NEUROMODULATION FOR SPEECH AND LANGUAGE

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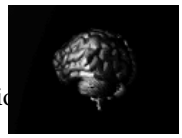
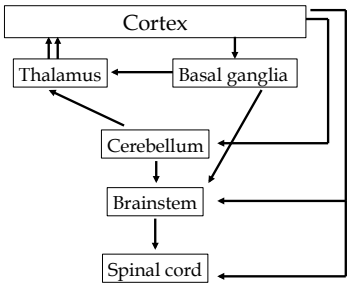
NEUROMODULATION

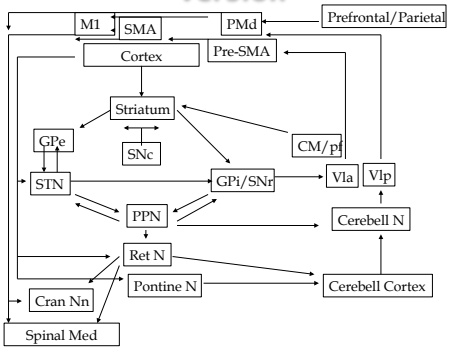
- Impact on neurophysiological functions
- Impact on clinical function of the nervous system
  - Pharmacological
  - Neurostimulation
  - Facilitated rehabilitati



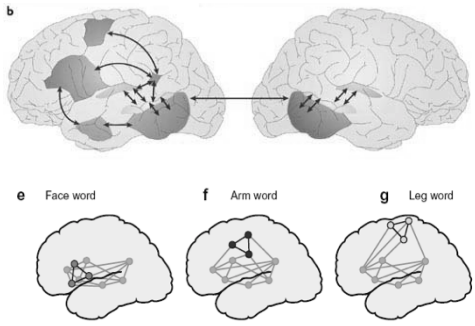
Motor networks : the simple version



Motor networks : the extended version



A distributed network for language perception



Pharmacological effects on speech and language

- Dopaminergic effects on speech
  - Effects of dopaminergic treatment on speech characteristics in PD
  - Disfluencies induced by alterations of dopaminergic systems
- Dopaminergic effects on language
  - Neurophysiological studies
  - Dopamine agonists in the treatment of aphasia
- Manipulation of other neurotransmitter systems : largely aspecific

Neurostimulation

- Cortical stimulation
  - Direct electrical stimulation (intraoperative)
  - Transcranial magnetic stimulation
  - Transcranial electric stimulation
- Deep brain stimulation in movement disorders
  - High-frequency stimulation
  - Low-frequency stimulation
- Peripheral nerve stimulation
  - Vagal nerve stimulation
  - Limb nerve stimulation

Cortical stimulation : applications

- Transcranial magnetic stimulation in the rehabilitation of language disorders
- Transcranial magnetic stimulation in parkinsonian disorders

Cortical stimulation

Peripheral rehabilitation
Sensory stimulation
Constraint-induced treatment

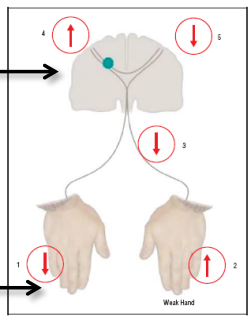
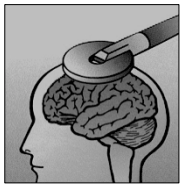


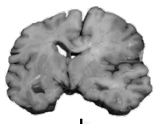
Figure 2. Diagram showing possible operational strategies to influence hand function (see "Possible Strategies to Enhance the Human Brain's Response to Injury" section for details).

Repetitive transcranial magnetic stimulation


High-frequency stimulation : excitation
Low-frequency stimulation : inhibition

Low-frequency stimulation



High-frequency stimulation

Inhibition of competing Processes Constraint-induced

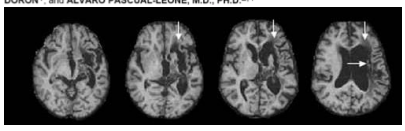
Aphasia Dysarthria

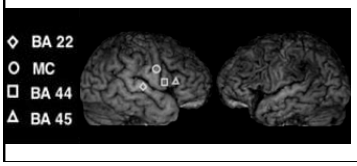
Stimulation of intact processes

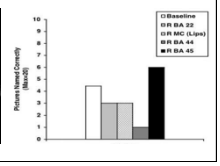
Neurocase. 2005 June ; 11(3): 182–193.

Improved naming after TMS treatments in a chronic, global aphasia patient — case report

MARGARET A. NAESER, PH.D.[1], PAULA I MARTIN[1], MARJORIE NICHOLAS, PH.D.[1], ERROL H. BAKER, PH.D.[1], HEIDI SEEKINS[1], NANCY HELM-ESTABROOKS, SC.D.[1], CAROL CAYER-MEADE, M.A.[1], MASAHITO KOBAYASHI, M.D.[2], HUGO THEORET, PH.D.[2,3], FELIPE FREGNI, M.D.[2], JOSE MARIA TORMOS, M.D.PH.D.[2,4], JACQUIE KURLAND, M.S.[1], KARL W. DORON[1], and ALVARO PASCUAL-LEONE, M.D., PH.D.[2,4]



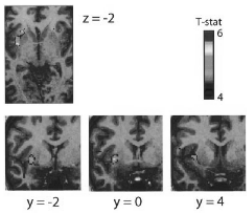




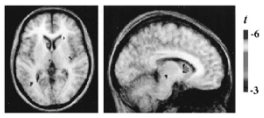
Repetitive transcranial magnetic stimulation in parkinsonism

- Impaired inhibition in the cortex in PD
- rTMS can reverse the alterations in cortical excitability
- Outcome of clinical studies highly variable
  - Stimulation frequency
  - Stimulation intensity
  - Localization of stimulation
  - Outcome parameters

rTMS can induce dopamine release in the striatum



Strafella et al, 2003
Motor cortex stimulation
High-frequency stimulation, subthreshold



Strafella et al, 2001
Prefrontal cortex stimulation
High-frequency stimulation, subthreshold

rTMS in PD : effects on voice and speech *(Dias et al, 2006)*

Rapid-rate stimulation, subthreshold, DLPFC

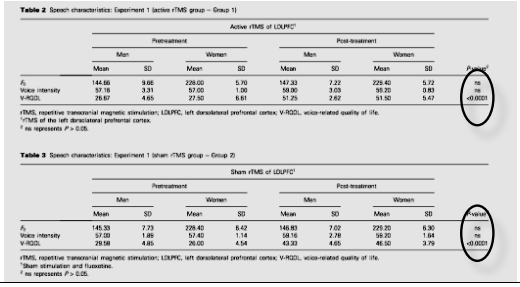


Table 2 Speech characteristics: Experiment 1 (active rTMS group – Group 1)

	Active rTMS of LDLPFC[1]								
	Pretreatment				Post-treatment				
	Men		Women		Men		Women		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P value[2]
F_0	144.66	9.66	226.00	5.70	147.33	7.22	229.40	5.72	ns
Voice intensity	57.16	3.31	57.00	1.00	58.00	3.03	55.20	0.83	ns
V-RQOL	26.67	4.65	27.50	6.81	51.25	2.62	51.50	5.47	<0.0001

rTMS, repetitive transcranial magnetic stimulation; LDLPFC, left dorsolateral prefrontal cortex; V-RQOL, voice-related quality of life.
[1]rTMS of the left dorsolateral prefrontal cortex.
[2] ns represents $P > 0.05$.

Table 3 Speech characteristics: Experiment 1 (sham rTMS group – Group 2)

	Sham rTMS of LDLPFC[1]								
	Pretreatment				Post-treatment				
	Men		Women		Men		Women		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P value[2]
F_0	145.33	7.73	226.40	6.42	146.83	7.02	229.20	6.30	ns
Voice intensity	57.33	1.89	57.40	1.14	58.16	2.78	55.20	1.64	ns
V-RQOL	29.58	4.85	26.00	4.54	43.33	4.65	46.50	3.79	<0.0001

rTMS, repetitive transcranial magnetic stimulation; LDLPFC, left dorsolateral prefrontal cortex; V-RQOL, voice-related quality of life.
[1]Sham stimulation and fluoxetine.
[2] ns represents $P > 0.05$.

rTMS in PD : effects on voice and speech *(Dias et al, 2006)*

Rapid-rate stimulation, subthreshold, M1 mouth area

Table 4 Speech characteristics: Experiment 2

	Active rTMS of the M1-mouth area[1]								
	Pretreatment				Post-treatment				
	Men		Women		Men		Women		
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	P-value[2]
F_0	139.20	1.30	223.00	2.00	121.20	7.94	240.00	2.00	<0.001
Voice intensity	58.20	0.83	59.00	1.00	70.20	1.30	70.00	1.00	<0.001

rTMS, repetitive transcranial magnetic stimulation.
[1]rTMS of the primary motor cortex (mouth area).
[2] ns represents $P > 0.05$ from a 2 × 2 ANOVA.

rTMS in patients with PSP

P.Santens, A.Sieben, M.De Letter : rTMS in patients with PSP – a pilot study
Acta Neurologica Belgica 2009; 109 : 200-204

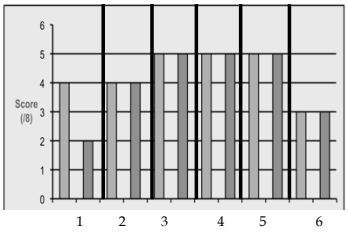
		Age	Dur Diagn	Gaze Palsy	Falls	Speech	Dysph	ENOG
1	F	60Y	3Y	Yes	Yes	Yes	Yes	Yes
2	M	77Y	2Y	Yes	Yes	Yes	Yes	Yes
3	M	75Y	2Y	Yes	Yes	Yes	No	ND
4	M	70Y	5Y	Yes	Yes	Yes	No	Yes
5	M	66Y	2Y	Yes	Yes	Yes	Yes	Yes
6	M	72Y	7Y	Yes	Yes	Yes	Yes	ND

Repetitive TMS in PSP patients : Methodology

TMS methodology

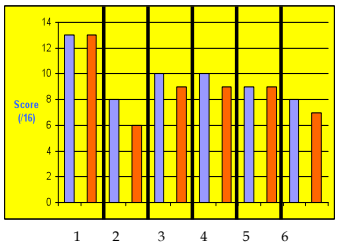
- Stimulation over motor cortex, using vertex coil
- Detection of motor threshold in intrinsic foot muscle
- Stimulation at 80% of threshold, 10 Hz
- Stimulation for 5 sec, followed by 55 sec rest
- 20 cycles
- Five consecutive days
- Evaluation by means of dedicated PSP scoring system *(Golbe et al., 2007)*

Results (1) : Bulbar exam



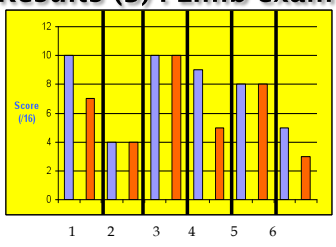
12. Dysarthria
13. Dysphagia

Results (2) : Supranuclear ocular motor exam



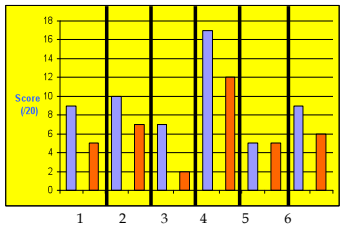
14. Voluntary upward saccades
15. Voluntary downward saccades
16. Voluntary right and left saccades
17. Eyelid dysfunction

Results (3) : Limb exam



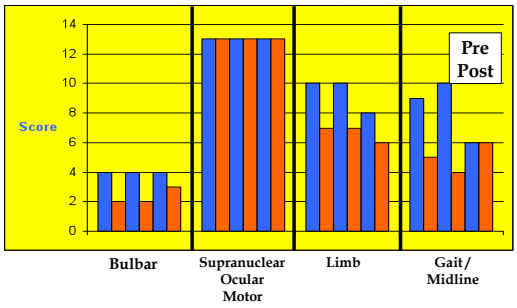
18.Limb rigidity
19.Limb dystonia
20.Finger tapping
21.Toe tapping
22.Apraxia of hand movement
23.Tremor of any part

Results (4) : Gait / Midline exam



24.Neck rigidity or dystonia
25.Arising from chair
26.Gait
27.Postural stability
28.Sitting down

Results (5) : Sequential testing in patient 1



Two weeks between testing

rTMS in PSP : conclusions

Using this methodology : rapid-rate, subthreshold motor cortex stimulation

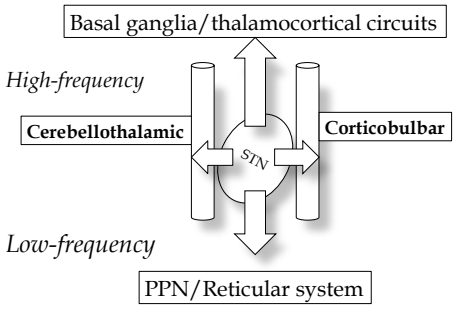
- Minor temporary improvements in some functions, especially midline functions
- Short-lived but consistent effects
- No consistent effects on speech and swallowing

Deep brain stimulation and speech in PD

- Effects of high-frequency subthalamic nucleus stimulation on speech in PD are variable and not consistent (Pinto et al, 2004)
- Differential effects on speech of parameter settings in DBS (Törnqvist et al, 2005), especially negative effects of higher frequencies and amplitudes
- Negative effects of left-sided stimulation (Santens et al, 2003)
- Increase of dysarthria is underreported in the literature on DBS of the STN

Prospects for speech and DBS

- Pedunculopontine nucleus stimulation ?
  - Low-frequency stimulation
  - Mainly effects on axial functions
  - Improvement of cognitive functions and grammatical performance (Alessandro et al, 2010)
- Low-frequency STN stimulation ?
  - Improvement of gait and axial functions (Moreau et al, 2008)
  - Preliminary experience suggests improved intelligibility in some patients.



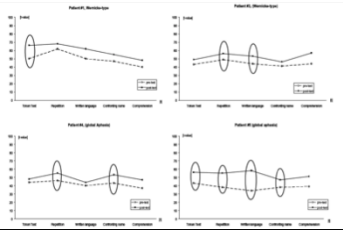
Peripheral nerve stimulation

- Vagal nerve stimulation for epilepsy
  - Intermittent low-rate stimulation
  - Hoarseness
  - Mechanism of action ?
- Limb nerve stimulation and peripheral rehabilitation
  - Sensorimotor effects with secondary effects on language perception and production ?

Restorative Neurology and Neuroscience 25 (2007) 9–15
IOS Press

Combined transcranial direct current stimulation and robot-assisted arm training in subacute stroke patients: A pilot study[1]

S. Hesse[a,*], C. Werner[a], E.M. Schonhardt[a], A. Bardeleben[a], W. Jenrich[b] and S.G.B. Kirker[c]
[a]Klinik Berlin, Department of Neurological Rehabilitation, Charité – University Medicine Berlin, Germany
[b]Klinikum Ernst von Bergmann, Department of Physical Medicine and Rehabilitation, Potsdam, Germany
[c]Addenbrooke's Hospital, Cambridge, UK

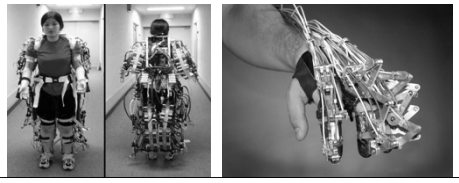


Rehabilitation facilitation

- Neurofeedback
- Virtual reality
- Brain-Computer interfaces

Signals for feedback

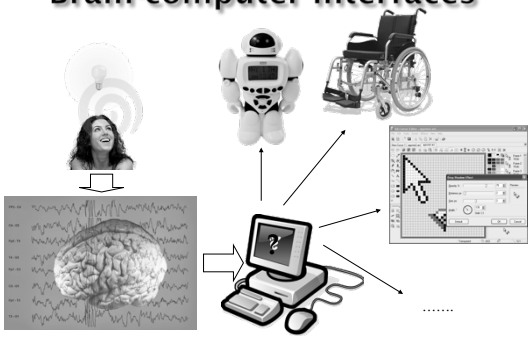
- Motor performance
- Speech output
- Neurophysiological signals : EEG, EP
- Assisted performance e.g. Robot-assisted training, exoskeletons



Virtual reality tools

•Direct feedback possible
•Psychosocial rehabilitation

Brain-computer interfaces



Neuromodulation : prospects for speech and language ?

- Pharmacological : unclear
- Cortical stimulation:
  - Language rehabilitation : promising
  - Speech in PD : targeting to mouth area – to be explored
- Deep brain stimulation
  - PPN stimulation to be explored
  - Low-rate STN stimulation to be explored
- Feedback-related strategies to be explored

Thank you !