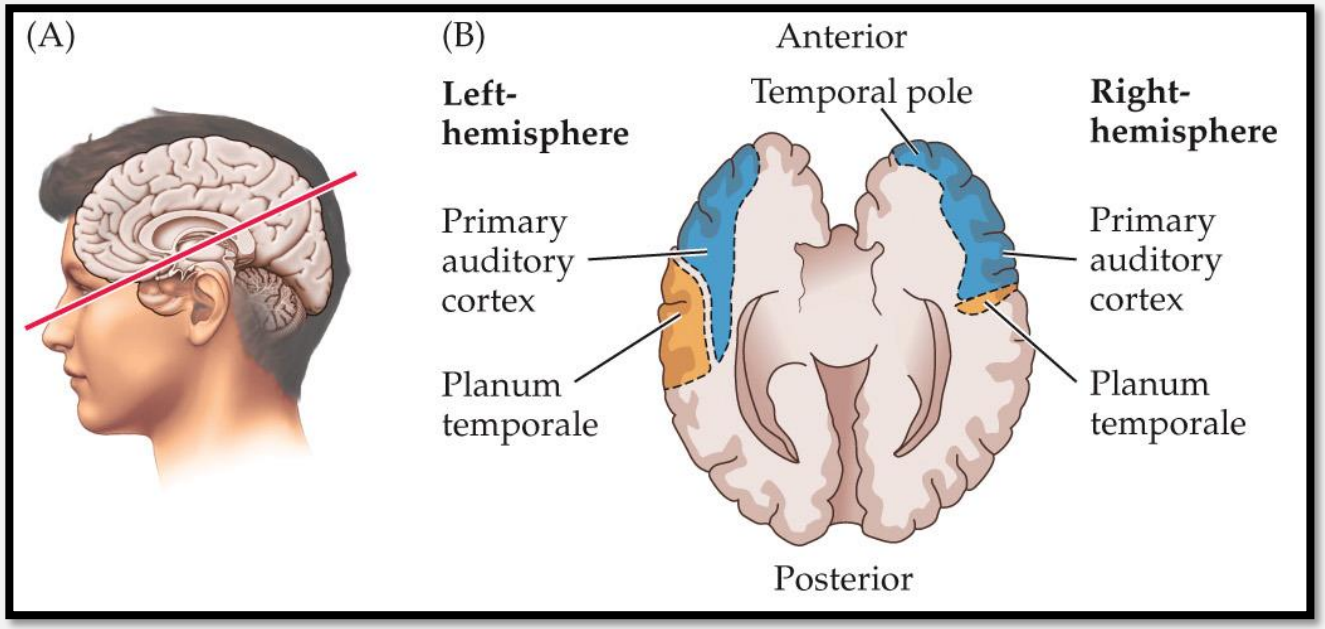
Hemispheric lateralization

Tachistoscope test:

- linguistic stimuli are briefly presented to left or right visual field.
- Left hemisphere (right visual field) shows better recognition of words and letters.
- Right hemisphere (left visual field) shows better recognition of faces and geometric forms.
- Light, hue, and simple patterns are recognized by both hemispheres.

Hemispheric lateralization

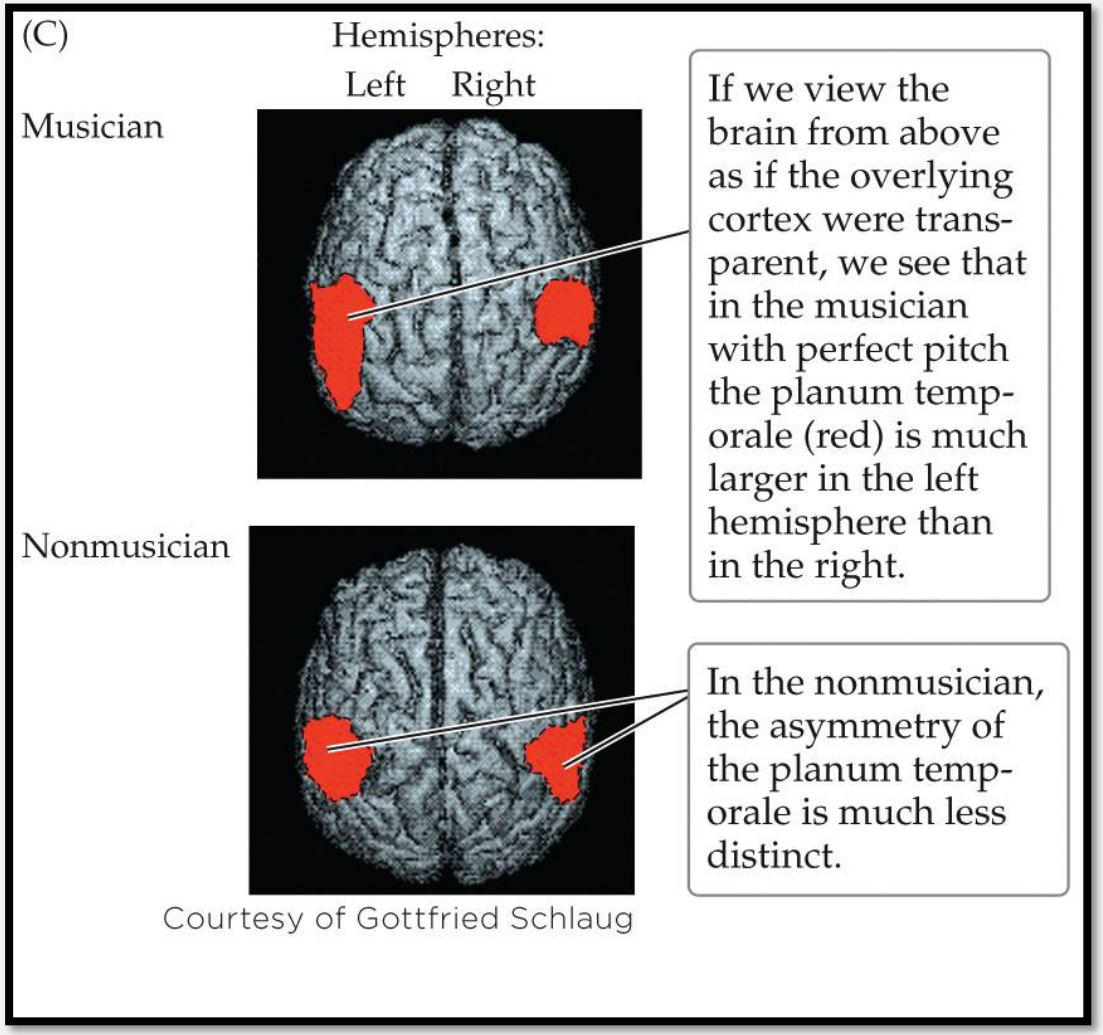
- Left and right auditory cortical areas play different roles.
- **Planum temporale**—the superior surface of the temporal lobe—is larger in the left hemisphere in most brains. Includes part of Wernicke's area, crucial for speech.
- This asymmetry is evident even before substantial experience with speech.



Hemispheric lateralization

Musical perception.

- Musical perception is impaired by damage to right hemisphere.
- Music activates the right hemisphere more than the left.
- **BUT** individuals with perfect pitch have a planum temporale twice the size of non-musicians
- Only damage to both hemispheres can abolish music perception.

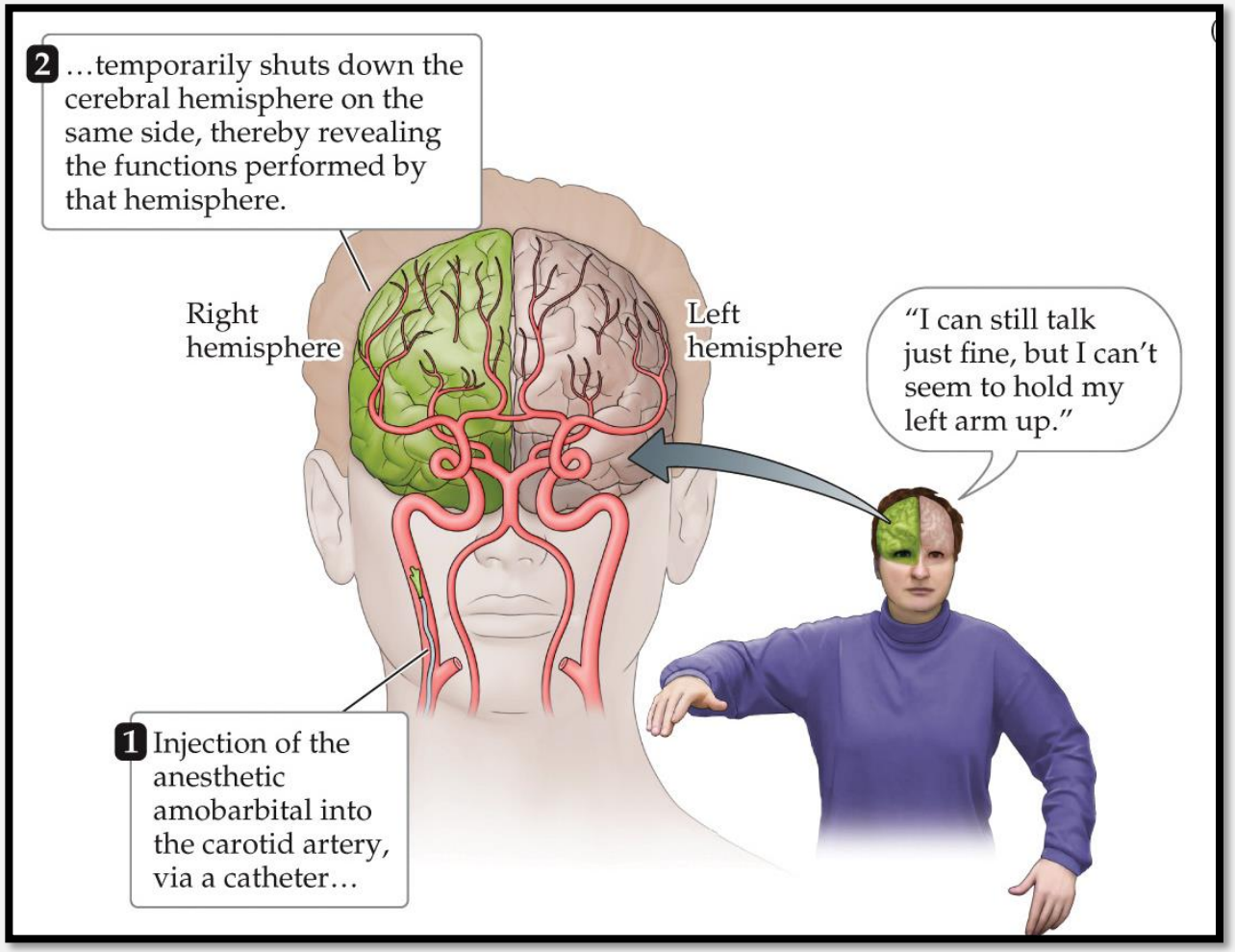


Lateralization and handedness

- Left-handed people make up about 10–15% of the population.
- Left-handed children do not differ from right-handed children on any measure of cognitive performance.
- Do you think handedness determines lateralization? Or visa versa?

Hemispheric lateralization

- **Wada test**: determines involvement of hemispheres in language by anesthetizing each hemisphere separately; simulates a stroke.
- Confirms that most people have left-hemisphere specialization for language, regardless of handedness.
- Rarely, language is lateralized to the *right* hemisphere; these individuals are usually left-handed.



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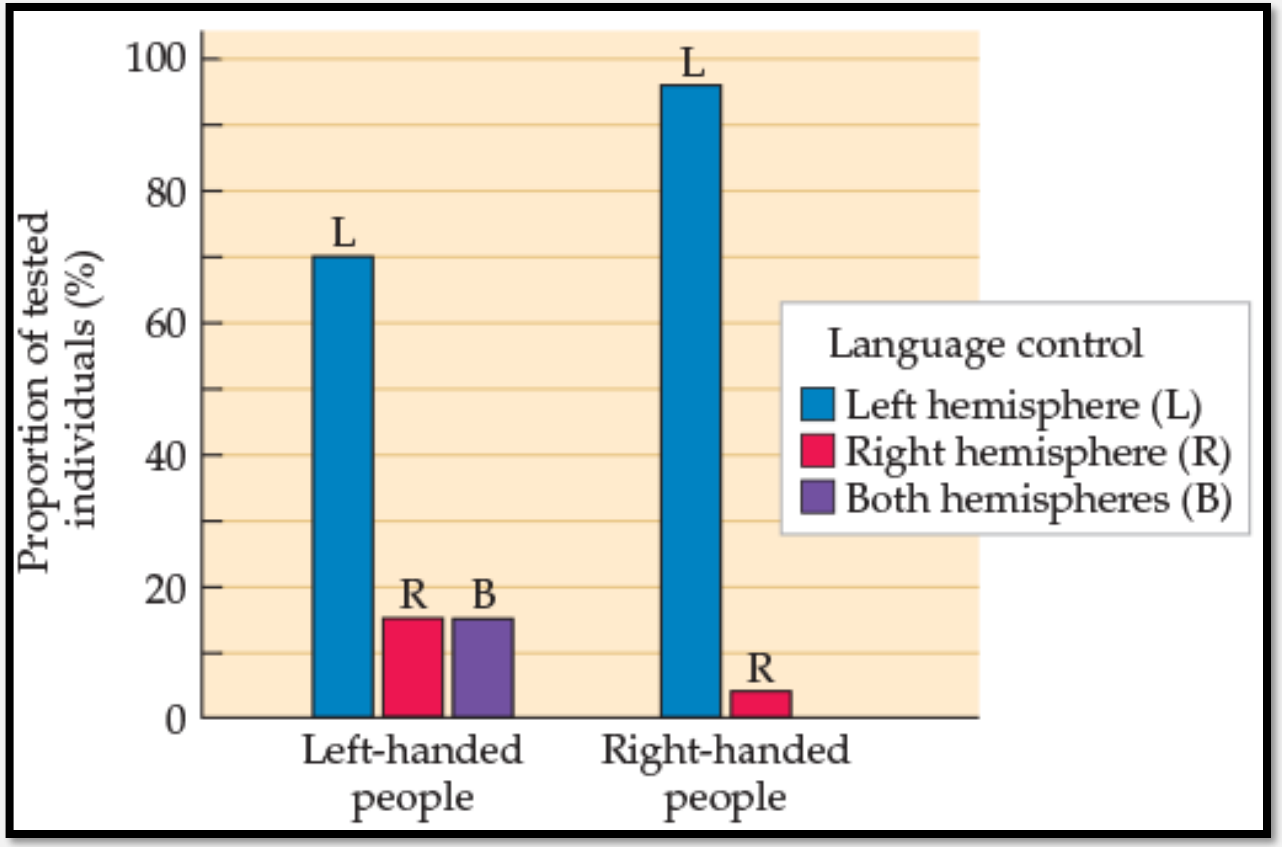


Hemispheric lateralization

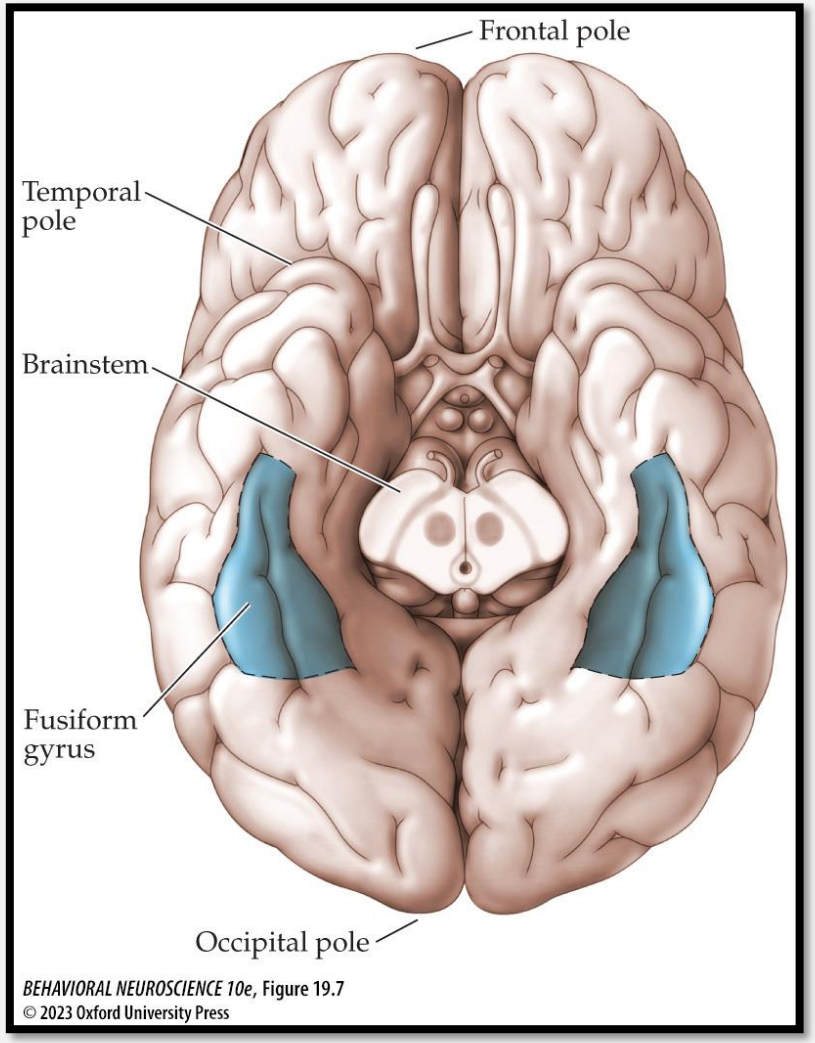
Right Hemisphere

- Behavioral and imaging techniques demonstrate a right-hemisphere advantage in processing spatial stimuli:
- Faces, geometric shapes and relations, direction and navigation, 3D rotation of imaginary objects.
- Right hemisphere lesions—especially posterior temporal and parietal lobes—produce related symptoms.

Right-Hemisphere Damage

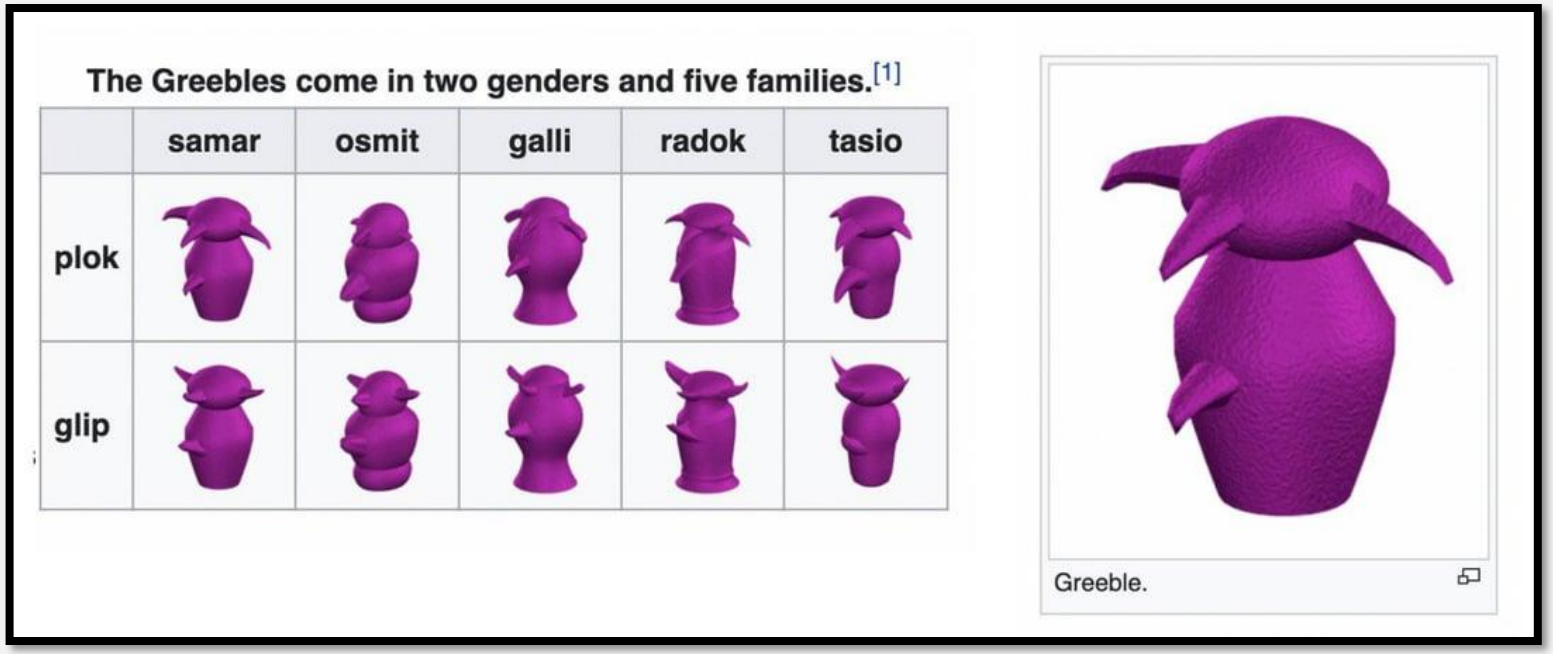
Prosopagnosia

- *face blindness*, people fail to recognize familiar faces, including their own.
- Bilateral damage to the **fusiform gyrus** causes complete prosopagnosia.



Right-Hemisphere Damage

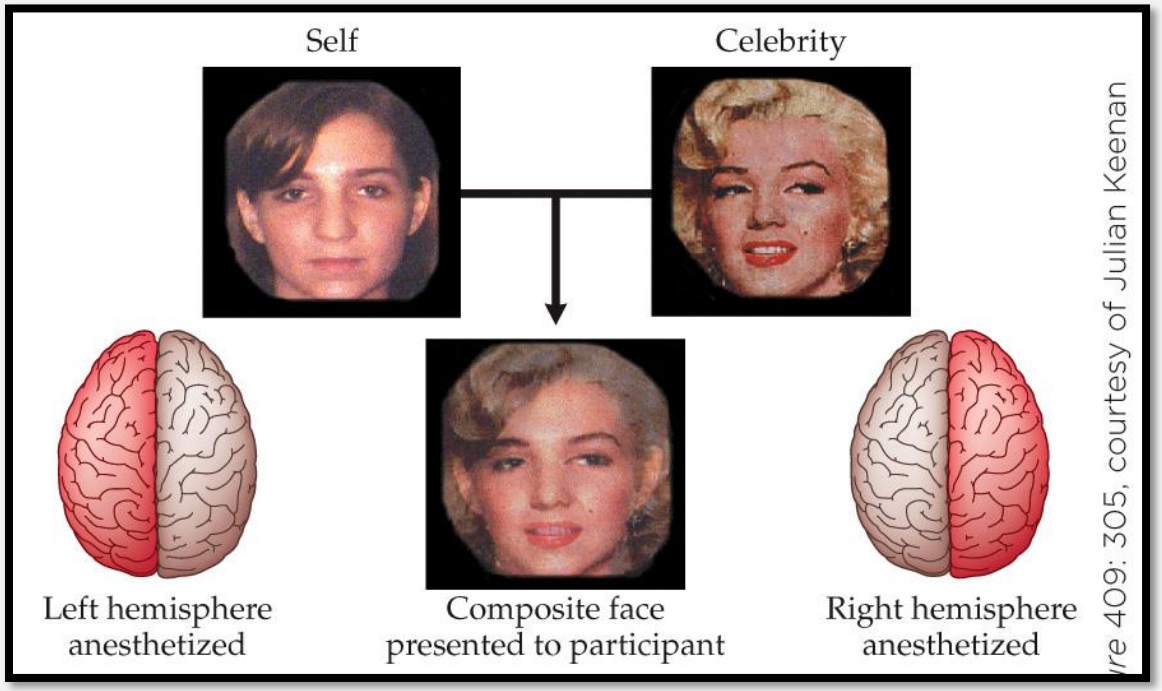
- Prosopagnosia may be accompanied by other forms of **agnosia**, an inability to identify items such as different kinds of cars or species of birds, dogs, greebles
- *Congenital prosopagnosia*—lifelong face blindness not due to brain damage—occurs in about 2.5% of people.
- On the other hand, some people are “super-recognizers.”



Right-Hemisphere Damage

Wada test

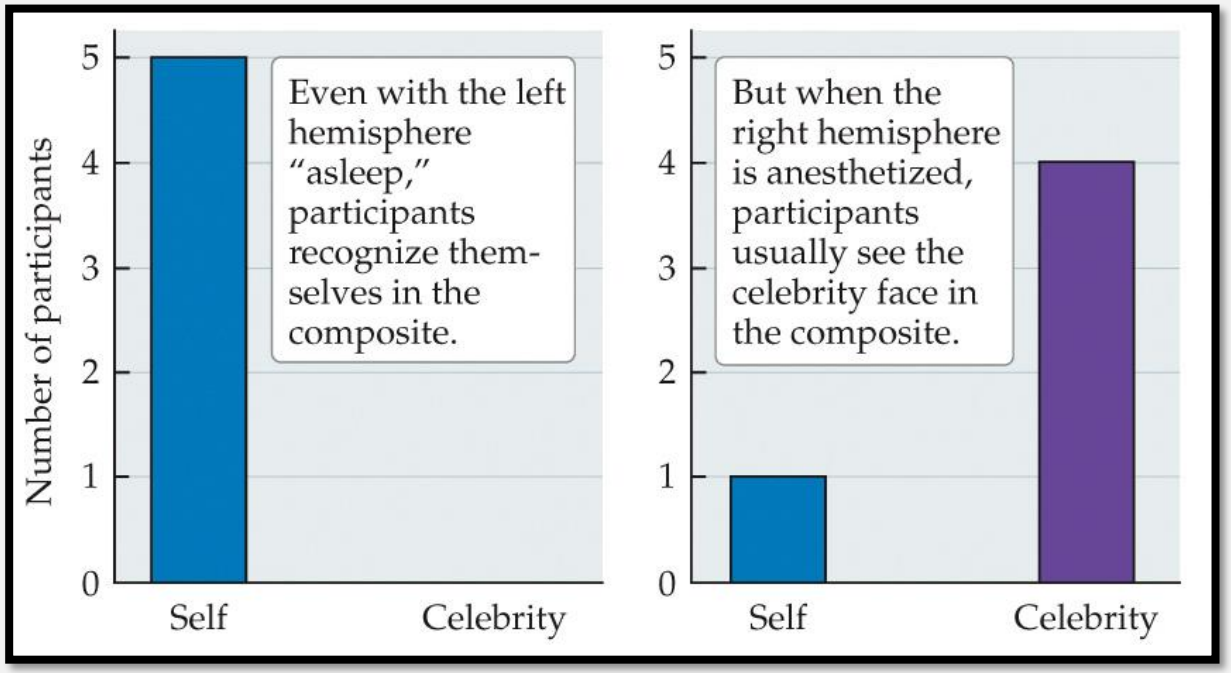
- Shutting down each hemisphere and test performance in recognizing composite faces (a morph between self and a celebrity)



Right-Hemisphere Damage

Wada test

- *Left hemisphere asleep* – no problem recognizing self in the composite
- *Right hemisphere asleep* – people tend to see the celebrity in the composite



Left hemisphere "asleep" **Right hemisphere "asleep"**

Break

Language

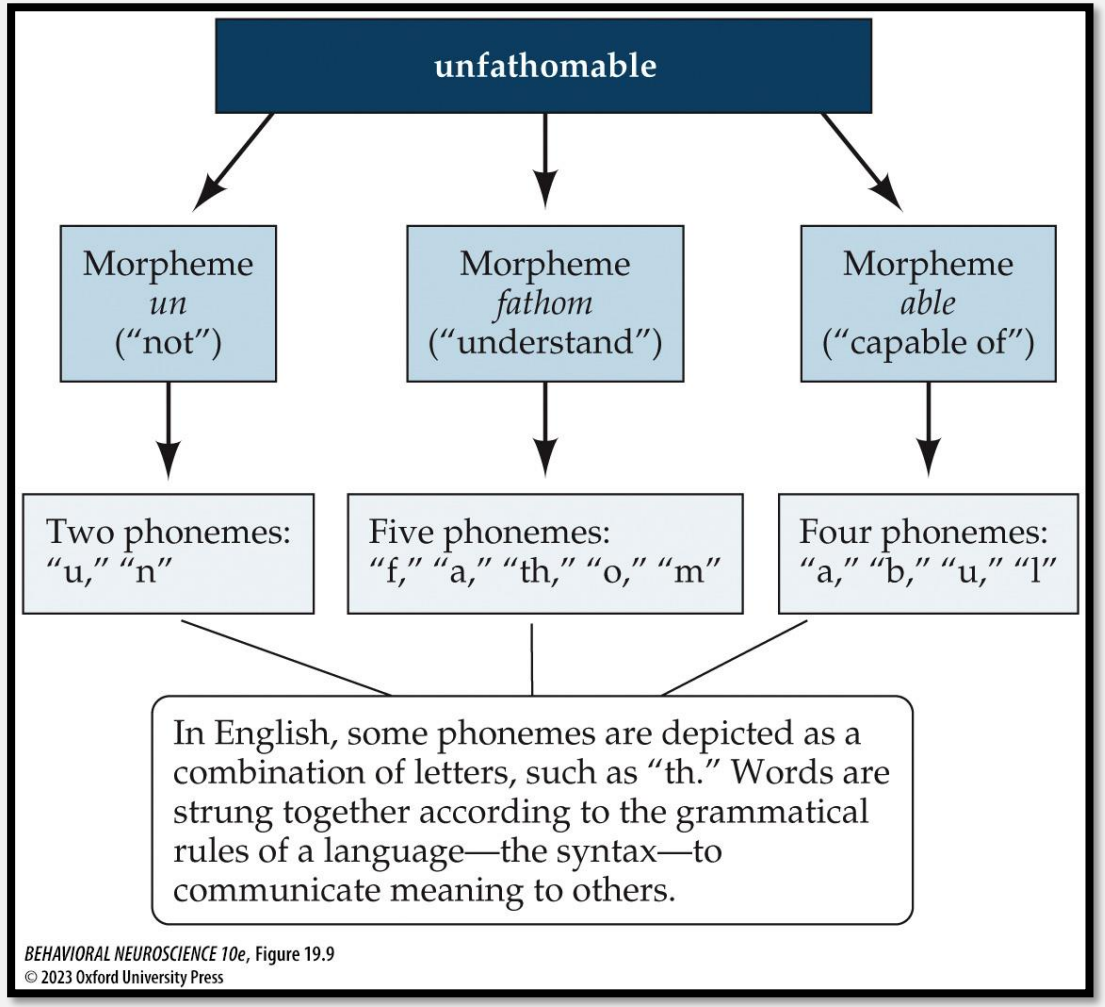
Learning objectives

1. Distinguish among aphasia, apraxia, agraphia, and alexia.
2. Describe Broca's and Wernicke's areas and the behavioral consequences of lesions of these areas.
3. Describe global aphasia, its causes and prognosis, and its relationship to concepts of personal identity.
4. Contrast the motor theory of speech with the Wernicke-Geschwind model, discussing research findings for and against each.
5. Summarize research using brain stimulation to map the brain's language network
6. Describe how experience impacts the development of lateralized brain functions.

Language

All languages have similar basic elements:

- **Phonemes**—basic speech sounds
- **Morphemes**—simple units of meaning
- **Semantics**—meanings of words or sentences
- **Syntax**—grammatical rules for constructing phrases and sentences
- **Pragmatics**—context in which a speech sound is uttered



Left-Hemisphere Damage

Aphasia:

- impairment in language ability caused by brain injury.
- 90–95% of aphasia cases result from damage to the left cerebral hemisphere.
- Less severe damage to left hemisphere may cause
- **paraphasia**—insertion of incorrect sounds or words.
- —along with labored, effortful speech production

Language Disorders

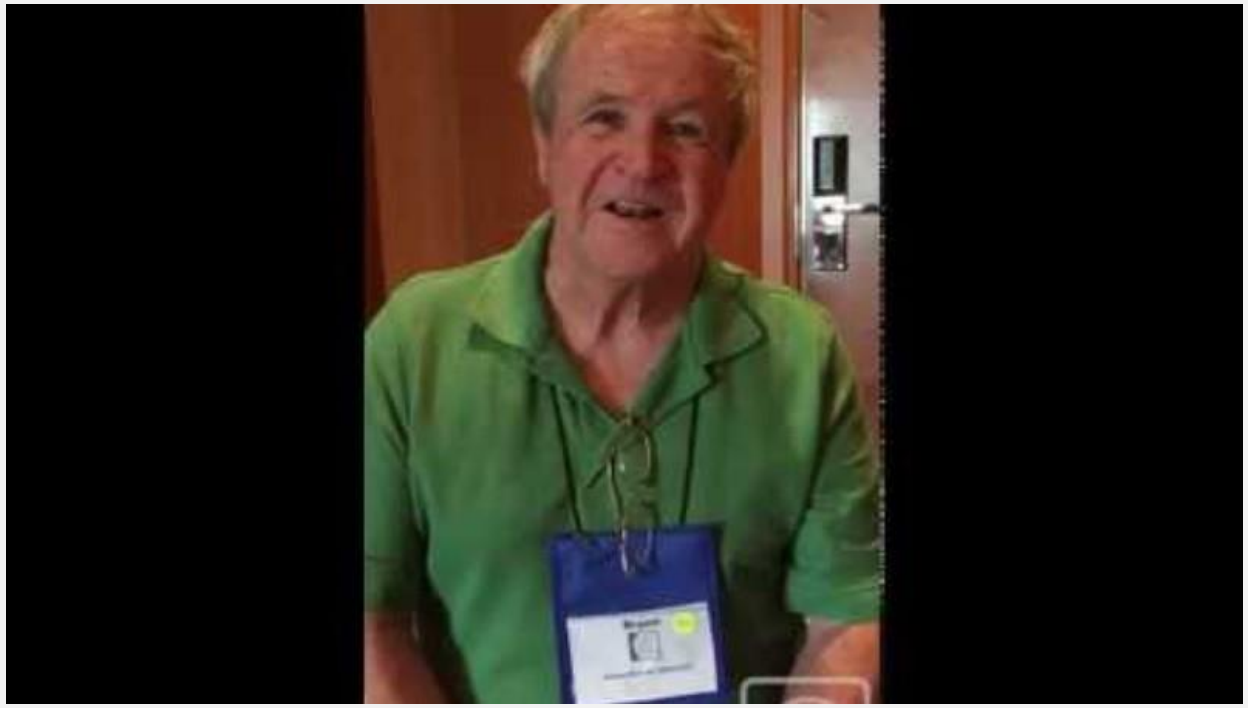
Other symptoms of aphasia:

- **Neologisms**: entirely novel nonsense words. May be generated via insertion or substitution of phonemes.
- **Nonfluent speech**: talking with considerable effort, in short sentences, and without the usual melodic character of conversational speech.

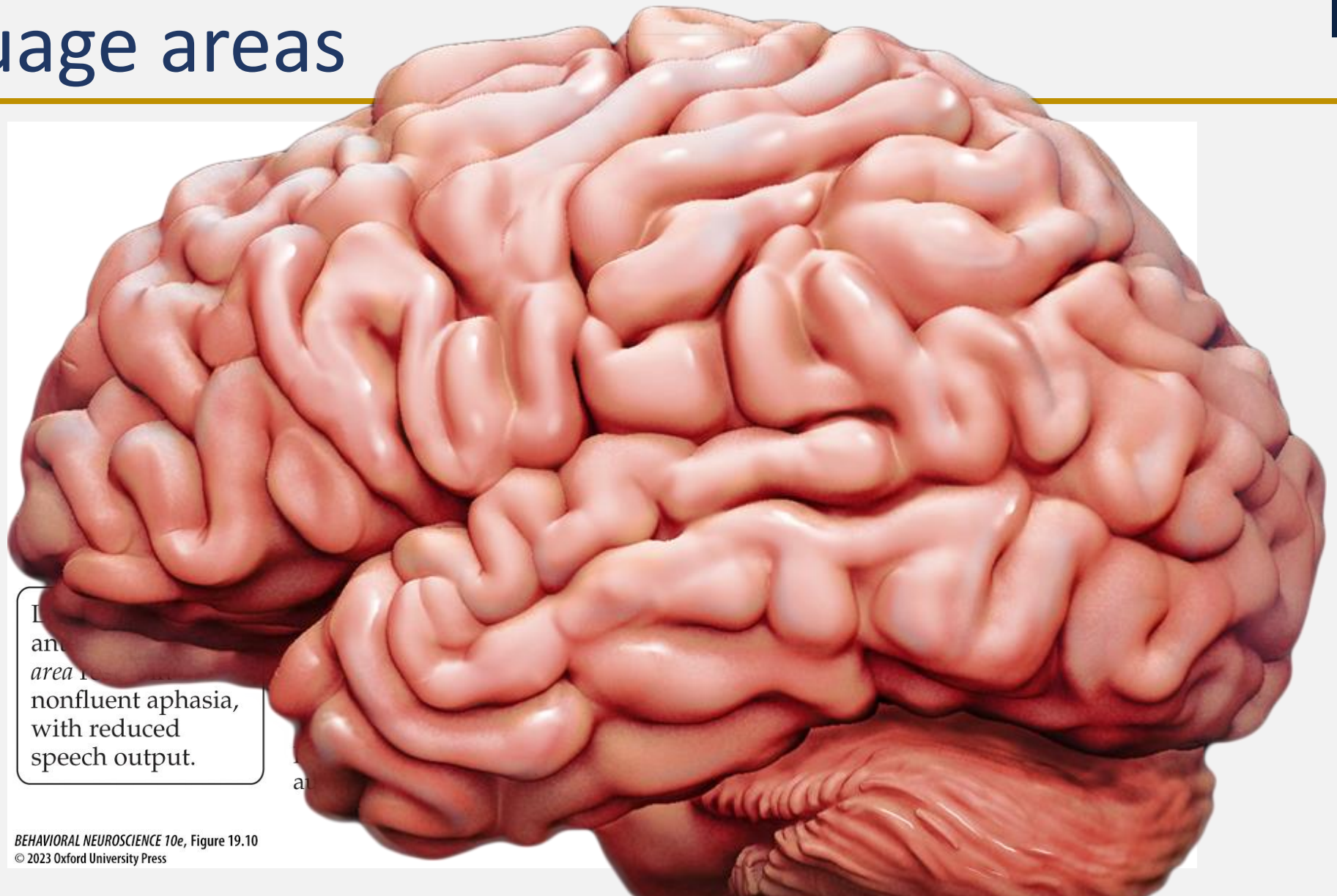
May also show

- **Agraphia**—inability to write
- **Alexia**—inability to read
- **Apraxia**—motor impairment in the ability to begin and execute skilled voluntary movements, even though there is no muscle paralysis.

Two disorders – two specialized zones



Language areas



BEHAVIORAL NEUROSCIENCE 10e, Figure 19.10

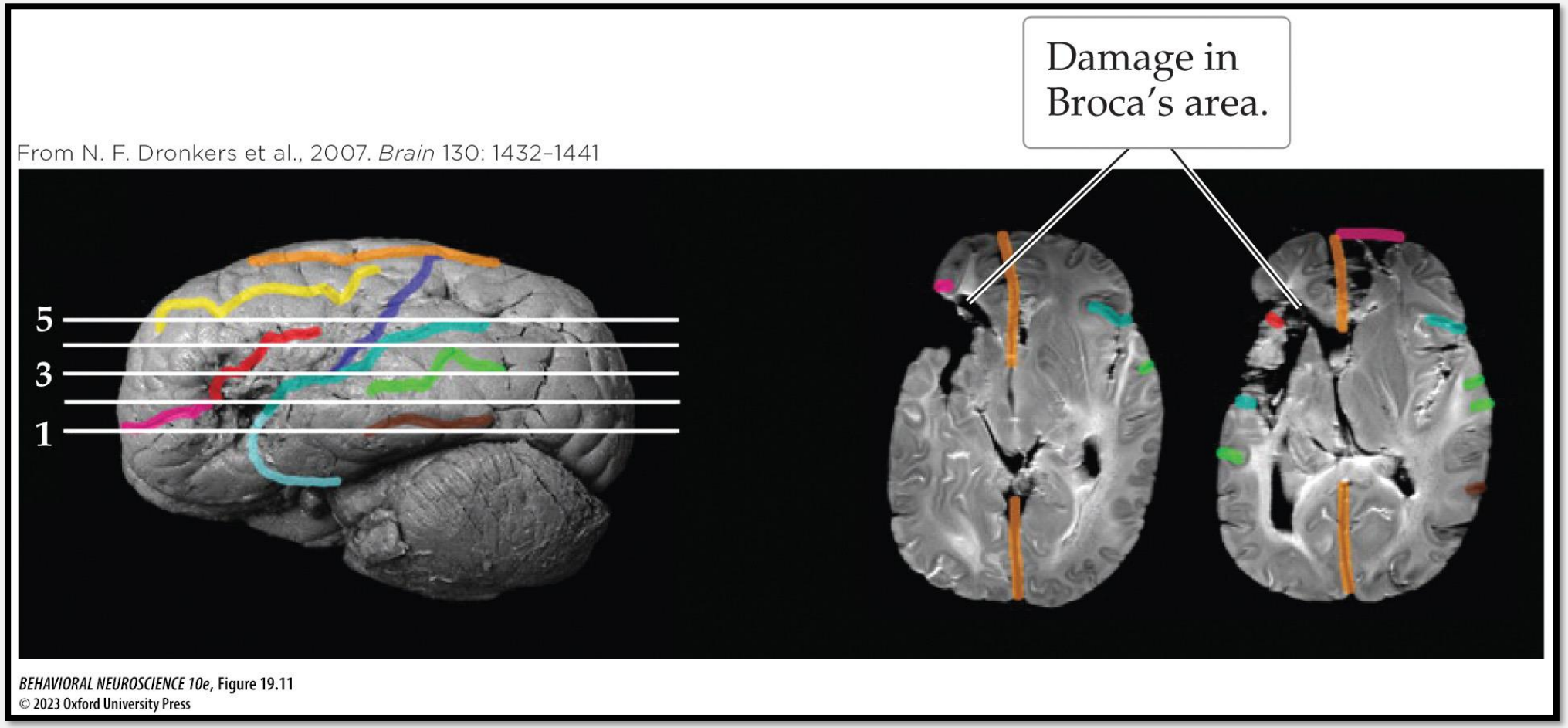
Left-Hemisphere Damage

Broca's area:

- region in the inferior frontal lobe involved in speech production.
- **Broca's aphasia** (**nonfluent aphasia**): characterized by difficulty producing speech but good comprehension; results from damage to Broca's area.
- What other side effects do you think someone with Broca's aphasia might exhibit?
-

The Brain of “Tan”

Paul Broca’s patient



Language Disorders

Wernicke's area:

- posterior regions of the left superior temporal gyrus and part of adjacent parietal cortex; involved in perception and production of speech.

Fluent (Wernicke's) aphasia:

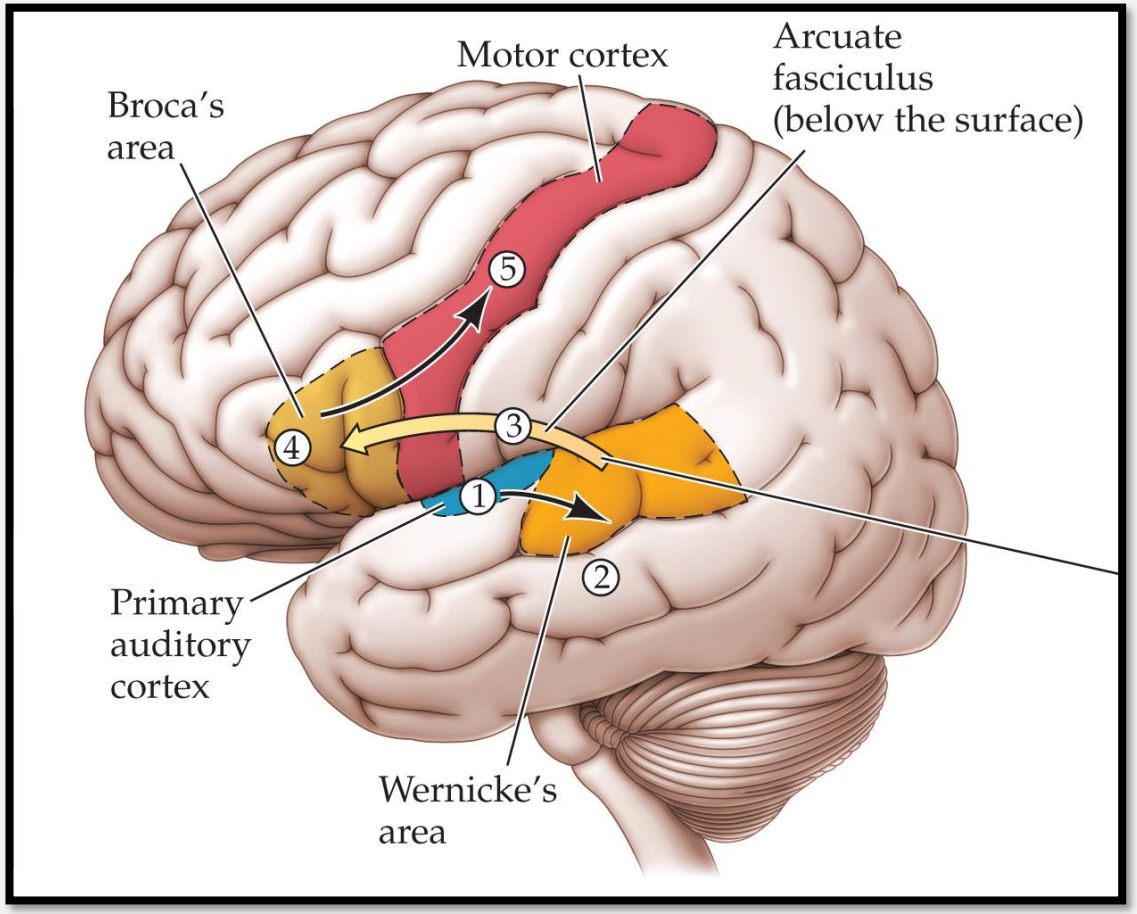
- complex verbal output with many paraphasia's (sound and/or word substitutions) that make speech unintelligible.

- What other symptoms might people with fluent aphasia exhibit?
-

Language Disorders

With fluent aphasia:

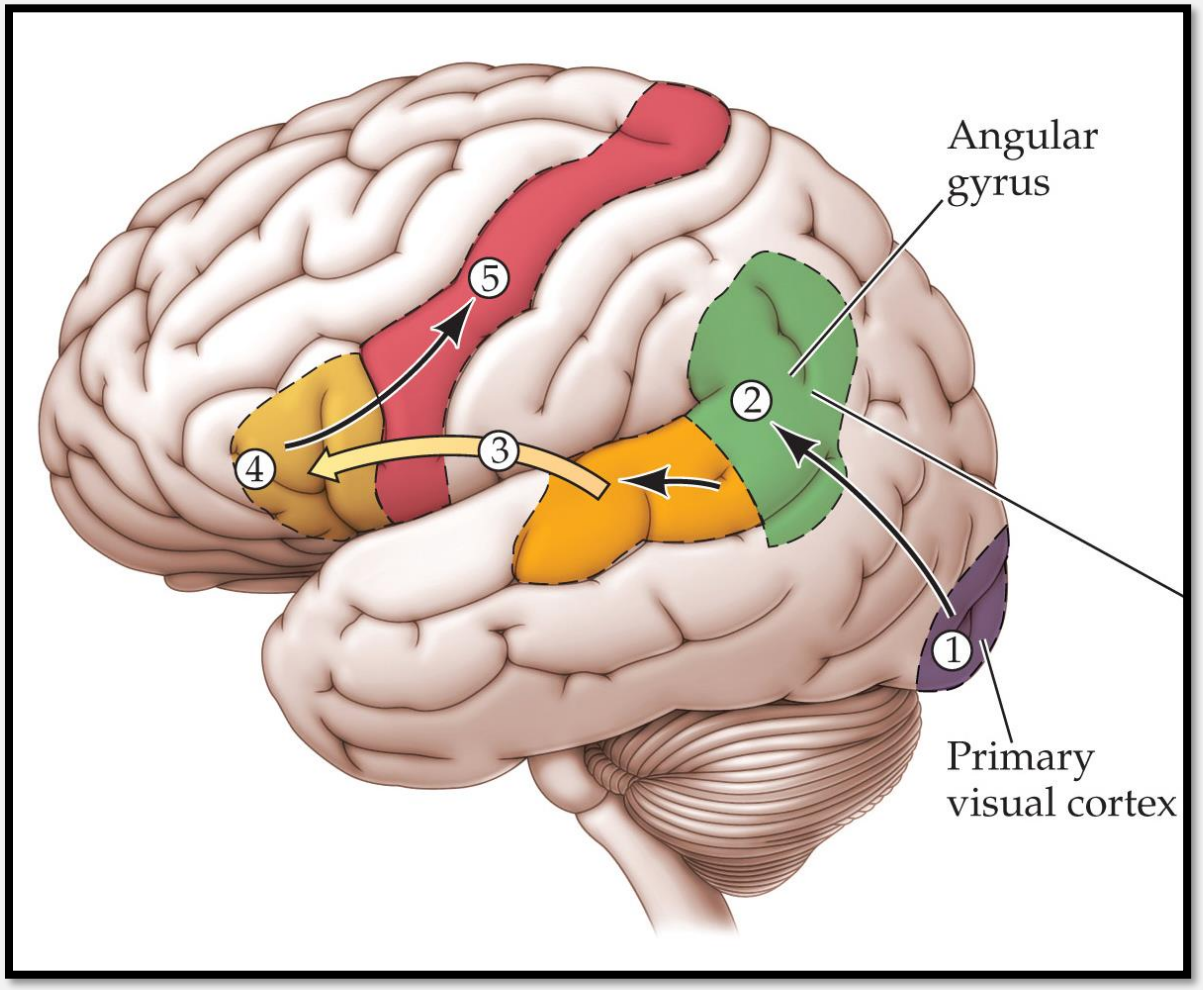
- Patients have difficulty *understanding* what they read or hear.
- *Word deafness* indicates damage to the **superior temporal lobe** and its connections to the auditory cortex.



Language Disorders

With fluent aphasia:

- Patients have difficulty *understanding* what they read or hear.
- *Word blindness* may suggest significant destruction of the **angular gyrus** and its connection to **V1**
- **Anomia**—inability to name persons or objects.



Language Disorders

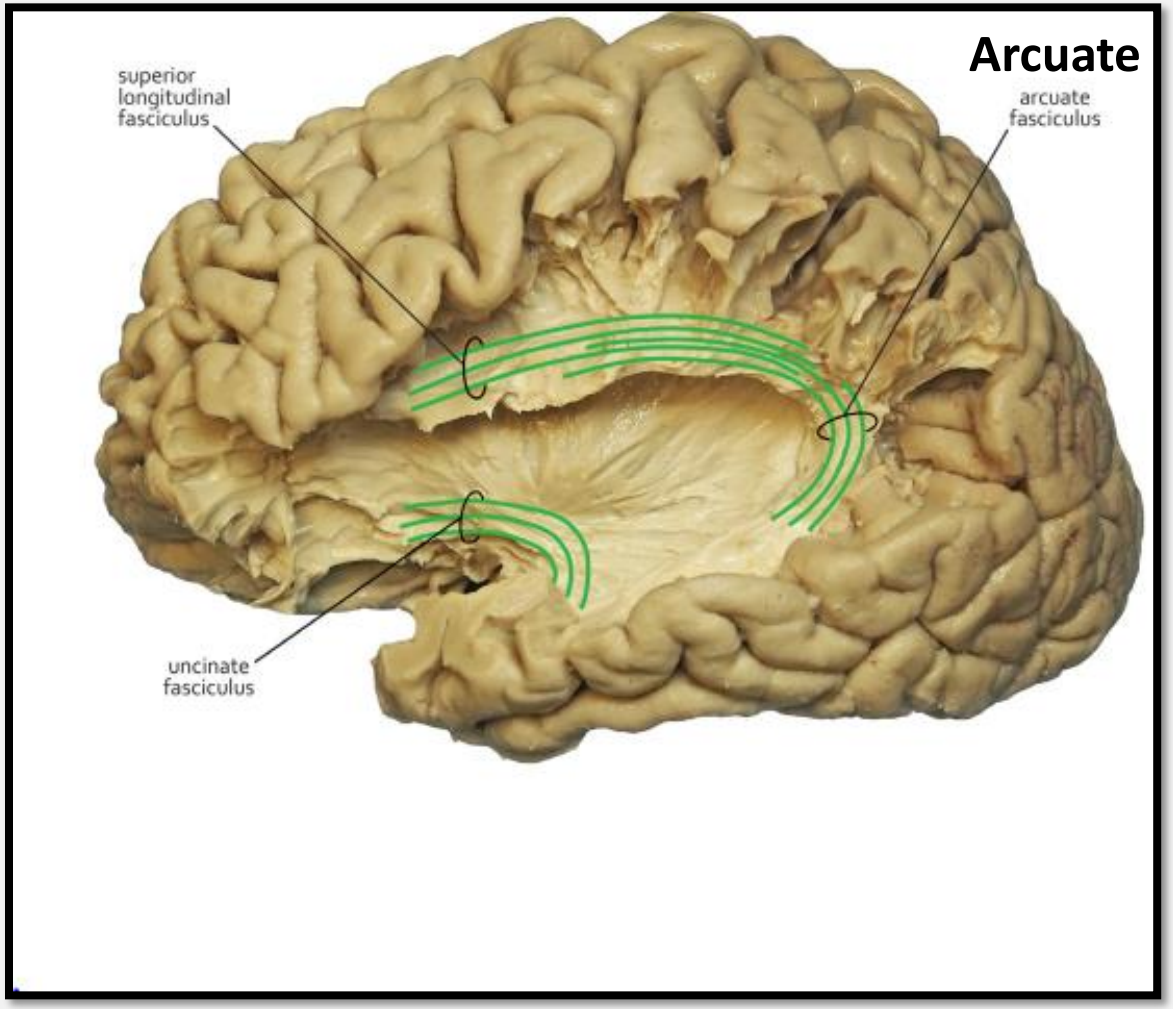
Global aphasia:

- total or near-total total loss of ability to understand language or to speak, read, or write.
- Results from large left-hemisphere lesions, affecting all language zones.
- Loss of “inner” voice
- Prognosis for language recovery is poor.

Left-Hemisphere Damage

Models of the brain's language circuitry:

- **Connectionist model of aphasia** (*Wernicke-Geschwind model*) attributes language deficits to disconnections between regions of the brain's language network.
- The **arcuate fasciculus**, a tract believed by some to connect Wernicke's and Broca's areas, is a key component.



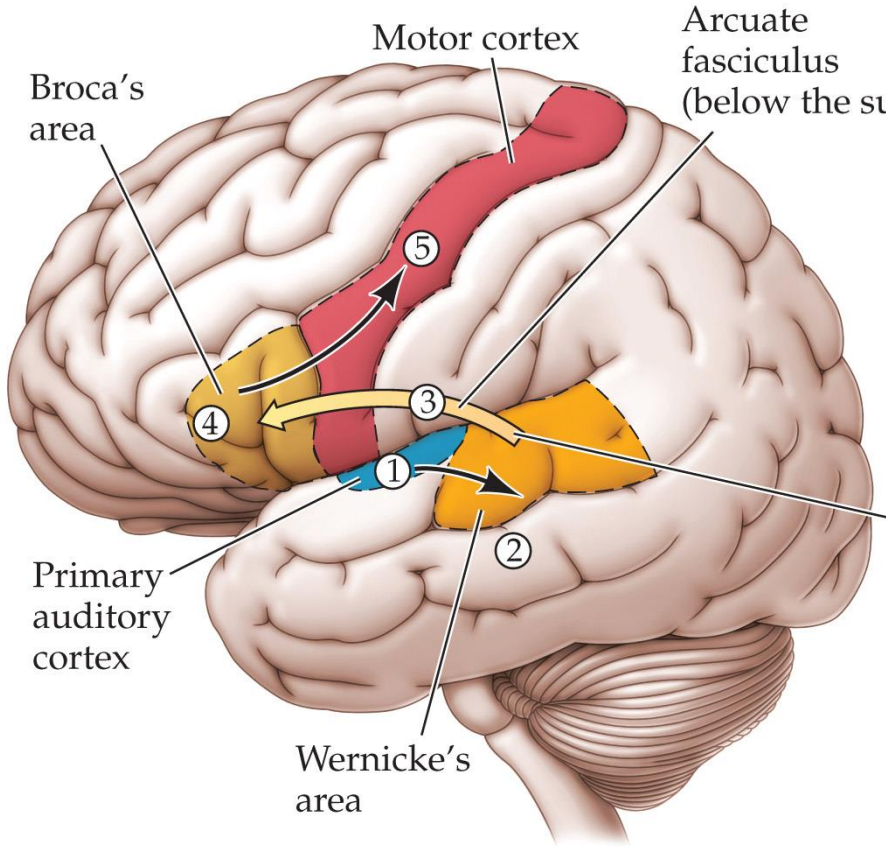
Wernicke-Geschwind model

(A) Speaking a *heard* word

1. Information about the sound is analyzed by primary auditory cortex and transmitted to Wernicke's area.

2. Wernicke's area analyzes the sound information to determine the word that was said.

3. Under the connectionist model this information is transmitted via the arcuate fasciculus. (Note, however, that anatomical research casts doubt on this projection.)



4. Broca's area forms a motor plan to repeat the word and sends that information to motor cortex.

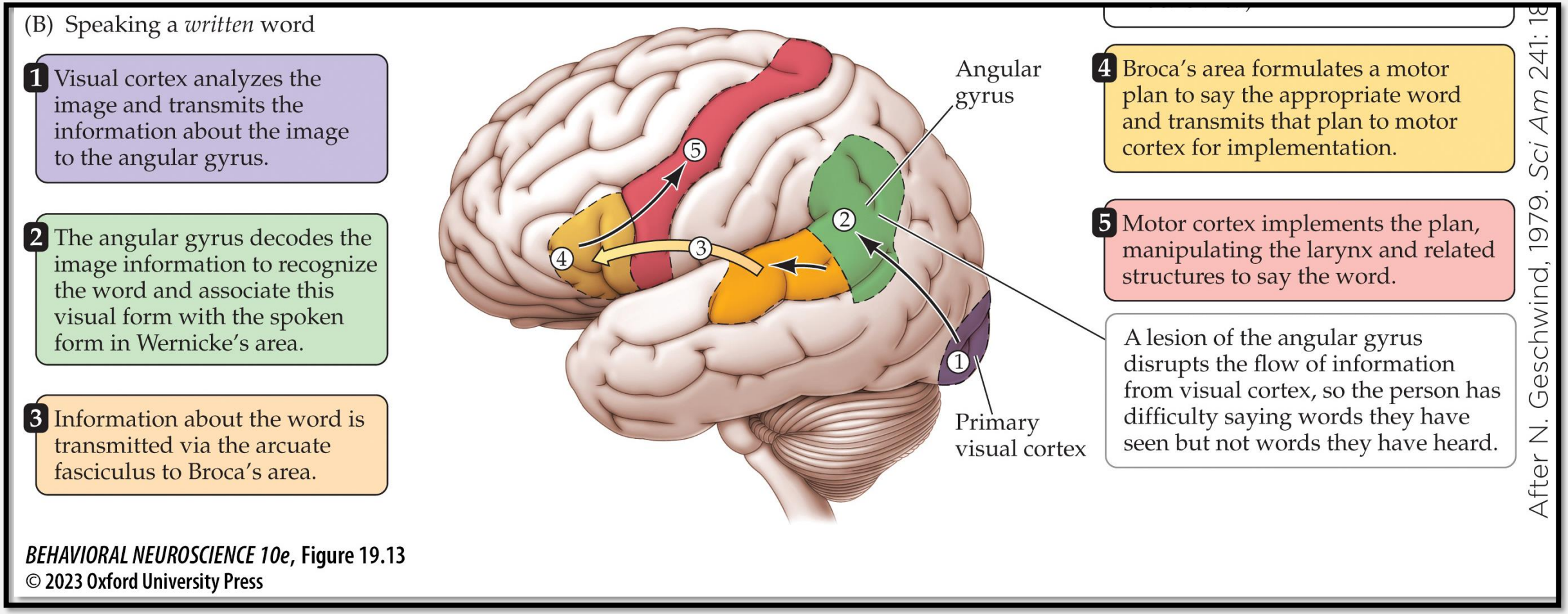
5. Motor cortex implements the plan, manipulating the larynx and related structures to say the word.

Lesions of the arcuate fasciculus disrupt the transfer from Wernicke's area to Broca's area, so the person has difficulty repeating spoken words (so-called conduction aphasia), but may retain comprehension of spoken language (because of intact Wernicke's area) and may still be able to speak spontaneously (because of intact Broca's area).

180–199

(B) Speaking a *written* word

Wernicke-Geschwind model



Wernicke-Geschwind model

Summary

- Lesions of arcuate fasciculus axons, but not Broca's or Wernicke's, may produce **conduction aphasia**, an impairment in the ability to correctly *repeat* words.
- Lesions affecting the angular gyrus would thus disconnect the systems involved in visual and auditory language; patients can speak and understand but have difficulty reading aloud.

Wernicke-Geschwind model

Critique

- oversimplifies the neural mechanisms of language and prematurely attached functional labels to anatomical findings.
- Modern studies show that the arcuate fasciculus—long believed to connect Wernicke's to Broca's area—actually terminates in the precentral gyrus (motor cortex).

Motor Theory

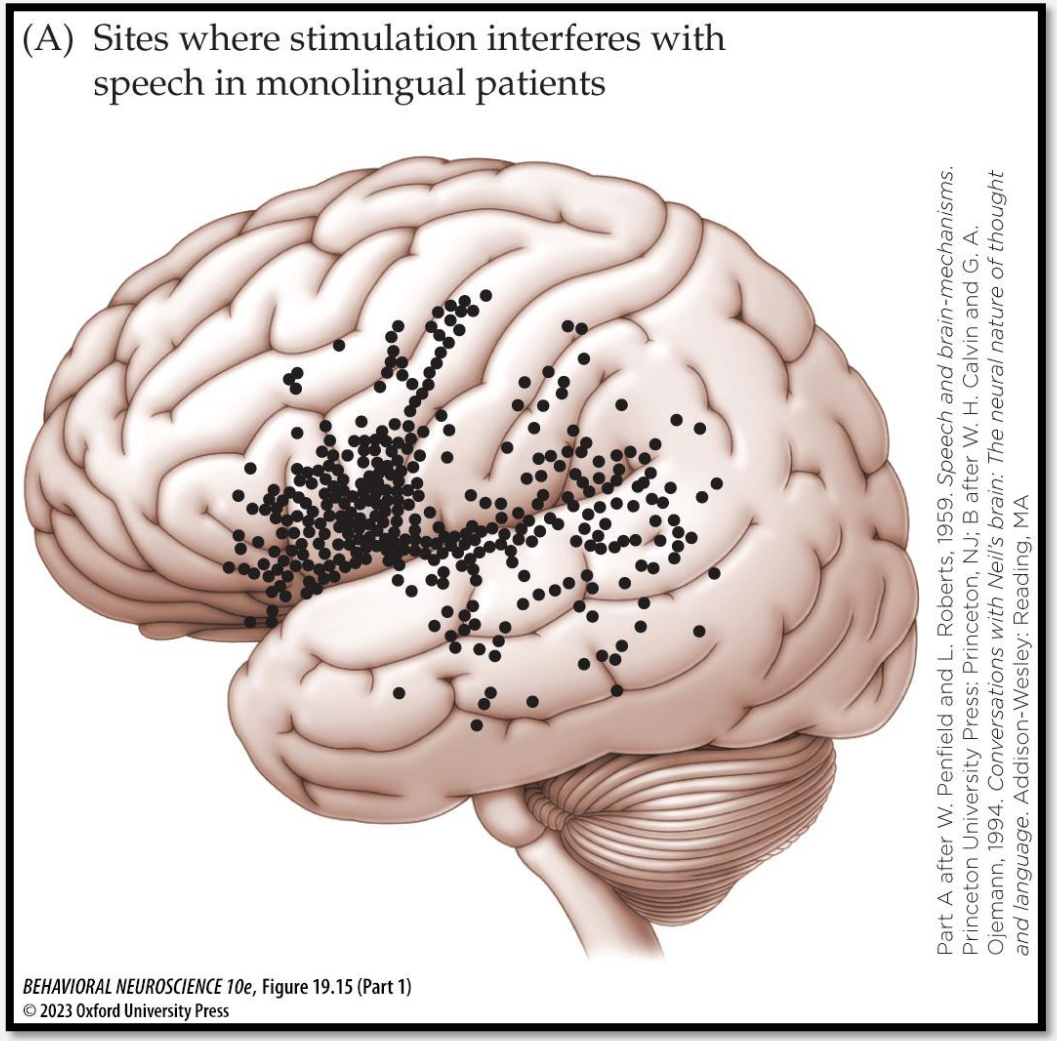
Motor theory of language:

- language zones are motor control systems, involved in both the production and *perception* of the complex motions that produce speech.
- The same language-related regions of the left hemisphere are employed during spoken and sign language. Mirror neurons may be involved.
- After left-hemisphere damage, similar aphasia occurs in deaf signers.

Brain mapping

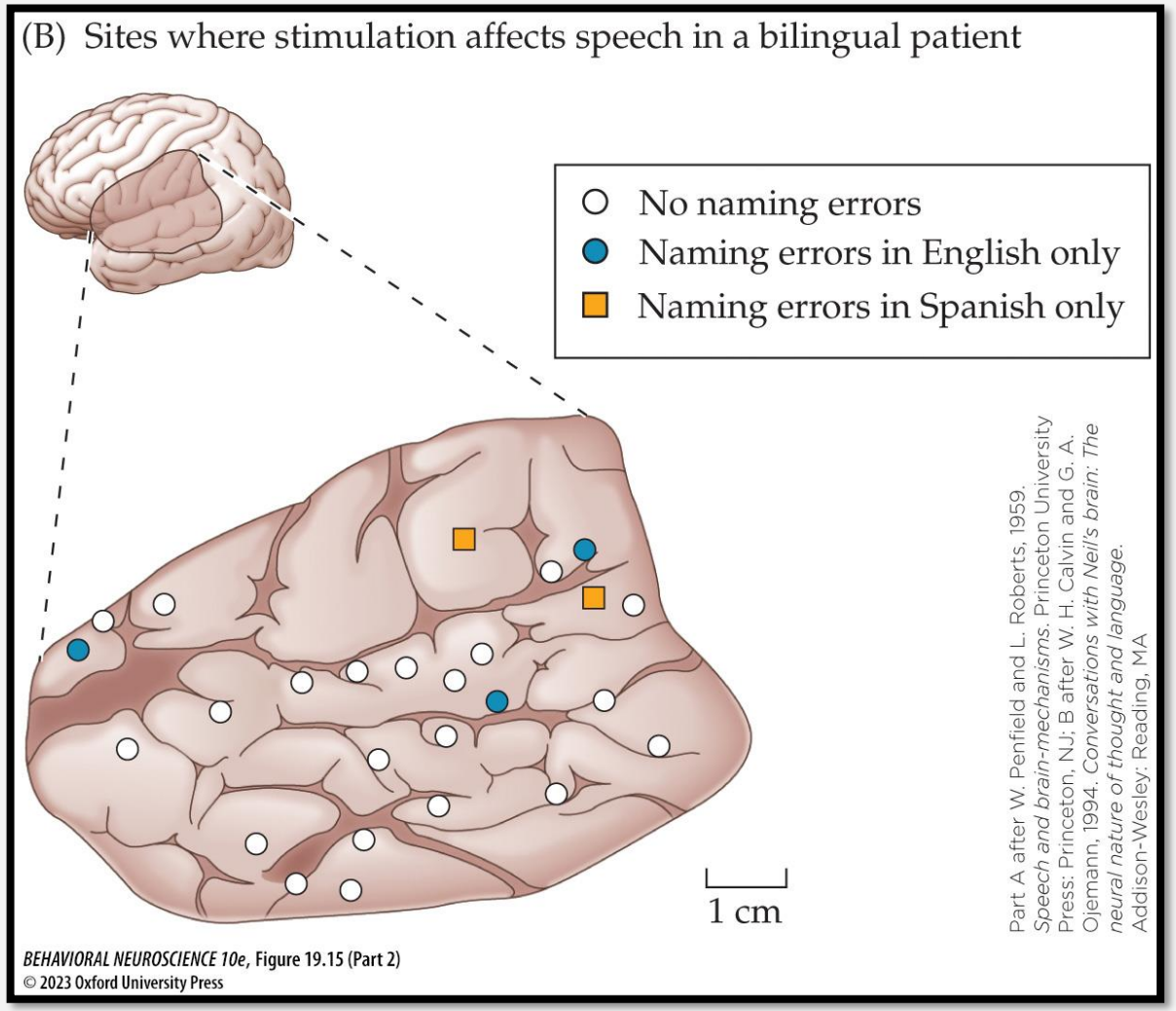
Brain mapping:

- researchers study the language network using functional imaging and electrical stimulation of discrete cortex areas.
- Stimulation of cortex in patients about to undergo brain surgery resulted in a map of language-related zones of the left hemisphere.



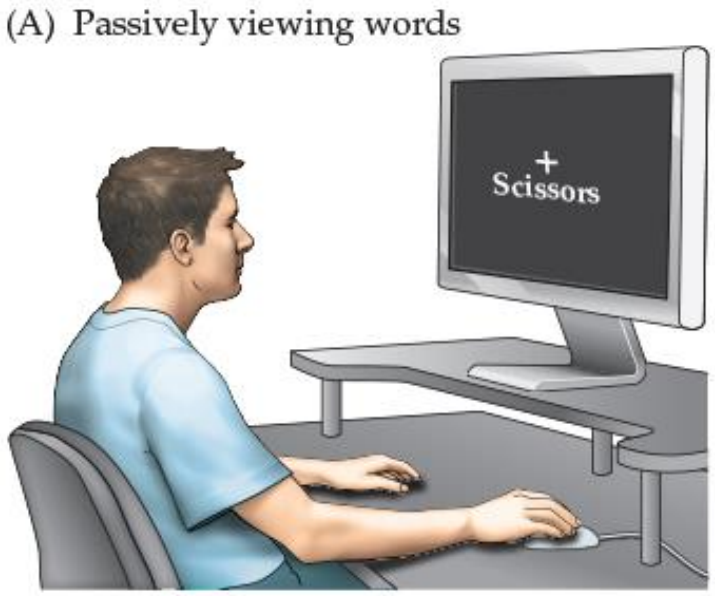
Brain mapping

- Later studies revealed compartmentalization of linguistic processes such as naming, reading, speech production, and verbal memory.
- Stimulation of language areas in bilingual subjects indicates that each language is affected by different areas.
- People who are bilingual from an early age show a complete overlap of the two language zones.



Functional neuroimaging

Which part of the brain would be active here?



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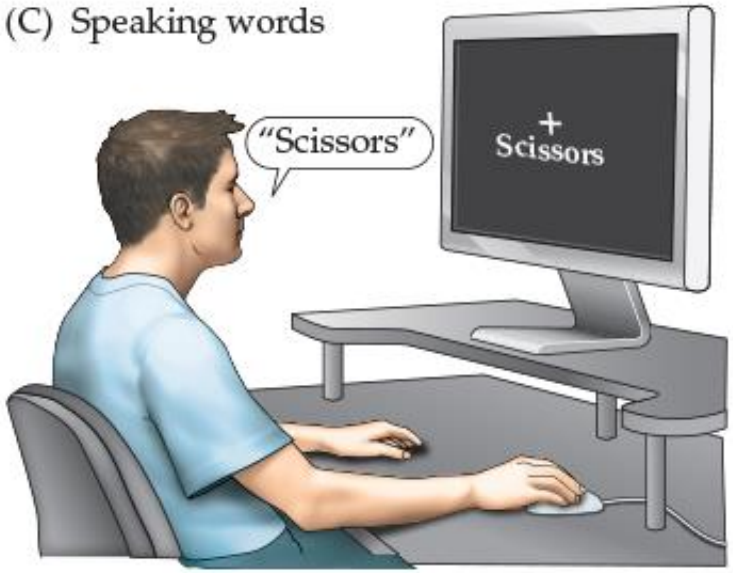

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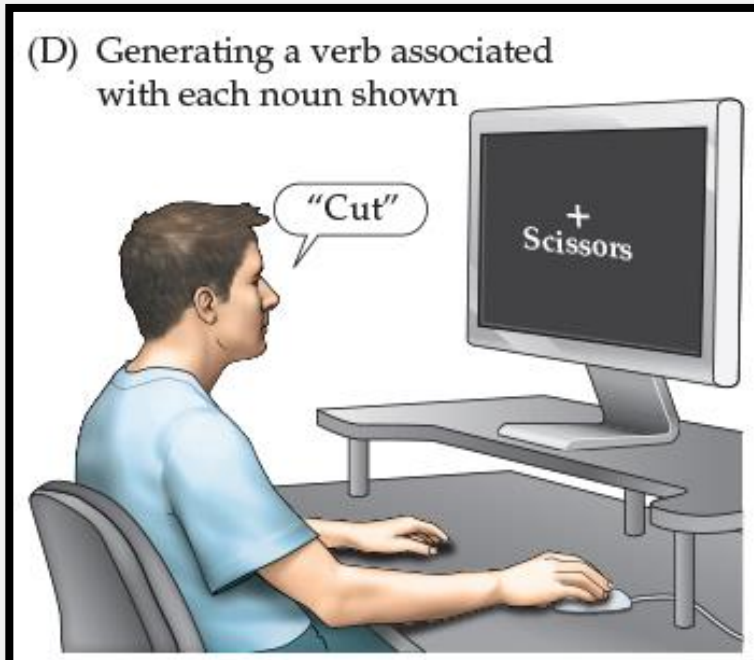
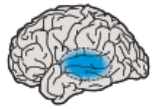
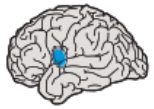


Aphasia and effected brain regions

TABLE 19.1 Language Symptomatology in Aphasia

Type of aphasia	Brain area affected	Spontaneous speech	Comprehension	Paraphasia	Repetition	Naming
Nonfluent (Broca's) aphasia		Nonfluent	Good	Uncommon	Poor	Poor
Fluent (Wernicke's) aphasia		Fluent	Poor	Common	Poor	Poor
Global aphasia		Nonfluent	Poor	Variable	Poor	Poor
Conduction aphasia		Fluent	Good	Common	Poor	Poor
Subcortical aphasia		Variable	Variable	Common	Good	Variable

Language

Silbo Gomero

- is a whistled language of the Canary Islands, used by shepherds to communicate over long distances.
- fMRI reveals that *silbadores* process Silbo using the same left-hemisphere mechanisms used for spoken language.
- Non-silbadore controls process the whistle sounds using completely different regions of the brain. The whistle sounds have no linguistic content for them.

Reading Skills

- Learning to read and write is far more difficult than learning to speak.

Dyslexia:

- difficulty with reading due to developmental or neurological causes.
- *Acquired dyslexia* (*alexia*) can occur in adults after injury to the left hemisphere.
- **Deep dyslexia**: an acquired dyslexia in which a person reads a word as another semantically related word.

Reading Skills

Surface dyslexia:

- the person attends only to the fine details of reading—which letter makes which sound.
- Surface dyslexics find it difficult to recognize words in which the letter-to-sound rules are irregular.
- Surface dyslexia does not occur in native speakers of languages that are perfectly phonetic (such as Italian).

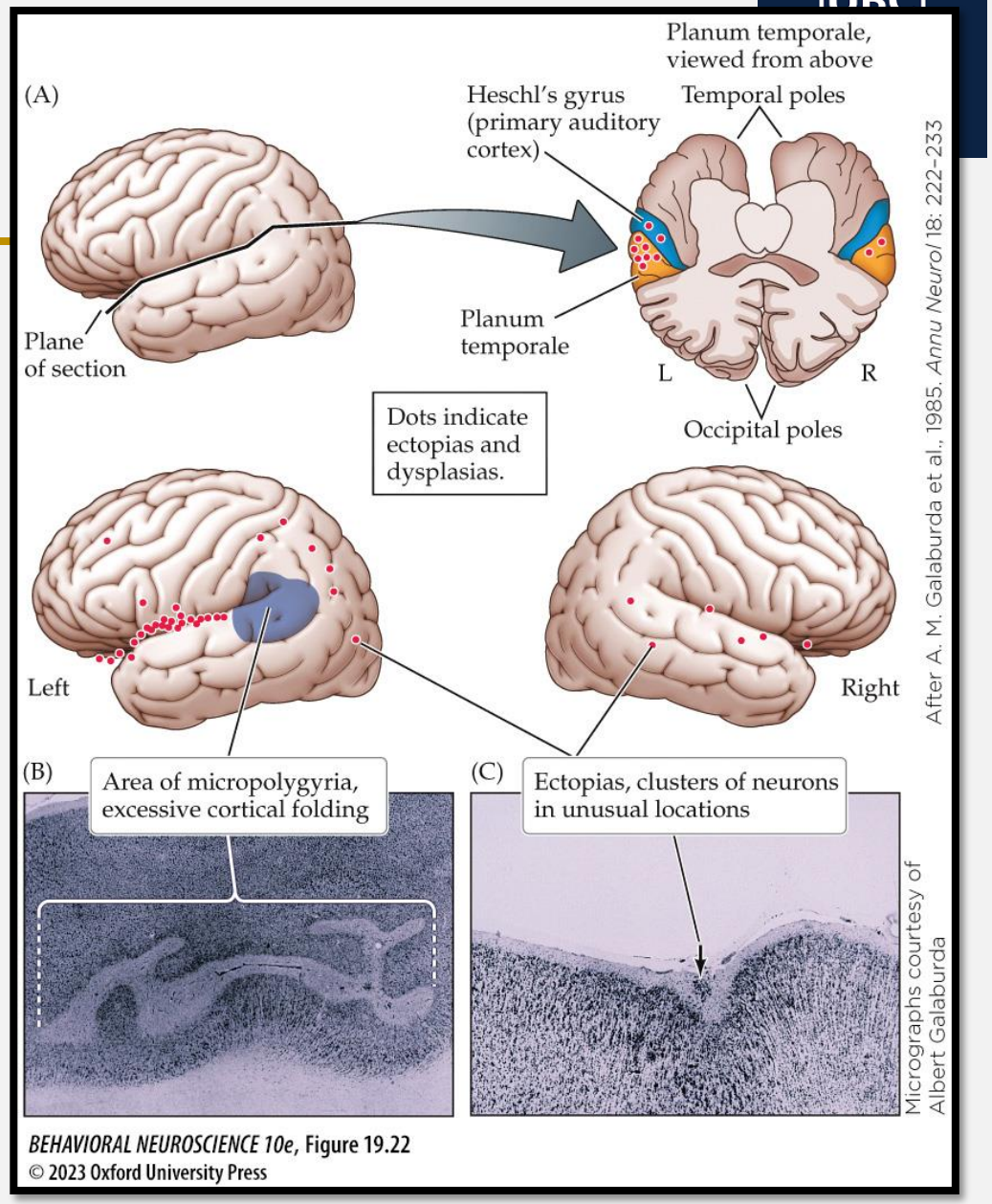
The Tough Coughs as He Ploughs the Dough

Reading Skills

Developmental dyslexia

- appears to be a problem in connecting reading with the brain systems for speech, and not a general cognitive deficit.
- Brains of dyslexics show unusual arrangements of cortical cells.

- **Micropolygyria**—small regions of excessive number of gyri
- **Ectopias**—clusters of cells in unusual places – distortions of layers and columnar organization



Reading Skills

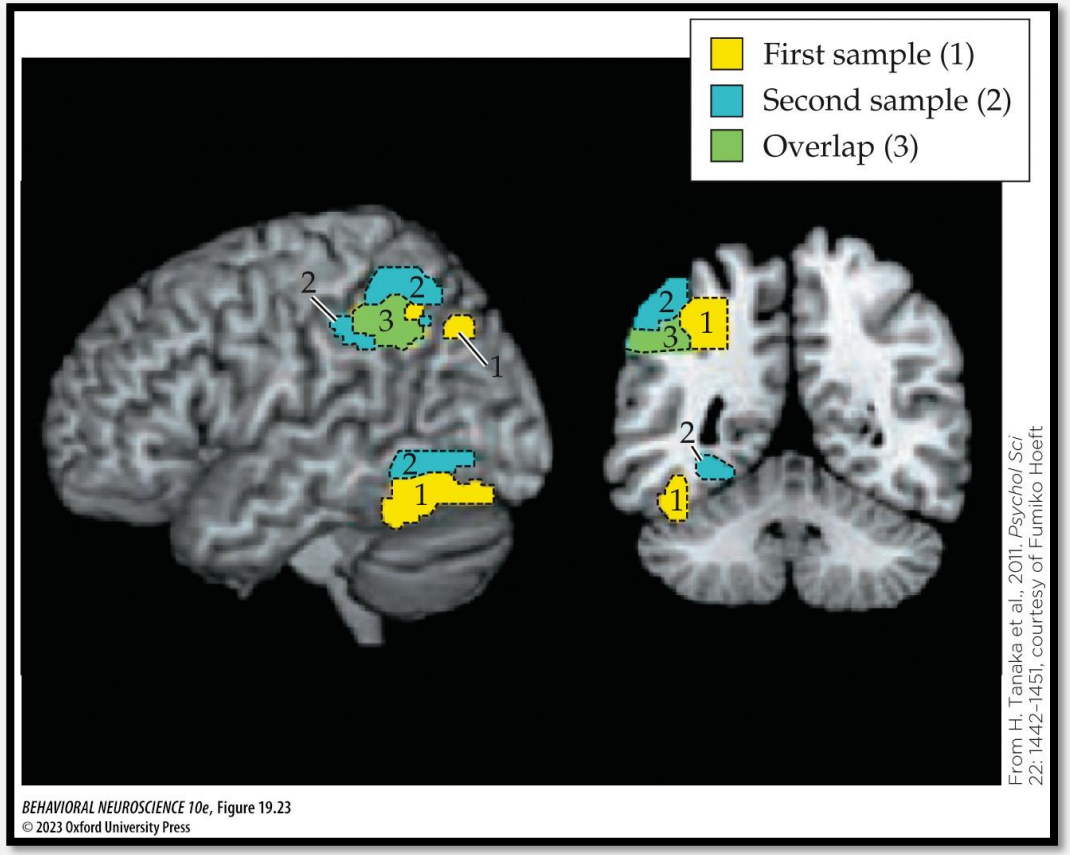
fMRI imaging

- indicates differences in brain activity in dyslexia:
- Compared with controls, people with dyslexia show diminished activation of left posterior regions including the superior temporal lobe and angular gyrus.
- Changes in fine structure of the temporo-parietal white matter pathways in adult dyslexics suggest problems with axonal connections between language areas.

Reading Skill

Brains rely on two language systems while reading:

- One focuses on sounds of letters (*phonology*)
- One focuses on meanings of whole words (*semantics*)
  - People with dyslexia often lack a connection between the two systems.



Reading Skills and genetics

Developmental dyslexia appears to have a heritable component.

- *ROBO1* is involved in growing axons to their destinations
- *DYXC1*—function not yet known
- *DCDC2* may participate in migration of neurons
- *KIAA0319* is linked to brain development processes

Developing research

- Those with dyslexia – less accurate at identifying voices of speakers of their own language (but not voices of people speaking other languages)
- Outperformance of others in other learning domains like spatial learning