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# Predicting upcoming events occurring in the space surrounding the body

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Predicting means choosing the next state of the upcoming movement given the knowledge of the past steps and of the inferred context. (Vargas, Rangel e Galves, 2014)

- forward state estimates
- upcoming events occurring in the space surrounding the body

Proper interaction with the environment and other people
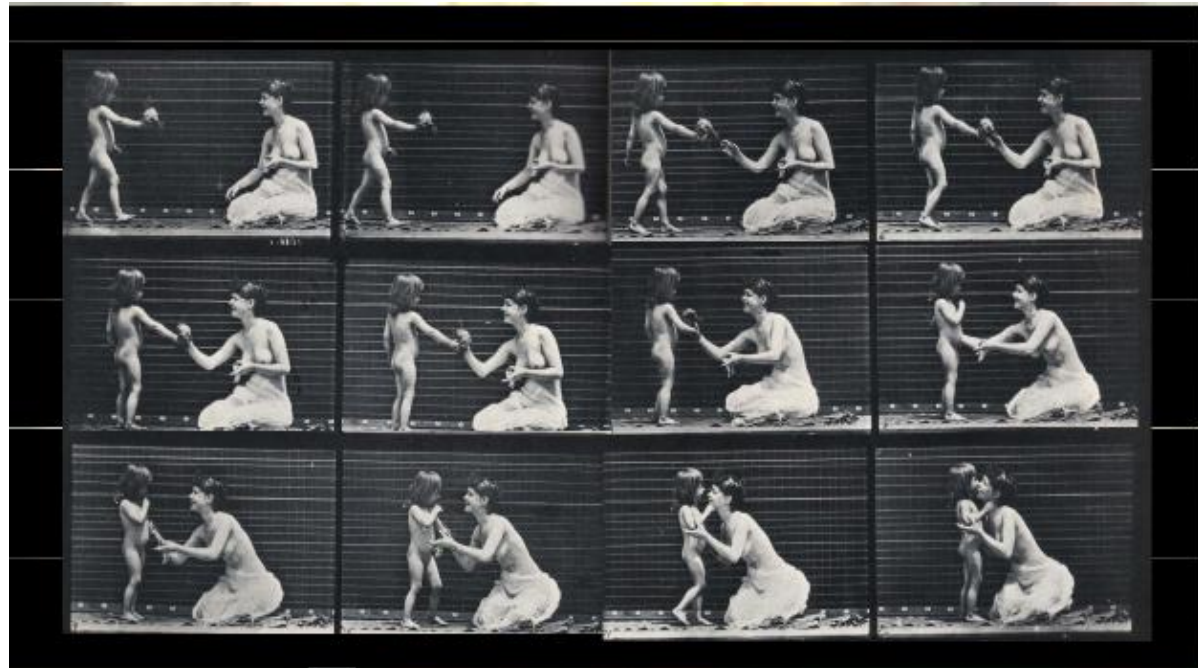
Eadweard Muybridge, 1885

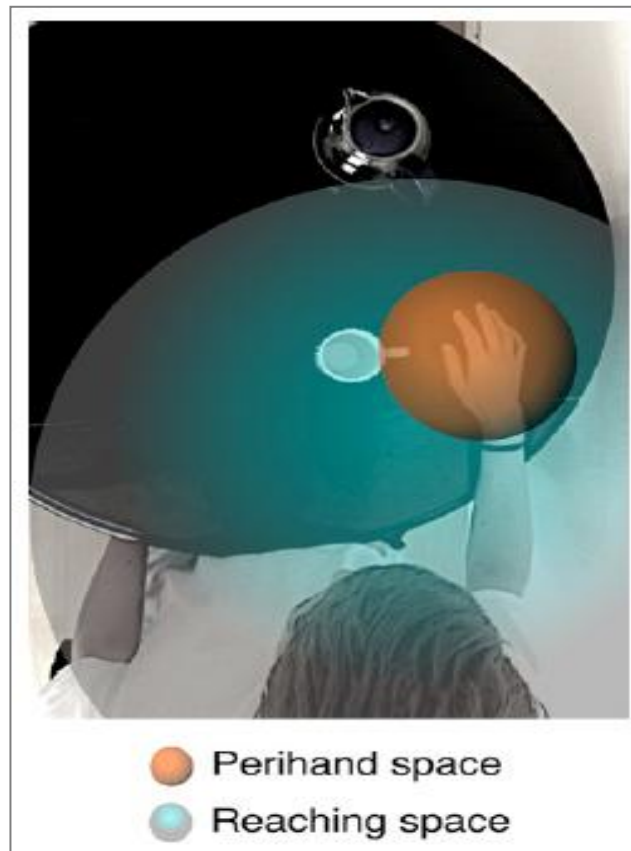Nude_child_bringing_a_bouquet_to_a_seminude_woman_video.mp4

Hand-centered space representation

Sensory guidance of movements toward objects

Sensory guidance for reacting to or avoiding approaching objects
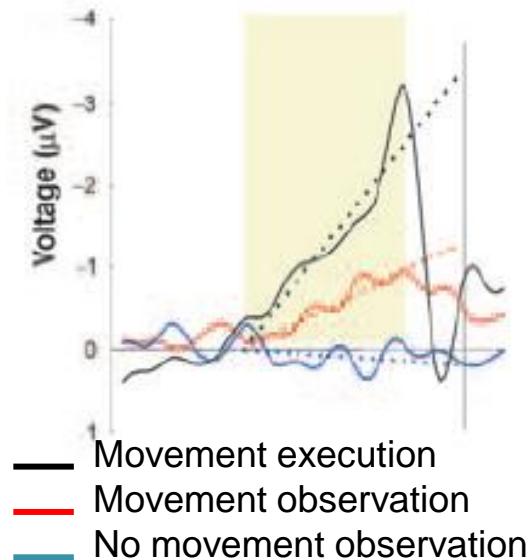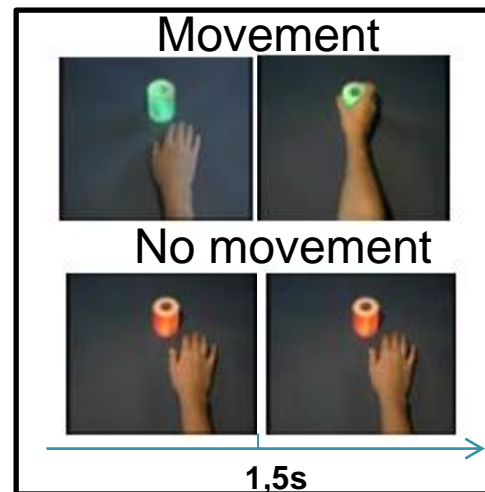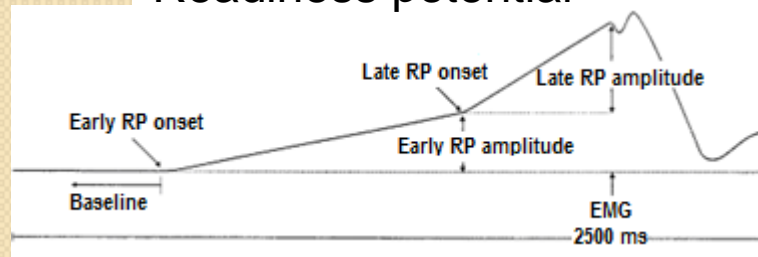
Limbs localization in space

PREDICTION

- Perihand space
- Reaching space

Brozzoli et al, 2014

Motor activation prior to observation of a predicted movement

James M Kilner[1,2], Claudia Vargas[1,3], Sylvie Duval[1,4], Sarah-Jayne Blakemore[4] & Angela Sirigu[1]

Movement

No movement

1,5s

Readiness potential

Early RP onset

Late RP onset   Late RP amplitude

Early RP amplitude

Baseline

EMG

2500 ms

Movement execution
Movement observation
No movement observation

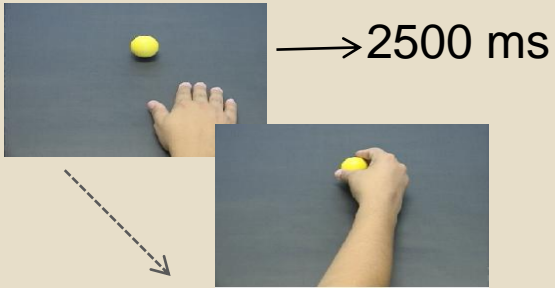Voltage (µV)

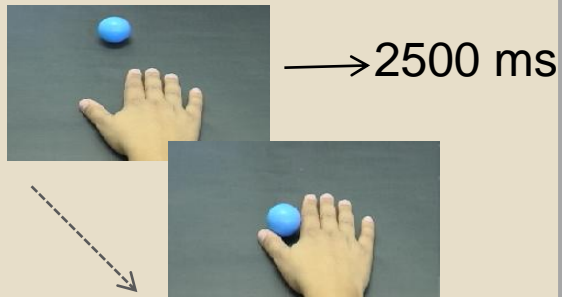Role of the parietal cortex in predicting incoming actions

A.P. Fontana [a,b], J.M. Kilner [c], E.C. Rodrigues [a,b], M. Joffily [a], N. Nighoghossian [d], C.D. Vargas [b], A. Sirigu [a,*]
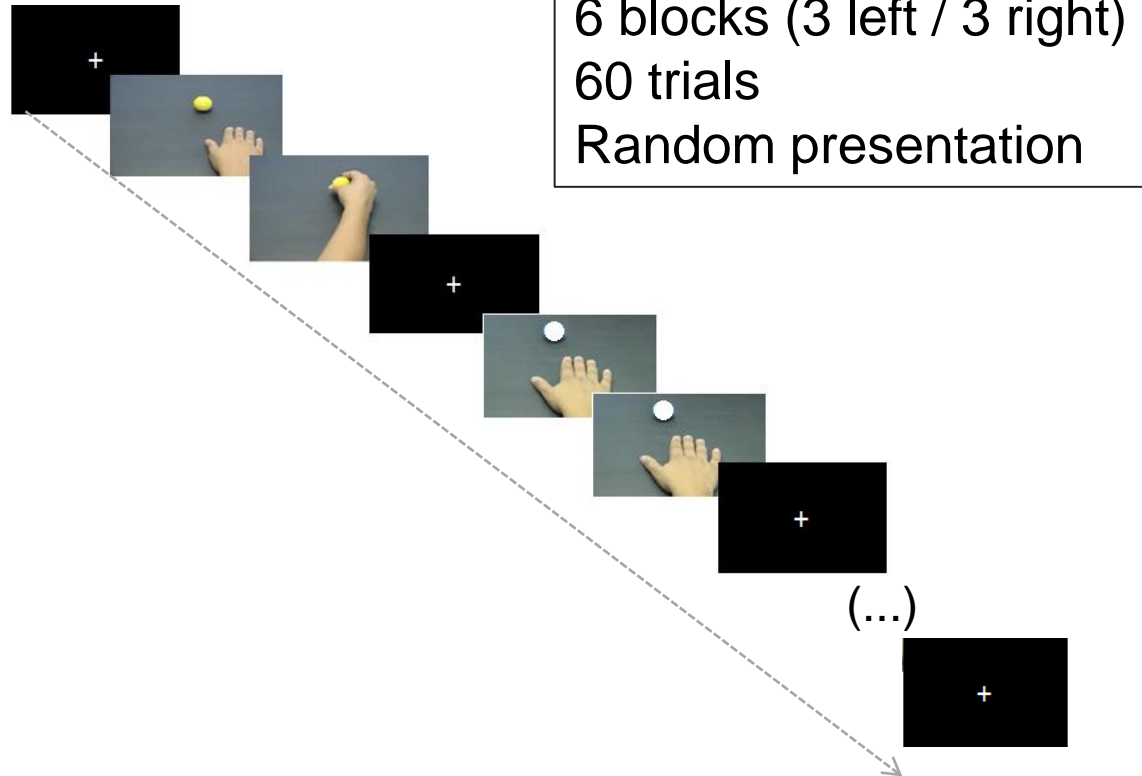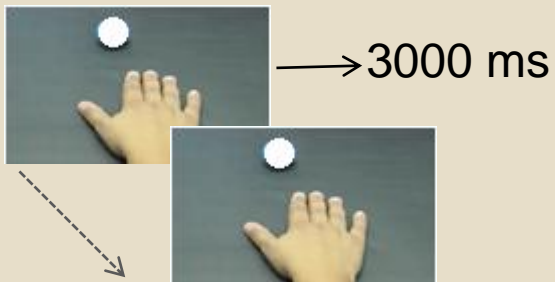
Experimental Design

Motor Event

$\longrightarrow$ 2500 ms

Sensory Event

$\longrightarrow$ 2500 ms

Resting

$\longrightarrow$ 3000 ms

6 blocks (3 left / 3 right)
60 trials
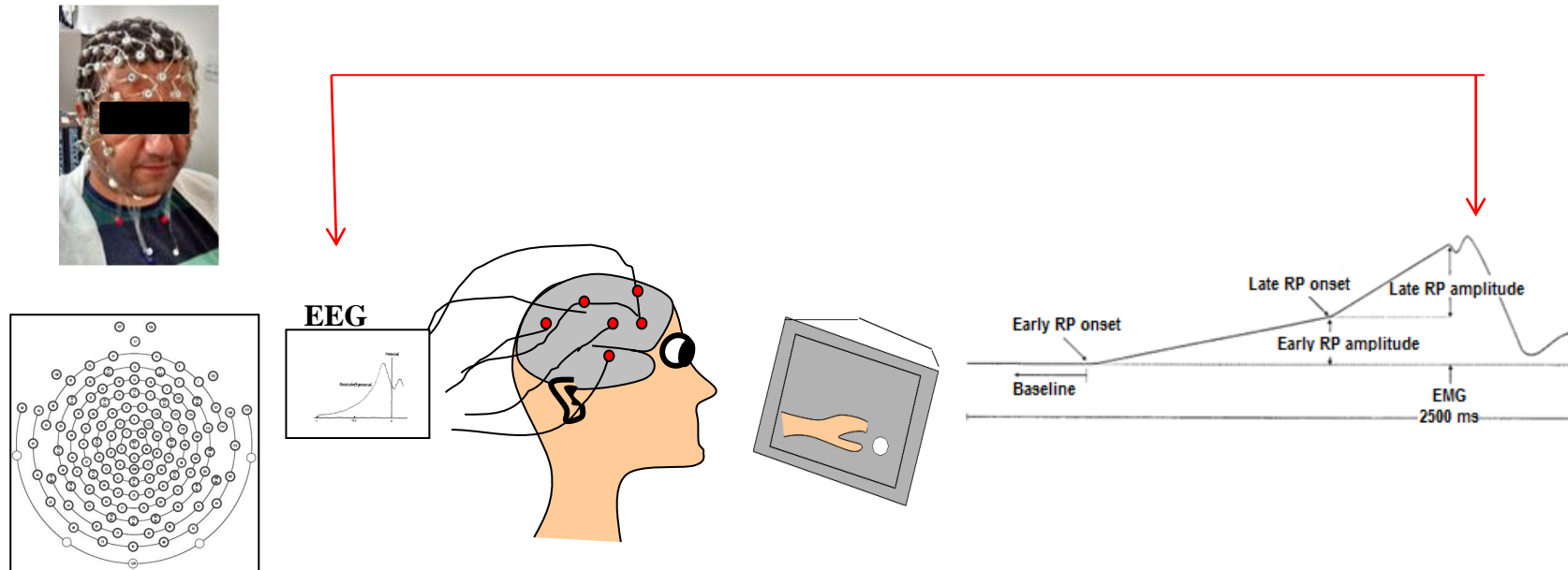Random presentation

(...)

Execution - control

1 block – 60 trials

Methods

- High density EEG (Geodesic 128 channels)
  - Readiness potential

- Eletromyography (Biceps and FDI)
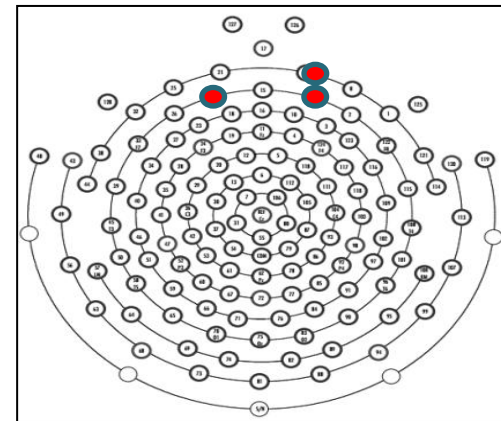
Inclusion criteria

- Presenting RP during movement execution of the dominant hand

- At least 50% data epochs after bad epochs rejection

- No neurological and/or orthopedic health problem

- 18 < age < 50

- Right-handed

Data pre-processing

- Bandpass filter 0.1 – 30 Hz
- Epoch segmentation (-0.1 ms – 3000 ms)
- Baseline: 1300 – 1500 ms

Bad epoch rejection

- Extreme values ±50µV, over electrodes 9, 14, 22,
- Window of interest:
  - Observation: 1200 ms to 2500 ms
  - Execution : -1300 ms a 0 ms
- Script emg_badtrial (Trials with muscle activity higher than 2 x sd from baseline(5s))

Participants included (green) after bad epoch rejection and inclusion criteria assesment

| Subject	Mantained epochs per conditon				RP (negative slope)
	Motor event	Sensory event	Hand at rest	Right hand execution	
S02	41	38	44	58	(EARLY – 0,31; LATE -2,33)
S03	22	19	17	40	(EARLY -7,03; LATE 2,09)
S04	21	20	15	40	
S05	51	46	47	59	EARLY 0,67; LATE -7, 72)
S06	31	31	31	55	EARLY -3,18; LATE -0,97)
S07	42	48	45	34	Left-handed
S08	42	36	47	25	EARLY 3,07; LATE -1,01
S09	22	25	16	13	EARLY -4,30; LATE -1,97
S10	24	25	18	27	EARLY 0,55; LATE -12,15
S11	48	49	48	37	EARLY -4,21; LATE -3,11
S12	20	15	17	30	EARLY 0, 92; LATE 0,24)
S13	41	39	33	32	EARLY -4,14; LATE -10,35
S14	30	42	34	41	EARLY -1,36; LATE -0,78)
S15	51	53	52	36	EARLY -3,52; LATE -5,77

Negative Slope
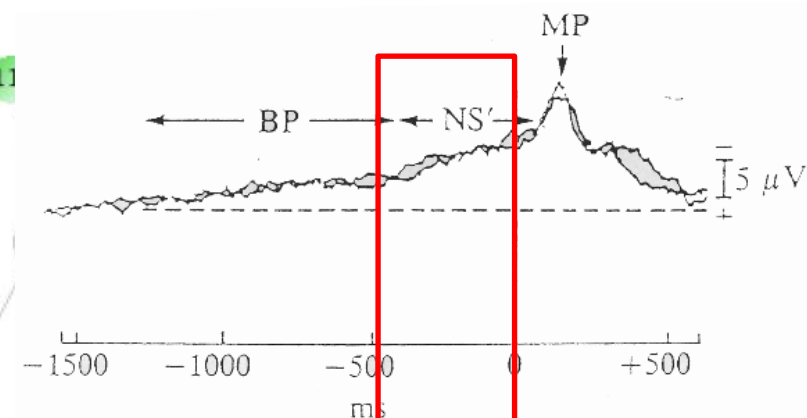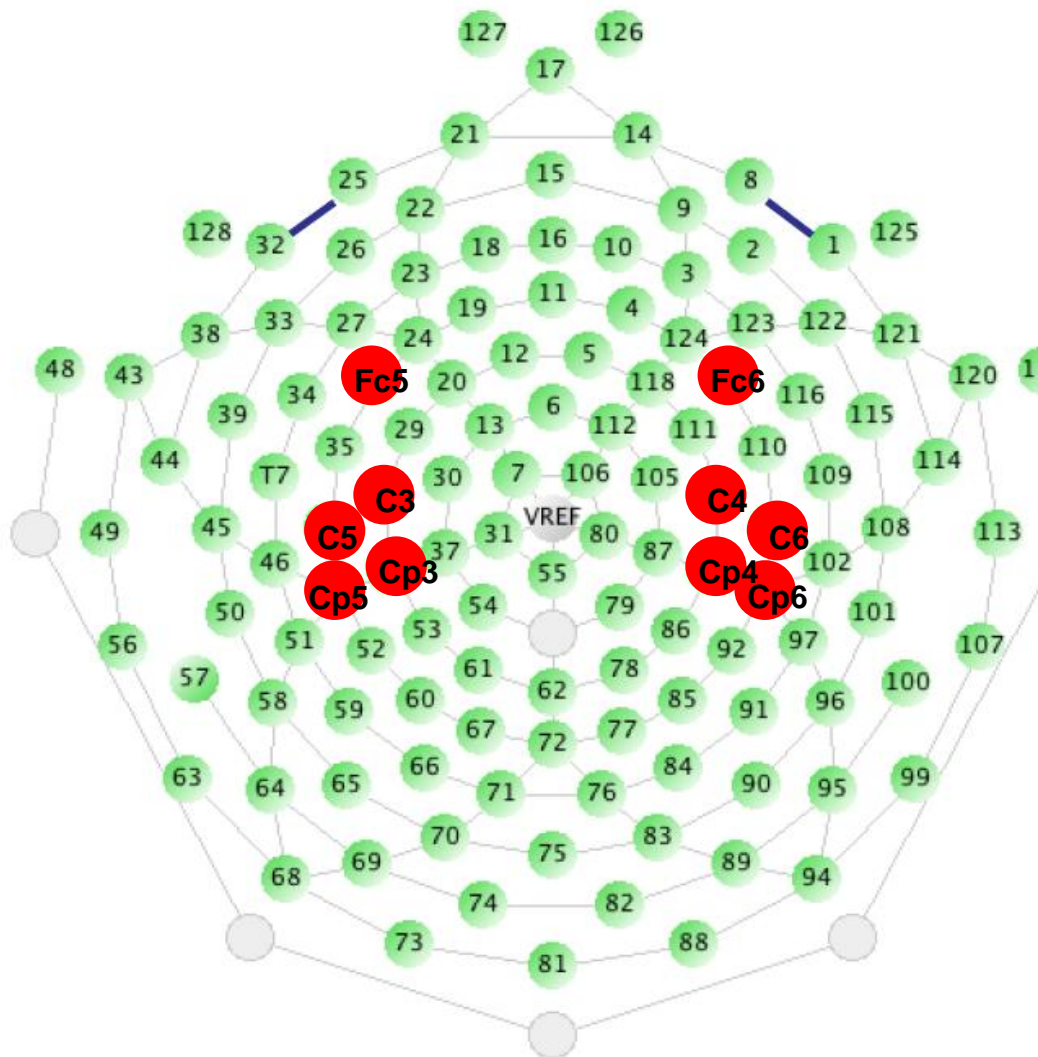
Movement onset

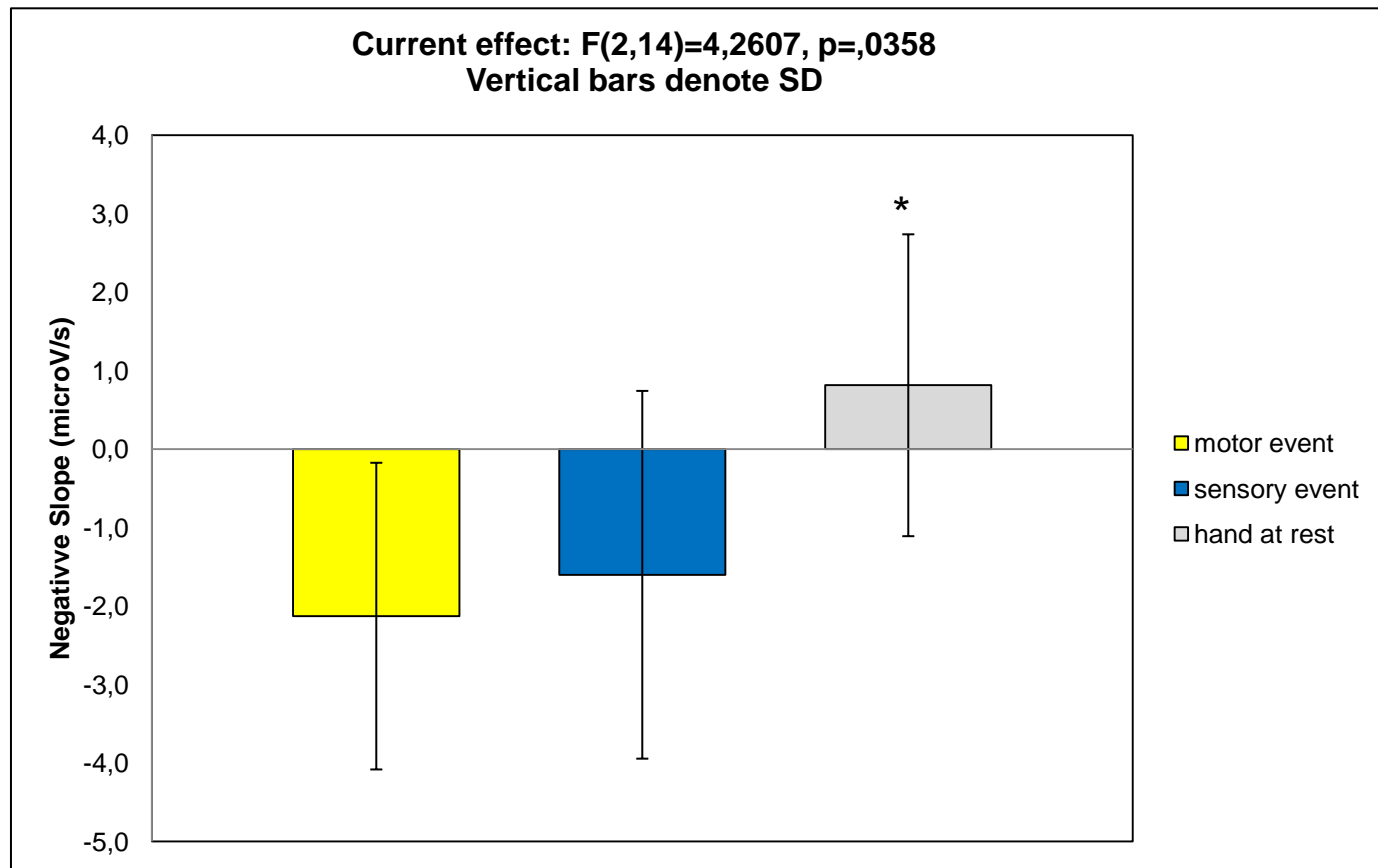# Results – Negative Slope (right hand observation) – Both Hemispheres

Repeated Measures ANOVA (Within factors: Hemisphere: contralateral x ipsilateral; Event: Motor x Sensory x Resting)

Current effect (Event): F(2,14)=5,5256, p=,01703
Vertical bars denote Std. Dv.
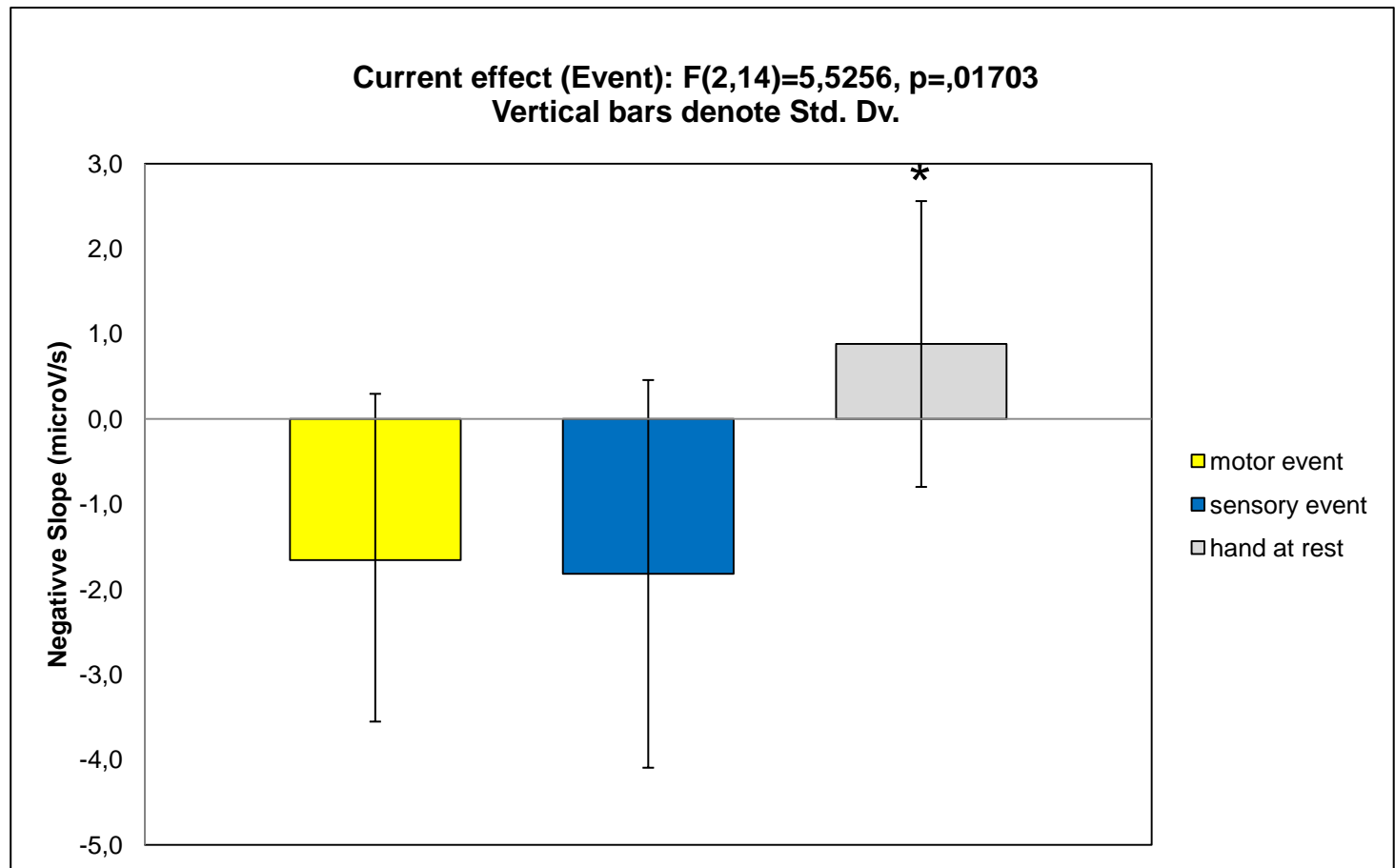
* Post Hoc Newmann Keuls p<0,05

Results – Negative Slope (right hand observation) – Contralateral Hemisphere

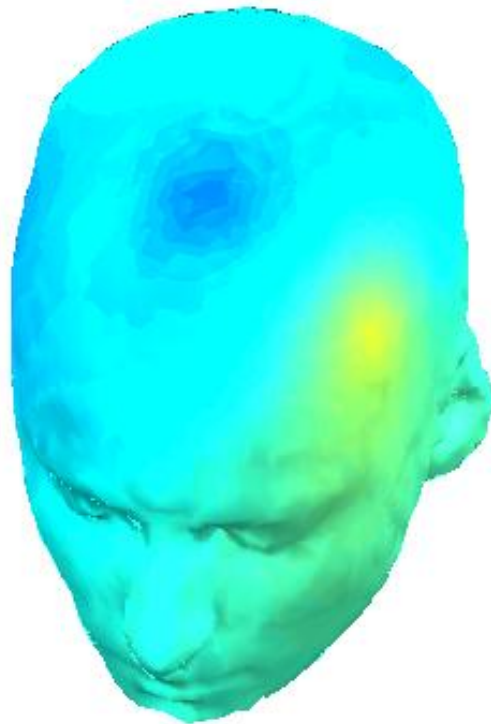*Repeated Measures ANOVA (within factor: Event: motor x sensory x resting)*

Current effect: F(2,14)=4,2607, p=,0358
Vertical bars denote SD
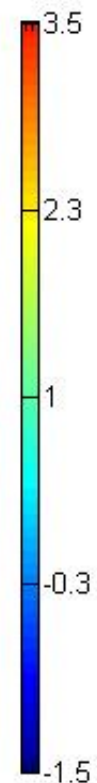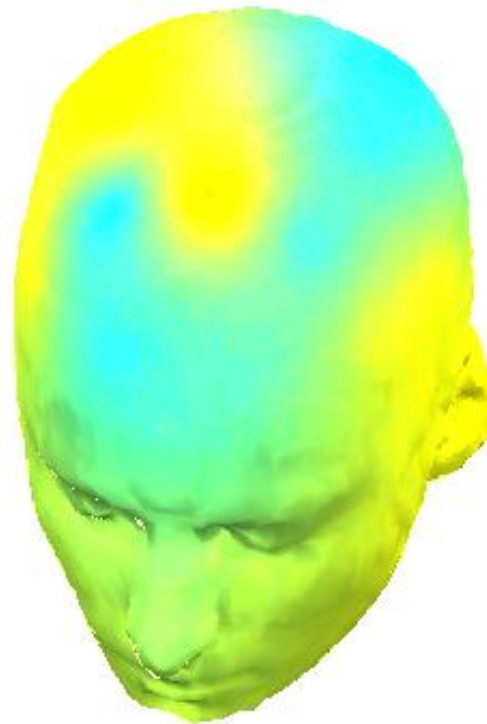
* Post Hoc Newmann Keuls p<0,05

Scalp maps
RP for right hand observation

Sensory-motor observation   **Hand at rest observation**

Grand average amplitude at Negative Slope time window (n8) – 128 channels

Our results show that a negative slope precedes the observation of an upcoming action (readiness potential) and the observation of the touch/contact of a moving object toward the hand.

We suggest that the functional significance of RP includes a strong sensorial prediction component, not only a motor expectancy correlate.

Could it reflect a predictive hand-centered representation of space?

Braquial Plexus Lesion (BPL)
Mechanisms of sensorimotor prediction and plasticity

- Peripheral lesions lead to sensorimotor cortex reorganization (Cohen et al., 1991; PascualLeone et al., 1996; Flor et al., 1995; Ojemann & Silbergeld, 1995; Reilly & Sirigu, 2008; Vargas et al, 2009).

Before   **After peripheral lesion**
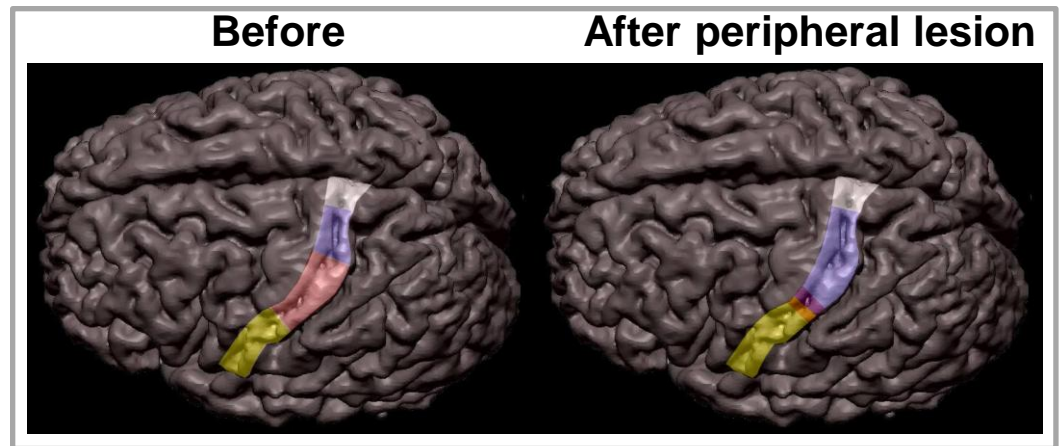
- Do these changes extende to non primary areas? Does it modulate prediction?
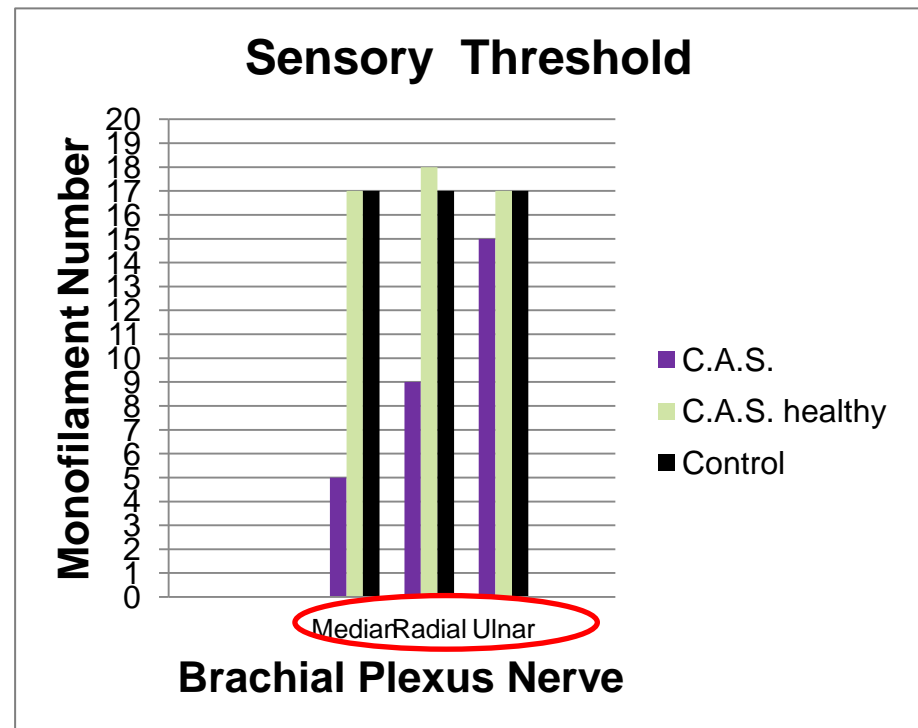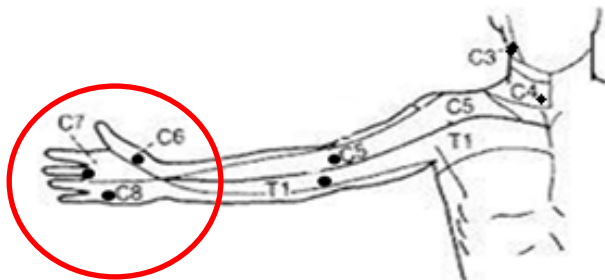
A case study
Patient C.A.S., male, age 32. Upper trunk extended BPL
Time since surgery – 5 months

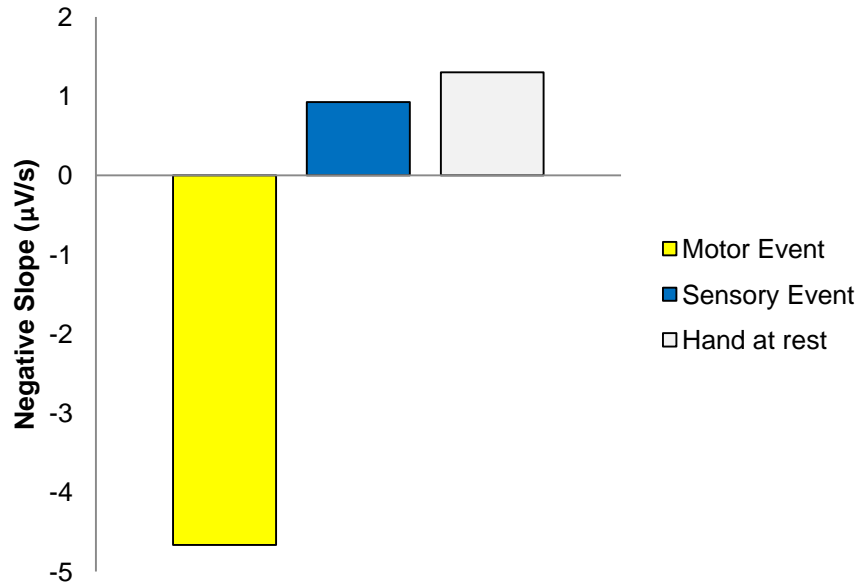**Hand motor function: preserved**
Elbow motor function : impaired
(measured by Muscular manual test)

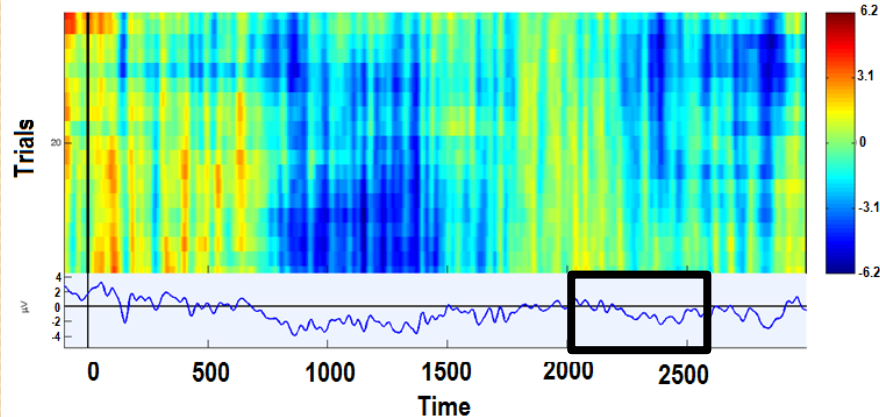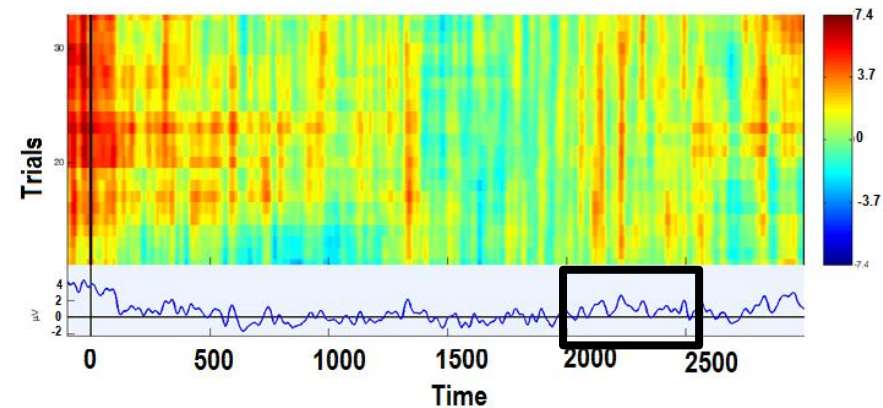**Hypoesthesia in the affected limb in the area of contact during sensory event observation**

Sensory Threshold

Legend:
- ■ C.A.S.
- ■ C.A.S. healthy
- ■ Control

Y-axis: **Monofilament Number** (0–20)

X-axis: Median Radial Ulnar

Brachial Plexus Nerve

Negative Slope modulation

Thanks!

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