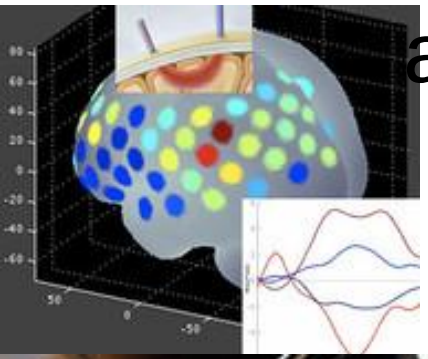
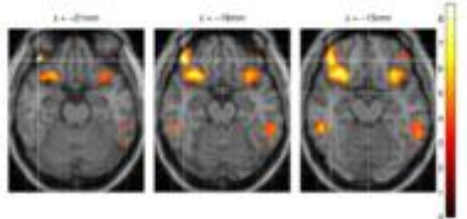
•Lecture II:

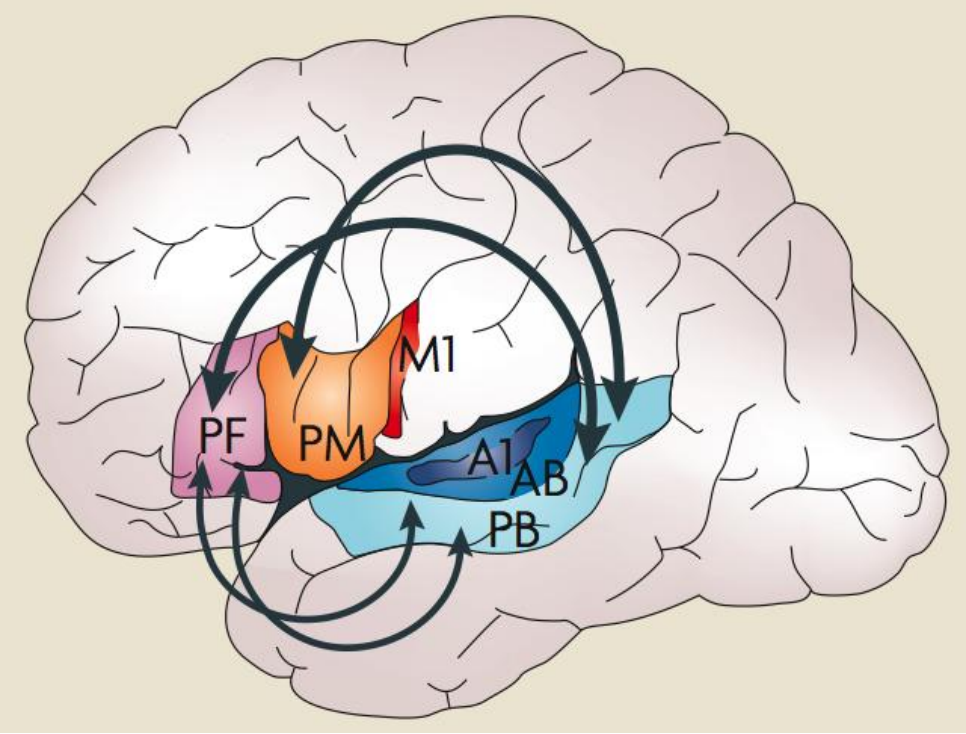
Sensorimotor Circuits as a basis for language





„Active perception“ - Senorimotor circuits as a cortical basis for language

- Language processing is based on neuronal circuits that reciprocally connect action systems of the brain with perceptual cicuits
- Action and perception circuits are interdependent



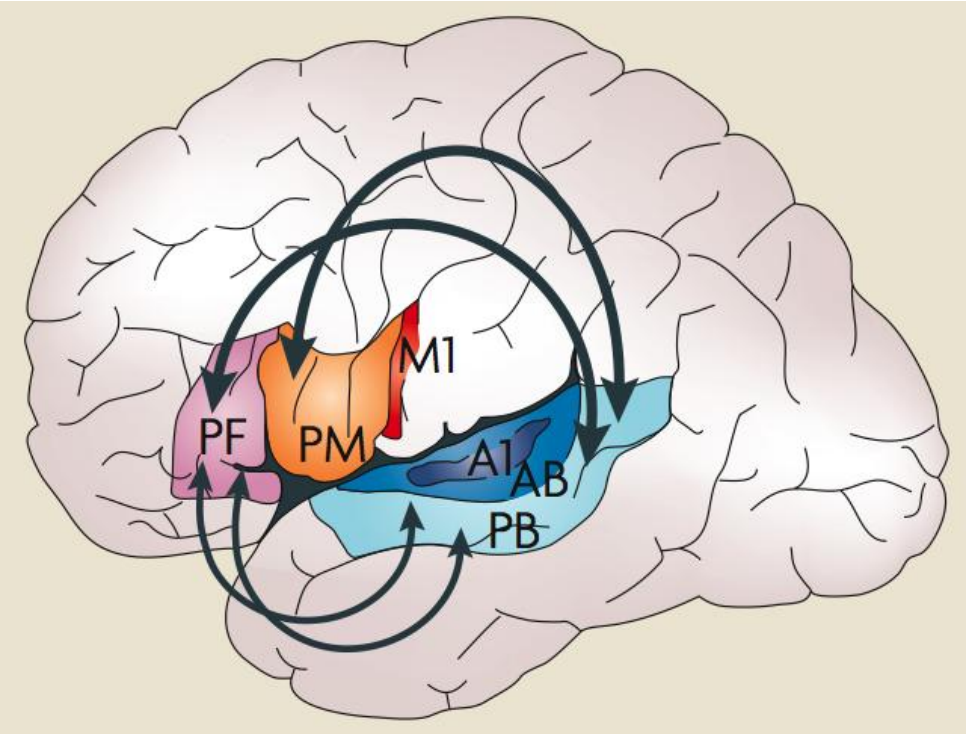
1. Co-activation: Action-Perception Learning
2. The Motor Somatotopy of Speech Perception
3. Evidences from Lesion studys
4. Category-Specific Semantic Circuits

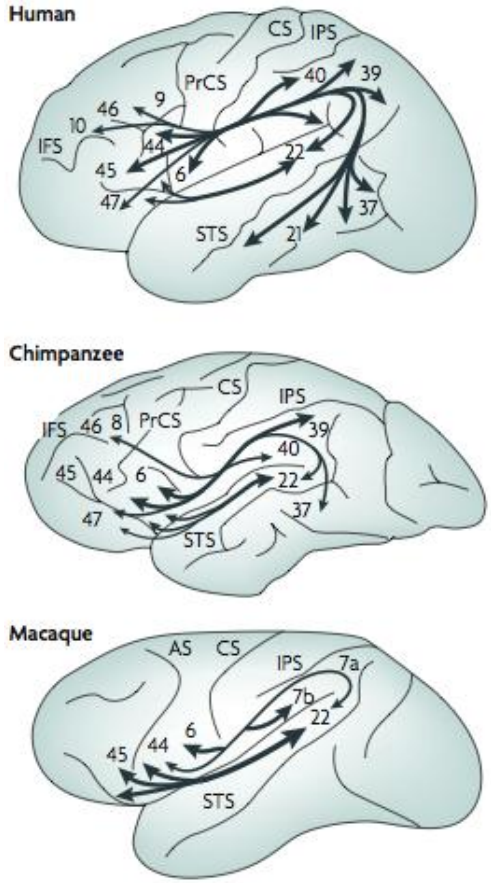
1. Co-activation: Action-Perception Learning

- Articulation („babbling“) of 6-12 month-olds becomes similar to phonemes that they hear frequently

- Neurobiological motor deficits that affected articulation leads to reduced auditory vocabularies compared to motor deficits that didn’t affect the articulation

1. Co-activation: Action-Perception Learning





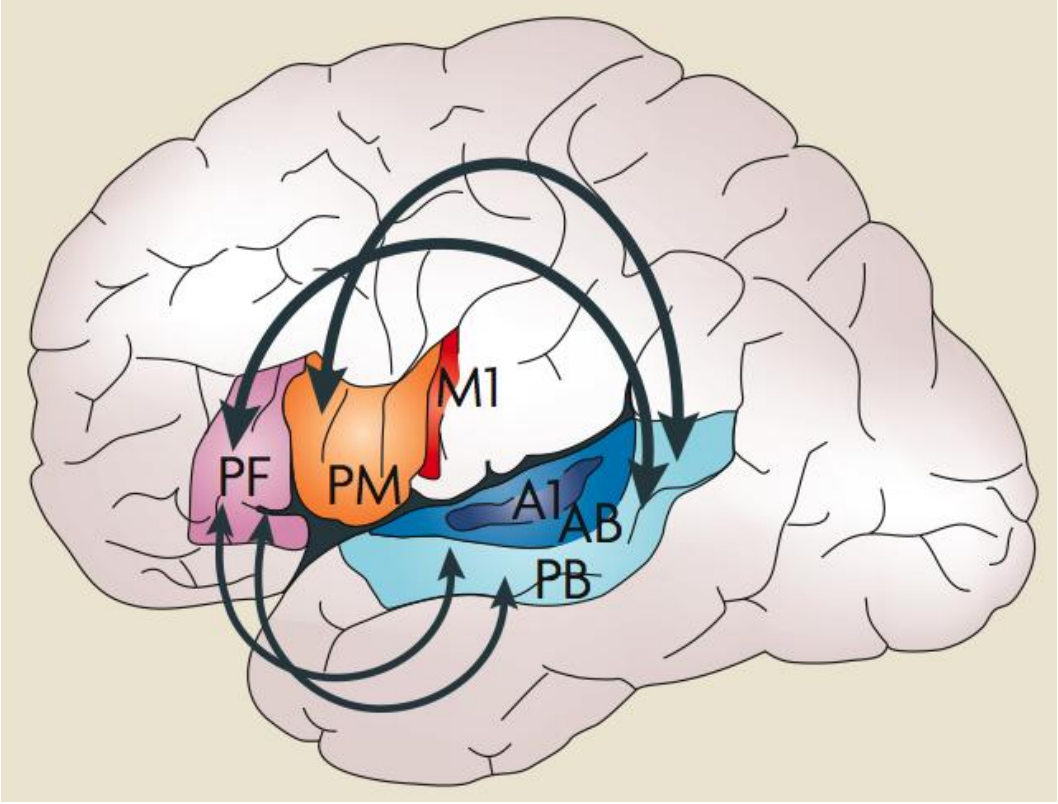
- frontotemporal action-perception connections due to extreme capsule, uncinate fascicle and arcuate fascicle (strongly developed in the left hemisphere)

= binding auditory and articulatory information in action-perception circuits

1. Co-activation: Action-Perception Learning

• Production of speech sounds
leads to spread activation of
the six involved areas

•Hebbian learning: Action-Perception circuits as a consequence of co-activation



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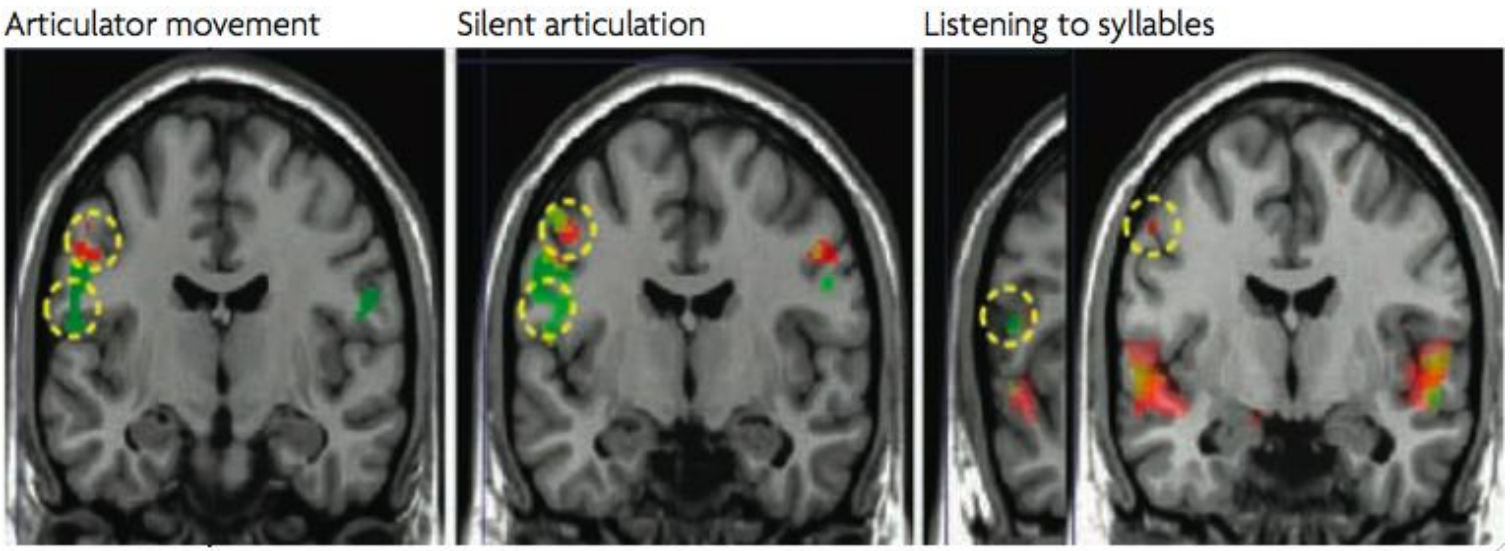
2. The Motor Somatotopy of Speech Perception



Pulvermüller et al., 2006

•Motor somatotopy differences depending on the phoneme type:

Inferior Precentral Cortex (Tongue)
dental „t“

Lateral Precentral Cortex (Lip):
labial „p“

•The precentral regions consistently activated by articulatory movement, syllable articulation, and speech perception demonstrate a shared speech-sound-specific neuronal substrate of these sensory and motor processes

2. The Motor Somatotopy of Speech Perception

Hypothesis:

Focal stimulation with TMS (inferior precentral cortex vs. lateral precentral cortex) facilitates the perception of the concordant phonemes (d/t vs. b/p) and inhibits the perception of discordant items (b/p vs. d/t)

IV_1: Phonemes (d/t; b/p)

IV_2: TMS Stimulation (IPCC; LPCC)

DV_1: Reation Time

DV_2: Error Rates

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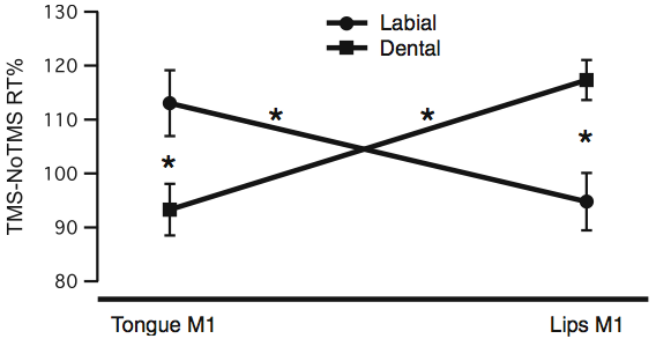
Results:



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D‘Ausilio et al., 2009

3. Evidence from Lesion studys

•Single word comprehension is impaired and delayed in patients with a left inferior frontal lesion and Broca's aphasia

= lesions in the inferior frontal and premotor areas compromise the patients' ability to comprehent meaningful words

= lesions hinder the cicuit in becoming fully active (no feedback activation)

4. Evidence: Category-Specific Semantic Circuits

•As the meaning of a word is the object it relates to, the area that links words to their meanings was sought in the middle and inferior temporal cortex (ITC)

•Here the auditory language areas and the visual stream for object processing converge

Example:

1. Superior ITC is activated by words regarding different kinds of visual information ("round" vs. "brown")

2. "cinnamon", and "telephone" activates specific sensory brain areas more strongly than controls

What does this have to do with the motor cortex?

4. Evidence: Category-Specific Semantic Circuits

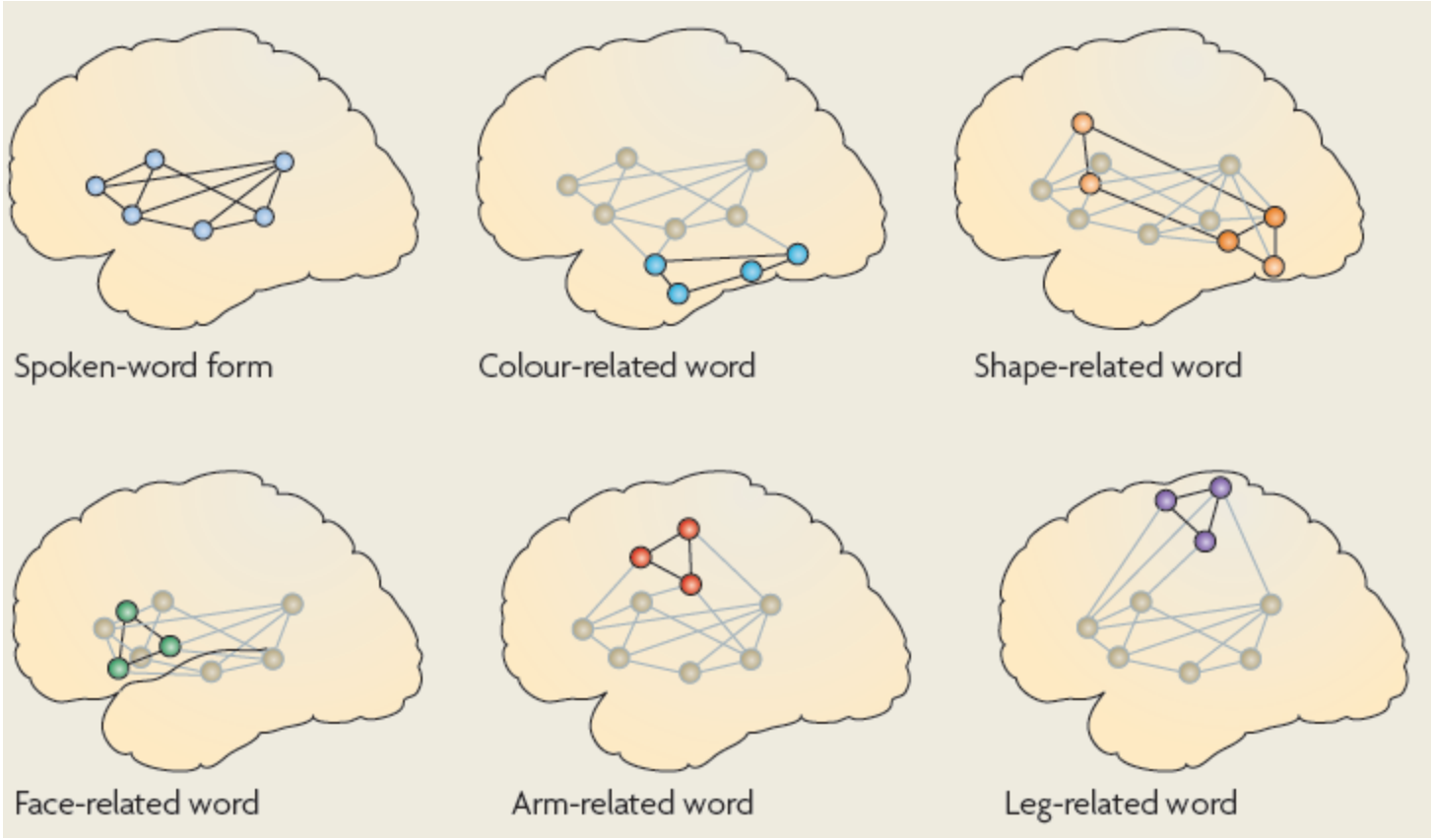
- Many types of words I not related to objects or sensations but to actions

  Example: "grasp" has a functional correlate in the activation of hand representation areas in premotor and motor cortex

- Further studies suggest an activation of the premotor and motor cortex in a somatotopy manner

- Activation was even found for abstract action phrases

4. Evidence: Category-Specific Semantic Circuits



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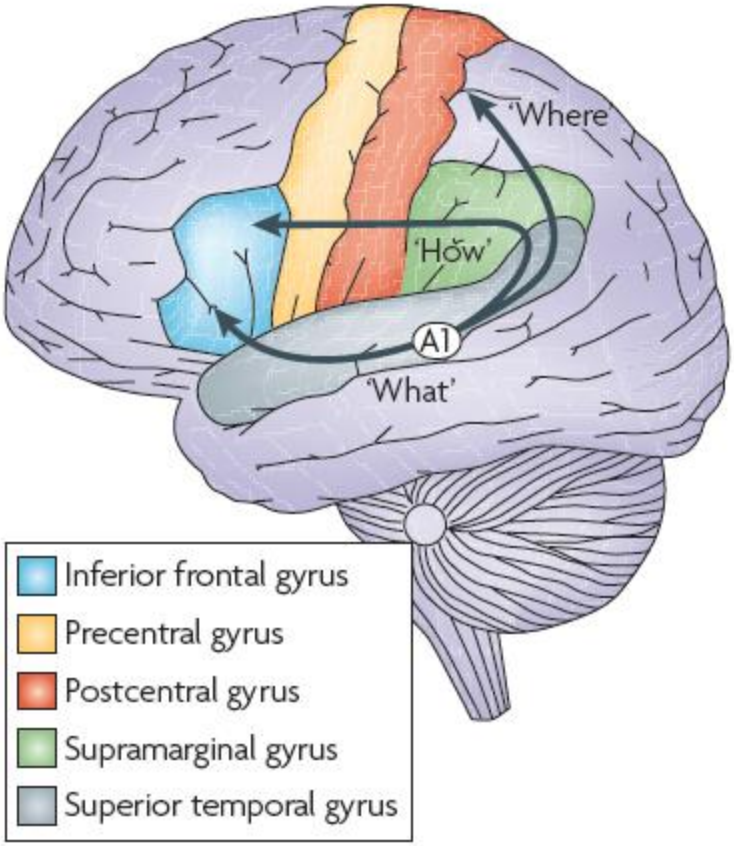
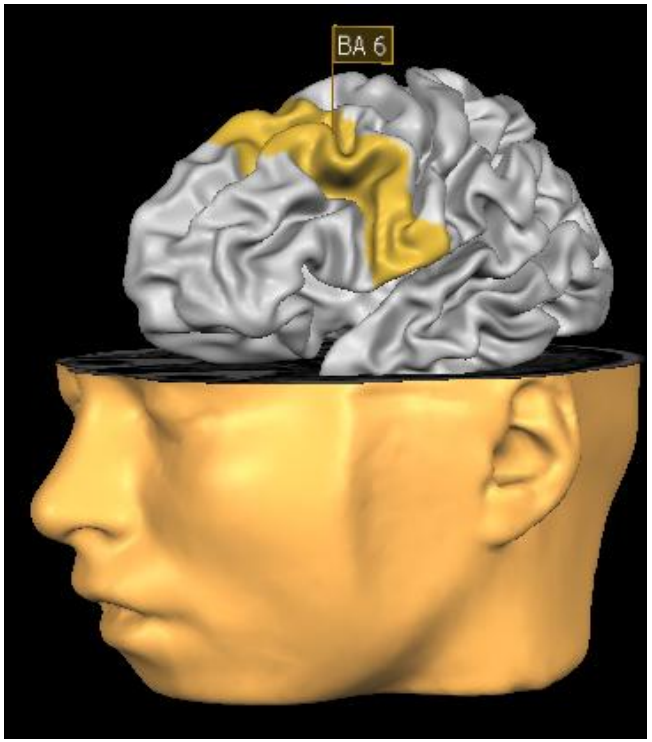


5. Evidence

- Braun et al. (2009) found, that conflict monitoring between PsH and control words are mainly processed in the BA 6, ACC and cingulate cortex
- Also significant activation was found in more posterior regions of the cortex
  - left supramarginal cortex
  - Superior temporal gyrus



x. References

- Braun, M., Hutzler, F., Ziegler, J. C., Dambacher, M., & Jacobs, A. M. (2009). Pseudohomophone effects provide evidence of early lexico-phonological processing in visual word recognition. *Human Brain Mapping*, *30*(7), 1977-1989.

- D'Ausilio, A., Pulvermüller, F., Salmas, P., Bufalari, I., Begliomini, C., & Fadiga, L. (2009). The motor somatotopy of speech perception. *Current Biology*, *19*(5), 381-385.

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