



# Neural activation to actions performed with hands and legs

Real movements versus action verb reading

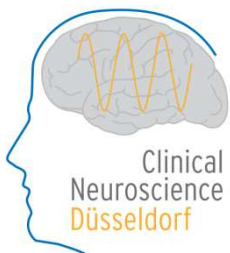
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SFB991 Project B03

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CTF'12, Düsseldorf, 24.08.2012



Institute of Clinical Neuroscience and Medical Psychology



# Introduction

# How is knowledge organized in the brain?

amodal symbols  
(Fodor, 2001)

multimodal representation  
(Barsalou, 2008)



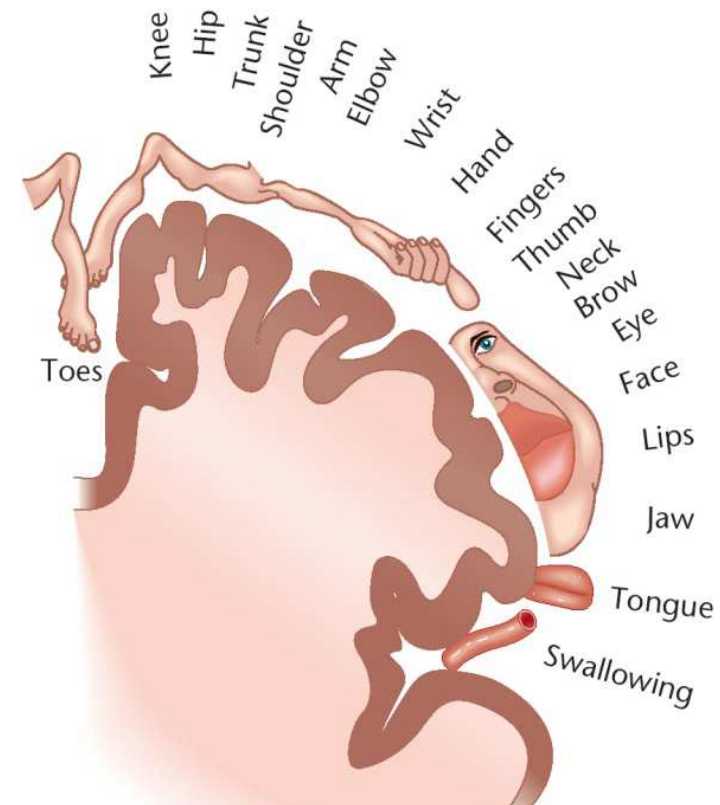
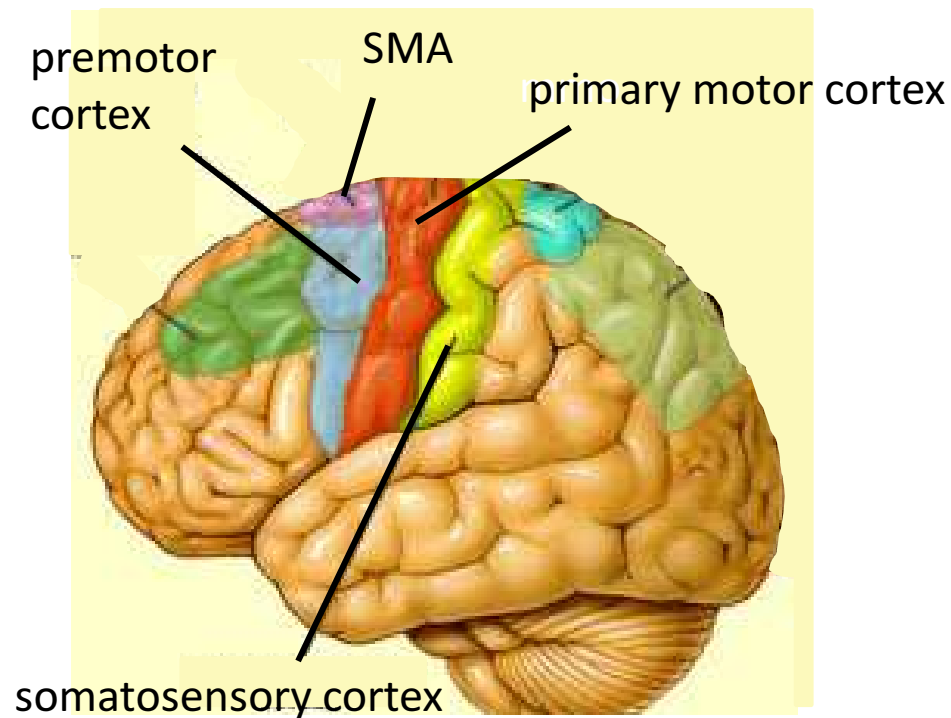
internal **simulation** of experiences acquired during **perception**,  
**action**, and **introspection** associated with an object (Barsalou, 2008)



**Cognition is grounded**

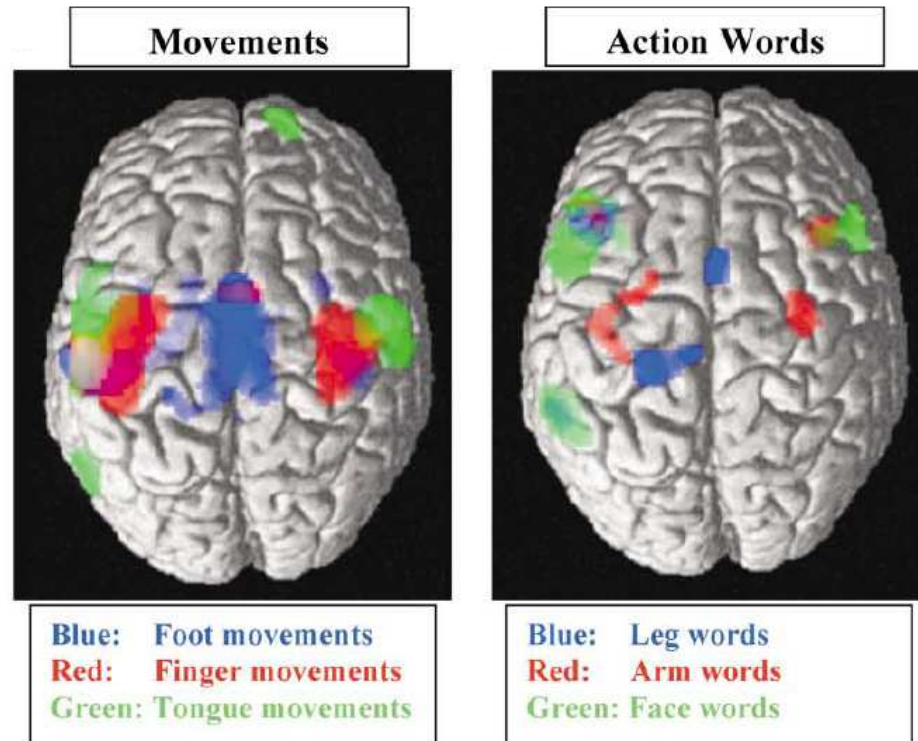
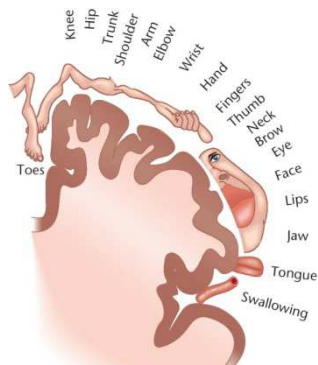
# Action concepts in the brain

- representation of action concepts in the brain involve the sensorimotor cortex (Barsalou, 2008)
- distributed neuronal networks (Pulvermüller, 2005)



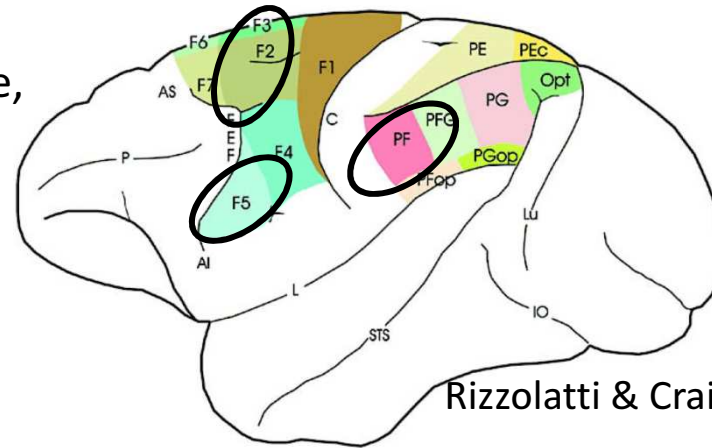
# Neurophysiological evidence

- reading of action verbs  
(Hauk et al., 2004)
- listening to action-related sentences (Tettamanti et al., 2005)



# The mirror neuron system

in F5 (Broca's area), inferior parietal lobule, and in premotor cortex



neurons that are active:

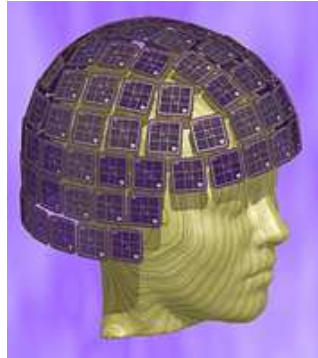
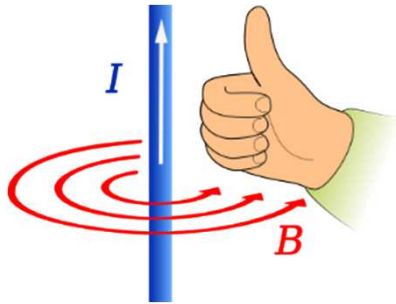
- **execution** of a movement
- **observation** of another person execute a movement (Rizzolatti et al., 2001)
- **hearing** a sound due to an action (Kohler et al., 2002)
- **when reading action words** (Hauk et al., 2004) and **action phrases** (Aziz-Zadeh et al., 2006)



possible role in language development

(Rizzolatti & Arbib, 1998; Arbib, 2005; Sterelny, 2012)

# MEG (magnetoencephalography)

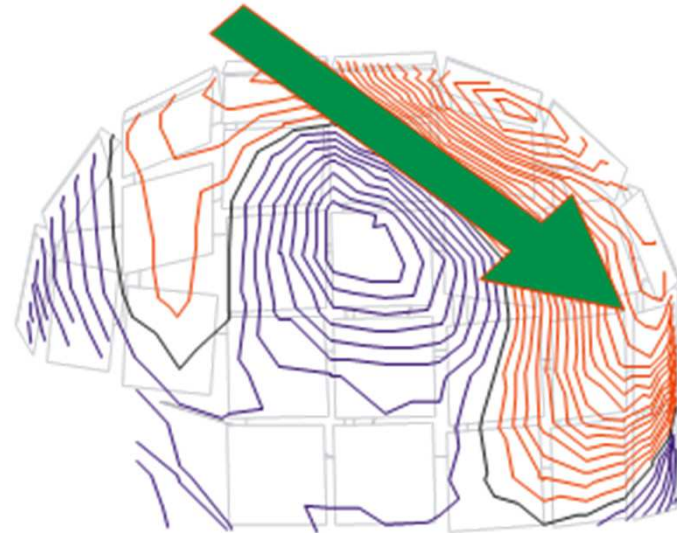


- non invasive measure of the cerebral activity
- high temporal resolution ( $< 1$  ms)
- good spatial resolution (cm)
- detection of sources of activation

# Dipole source analysis

Dipole:

- represents the center of the active cortical area
- x-, y-, z- coordinates → location in the brain
- orientation
- magnitude (strength)
- time course of activation





# Aim of the study

1. Are neuronal sources of hand/foot movement active during silent reading of hand/foot action verbs ?
2. somatotopical activation

# Methods

# Methods: Subjects

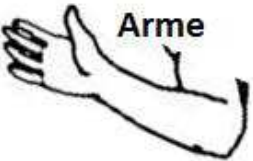





- 15 (8 females) university students, age 22 (SD=2)
- right-handed: Edinburgh Inventory (Oldfield, 1971)
- right-footed: Laterality Preference Inventory (Ehrenstein & Arnold Schulz-Gahmen, 1997)
- monolingual and German native speaker
- no linguists

# Methods: Material

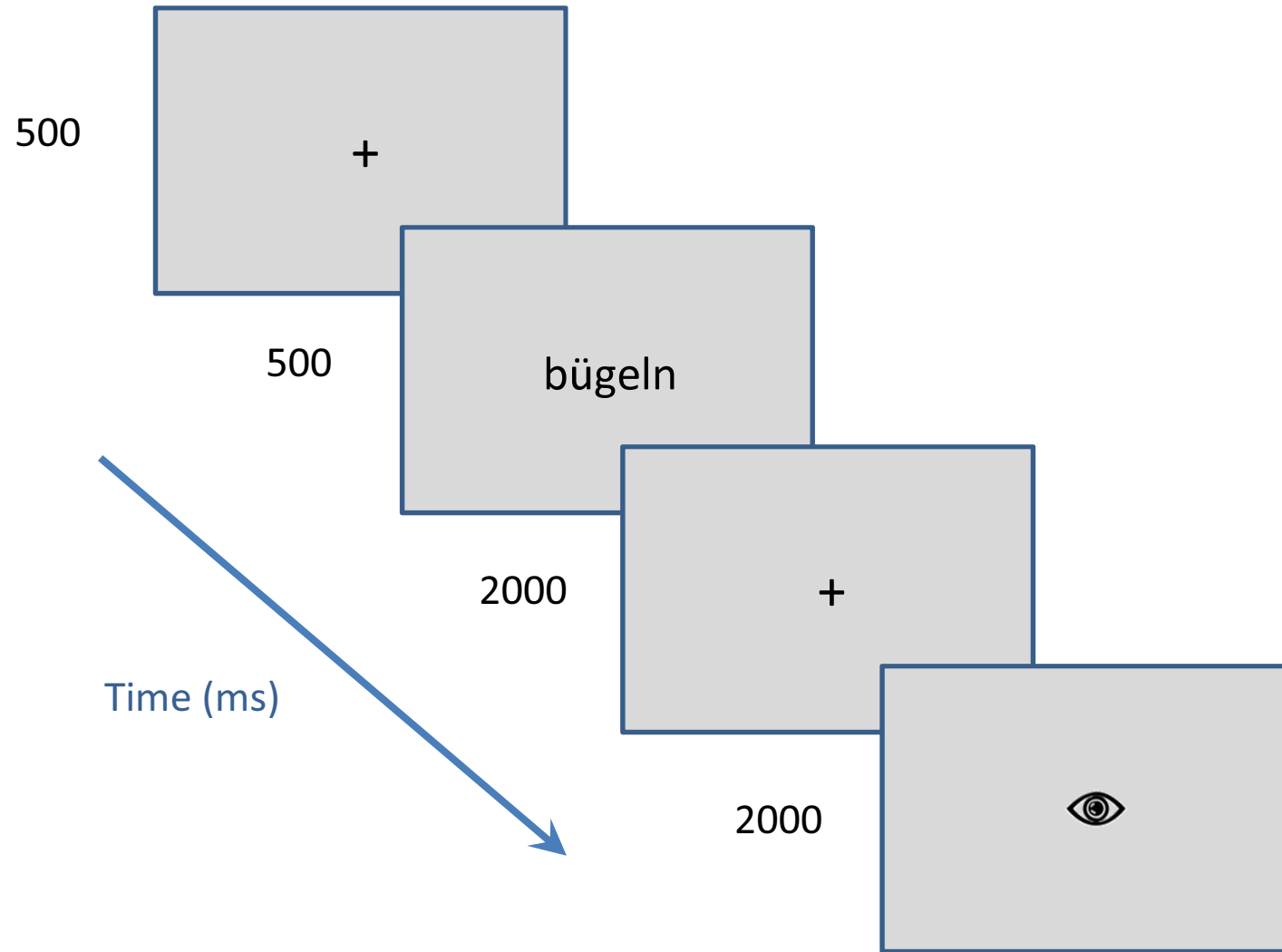
verbs (infinitives)

1. hand verbs (n = 48\*2)
2. foot verbs (n = 48\*2)
3. nonbody verbs (n = 48\*2)

based on body part rating study with 30 participants

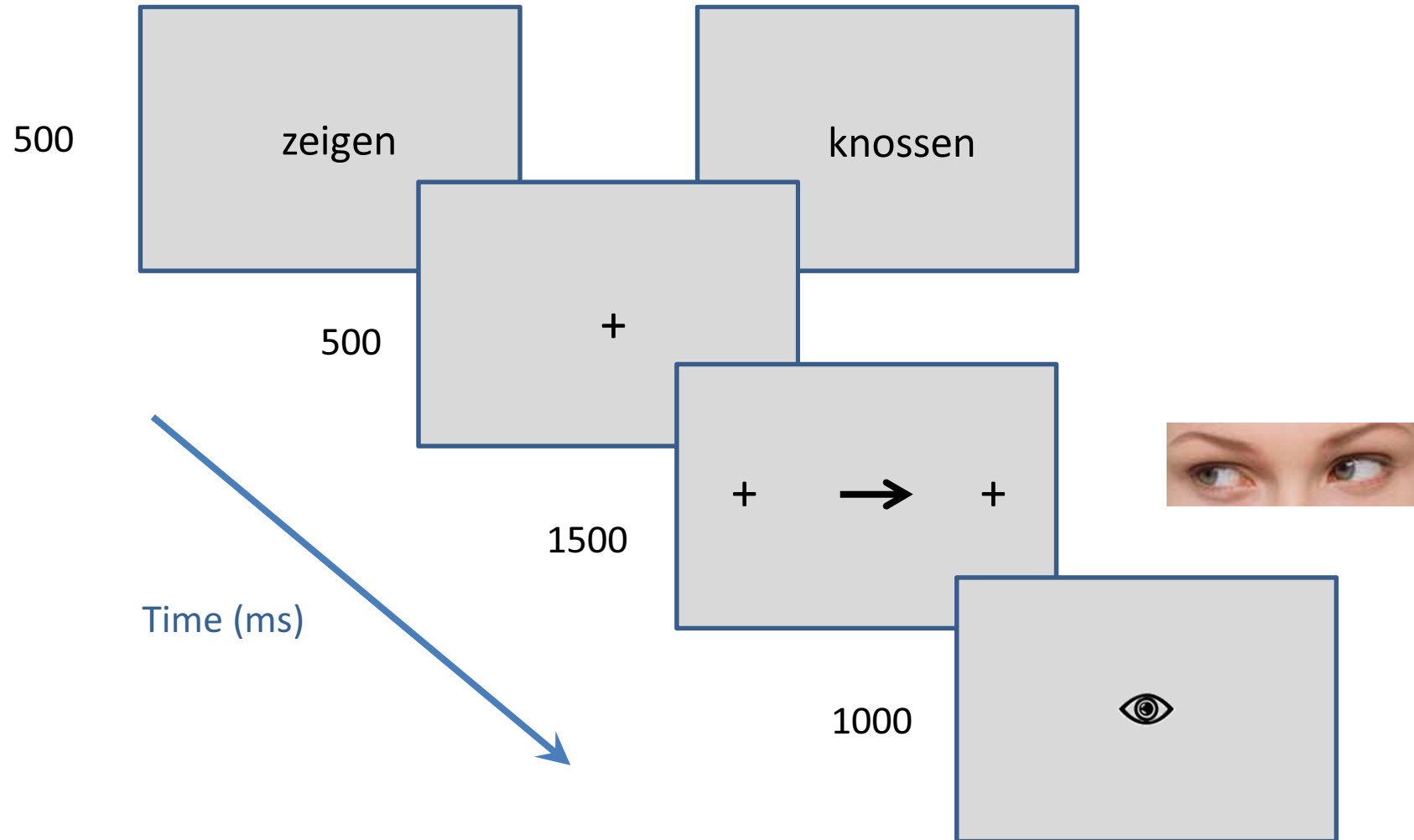
<b>hand ve</b>	<b>Hände</b> <b>Arme</b>	<b>Körper und primär</b> <b>Füße / Beine</b>	<b>Fast alle</b> <b>Körperteile</b>	<b>s</b>
schlager				nk)
schreibe				s)
greifen (	<b>Mund</b> <b>Gesicht</b>	<b>Gar kein</b> <b>Körperteil</b>	<b>Weiß ich</b> <b>nicht</b>	e)
nähen (t				eam)
klatsche				we)

# Verb reading task



# Verb reading task

lexical decision task: *filler* or *pseudo verb*



# Movement tasks

1. alternating hand movement
2. alternating foot movement

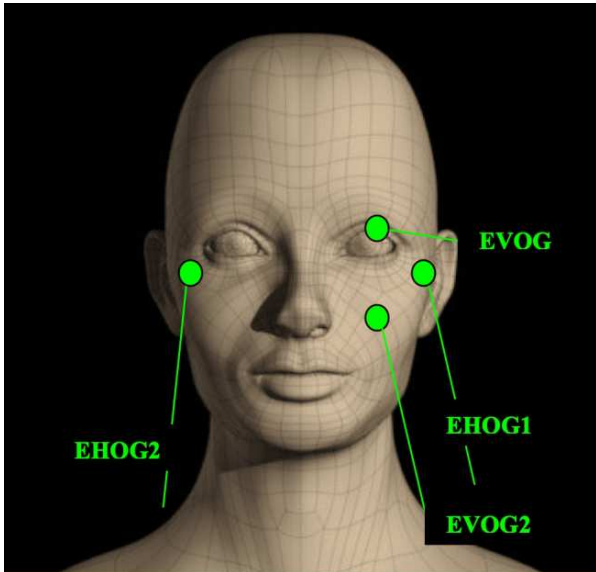
## Movement details:

- self-paced
- brisk extension
- every 2 seconds for 5 minutes



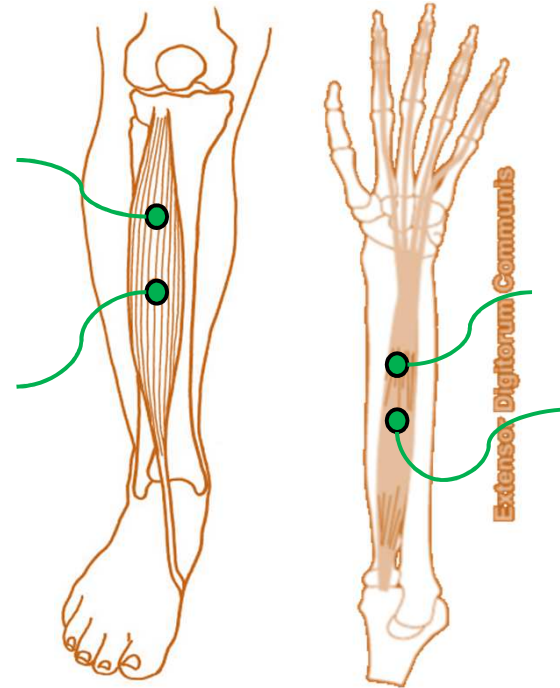
# MEG setup

EOG  
for eye  
movements



EOG = electroculogram  
EVOG → vertical EOG  
EHO2 → horizontal EOG

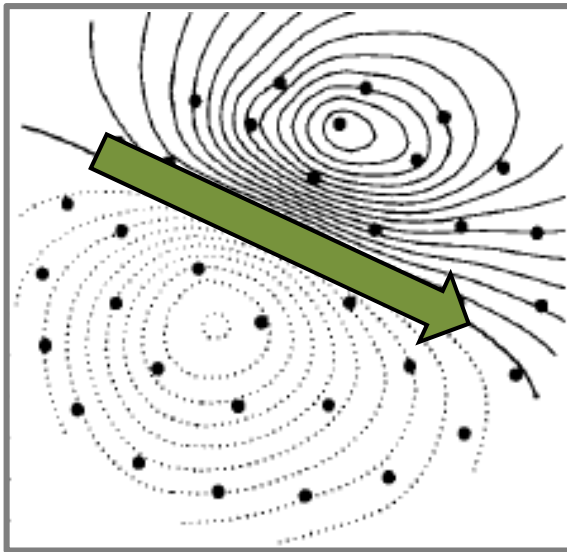
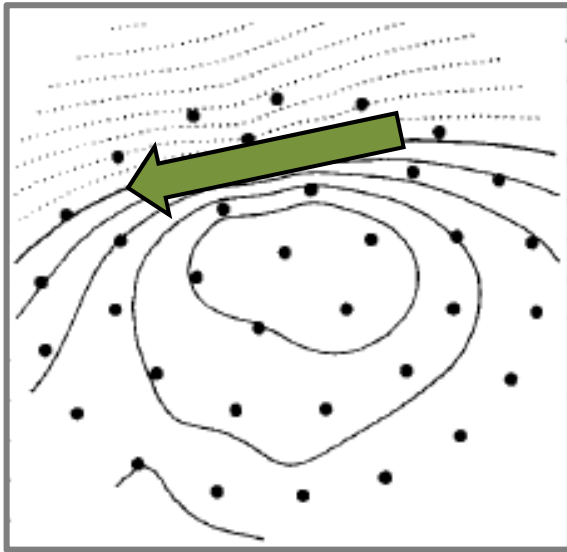
EMG for  
hands/feet  
movements



EMG = electromyogram  
M. tibialis anterior  
M. extensor digitorum communis



# Data analysis



## Movement paradigm

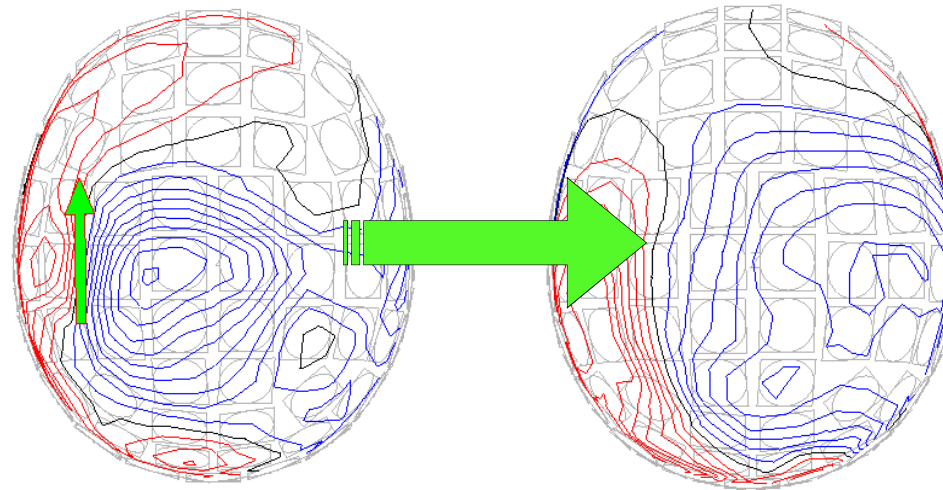
- Movements of hand and foot induce characteristic neuromagnetic fields
- **motor field (MF)** = preparatory changes in primary motor cortex
- **movement-evoked field (MEF)** = sensory feedback after movement onset

(Kristeva-Feige et al., 1994; modified)

# Source transfer to the word paradigm

Brain activity during  
hand movement

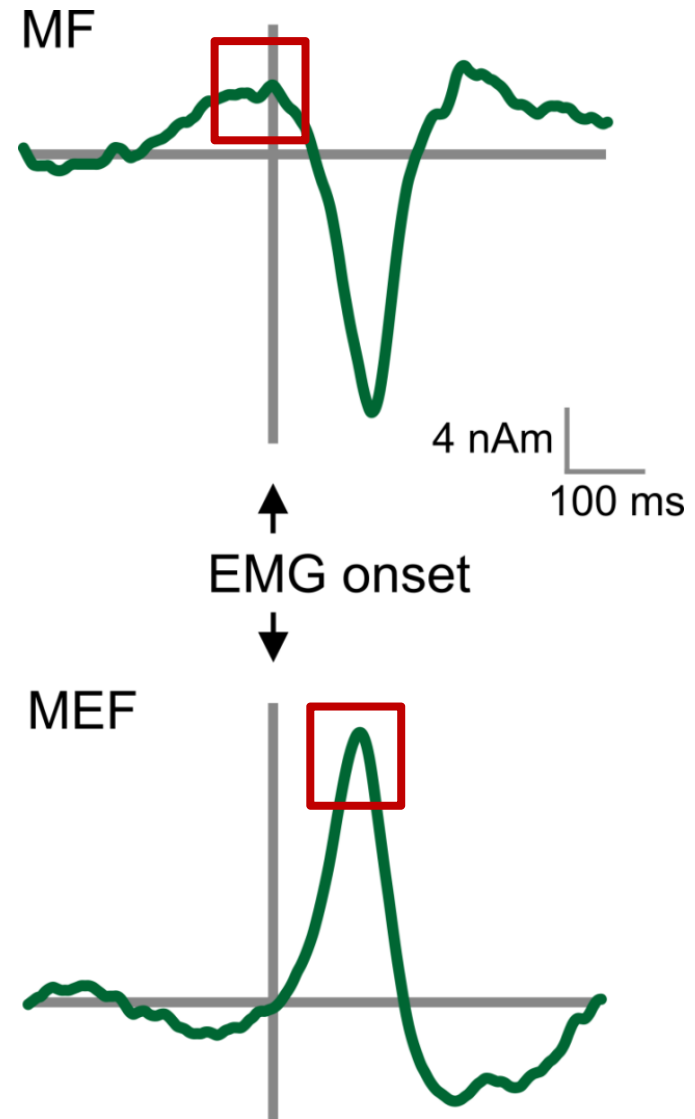
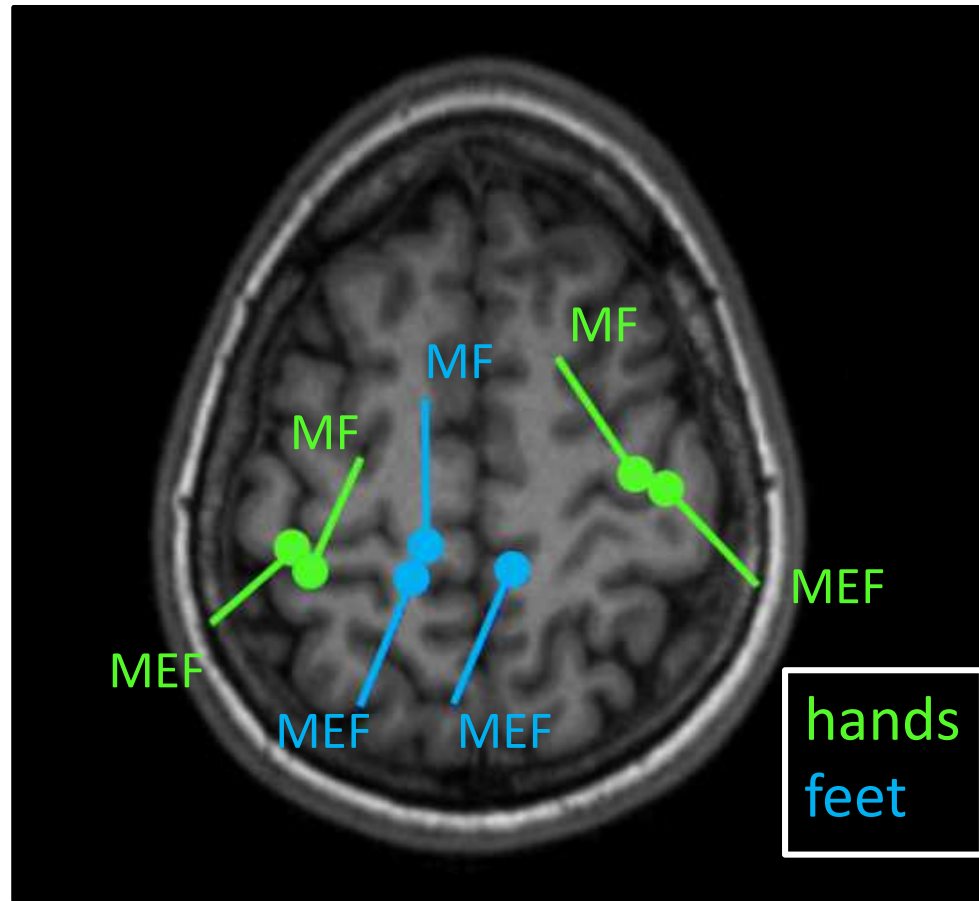
Brain activity while  
reading hand verbs



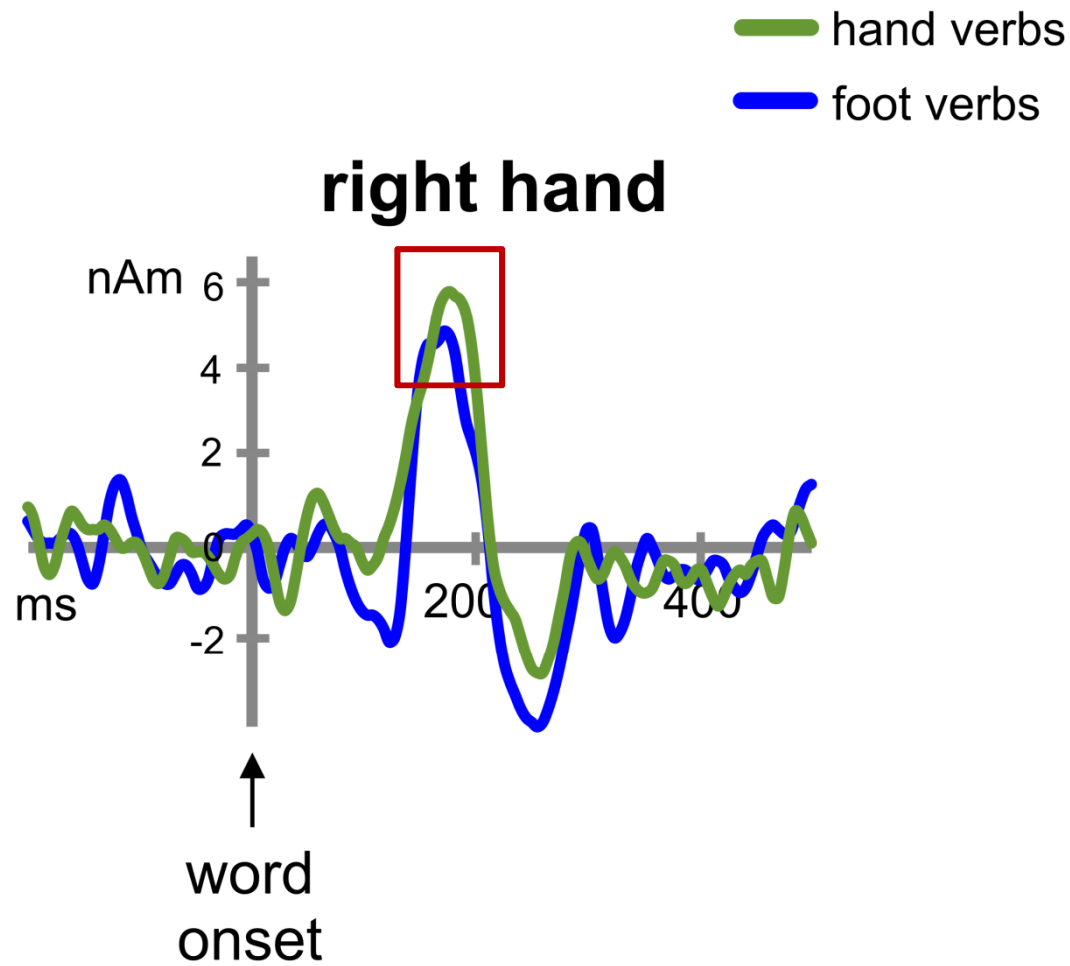
Neuronal sources of hand/foot movement revealed by dipole source modelling are active during hand/foot action verb reading (somatotopically)

# Results

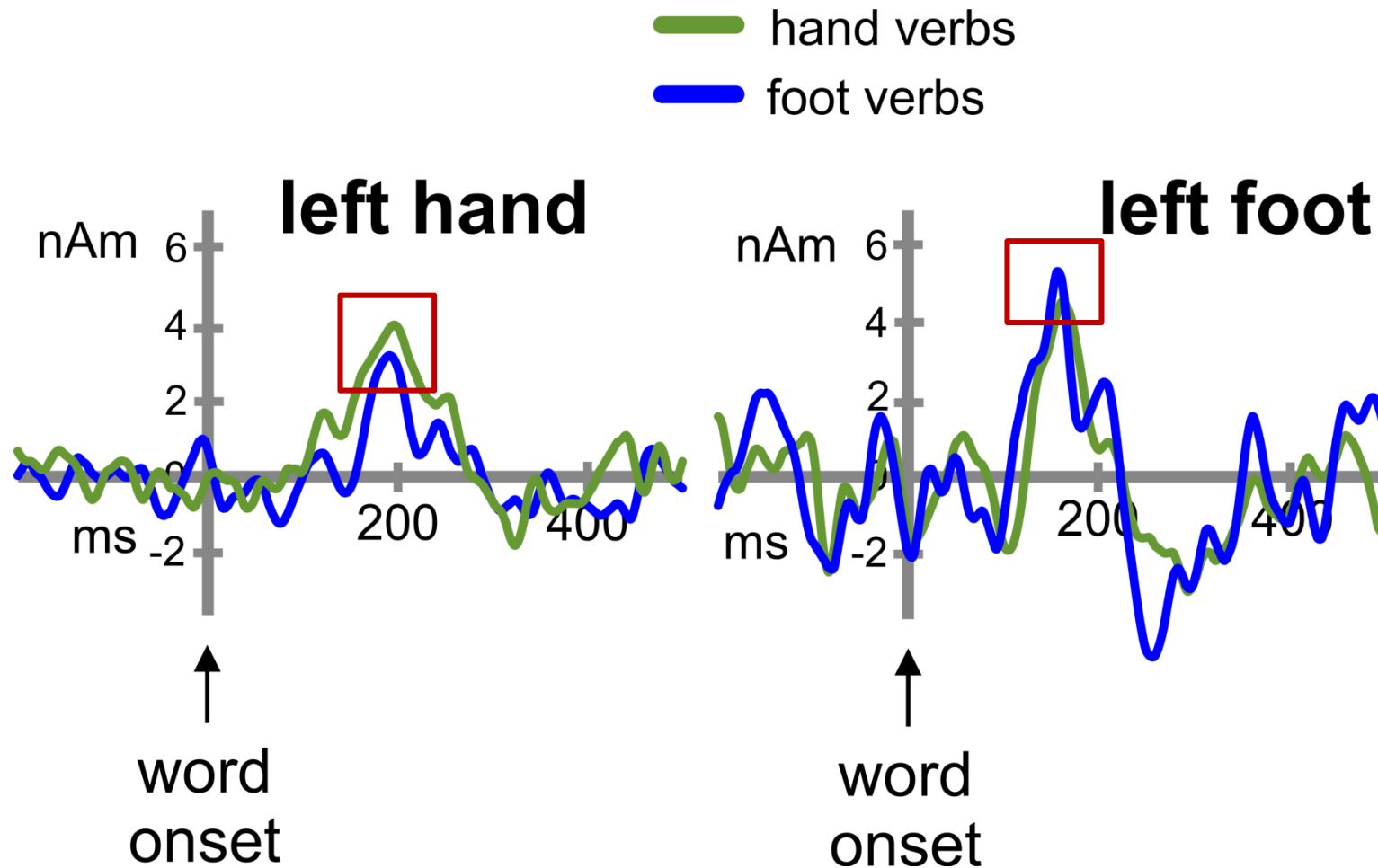
# Movement-related sources



# MF source activation in the verb conditions

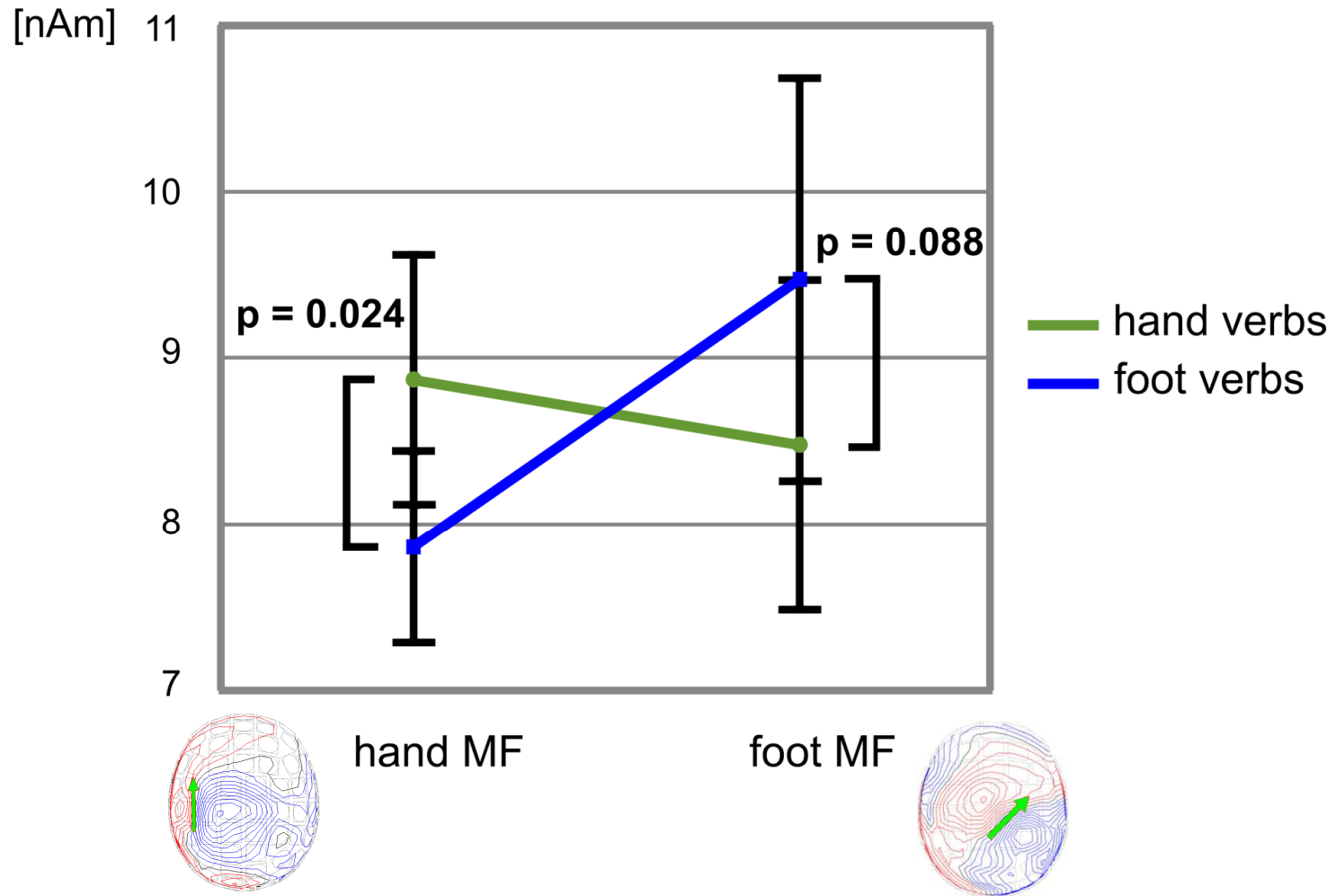


# MF source activation in the verb conditions



# Statistics

interaction words x extremity  $p < 0.001$



# Discussion



# Summary

1. Are neuronal sources of hand/foot movement revealed by dipole source modelling also active during hand/foot action verb reading ?



activation of motor field sources within 200 ms of action verb processing

2. Somatotopical activation of movement-related sources



significantly higher activation of hand MF source in hand verb condition ( $p = 0.024$ );  
strong tendency of higher activation of foot MF source in foot verb condition ( $p = 0.088$ )

# Discussion

activation of motor field sources within  
the first 200 ms of action verb processing

→ crucial for **semantic processing** (Pulvermüller et al., 2009)

→ possible link between **mirror neuron system** and **language**

# What is new in our study?

- preliminary body part rating study: in addition to hand, foot and nonbody verb category also face/mouth and whole body as possible answers
- EMG recordings assured that no movement of arm and leg muscles occurred during action verb reading
- MEG: distinguish between several early motor-related activations (MF and MEF)

## Outlook

- nonbody verb condition
- prefixed verbs with motor stem → motor activation?

**Thank you for your attention!**