

The background of the slide is a stylized, semi-transparent illustration. It depicts a modern building with large windows and a flat roof. In front of the building is a paved plaza with several rectangular, low-lying green planters. A group of people is walking across the plaza, and a few trees are scattered around. The overall style is clean and modern, with a focus on architectural and urban elements.

# **Mental practice through motor imagery in gait rehabilitation following acquired brain injury**

**Kristine M. Oostra, MD, PhD**

# **Mental practice through motor imagery in gait rehabilitation following acquired brain injury**

Introduction

Motor neural network and rehabilitation

Mental practice

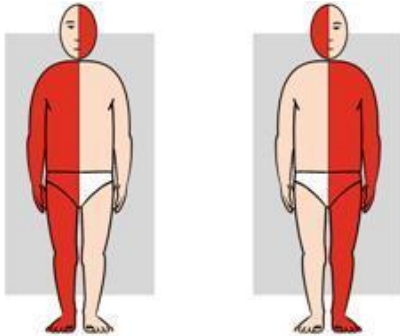
Motor imagery and traumatic brain injury

Motor imagery and mental practice

Mental practice and gait rehabilitation

Motor imagery and brain lesion localization

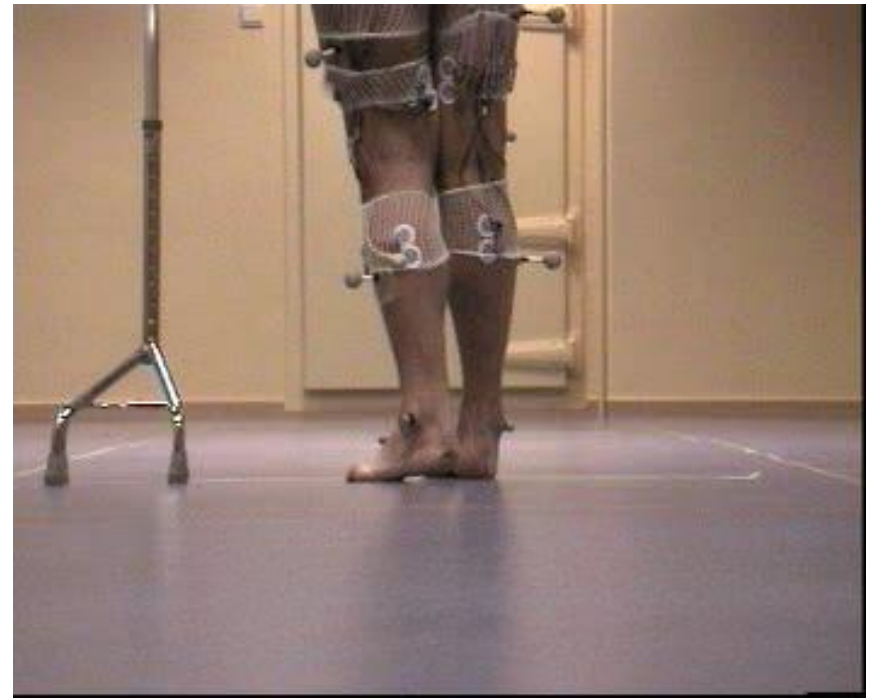
# Stroke and gait rehabilitation



**1-1.4 m/s**  
**= 300-420 m/5min**

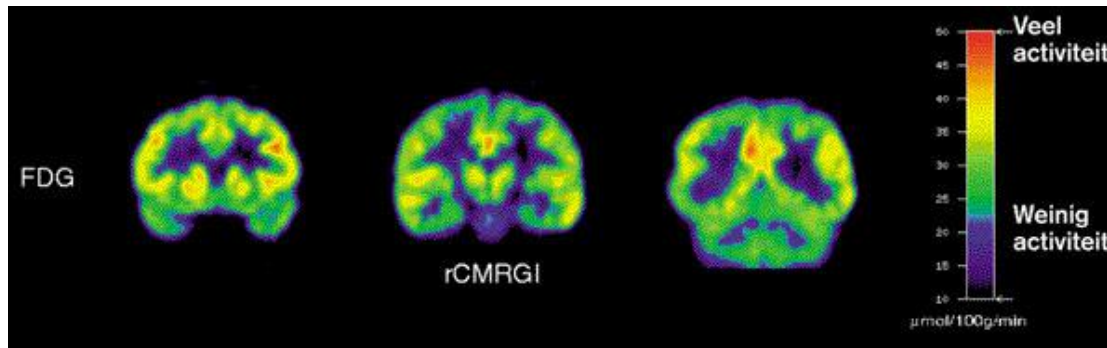


**0.4 m/s**  
**120 m/5 min**



# Motor network and rehabilitation

Evidence functional brain imaging:



motor recovery through cortical reorganization

correct input and feedback:

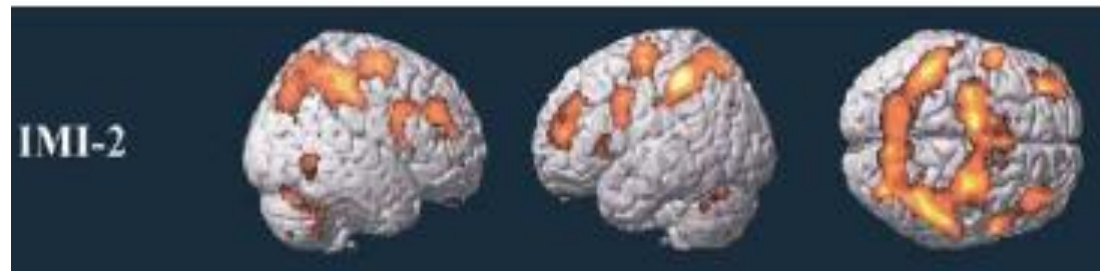
optimization of brain reorganization

# Motor network and rehabilitation

Action  
observation



Motor imagery



Motor  
execution



Buccino, G., S. Vogt, et al. (2004). "Neural circuits underlying imitation learning of hand actions: an event-related fMRI study." *Neuron* **42**(2): 323-34.



# Motor network and rehabilitation

## Motor imagery

internal mental representation of a movement

→ activation of the motor neural network

→ optimization  
representation movement



# Mental practice

Training method

repeated mental simulation without actual execution

→ optimization motor execution

**Offline-activation motor cortex  
not depending on motor function**

# Mental practice

sport psychology

physical training + mental training > physical training > mental training > no training

rehabilitation  
training  
prior to competition





# Mental practice



# **Mental practice through motor imagery in gait rehabilitation following acquired brain injury**

Introduction

Motor neural network and rehabilitation

Mental training

Motor imagery and traumatic brain injury

Motor imagery and mental practice

Mental practice and gait rehabilitation

Motor imagery and brain lesion localization

# Mental training through motor imagery: a rehabilitation technique following acquired brain injury?

## Research questions

- 1. Is motor imagery preserved in patients with an acquired brain injury?**
2. Is motor imagery a skill that can be trained?
3. Mental practice with motor imagery:  
a potential technique in gait rehabilitation in  
subacute stroke?
4. Does brain localization influence motor imagery ability?

# Motor imagery ability following traumatic brain injury

Motor imagery ability:

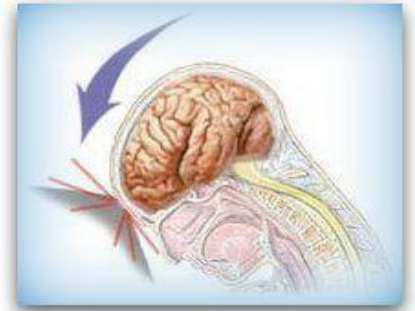
stroke

Parkinsons' disease

cerebral palsy

multiple sclerosis

~~traumatic brain injury (TBI)~~



Hypothesis 1:

motor imagery ability hampered after TBI  
due to

presence frontal and prefrontal lesions  
interruption fronto-parietal network

# ***Motor imagery ability in patients with traumatic brain injury***

***K. M. Oostra, A. Vereecke, K. Jones,  
G. Vanderstraeten, G. Vingerhoets  
Arch Phys Med 2012; 93:828-833***

## ***Methods:***

***20 participants (4 F, 16 M), 13 controls  
matched for age, gender and level of education  
mean age: TBI group 31 Y, control group 33 Y  
age min/max: TBI group 16 Y/57 Y, control group 14 Y/61 Y  
mean coma duration: 18 d (SD 13 d)  
coma duration min/max: 2 d /49 d  
mean time since insult: 16 months  
time since insult min/max: 3 mts/33 mts***



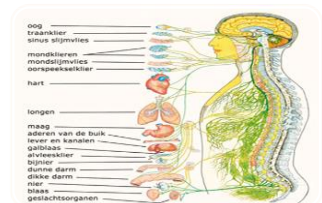
# Motor imagery ability following traumatic brain injury

Movement Imagery Questionnaire  
motor imagery vividness

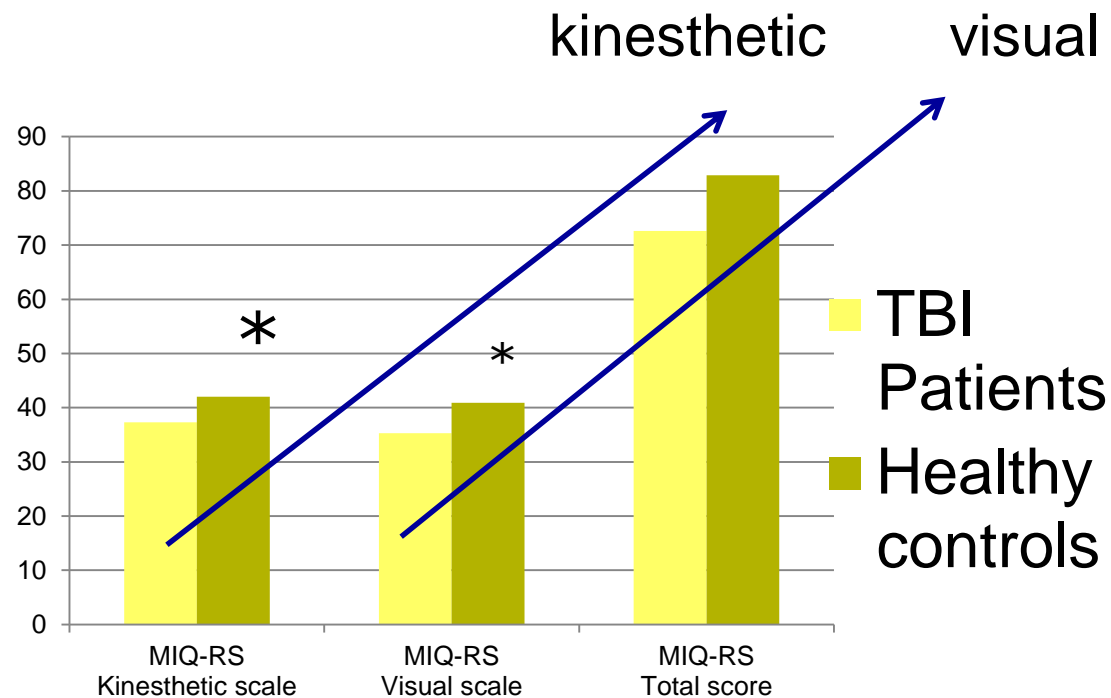
Mental chronometry  
temporal organization motor imagery

Mental rotation tasks  
motor imagery accuracy

Effect on autonomic nervous system  
real-time measurement motor imagery



# Motor imagery ability following traumatic brain injury



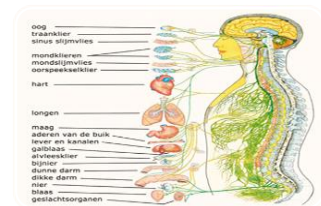
# Motor imagery ability following traumatic brain injury

Movement Imagery Questionnaire  
motor imagery vividness

Mental chronometry  
temporal organization motor imagery

Mental rotation tasks  
motor imagery accuracy

Effects on autonomous nervous system  
real-time monitoring



# Motor imagery ability following traumatic brain injury

## Mental chronometry

imaging time = execution time  
writing sentence, walk

Fitts' law:

difficult movement

→ longer execution time

→ longer imaging time



# Motor imagery ability following traumatic brain injury

Temporal congruence walking trajectory-test  
execution time  $\sim$  imaging time  
walking traject 2 m, 5 m en 10 m



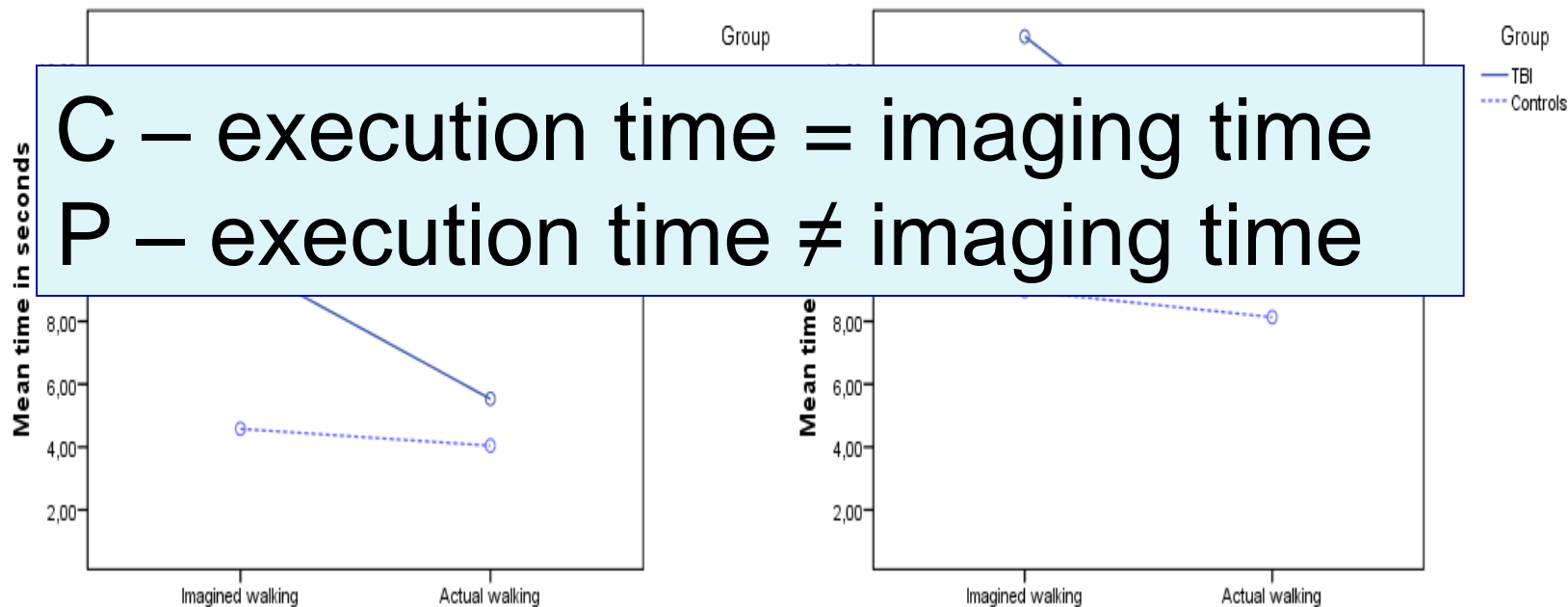


# Motor imagery ability following traumatic brain injury

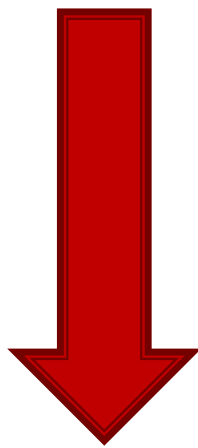
## Temporal congruence walking trajectory-test

5 meter

10 meter



# Motor imagery ability following traumatic brain injury



Motor imagery ability

vividness

temporal congruence

Candidate mental practice?

# Mental training through motor imagery: a rehabilitation technique after acquired brain injury?

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a potential technique in gait rehabilitation in  
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# Motor imagery ability a trainable skill ?

Patients with a stroke:

'chaotic' motor imagery ability

talent or skill?



Hypothesis 2:

patients with a stroke

trainable motor imagery ability

# ***Influence of motor imagery training on gait rehabilitation in sub-acute stroke: a randomized controlled trial***

***K.Oostra, A.Oomen, G. Vanderstraeten, G. Vingerhoets.  
J Rehab Med 2015; 47:204-209.***

*Methods:*

*randomized controlled trial*

*44 patients*

*21 pts vs 23 ctl*

*first time stroke*

*gait: F(unctional) I(ndependence) M(easure) > 4*

*able to perform a TDMI screening test*

*between 16 and 70 Y old*

*no other psychiatric or neurologic disease*



# Motor imagery ability a trainable skill?

	<i><b>Patients</b></i> <i>n=44</i>	<i><b>Controls</b></i> <i>n=27</i>	<i><b>p-value</b></i>
Questionnaire			
visual scale (/49)	33.05 (9.55)	39.11 (7.76)	.007
kinest. scale (/49)	29.30 (9.18)	35.95 (9.11)	.004

motor imagery vividness ↓ stroke

Patients with stroke

# Motor imagery ability a trainable skill?

	<i><b>Patients</b></i> <i>n=44</i>	<i><b>Controls</b></i> <i>n=27</i>	<i><b>p-value</b></i>
<i>Walking test IWT/AWT</i>	<i>1.31 (.81)</i>	<i>1.19 (.38)</i>	<i>.5</i>

Temporal congruence = after stroke

# Motor imagery ability a trainable skill?

## Experimental group

mental practice + standard rehabilitation  
6 weeks  
motor imagery 30 min daily  
5 d/week



## Control group

relaxation (Jacobson) + standard rehabilitation  
6 weeks  
relaxation 30 min daily  
5 d/week



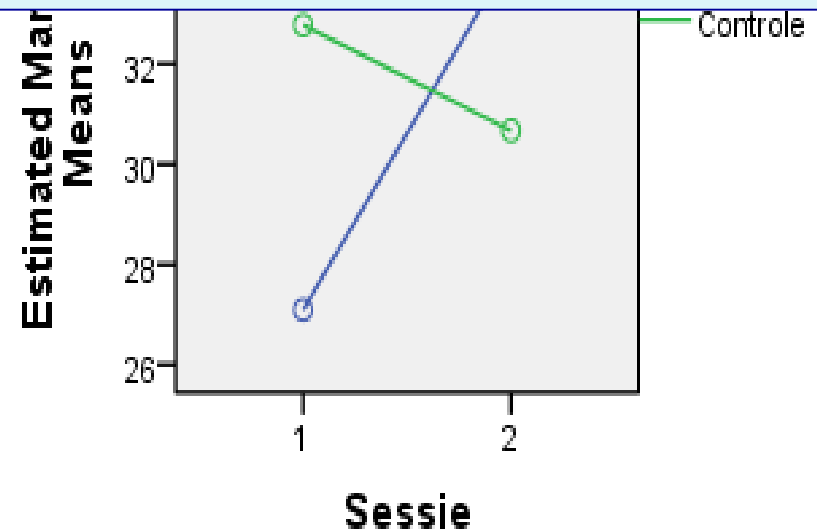
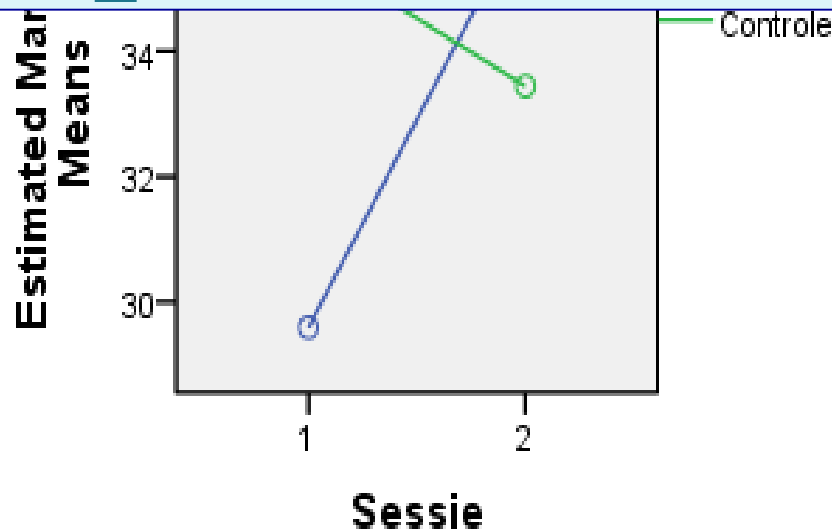
# Motor imagery ability a trainable skill?

Effect mental practice on  
motor imagery vividness

mental practice



motor imagery vividness



# Motor imagery ability a trainable skill?

Motor imagery ability  
= a trainable skill

after mental training:  
normalization motor imagery vividness

candidate mental practice?

# Mental training through motor imagery: a rehabilitation technique after acquired brain injury?

## Research questions

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a potential technique in gait rehabilitation in  
subacute stroke?**
4. Does brain localization influence motor imagery ability?

# Mental practice through motor imagery

Literature research

chronic phase after stroke (more than six months)

positive results arm function

~~studies mental practice lower limb~~

Hypothesis 3:

mental practice

= optional treatment

gait rehabilitation

subacute phase after stroke (less than six months)



# Mental practice through motor imagery

## Randomized controlled trial

Patients in a subacute phase after a first time stroke  
Allocated to one of two treatment protocols

## Experimental group versus control group

6 weeks intervention (5d/week)

Standard rehabilitation + 30 min mental practice

Standard rehabilitation + 30 min muscle relaxation

**Gait velocity:** 10 m- test

**Motor recovery:** Fugl-Meyer lower limb

# Mental practice through motor imagery

## Mental practice

quiet room

sitting position, eyes closed

visual imagery: self-visualization movement

kinesthetic imagery: 'feel' the movement



# Mental practice through motor imagery

## First week

learning imagery technique using  
visual, auditory and sensory cues



## Second week

focus on individual gait problems  
gait specific movements of the lower limb

hip flexion/extension  
knee flexion/extension  
ankle flexion/extension



# Mental practice through motor imagery

## Third and fourth week

Gait symmetry and velocity  
Different walking tasks



## Fifth and sixth week

Gait exercises integrated in daily activities  
Different surroundings, situations and soils



# Mental practice through motor imagery

Effect on gait velocity

AW10m  $p < .001$



both groups gait velocity ↑

group mental training gait velocity ↑

21 cm/s versus 16 cm/s = 5cm/s

minimal detectable change ~ minimal clinical change

# Mental practice through motor imagery

Mental practice with motor imagery  
= complementary rehabilitation technique  
in a subacute phase after stroke

which patients would benefit the most?  
how to apply to obtain the best result?

# Mental training through motor imagery: a rehabilitation technique after acquired brain injury?

## Research questions

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# **Influence of brain injury localization on motor imagery ability**

Functional imaging  
motor imagery and motor execution  
share a similar neural network

Motor imagery  
activation of a broad neural network

Hypothesis 4:  
impaired motor imagery ability  
~ localization brain lesion

# ***Damage to fronto-parietal networks impairs motor imagery ability after stroke: A voxel-based lesion symptom mapping study***

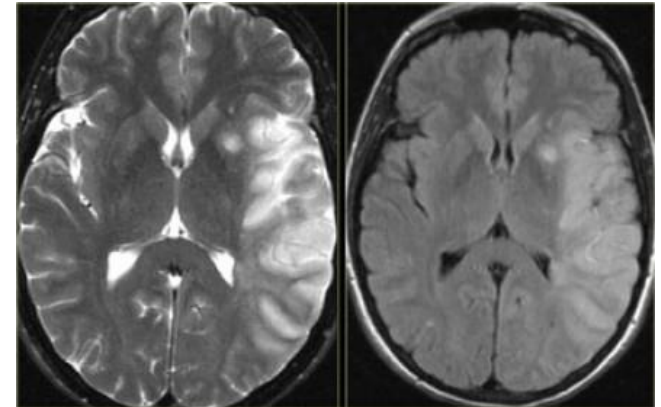
***K. Oostra, A. Van Bladel, A. Vanhoonacker, G. Vingerhoets  
Front Behav Neurosci - Doi: 10.3389/fnbeh.2016.00005***

Characteristics:	
Age (years)	53 ( range 17-68 yrs)
Gender (♀: ♂)	12:25
Side hemiplegia	
right	15
left	22
Cause hemiplegia	
ischemic	21
hemorrhagic	16
Time since stroke (months)	4 (range 1-12 mths)
Fugl-Meyer Assessment Scale Upper Extremity (/66)	30.1±10.3 (mean±SD)
Fugl-Meyer Assessment Scale Lower Extremity (/34)	19 ±6.2 (mean±SD)
Test of Attentional Performance	-0.86 ±0.9 (Z-score, mean±SD)

# Influence of brain injury localization on motor imagery ability

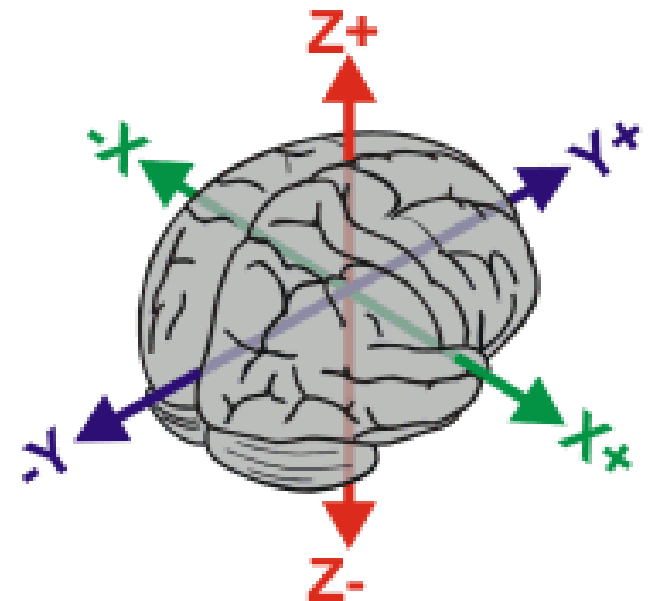
## Structural brain scans

MRI-scans on clinical indication in a subacute phase after stroke



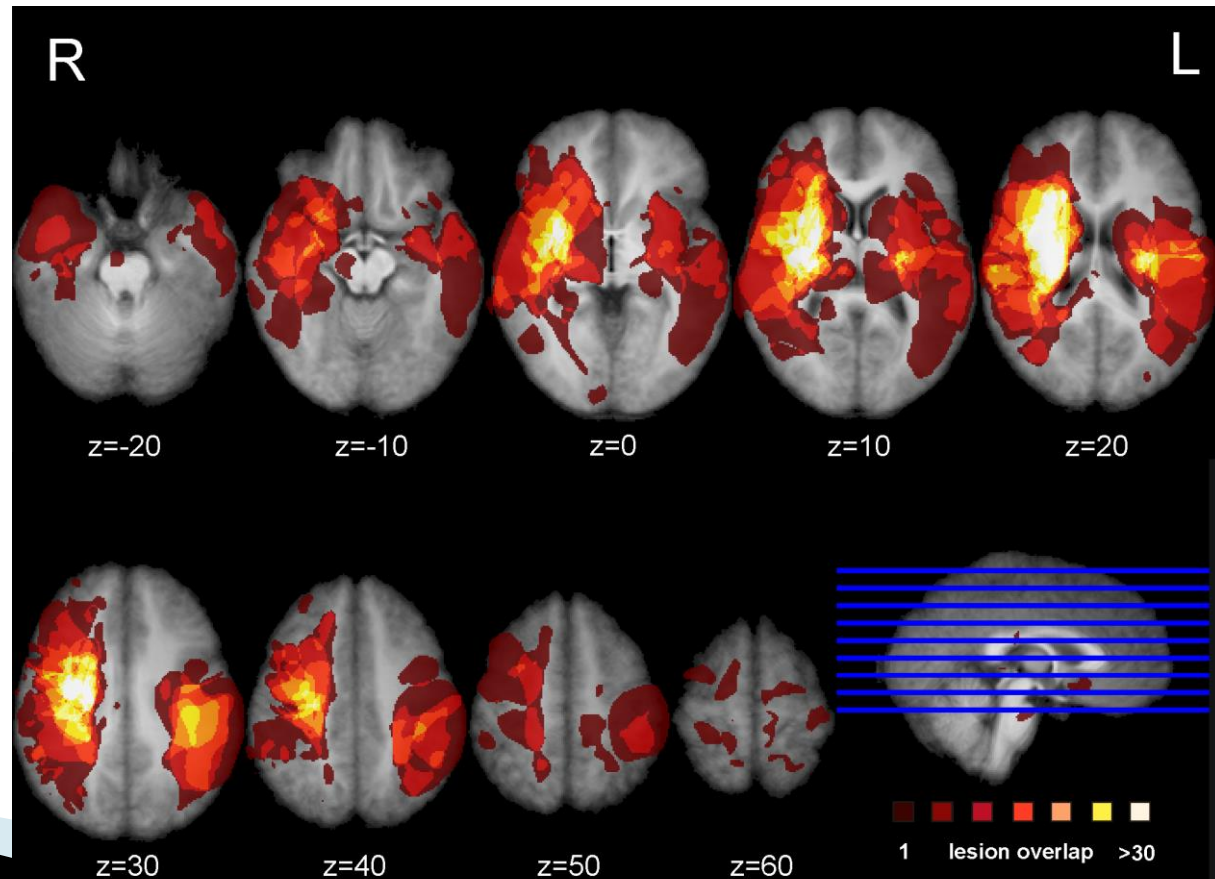
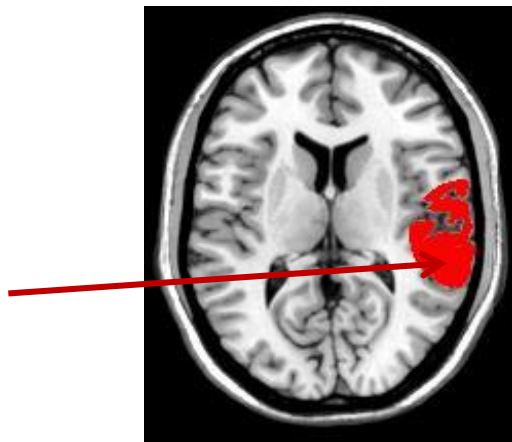
normalization

→ Talaraich-space



# Influence of brain injury localization on motor imagery ability

MRICron-software: lesion demarcation FLAIR-images  
(Rorden, Brett, 2000)



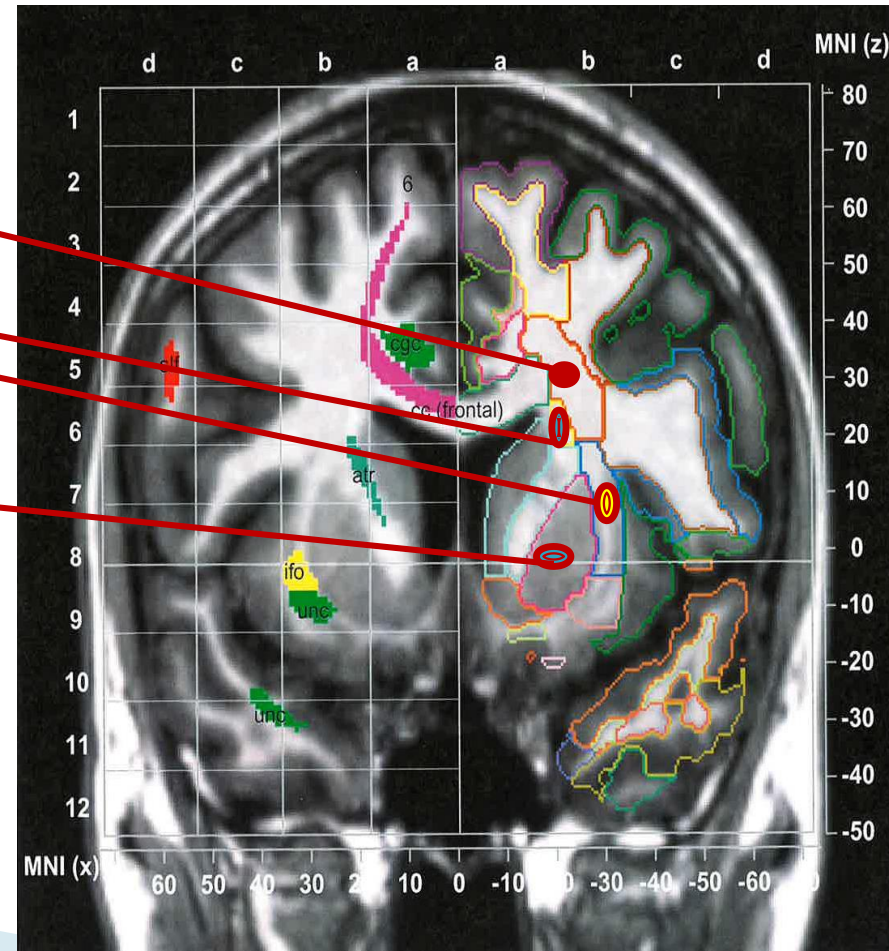
# Influence of brain injury localization on motor imagery ability

## Voxel-Lesion Symptom Mapping

corona radiata

frontoparietal network

putamen





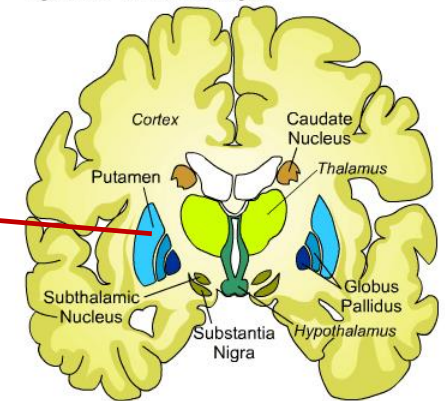
# Influence of brain injury localization on motor imagery ability

Putamen

motor learning

motor imagery network

Figure AB-18: Basal Ganglia

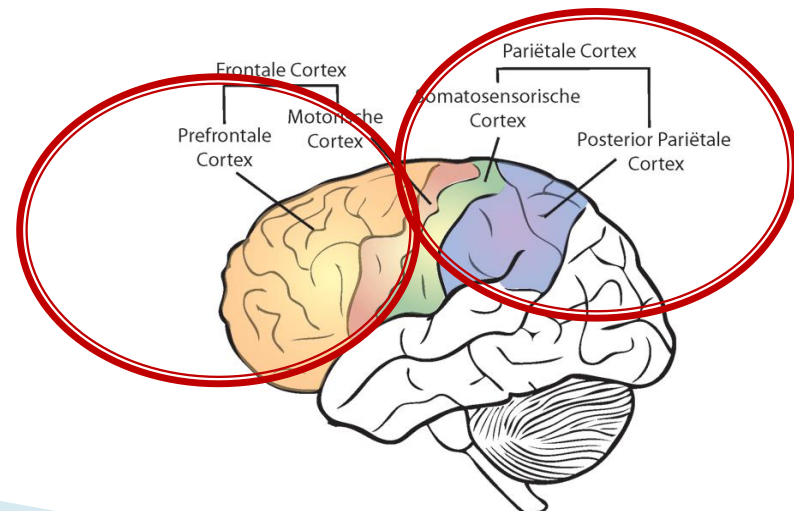


Frontoparietal network

integration multimodal sensory information

→ motor plan

Left hemisphere



# **Influence of brain injury localization on motor imagery ability**

Disconnection frontoparietal network

→ impaired motor imagery ability



# Mental training through motor imagery: a rehabilitation technique after acquired brain injury?

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- 5. Mental Practice: how to apply to obtain the best result?**

# Mental practice through motor imagery: best practice

Assess MI ability  
Familiarization

Motor imagery introduction program

3x 30 min MI theory and MI practice  
Added to standard rehabilitation  
Measure motor imagery ability

# Mental practice through motor imagery: best practice

Individual

Supervised

Added vs embedded

Before PP: priming function

After PP:  number repetitions,

~~fatigue~~

15 min, max 30 MI trials



# **Mental practice through motor imagery: a treatment technique in gait rehabilitation following acquired brain injury?**

Motor imagery ability is impaired following acquired brain injury

Motor imagery ability is a trainable skill

Mental practice through motor imagery is an optional treatment in gait rehabilitation in a subacute phase after stroke

Lesions of the putamen and frontoparietal network hamper motor imagery ability

