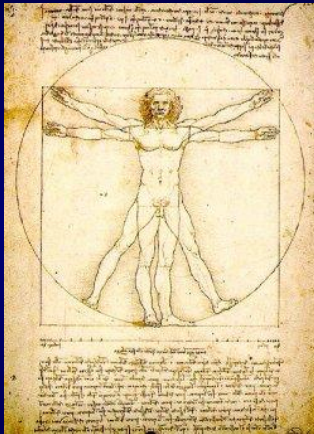
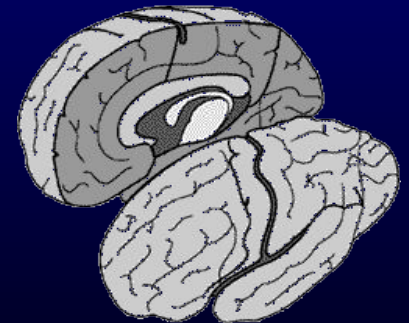


Cerebral asymmetry and the specific functions of the right hemisphere



Leonardo Da Vinci

*Anke
Bouma*

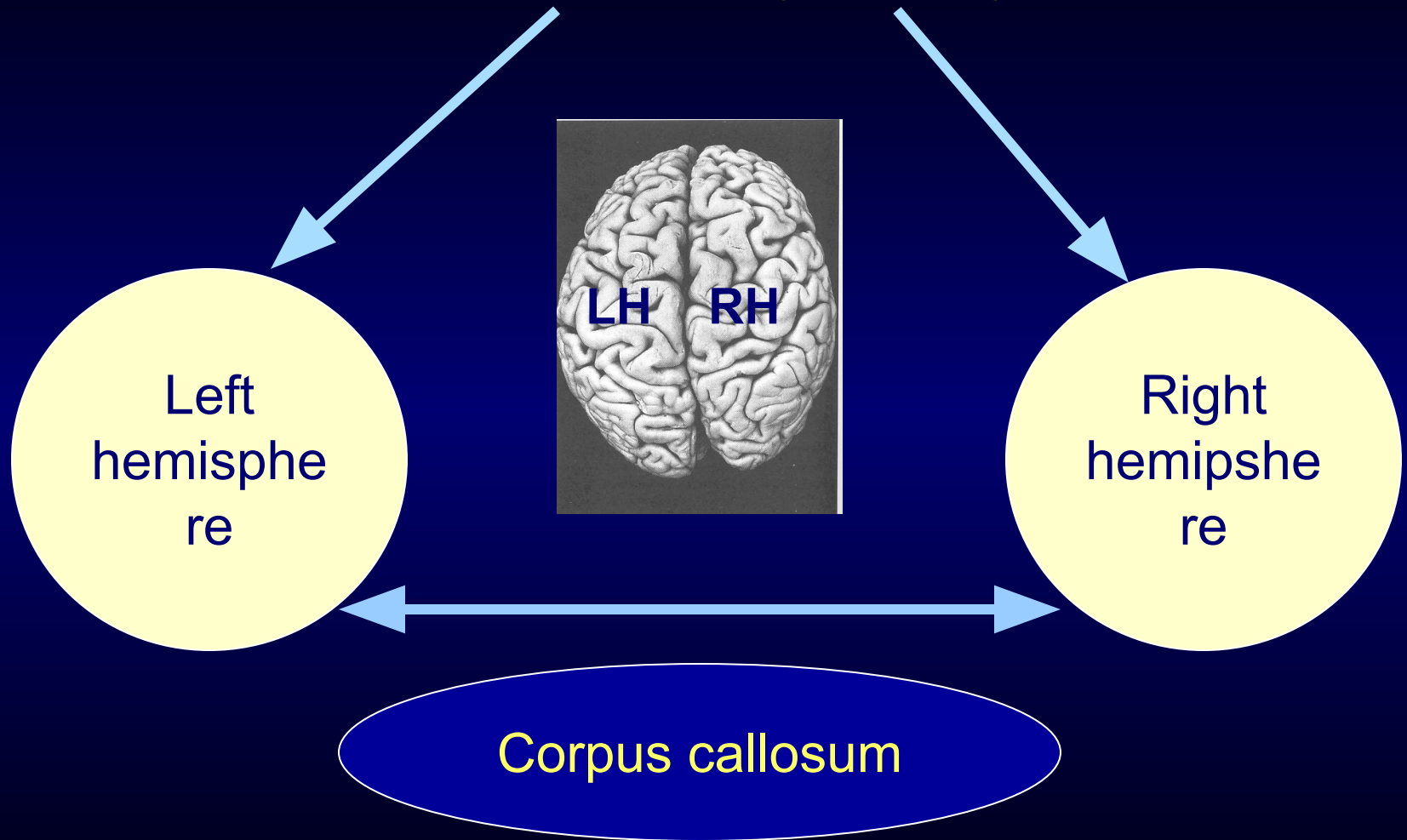


*Dept. of Clinical and Developmental Psychology
RijksUniversiteit van Groningen*

Cerebral asymmetry and the specific functions of the right hemisphere

- General overview of the cerebral asymmetries and the functions of the corpus callosum
- Specific functions of the right hemisphere, and consequences for neuropsychological assessment

Cerebral asymmetry



Cerebral asymmetry



Brain asymmetry has been observed in animals and humans structurally, functionally, and behaviorally. This lateralization is thought to originate from evolutionary, hereditary, developmental, experiential and pathological factors”

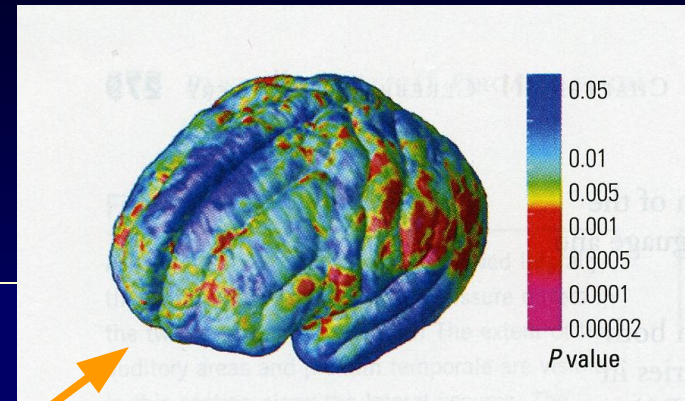
Toga & Thompson, Nature Reviews Neuroscience, 2004



Human brain asymmetries

Research methods

- Structural brain asymmetries
- Functional brain asymmetries
- Perceptual asymmetries
- Motor asymmetries
- Neurochemical differences



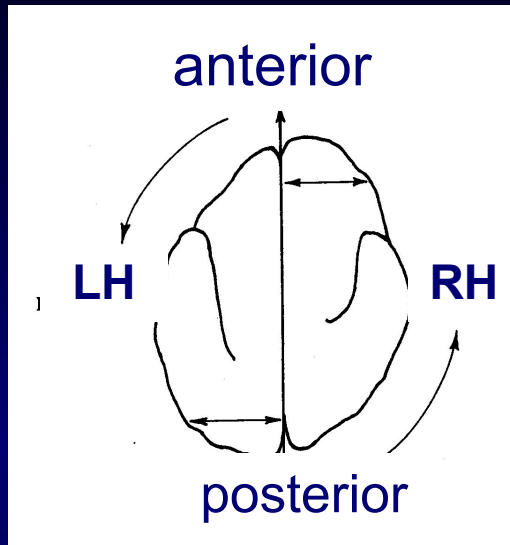
Human brain asymmetries

Clinical relevance

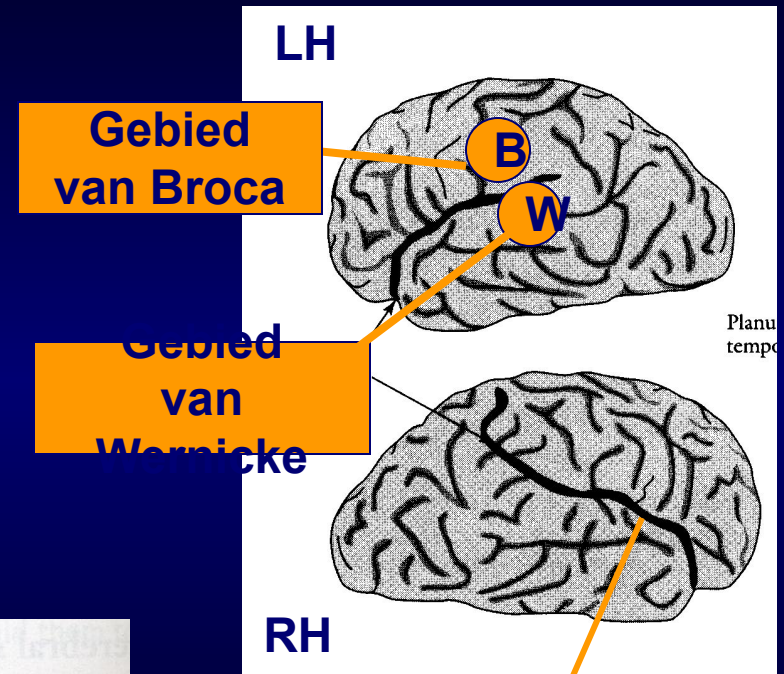
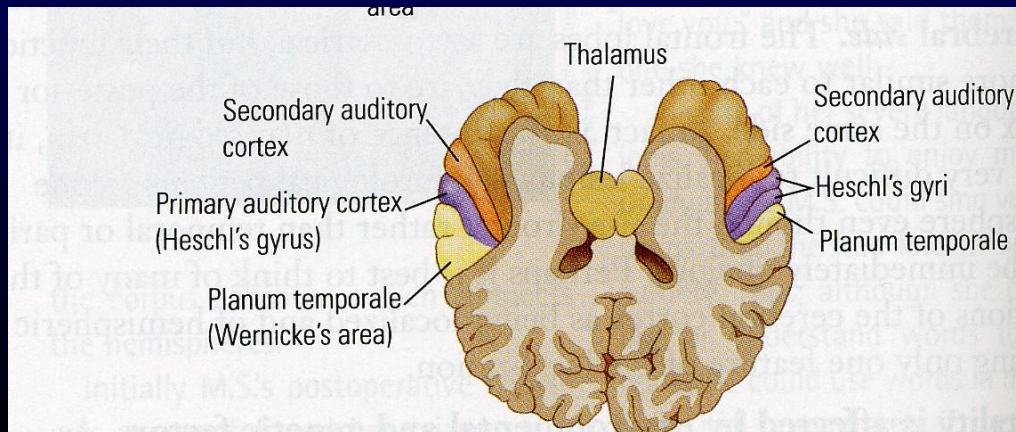
- Patients with unilateral lesions
- Split-brain patient
- Normal subjects (*age, sex, hand preference*)
- Bilateral lesions (*e.g., Alzheimerpatienten*)
- Developmental disorders
- Psychiatric patients

Structural brain asymmetries

Macroscopical



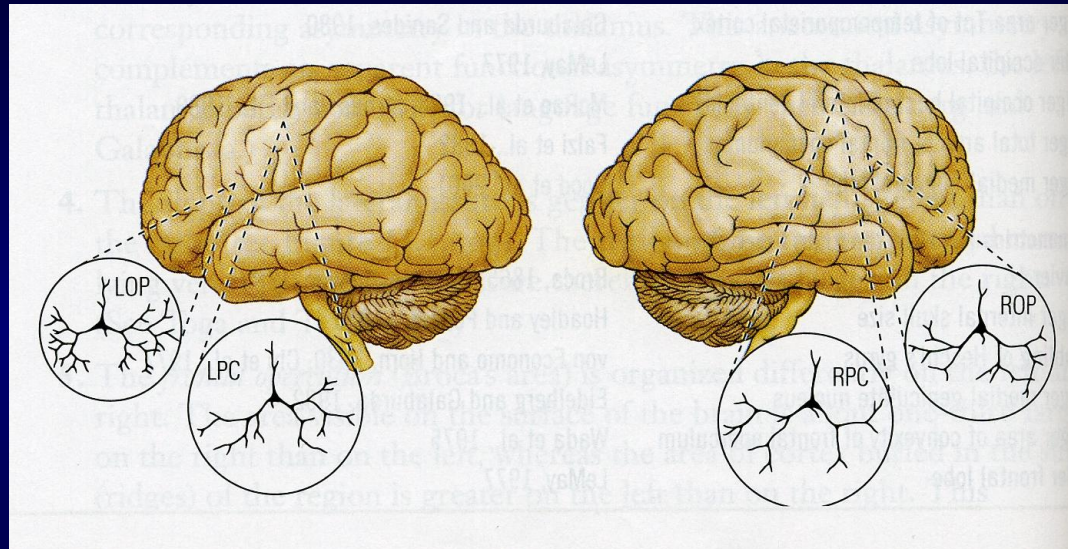
Counterclockwise torque



Sylvian fissure

Structural brain asymmetries

Microscopical



Left hemisphere: more detailed processing and expression of information

Right hemisphere: more focused on connectivity between different brain regions

Structural brain asymmetries

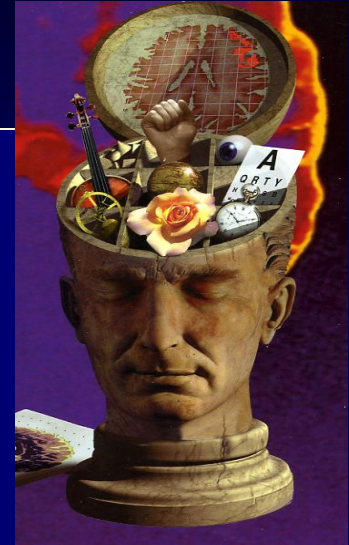
Neurochemical

Left hemisphere: dopamine (motor activation)

Right hemisphere: norepinephrine (alertness, orientation to new stimuli)

Functional brain asymmetry

- Not a simple dichotomy
- Not a modern phrenology
- Is not absolute, but relative
- Modular brain circuits (neuronal networks)
 - subprocesses
 - patterns of activations (intra- and inter-hemispheric connectivities)



Unilateral lesions of the left hemisphere



- primary perceptual and motor disturbances at the right side of the body (contralaterally)
- aphasia
- language-related disorders and verbal disorders
(alexia, agraphia, acalculia, verbal memory disorders)
- apraxia
- disturbances in temporal order / sequencing

'conscious awareness'

Unilateral lesions of the right hemisphere



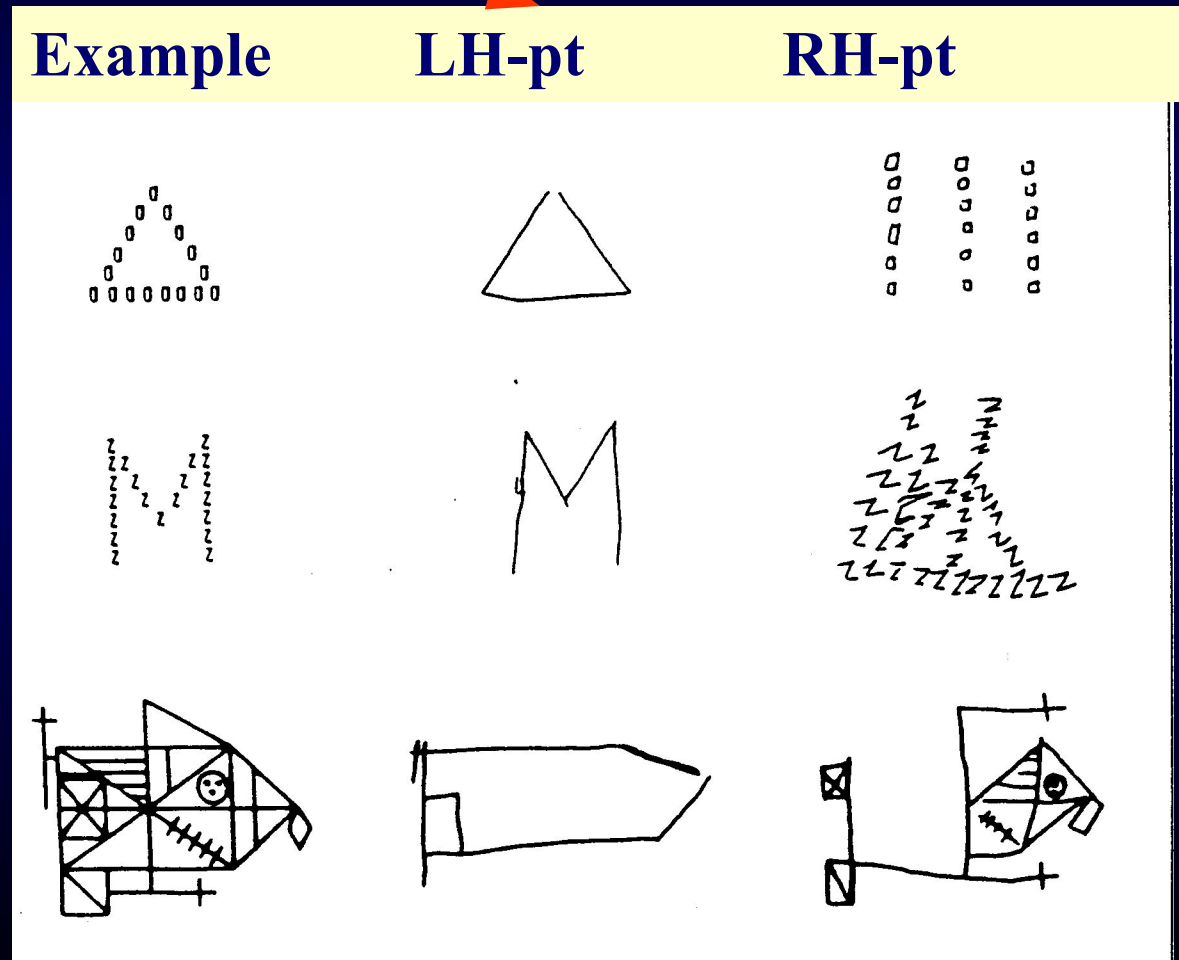
- primary perceptual and motor disturbances at the left side of the body (contralaterally)
- hemi-inattention (neglect); anosognosie and denial
- nonverbal information processing and nonverbal memory
(faces, visuospatial processes, environmental sounds, music (melodies, but not rhythm; LH involved by experienced musicians))
- Semantic, paralinguistic and affective aspects of language
(‘context’)
- emotions (*‘somatic markers’*); m.n. negative emotions

LH patients draw the overall global form of the figure, not on local parts of the figure

RH patients draw the local parts of the figure, but the overall global form is incorrect

Construtive
apraxia

Task: drawing



Right hemisphere:

Examples of emotional and social behavior



Ekman's faces varies from anxiety to depression



Actual social interaction

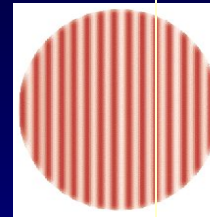


Anxiety in animals

Functional brain asymmetries

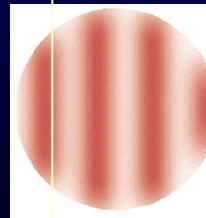
Left hemisphere

- high spatial frequency
- local processing
- analytic, detailed processing



Right hemisphere

- low spatial frequency
- global processing
- holistic processing



Right hemisphere:
stronger 'connectivity'
between different
brain regions than the
left hemisphere

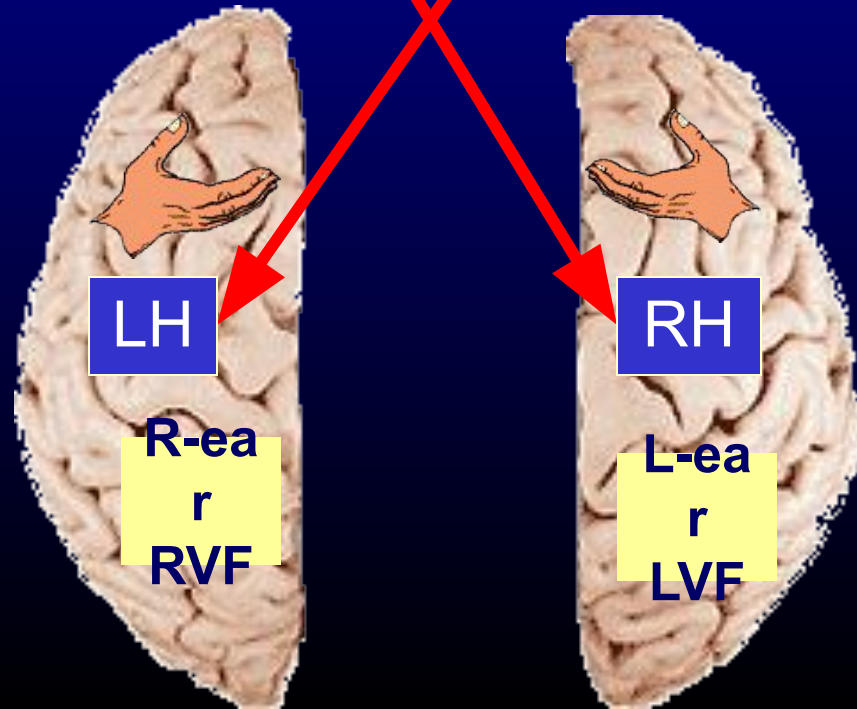
Left and Right

Left side of the body

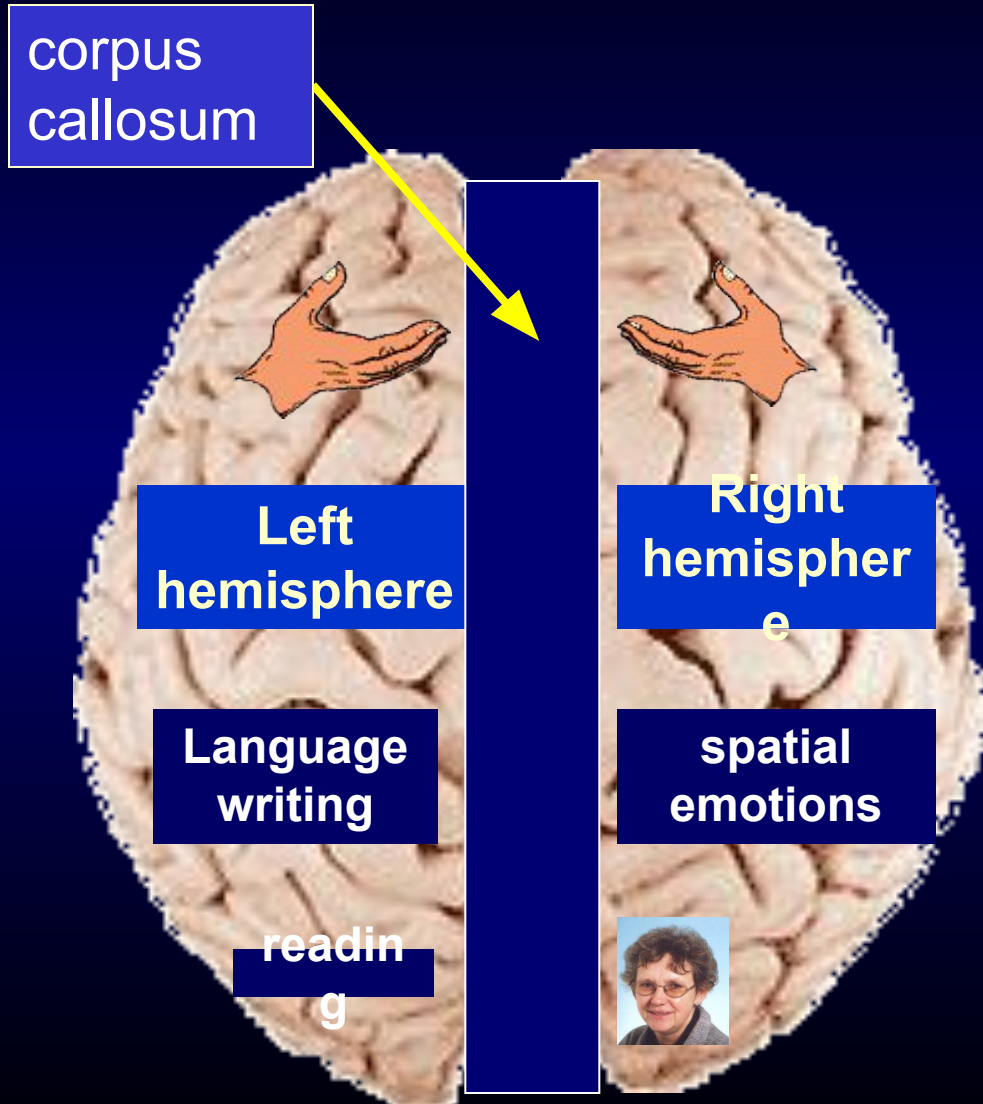
- Left hand
- Left ear
- Left Visual Field (LVF)

Right side of the body

- Right hand
- Right ear
- Right visual field (RVF)



Brain asymmetries and the role of the corpus callosum



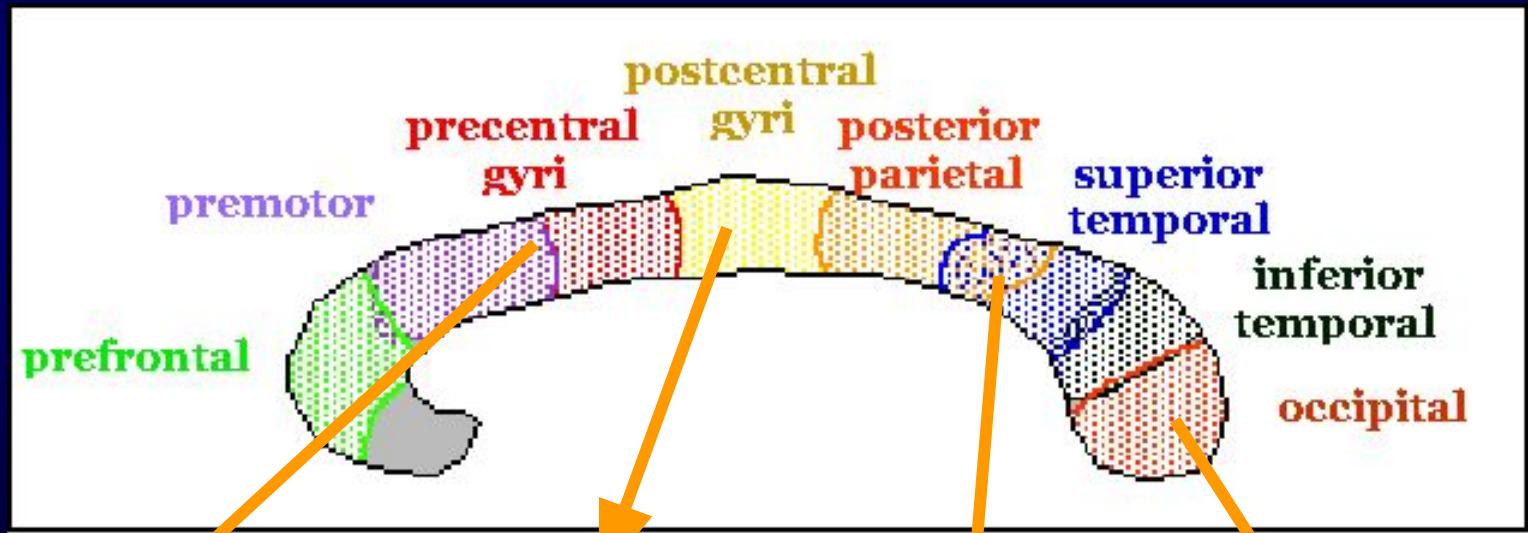
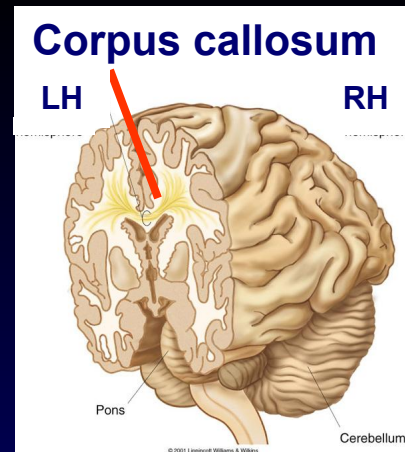
Inter-hemispheric interaction across the corpus callosum

- Transfer of information from the LH to the RH, and vice versa
- Inhibition of equivalent regions in the other hemisphere, and at the same time increased activation of the surrounding neurons for encoding related or contextual information

Split-brain patients



Corpus callosum



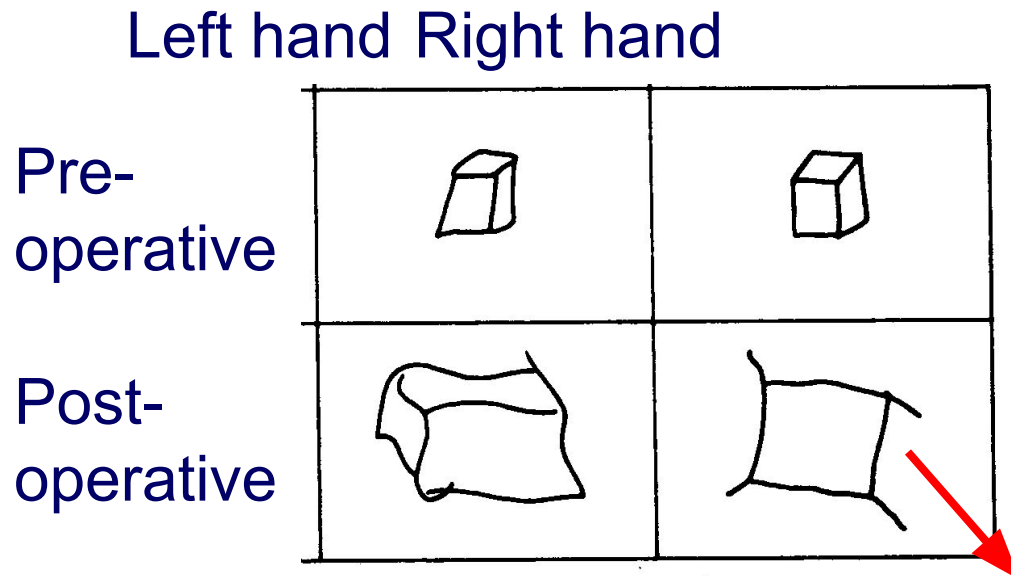
Motor system

Somatosensory system

Auditory system

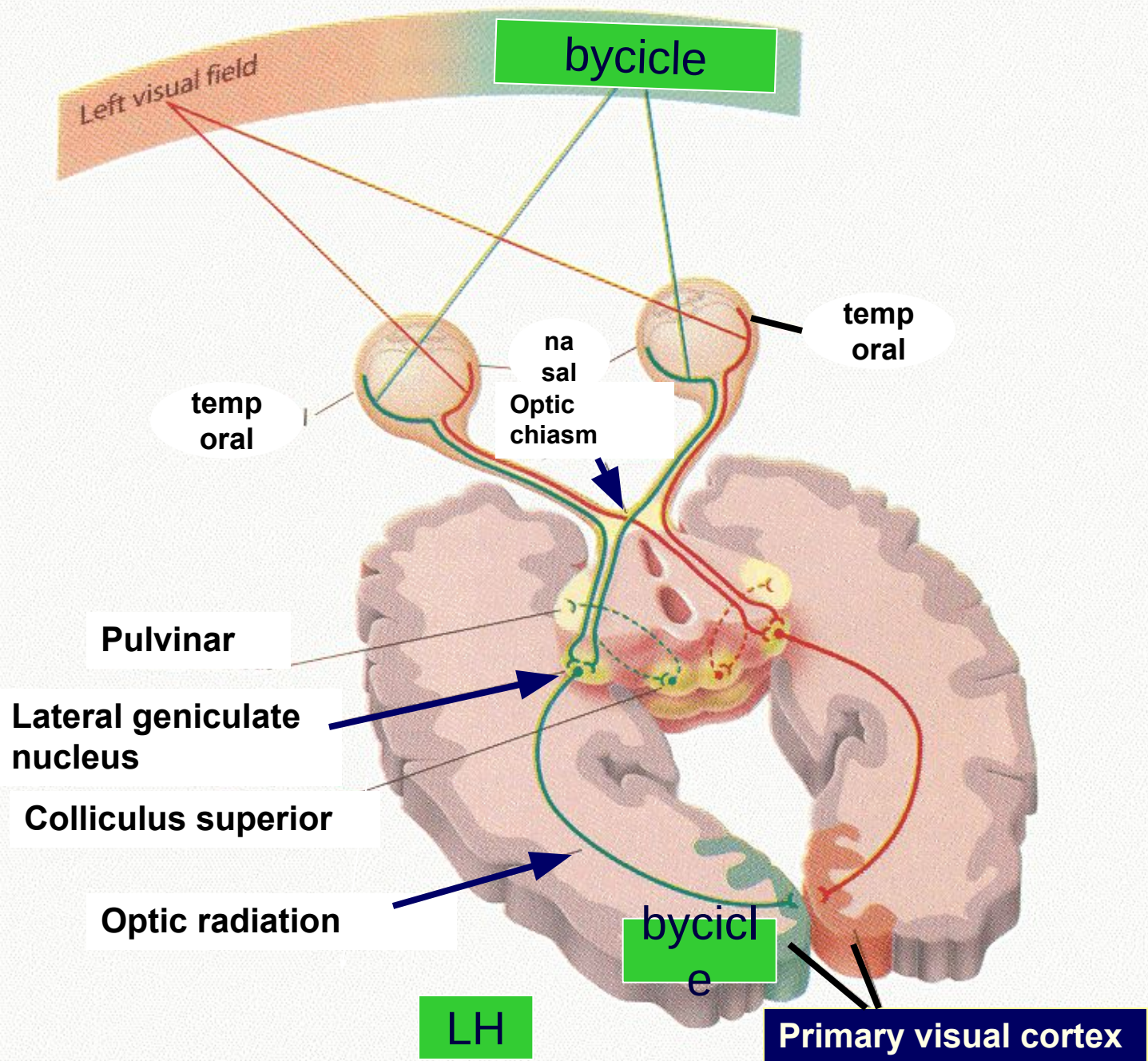
Visual system

Split-brain patient

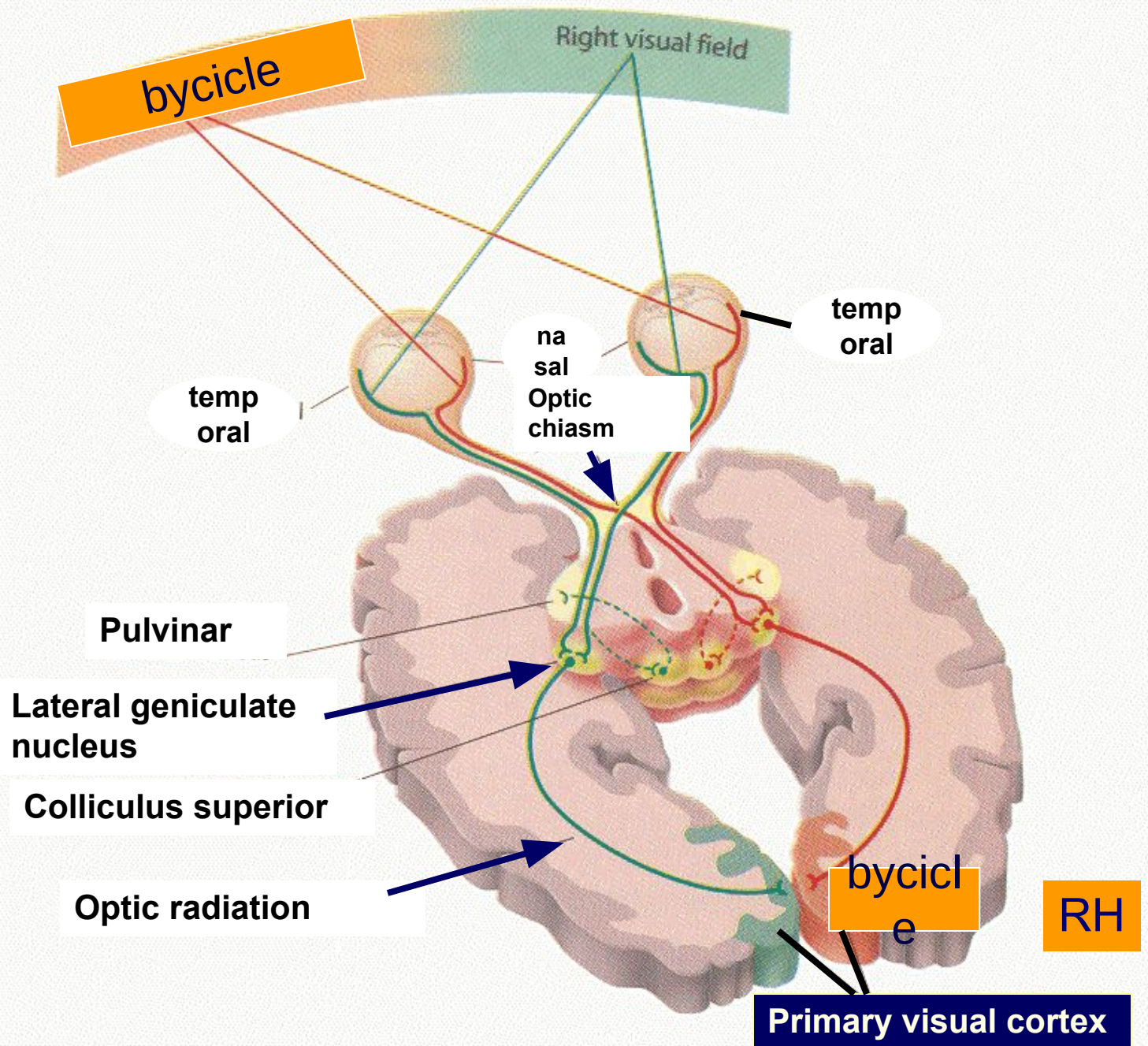


Postoperatively, the right hand performed poorly due to the disconnection of the LH (right hand) and the RH (spatial functions)

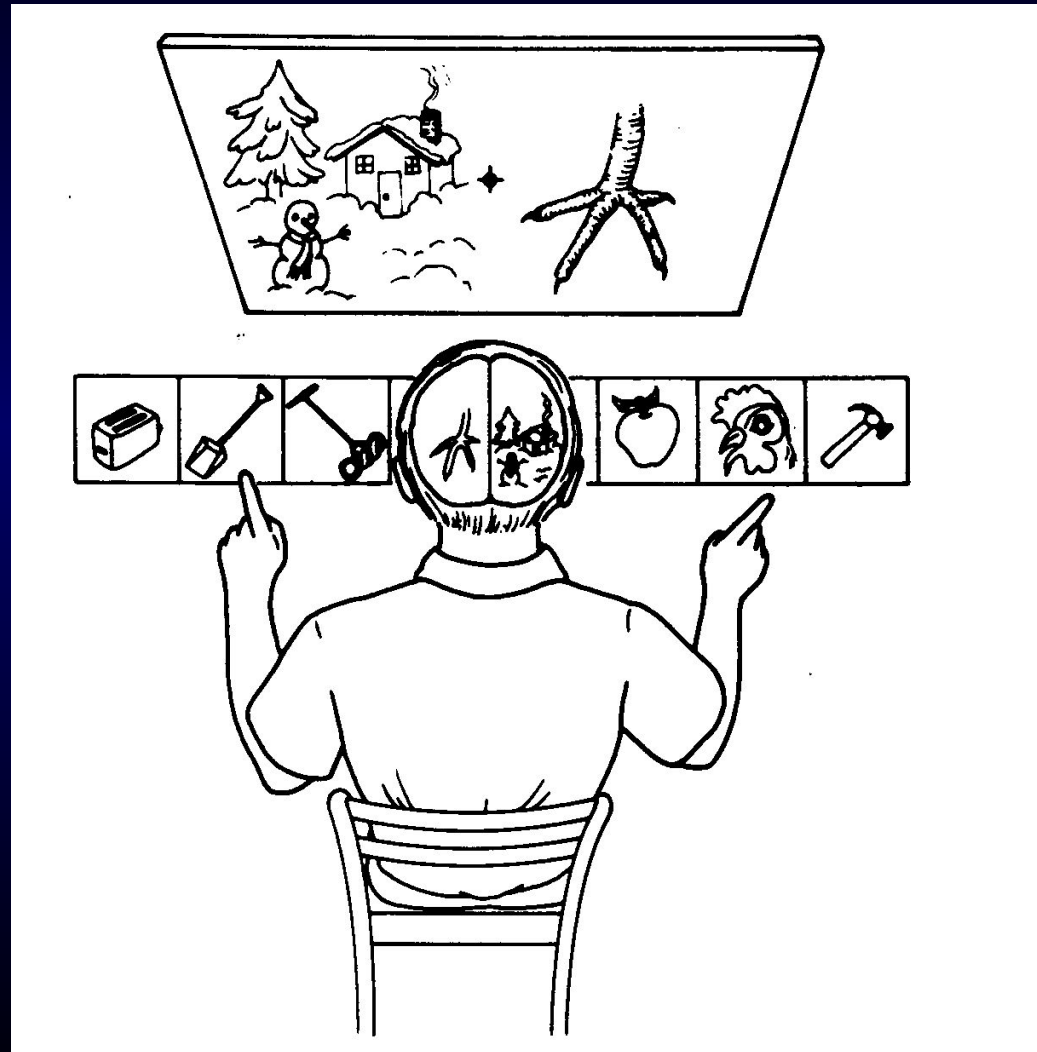
Visual system



Visual system



Split-brain patient



Disconnection syndromes in patients with lesions of the corpus callosum (*split-brain patients, partial disconnection*)

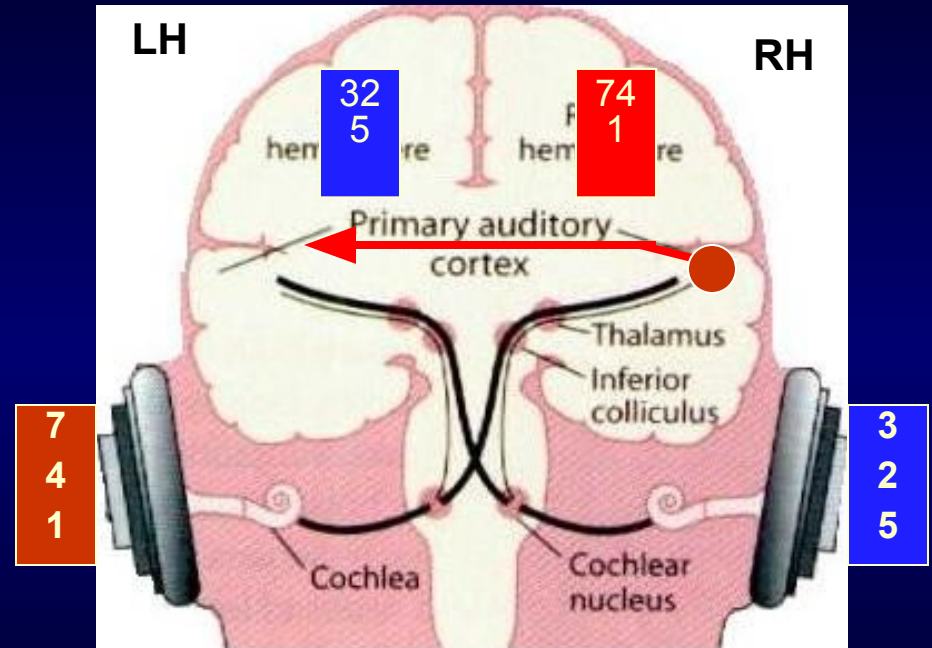
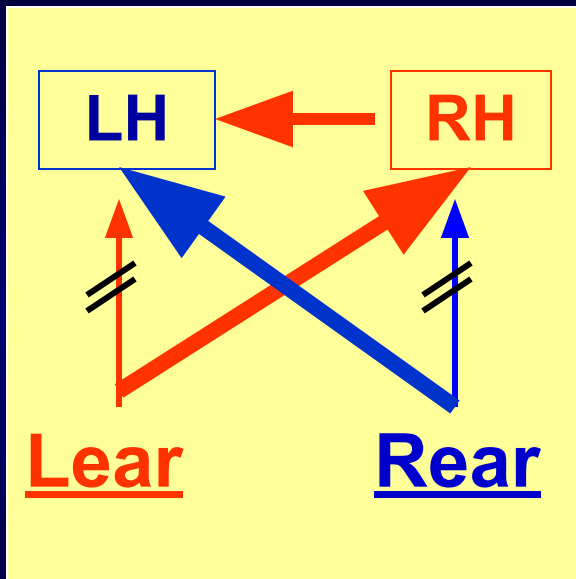
- 'alien' hand syndroom (Lh)
- unilateraal L-hand anomie
- hemi-alexie (LV)

Perceptual asymmetries

- Visual half-field method
- Dichotic listening task

Dichotic listening and hemispheric asymmetry

Kimura's structural model

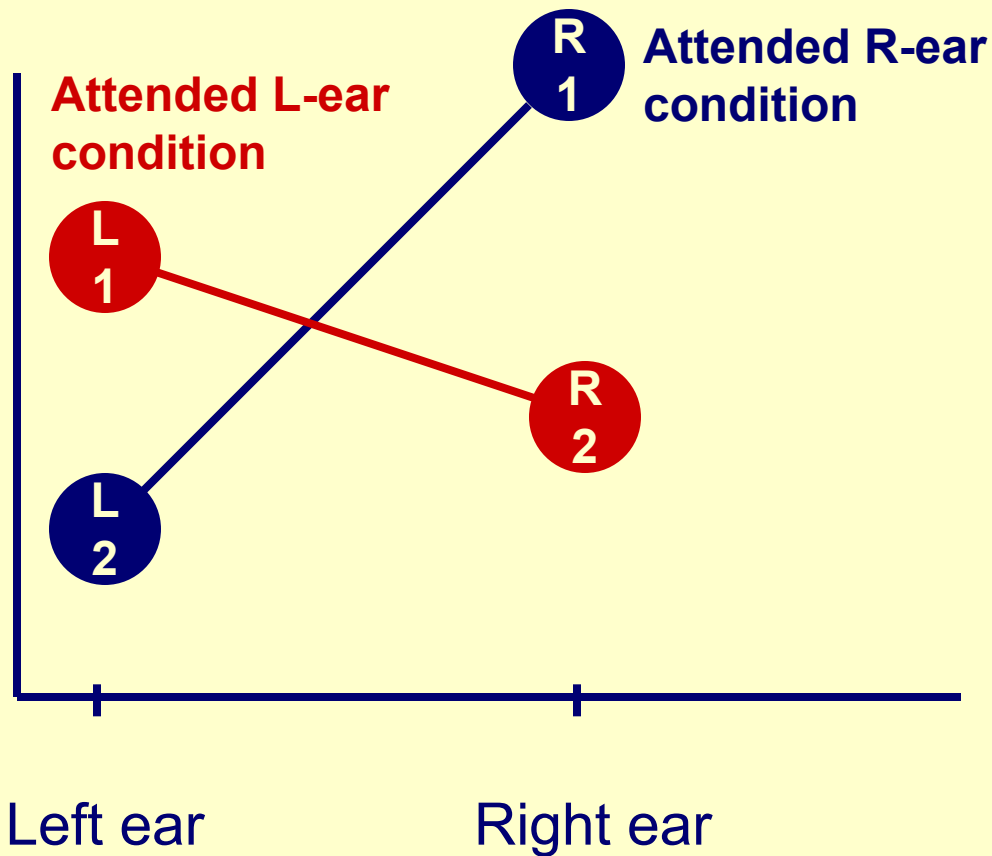
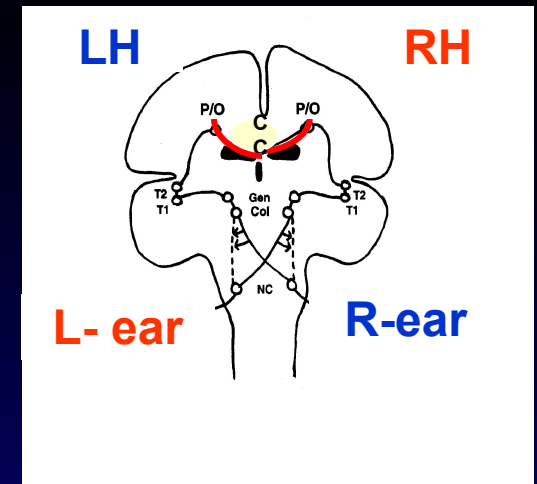


Presentation time:

500 msec pear stimulus pair

Results: R-ear > L-ear

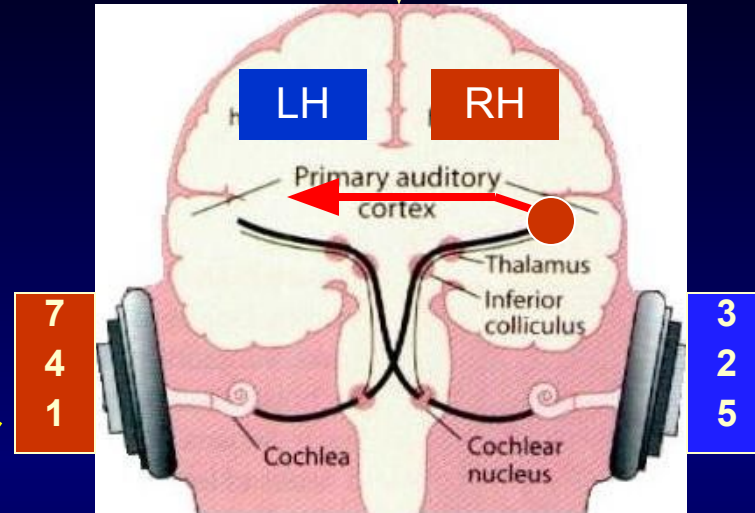
Effects of attention on dichotic listening (*focused attention task*)



Attended Rear condition:
Recall first Rear digits and
then Lear digits

Attended Lear condition:
Recall first Lear digits and
then Rear digits

Dichotic listening: language perception and laterality

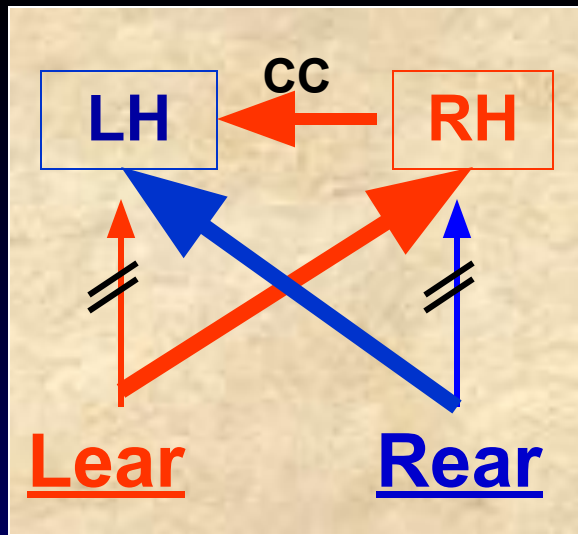


Attended L-ear condition

Inhibitory control / EF
= *'top down' process*

Attended R-ear condition

automatic processing
= *'bottom up' process*

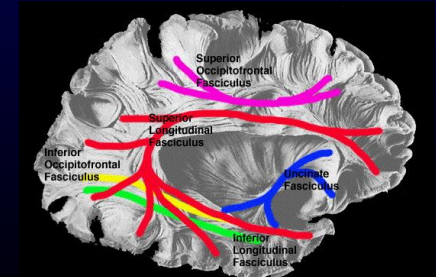


Dichotic listening is based on a distributed network of different hemispheric regions

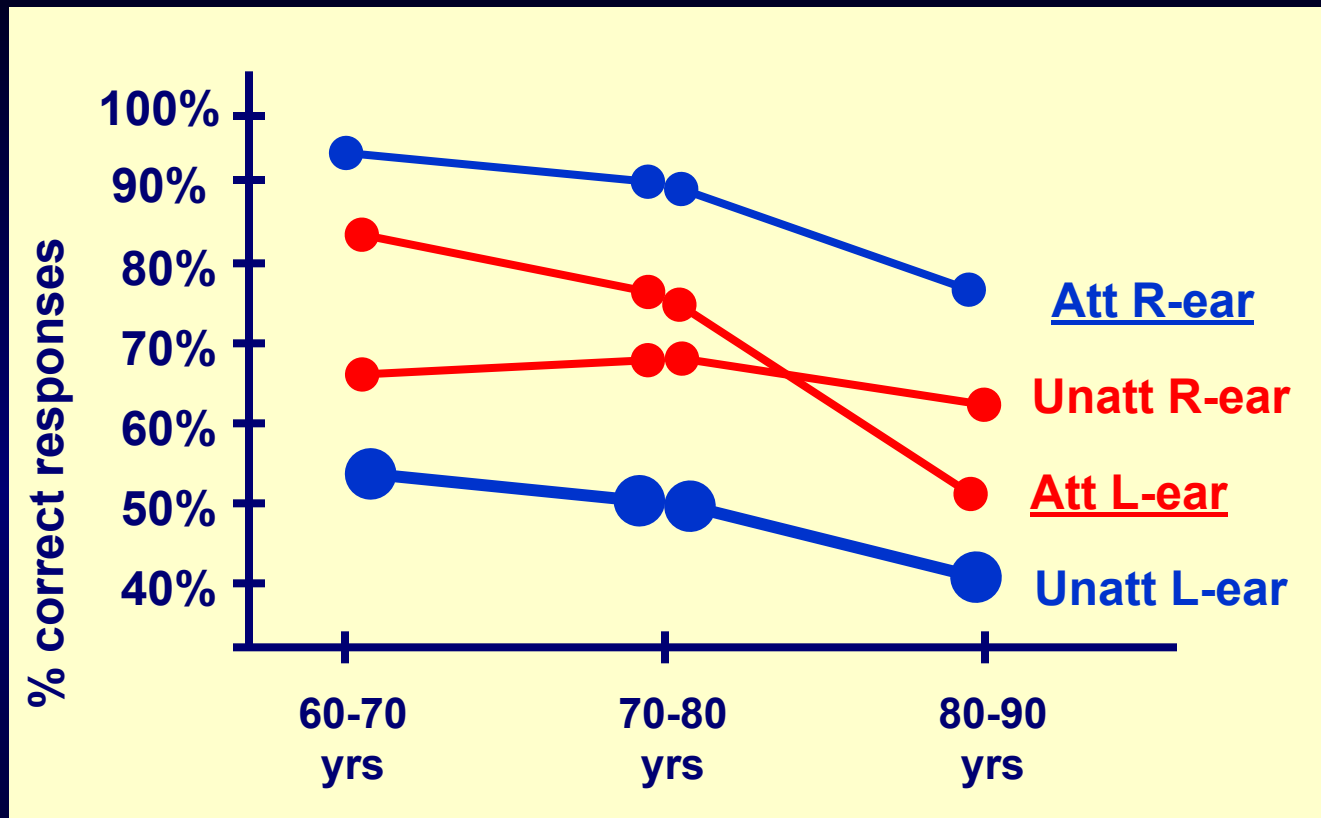
- intra-hemispheric (*temporal, frontal, parietal*)
- inter-hemispheric (*corpus callosum*)

Attended L-ear condition:

= *particularly sensitive to disconnectivity*

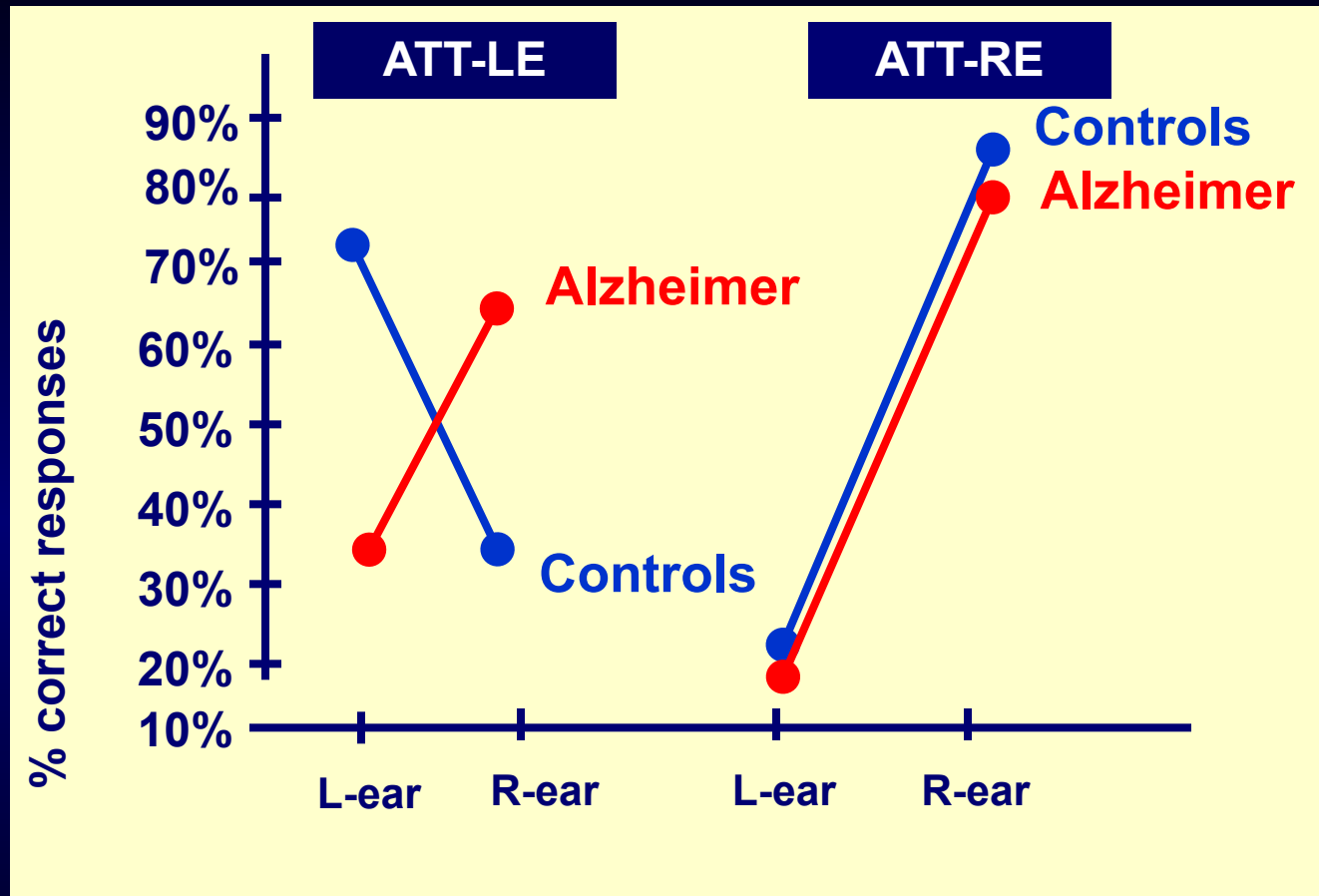


Age effects in dichotic listening



- (a) corpus callosum dysfunction
- (b) RH-dysfunction ('hemi-aging')
- (c) attentional deficits (EF: inhibitory control dysfunctions)

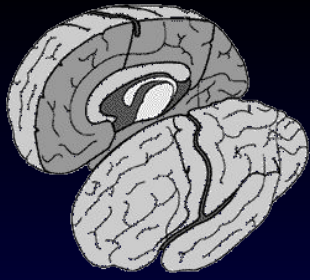
Dichotic listening in Alzheimer's Disease



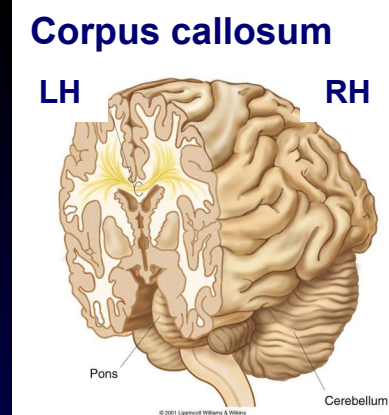
Effects enhanced in Alzheimer patients

- (a) corpus callosum dysfunction
- (b) RH-dysfunction ('hemi-aging')
- (c) attentional deficits (EF: inhibitory control dysfunctions)



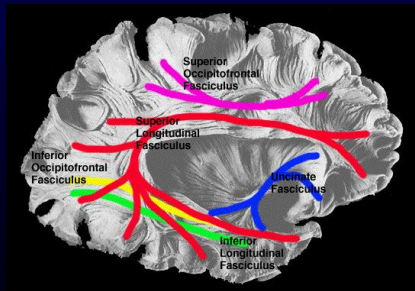


Methods of cerebral asymmetry



Methods of cerebral asymmetry play an important role in measuring:

- inter-hemispheric connectivity (corpus callosum)
- intra-hemispheric connectivity



RH > LH

Clinical applications in neuropsychological assessment

- patients with unilaterale lesions
- aging and dementia (e.g., Alzheimer patiënten)
- patients with (partial) lesions of the corpus callosum
- patients with multiple sclerose
- psychiatric patients
- developmental disorders



Left-right asymmetries

- Handedness
- Footedness
- Head turning
- Eye preference
- Ear preference
- Facial expression
- Cradling



Handedness questionnaire (Van Strien & Bouma)

Writing hand (social pressure?)

1. drawing left / right / both
2. tooth-brush left / right / both
3. bottle opener left / right / both
4. throwing ball left / right / both
5. hammer left / right / both
6. (tennis)racket left / right / both
7. cutting robe with knife left / right / both
8. stirring with spoon left / right / both
9. rubbing out left / right / both
10. Striking a match left / right / both

Scoring -1 / +1 / 0 (range -10, + 10)

Handedness and language dominance



Broca's law of contralateral dominance:

(until mid-20th century):

- In right-handers, the left hemisphere is dominant for language and the use of the preferred hand
- In left-handers the right hemisphere is dominant

Broca's law is not supported by the data!

Handedness and language dominance

Likelihood of right-hemisphere dominance (%)

- extreme left-handedness : 25%
- ambidexter : 15%
- extreme right-hander : 5%

Formula: $15\% - \text{handedness score} (-10 \text{ to } +10)$

Left-handedness - prevalence

In the Netherlands, but also in other countries

-females 9.6%

-males :11.8%

CBS (1985)

Left-handedness

- a) genetic models (*'nature'*)
- b) developmental factors (*'nurture'*)
 - prenatal environment (*hormonal factors: testosterone; stress*)
 - developmental disorders (*e.g., neural tube defects, stuttering, dyslexia, schizophrenia, autism*)
 - birth stress (*e.g., premature birth, respiratory problems*)
 - low birth weight
- c) cultural influence (*e.g., cultural pressure; costs of left-handedness*)
- d) evolutionary factors (*benefits of left-handedness*)

Sex differences in cerebral asymmetries

Male advantage:

- visuospatial skills
 - mental rotation
 - perceptual closure
 - embedded figures
- mathematical reasoning
- target directed motor skills

Females advantage:

- verbal skills
 - verbal fluency
 - speed of articulation
 - grammar
 - earlier language acquisition
- perceptual speed
- fine motor skills and rapid sequential movements

Sex differences in cerebral asymmetry

Cerebral asymmetries tend to be *smaller in females* than in males, presumably related to stronger *inter-hemispheric connectivity*

Higher level of testosterone during development of the brain:
leads to

- reduced inter-hemispheric connectivity and
- increased cerebral asymmetries

Functions of the right hemisphere: neuropsychological assessment