Cognitive Neuroscience
Hemispheric Specialization

1. Review of the crossed nature of sensory & motor systems.

a. Somatosensory system: cortical lesion --> contralateral *hemianesthesia* -- impaired somesthesis

b. Visual system: cortical lesion --> contralateral *hemianopsia* -- defective visual field. Affects both eyes.

c. Motor system: cortical lesion --> contralateral *hemiperesis* (body weakness) or *hemiplegia* (paralysis)

2. *Wada test* evidence for hemispheric lateralization

Wada test: injection of sodium amytal (a barbiturate) into carotid artery selectively puts to sleep left or right hemisphere for several minutes and thus is used to differentiate left vs right hemispheric function.
It shows that hemispheres have both language & emotional differences.

a. Principally used for determining the side of language dominance in pre-surgery epileptic patients.

Patient instructed to speak continuously while sodium amytal is injected. If hemisphere dominant for speech is affected, patient stops speaking & does not respond to a command to continue.

Language lateralization studied by Rasmussen & Milner (1977):
96% of right handers have left representation
4% of right handers have right representation
70% of left handers have left representation
15% of left handers have right representation
15% of left handers have bilateral representation

Studies of children indicate that childhood left hemisphere lesions may cause shifts to right or bilateral representation in either right- or left-handers.

b. In addition to the effect on language, sodium amytal can affect mood.

left injection --> brief depression
right injection --> euphoria

3. Lesion evidence for left hemispheric lateralization

Usually patients don't have a single impairment, but show a complex pattern of symptoms. Most patients show the following symptoms due to left hemisphere lesion:

a. *dysarthria* -- impaired speech articulation
b. *aphasias* -- disturbances of language comprehension
c. *apraxias* -- impaired ability to carry out purposeful movement -- not paralysis or inability to comprehend instructions. (may affect both sides of body but typically occurs with left cortical lesions.)

    e.g. use of objects (blow out match)
    or symbolic gestures (stick out tongue)

d. Conclusion about left hemisphere function

It is primarily specialized for language in most people. It supports functions such as:

i. reading
ii. writing
iii. understanding & speaking
iv. verbal ideation
v. verbal memory

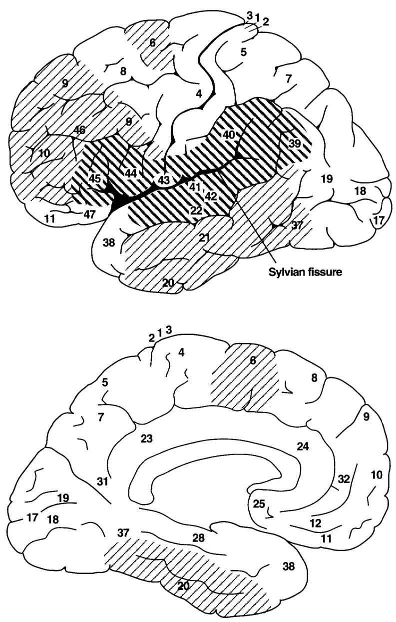


Figure 7.1. Cortical areas of the left hemisphere implicated in language by the study of the effects of cerebral lesions. Heavy crosshatching marks the posterior and anterior (frontal) language areas, lesions of which often result in severe language disorders. Lesions in lightly crosshatched areas result less frequently in less severe language disorders. Areas are numbered according to Brodmann's cytoarchitectonic map.

The left hemispheric specialization for language that has been determined by lesion evidence has largely been verified by neuroimaging.

4. Lesion evidence for right hemisphere lateralization

a. impaired spatial orientation -- manifested by reduced ability to perform block constructions, copy drawings or interpret maps.
includes difficulty in extrapersonal space, e.g. noting differences in external landmarks; & intrapersonal space, e.g. distinguishing left from right.

b. *dressing apraxia* -- reduced ability to dress

c. neglect of left visual field -- cardinal feature of extrapersonal space disorder for right hemisphere disease; not blind, but rather unaware
examples: word crowding (recovery may subsequently occur)
crowding of numerals on clock

Neglect of right side of space rarely seen in patients with left hemisphere lesions

d. *visual agnosia* -- impaired recognition of visual forms, e.g.
interpretation of flowers as arrows, face recognition

e. Conclusions about right hemisphere function

i. manipulospatial skills -- e.g. block arrangement
ii. representation of non-verbal form e.g. abstract drawing, patterns of dots, line figures
iii. face recognition
iv. recognition of musical stimuli

5. Split-brain experiments

a. Anatomy

Corpus Callosum -- bidirectional fiber pathway connecting left & right cortex
3 parts:
i) anterior genu -- between frontal lobes
ii) medial body -- between temporal & parietal lobes
iii) posterior splenium -- between occipital lobes

A.C. -- between medial temporal lobe structures, e.g. amygdala

As a general rule, fibers from a particular layer of cortex in 1 hemisphere project to & receive from the same region & layer of opposite hemisphere.

b. History

Before 1960's, role of C.C. not known. As recently as 1950, Lashley facetiously expressed the opinion that C.C. only serves to keep the hemispheres from sagging.

Then patients started having C.C & A.C cut to prevent spread of epileptic seizures.

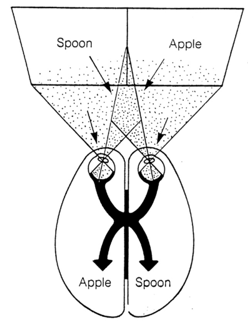
In a series of studies in 1960's, Roger Sperry with Michael Gazzaniga tested humans with C.C. sectioned.

Sperry had worked with animals with C.C. sections. He cut optic chiasm in addition to C.C. & A.C.
Animal trained to make visual discriminations with 1 eye.
When tested with untrained eye, they behaved as if completely naive.
The training experience was limited to 1 hemisphere.

c. Hemispheric differences in split-brain patients

Human patients with *split brains* normally do well in
real-life situations
because both hemispheres normally obtain common info.
E.g. as eyes scan environment, each hemisphere receives complete representation of surroundings.

Sperry & Gazzaniga set up expt so hemispheres received different info.
Used brief tachistoscopic visual stimuli projected to rt or left vis. field.
Transmitted only to opposite hemisphere (optic chiasm not cut)



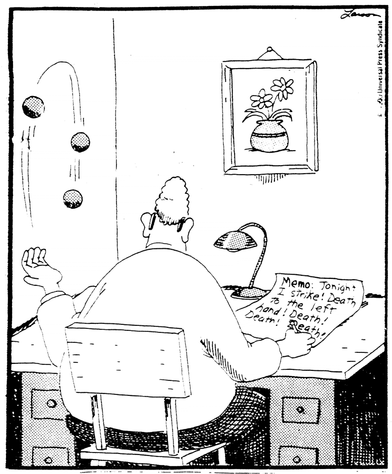
Classical expt -- apple presented to right visual field & asked what was seen -- answered "apple".
When presented to left visual field, denied seeing anything.
If prompted, would guess or make up answer.
However, patient could identify the object by pointing to it or picking
it out manually from several others -- using tactile cues.
Suggests that learning, memory, motor coordination intact in right hemisphere.

Right hemisphere almost totally incapable of language output, but can process simple linguistic input.
Does have some primitive understanding of language.
Many words projected to right hemisphere can be read & understood.
Letters D-O-G projected in left visual field, patient could pick model of dog with left hand. More complicated commands not understood.

d. Hemispheric competition

Hemispheres sometimes are seen to interfere with each other.

GARY LARSON



Innocent and carefree, Stuart's left hand didn't know what the right was doing.

When patients do block task with the left hand, controlled by the right hemisphere, the left hemisphere sometimes tries to interfere with task.

It can impede successful completion by interference with right hand.
The left hemisphere also sometimes initiates verbal comments about performance of the non-dominant hemisphere.

e. Chimeric face experiments

What happens when a split-brain patient is put in a situation where either hemisphere can take control?

Levy, Trevarthen & Sperry (1972) showed *chimeric faces* to split-brain patients.

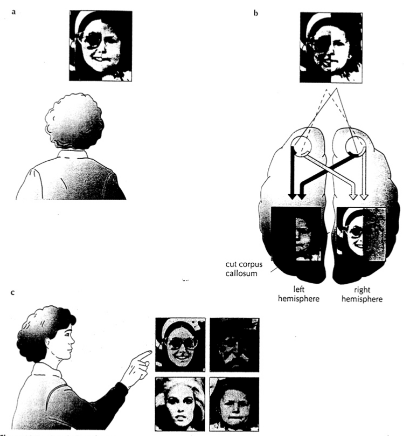


Figure 18.7 ***Levy's Experiment***
(a) The split-brain subject fixates on a picture consisting of the left half of one face and the right half of another. (b) Even though each eye sees both faces, the face in the right visual field is projected to the left hemisphere and the face in the left visual field is projected to the right hemisphere. (c) When the subject is asked to point to the picture she saw, she chooses the picture projected to the right hemisphere. It should be noted that even though half a face is projected to each hemisphere, the subject is unaware of the incompleteness of the pictures and behaves as though both hemispheres see one normal face.

When shown picture with fixation pt in middle, verbal report is that of right side of face. As expected, left hemisphere responds verbally.

But, what happens when non-verbal response is required? Either hemisphere can direct behavior. Presumably either side could respond when asked to point when shown a series of whole faces.
However, patients pick the left-sided face.

Right hemisphere appears more competent at this & it takes control.

Which 1 gains control seems to depend on which 1 is best suited for task to be performed.

Conclusion: Tasks that can be broken into logical elements in an analytic way are best performed by left hemisphere.
*Left hemisphere is best suited to verbal encoding.

Tasks that require global processing of whole input are best performed by right hemisphere.
*Right hemisphere is best suited to spatial-perceptual analysis.