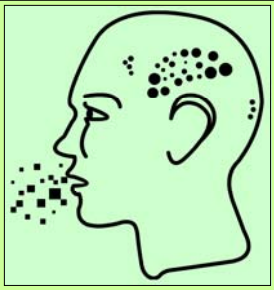
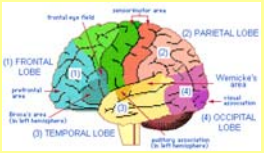


Language and the Brain

1

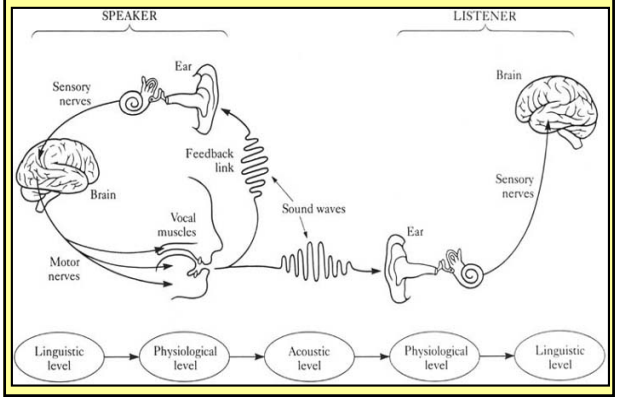


Topics:

1. Introduction to Brain and Language
2. Aphasia
3. Lateralisation tests

2

The picture of speech communication:



The picture of speech communication:

-a person has an idea s/he wishes to communicate

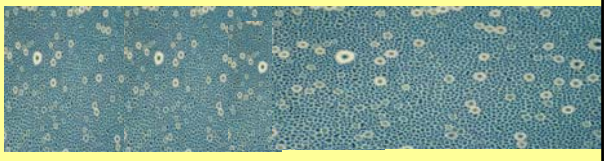
-s/he puts the idea into words and utters them

-another person hears the sound, recognizes the words, and grasps the speaker's intent

4

Did you know that . . .

► There are about 10 billion nerve cells (i.e., neurons) in the brain



5

And that?

► The 'thinking', 'receiving messages' and 'decision making' parts of the brain lie on the outer surface of the brain (i.e., the cortex)

(Fromkin and Rodman)

6

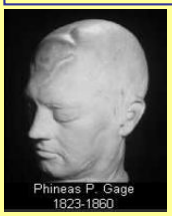
And that?

- When speaking normally we produce one speech sound about every tenth of a second (3 words per second).
- But we only make about one sound error per million sounds, and one word error per million words

(Caplan 1995)

7

Phineas P. Gage [fin'i:əs geidʒ] (1823 – May 21, 1860)-1



PG was a young railroad construction supervisor. On **September 13, 1848,** he was working outside the small town of Cavendish, Vermont on the construction of a railroad track where he was employed as a foreman.

One of his duties was to set explosive charges in holes drilled into large pieces of rock so they could be broken up and removed.

This involved filling the hole with gunpowder, adding a fuse, and then packing in sand with the aid of a large tamping iron.

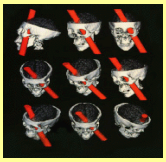
Gage was momentarily distracted and forgot to pour the sand into one hole. Thus, when he went to tamp the sand down, the tamping iron sparked against the rock and ignited the gunpowder, causing the iron to be blown through Gage's head.

Phineas P. Gage [fin'i:əs geidʒ] (1823 – May 21, 1860)-2

The one meter long tamping iron with a diameter of 3.2 cm, weighing 6.12 kg entered his skull below his **left cheek bone and exited after passing through the anterior frontal cortex and white matter.**
Remarkably, after such a dramatic accident, Gage regained consciousness within a few minutes, he **was able to speak and to understand language,** and survived a 45-minute ride back to his boarding house sitting in a cart.
As the doctor arrived, he was reportedly **conscious,** and had **a regular pulse** of about 60 beats per minute, suggesting that he only suffered minimal blood loss.

Even though there were not any changes in his ability to use and comprehend language, according to Gage's physician, Dr J.M. Harlow, his personality seemed to have been radically altered after the accident. Before the accident he had been hard-working, responsible and popular with the men in his charge. After the unfortunate event he became impatient and irresponsible.

Phineas P. Gage [fin'i:əs geidʒ] (1823 – May 21, 1860)-3



After his injury, Gage lost his job with the railroad construction company.

When he was well enough again in or around 1850, he spent about **a year as a SIDESHOW ATTRACTION at P. T. Barnum's New York museum,** putting his injury, and the tamping iron which caused it, on display to anybody willing to pay for the show.

He then worked as an assistant in New Hampshire and, for nearly seven years, as a coach driver in Chile.

When his health started to fail in 1859, he returned to San Francisco, where he lived with his mother and, for some months before his death, was employed as a farm worker.

Phineas P. Gage [fin'i:əs geidʒ] (1823 – May 21, 1860)-4

Today, **Gage's skull and the tamping rod** which damaged it are on permanent display at **Harvard's Countway Library of Medicine.**

The incident did much to advance the field of **neurology,** as it was among the first evidence suggesting that **damage to the frontal lobes could alter aspects of personality and affect social skills.** Before Gage's brain injury, the frontal lobes were largely thought to have little role in behaviour.

Did you know that

- A man with an IQ of between 60 and 70 who was so retarded that he could not even cut his fingernails, could speak about 20 languages, even though he had no formal instruction

(Fromkin & Rodman)

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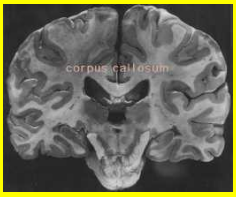
QUESTION?

- **How can the brain be so important to language and at the same time not important?**

- Let's look at the brain in more detail

13

The Brain : 2 halves



The brain has two roughly identical halves -the left and the right hemispheres.

The two hemispheres are connected by the corpus callosum.

14

Left and Right

- **There are small differences in the sizes of some regions in the two hemispheres.**
- **These differences may form the basis for the first major brain specialization for language –**

lateralization

of language.

15

BUT TO WHICH SIDE?

To the LEFT?

To the RIGHT?

16

Answering the telephone

To which ear do you place the receiver when you answer the phone?

17

Radio: A single earphone

In which ear does a single earphone go?

LEFT? **or** **RIGHT?**

18

Most people:

- will put telephone receivers and earphones to their right ears.
- So where's language in the brain?
- On the RIGHT SIDE?!?
- WRONG!!!!!!!

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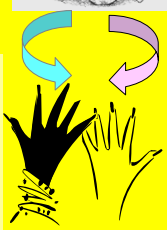
CONTRALATERAL...

- Human brains are contralateral!!!!
- What does it mean?

It's easy enough to understand:



- Left brain controls the right hand/side of our body

and

- the Left hand/side of our body is moved/controlled by the right brain

Some statistics

- In about 98 percent of right-handers, the **LEFT HEMISPHERE** accomplishes most language processing functions.
- In **NON-RIGHT HANDERS (which include left-handed and ambidextrous people)**, language functions are far more likely to involve the right hemisphere.
- There is some evidence that lateralization differs in males and females.

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and

- There is also evidence that the non-dominant hemisphere is primarily involved in functions that are just one step beyond the essential language functions of relating form to literal meaning.

ANY IDEA WHAT COULD THOSE BE?

Examples:

(1) determining the emotional state of a speaker from his or her tone of voice

(2) appreciating humour and metaphor

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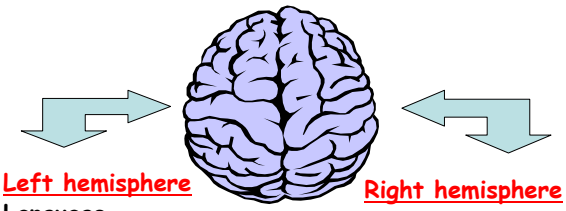
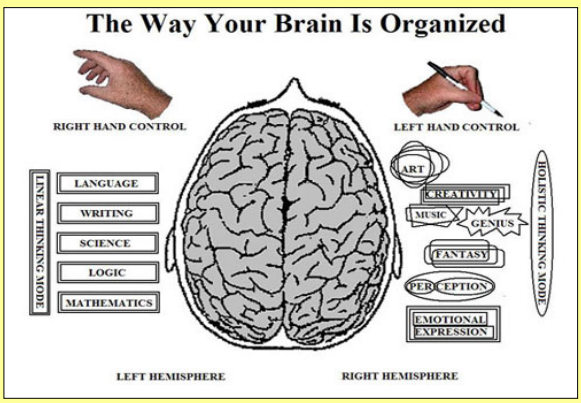
Lateralization of other abilities-1



Left hemisphere
Language
Math
Logic
Reasoning

Right hemisphere
Spatial abilities
Face recognition
Visual imagery
Music

Lateralization of other abilities-2



Aphasia-1

Aphasia [əf'eiʒə] ("not speaking") is an impairment of language. It is a neurological term used to refer to language disorders that follow brain lesions caused by a stroke, a tumor, a gunshot wound, other traumas, or an infection.

Aphasia can affect:
*the production of speech
*the comprehension of speech
*the ability to read
*the ability to write

What does aphasia cause?

- Aphasia can be so severe as to make communication almost impossible, or it can be very mild.
- It may affect mainly a single aspect of language use, such as

(1) the ability to retrieve the names of objects, or
(2) the ability to put words together into sentences, or
(3) the ability to read.

- More commonly, however, multiple aspects of communication are impaired, while some channels remain accessible for a limited exchange of information.

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Aphasia-2

✓Aphasia is always due to injury to the brain - most commonly from a stroke, particularly in older individuals. But brain injuries resulting in aphasia may also arise from head trauma, from brain tumors, or from infections.

✓ The two most famous types of aphasia result from injury to two specific areas of the brain, with dramatically different consequences. These areas and their aphasias are called Broca's and Wernicke's.

Aphasia-History-3

- Ancient Greeks noticed that brain damage could cause aphasia.
- Centuries later, in 1836, Marc Dax an obscure French country doctor attended a medical conference in Montpelier, France, and presented the only scientific paper of his life.
- At that conference, Dax described a group of patients who could not speak properly. He claimed that, in 40 aphasic patients he had seen in his practice, loss of language ability always correlated with DAMAGE TO THE LEFT HALF OF THE BRAIN.
- Unfortunately, the paper went unnoticed and his remarkable insight was soon forgotten.

Broca's Area-1

A quarter of a century after Dax, in 1861, the French physician, anatomist and anthropologist Paul Broca dramatically proved Dax's original claim.

Broca discovered that the SPEECH production centre of the BRAIN is located in the VENTROPOSTERIOR REGION of the frontal lobes (now known as the Broca's area).

He arrived at this discovery by studying the brains of aphasic patients (i.e., persons with speech and language disorders resulting from brain injuries), particularly the brain of his first patient in the Bicetre Hospital.

Paul Broca (1824-1880)

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Broca's Area-2

Broca's first patient was unable to clearly speak any other word but the word "tan". For this reason, Broca called him "TAN".

When Tan died, Broca examined his brain and found that there was a damage to part of the left frontal cortex. This part of the brain has come to be known as the "Broca's Area".

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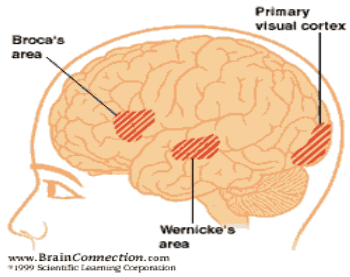
Where is the left frontal cortex? (i.e., Where is Broca's area?)



31

Aphasia caused by damage to Broca's area has the following characteristics:

1. Language can be mostly understood BUT!!!!!!!
2. Speech output is severely reduced, limited mainly to short utterances of a few words.
3. Vocabulary access is limited.
4. Lack of syntax and diminished morphology.
5. Formation of sounds is often laborious and clumsy.
6. May understand speech relatively well and is able to read, but the patient is limited in writing.

An example of speech from a 64 year old Broca's aphasic asked to describe a picture showing a little boy stealing cookies from a cookie jar while his chair is tipping over; a little girl is helping him. Their mother stands at the window staring into space while the sink in front of her overflows.

Kid … kk … candy … cookie … caandy … well, I don't know but it's writ … easy does it … slam … early … fall … men … many no … girl. Dishes … soap … soap … water … water … falling pah that's all.

33

Features of speech:

*Effortful speech
*Word finding pauses
*Unclear words
*Grammatical words are rare
*He is aware of his problems

(Source: Obler and Gjerlow)

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Another example:

M:E: Ah … Monday … ah, Dad and Paul Haney [himself] and Dad … hospital. Two … ah, doctors … and ah … thirty minutes … and yes … ah … hospital. And, er, Wednesday … nine o'clock. And er Thursday, ten o'clock … doctors. Two doctors … and ah … teeth. Yeah, … fine.

M.E: Cinderella … poor … um 'dopted her … scrubbed floor, um, tidy … poor, um … 'dopted … Si-sisters and mother … ball. Ball, prince um, shoe …

Examiner: Keep going.

M.E: Scrubbed and uh washed and un…tidy, uh, sisters and mother, prince, no, prince, yes. Cinderella hooked prince. (*Laughs.*) Um, um, shoes, um, twelve o'clock ball, finished.

Examiner: So what happened in the end?

M.E: Married.

Examiner: How does he find her?

M.E: Um, Prince, um, happen to, um … Prince, and Cinderalla meet, um met um met.

Examiner: What happened at the ball? They didn't get married at the ball.

M.E: No, um, no … I don't know. Shoe, um found shoe …

Broca's aphasic comprehension of language seems to depend more on word meaning than on syntactic structure.

A sentence such as

"the girl is reading the yellow book"

is generally understood rather well, since the basic word meanings can be combined in just one reasonable way. But where the role of participants is unpredictable, as in

"the dog chased the cat"

the ability to recognize the sentence drops. Without syntax, either the cat or dog could be doing the chasing.

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Kark Wernicke (1848-1904)

Wernicke's Area-1

- In 1876, Karl Wenicke found that damage to a different part of the brain also caused language problems. This area of the brain ("Wernicke's Area"), was further back and lower in the brain compared to Broca's area. In fact, Wernicke's area is in the POSTERIOR PART OF THE TEMPORAL LOBE.

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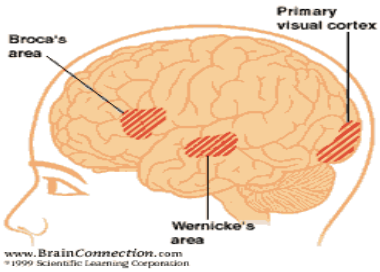
Wernicke's area is at the back (on the left)



38

Aphasia caused by damage to Wernicke's area has the following characteristics

*loss of the ability to understand language

*person can speak clearly, but the words that are put together make no sense. This way of speaking has been called **"word salad"** because it appears that the words are all mixed up like the vegetables in a salad.

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Example of speech from a 75 year old Wernicke's aphasic:

What's wrong with me because I … was myself until the taenz took something about the time between me and my regular time in that time and they took the time in that time here and that's when the the time took around here and saw me around in it it's started with me no time and then I bekan [began] work of nothing else that's the way the doctor find me that way …

40

And another Example:

The patient in the passage below is trying to describe a picture of a child taking a cookie.

C.B. Uh, well this is the … the /dədəü/ of this. This and this and this and this. These things going in there like that. This is /sen/ things here. This one here, these two things here. And the other one here, back in this one, this one /gə/ look at this one.

Examiner. Yeah, what's happening there?

C.B. I can't tell you what that is, but I know what it is, but I don't now where it is. But I don't know what's under. I know it's you couldn't say it's … I couldn't say what it is. I couldn't say what that is. This shu-- that should be right in here. That's very bad in there. Anyway, this one here, and that, and that's it. This is the getting in here and that's the getting around here, and that, and that's it. This is getting in here and that's the getting around here, this one and one with this one. And this one, and that's it, isn't it? I don't know what else you'd want.

- **Wernicke's patients seem to suffer from much greater disorders of thought than Broca's patients, who often seem able to reason much as before their stroke, but are simply unable to express themselves fluently.**
- **However, their non-fluency causes them much frustration, and they are said to be unhappier than Wernicke's patients, who are often blissfully unaware that nothing they say makes any sense at all, and whose higher-level thinking processes are often as haphazard as their language is.**

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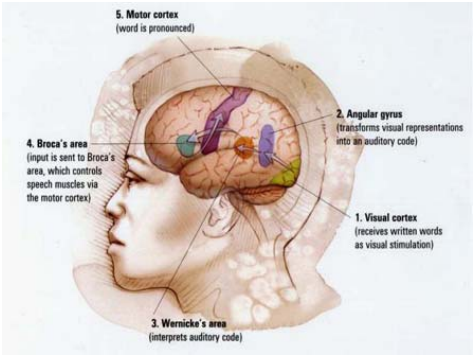
- In the early 1950's, the famous neurosurgeon Wilder Penfield and his colleague Herbert Jasper, described how electrical stimulation of certain areas of the brain blocked language. These neurosurgeons were able to perform these studies asking their patients questions during the surgical procedure.
- More recently (late 1980's), Dr. George Ojemann at the University of Washington has used electrical stimulation experiments to show that there can be a large difference in the brain area that is important for language from person to person.
- Nevertheless, the results of these studies agree with the earlier findings of Broca and Wernicke.

One last look at the 2 areas we have studied in this lesson



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Evidence for lateralization

1. Dichotic Listening
2. Split Brain Patients
3. WADA Test
4. MRI, PET, ERPs and other types of brain imaging: these may also be used to show modularity

45

1. Dichotic Listening Tests-1

*Subjects heard two different sounds simultaneously through earphones (e.g., '**boy**' in one ear, '**girl**' in the other).

*When asked what they heard in each ear, they more frequently **correctly report words heard in the right ear** than words heard in the left ear.

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1. Dichotic Listening Tests-2

BUT…
They more frequently give correct responses to environmental and musical sounds delivered to the left ear

So, while language processing goes on in the left hemisphere, other sounds are processed in the right hemisphere. (and Language is treated as separate from the other sounds we hear).

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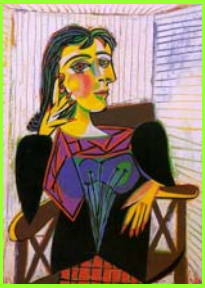
2. Split Brain Surgery-1

Split Brain surgery is only done when there is NO choice AND when it might help!



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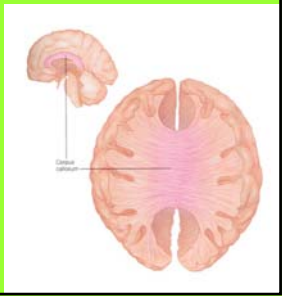
2. Split Brain Surgery-2

Remember the brain is already mostly split:
The two hemispheres are connected by a bundle of about two million fibers called the CORPUS CALLOSUM



2. Split Brain Surgery-3

Cutting apart the two hemispheres of the human brain is a drastic step,

YET it can succeed, when all else fails, -in relieving violent, drug-resistant epileptic seizures

50

2. Split Brain Experiments-4

Michael Gazzaniga

Roger Sperry (who won the Nobel prize in 1981) and Michael Gazzaniga are two neuroscientists who studied patients who had surgery to cut the corpus callosum. These studies are called "Split-Brain Experiments".

After surgery, these people appeared quite "normal" - they could walk, read, talk, play sports and do all the everyday things they did before surgery. Only after careful experiments that isolated information from reaching one of the hemispheres, could the real effects of the surgery be determined

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2. Split Brain Experiments-5

If the patient holds up something like a comb or a coffee cup in his left hand, he can't speak its name.

Transferred to the right hand -no trouble at all.

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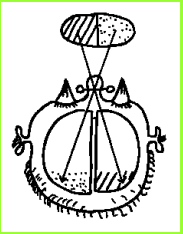
2. Split Brain Experiments-6

-The same happens with words.
-In tests, if a card is held up with a printed word like LOUSE visible only in the patient's left visual field, he cannot read it.
-Yet the left eye is fine.
-The left visual field flashes only to the right side of the brain.
-And so when the LOUSE is put in the right field, the patient immediately recognizes it.



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3. The WADA Test-1

In 1960, another technique was discovered that allowed researchers to study the brain mechanisms of language.

This method, called the WADA Test, uses a fast acting anesthetic called sodium amytal (amobarbital) to put one hemisphere of the brain asleep.

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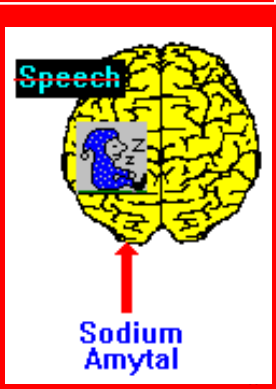
3. The WADA Test-2

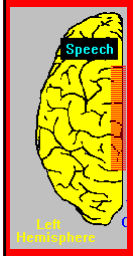
Sodium amytal is injected into the right or left carotid artery.

The right artery supplies the right cerebral hemisphere and the left artery supplies the left cerebral hemisphere.

Therefore, either the right or left hemisphere can be "put to sleep" temporarily.

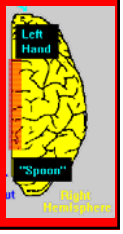


3. The WADA Test-3



If the left hemisphere is put to sleep in people who have language ability in the left hemisphere, when asked to speak, they can not.

However, if the right hemisphere is put to sleep, then these people will be able to speak and answer questions.



4. Tests for Modularity

The most recent technique used to study language is by using **brain imaging techniques**

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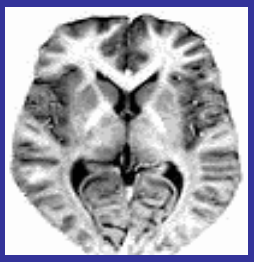
4.1. Magnetic Resonance Imaging

- MRI uses the detection of radio frequency signals produced by displaced radio waves in a magnetic field.
- It provides an anatomical view of the brain.



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MRI Advantages:

1. No X-rays or radioactive material is used.
2. Provides detailed view of the brain in different dimensions.
3. Safe, painless, non-invasive.
4. No special preparation (except the removal of all metal objects) is required from the patient.
5. Patients can eat or drink anything before the procedure

60

MRI Disadvantages:

1. Expensive to use.
2. Cannot be used in patients with metallic devices, like pacemakers.
3. Cannot be used with uncooperative patients because the patient must lie still.
4. Cannot be used with patients who are claustrophobic (afraid of small places). However, new MRI systems with a more open design are now available.

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4.2. PET

(known as)
Positron Emission Tomography studies

- show that **many** of the expected areas of the brain have **increased blood flow** during **language tasks**

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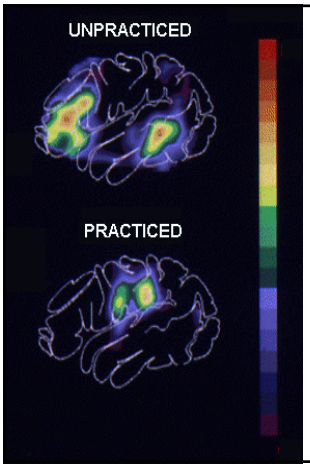

The top image here shows the PET scan of an individual **hearing a text**, in order to learn a new language task.

The color map shows the regions of the brain which were activated by this task.

Yellow and red regions are "hotter", that is, they indicate a higher cell activity. Blue and black regions show **decreased** activity or none at all.

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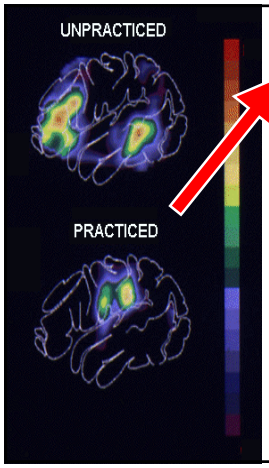

- In the bottom image, the same individual has **now learned** the language task and **is spelling out**. Now the activity is concentrated in the area of the cortex which is responsible for **the motor control of voice**, Broca's area.
- Thus, the functional map obtained with PET closely **corresponds with what we know about the brain's functional neuroanatomy**, discovered by other methods.
- The difference here is that we can actually obtain a **real-time image of brain function**!

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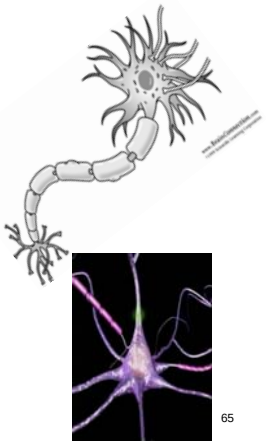
References

MRI section used information from http://www.bic.mni.mcgill.ca/users/robin/bic/bic.htm'

Information about splitting the human brain was taken from an internet essay By Paul Pietsch on http://www.indiana.edu/~pietsch/split-brain.html

Useful internet sites

http//www.indiana.edu/¬pietsch/split-brain.html



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