



## INTRODUCTION

Activated brain areas have been shown to widely overlap during perception, planning, and mental simulation of actions. Jackson and Decety [1] speak of shared representations.

Ruby and Decety [2] found pronounced activation differences in a mental imagery task when subjects took either a first-person or a third-person perspective. These differences were especially pronounced in the inferior parietal cortex (IPC). Because of the selectively higher activation in the right IPC when taking the third-person perspective, this area has been suggested to play an important role in the self-other distinction [3].

Our EEG study sought to test whether the cerebral activation patterns in the right IPC found in the PET study by Ruby and Decety [2] correspond to cognitive costs as indicated by EEG-alpha (8-12 Hz). Alpha power is inversely related to the cognitive demands of a task.

We expected to find higher EEG-alpha power at right parietal electrode positions for mental simulation of self-generated actions as compared to mental simulation of actions performed by a third person.

Time-dependent spectral analyses were performed using the S-transform [4,5]. The S-transform can be considered as a highly efficient short-time Fourier analysis enabling the use of windows with frequency dependent length.

**?** Does EEG-alpha differ between mental simulation of actions either performed by oneself or by a third person.

## METHODS

### Task and Stimuli

Subjects were instructed to imagine themselves, their best friend, and the experimenter performing a specific motor action.

Within each of these three conditions, they were asked to perform clear mental simulations of the following daily-life scenes:

- washing glasses / eating an apple / washing their hair / packing a backpack / cutting bread / closing a window

Each simulation concluded with a timeout after 8 seconds or when the subject pressed a button to signal successful mental simulation.

Post hoc interviews revealed whether subjects took an egocentric or allocentric perspective in the self condition.

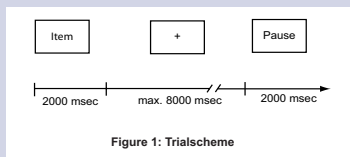


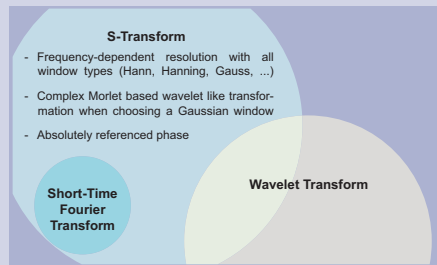
Figure 1: Trialscheme

### Data analysis

EEG data analysis of the channels P3, P4, P7, and P8 was performed for a segment of 4000 msec duration immediately prior to the button press or the trial end. These data were subjected to a Gaussian window S-transform

$$ST(\tau, f, k) = \int_{-\infty}^{\infty} x(t) \frac{|f|}{k\sqrt{2\pi}} e^{-\frac{f^2(t-\tau)^2}{2k^2}} e^{-i2\pi f t} dt$$

with  $k=2$ , i.e., two periods of the Fourier frequency equal one standard deviation. At 10 Hz this procedure leads to a window length of about 1.2 sec. Power values were calculated from 4-20 Hz and subjected to a  $\log_{10}$  transform to normalize distribution.



### Gaussian Window S-Transform: Synthetic Data Example

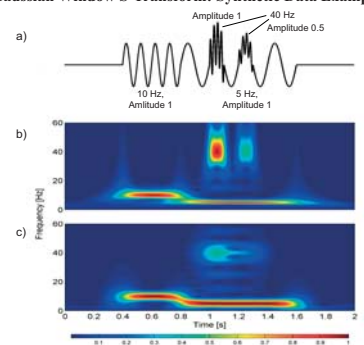


Figure 2

- Time series consisting of four sinusoidal components, each lasting for four periods.
- S-transform with window factor  $k$  set to 1, resembling complex Morlet wavelet transform with wave number of about 6. All four components are detected adequately. Note the change in frequency resolution with increasing frequency.
- Gaussian window S-transform with fixed window length of about 500 msec, resembling a short-time Fourier transform. The detection of the high frequency components is unsatisfactory.

## RESULTS

In post hoc interviews, 7 of 15 subjects reported to have chosen an egocentric perspective in the self condition. For this reason, we analyzed these two self perspectives separately, resulting in four categories: self egocentric, self allocentric, friend, and experimenter.

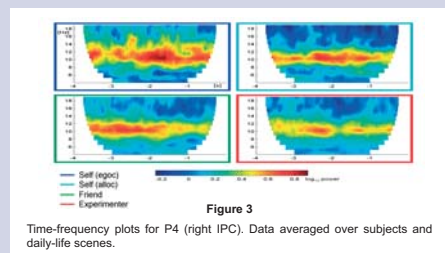


Figure 3

Time-frequency plots for P4 (right IPC). Data averaged over subjects and daily-life scenes.

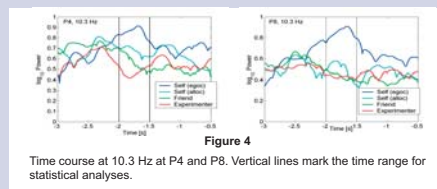


Figure 4

Time course at 10.3 Hz at P4 and P8. Vertical lines mark the time range for statistical analyses.

### Statistical analysis

We performed a four factorial (self egoc, self alloc, friend, experimenter) univariate ANOVA for the averaged power values at 10.3 Hz. The frequency bin and the time window from -2.0 to -1.5 sec prior to trial end were chosen after visual data inspection (Fig. 3).

Conditions varied significantly at the right hemisphere electrodes P4 ( $F=2.67, p=.049$ ) and P8 ( $F=3.40, p=.019$ ) (Fig. 4). In more detail, the self egocentric condition differed significantly from both the friend and the experimenter condition.

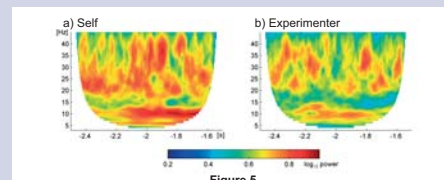


Figure 5

Experimental data from channel F4, demonstrating S-transform capability to deal with both low and high frequencies. Here, the window factor  $k$  is set to 1, so that the S-transform is resembling a complex Morlet wavelet transform with wavenumber about 6.

## DISCUSSION

The data show that the cerebral activations reported in the PET study by Ruby and Decety [2] correspond to the amount of cognitive costs as indicated by EEG-alpha.

According to our hypothesis, alpha power values at P4 (right IPC) and P8 were highest when subjects took the first-person perspective and lowest when they imagined actions of the experimenter.

Post hoc data analysis showed substantial differences between the egocentric and the allocentric perspectives in the first-person task.

The higher alpha power in the egocentric perspective indicates less cognitive demands in comparison to all other, allocentric perspectives. This pattern likely reflects the rather automatic mechanisms that result from the high familiarity of one's own actions. At P4, the stepwise

increase of alpha power may correspond to an increase in familiarity with the imagined agent.

**As revealed by EEG-alpha, the imagination of actions performed by a third person takes higher cognitive costs than imagination of actions performed by oneself.**

### Subjects

15 right handed male students (age 19-37, mean 25.8)

### EEG measurement and analyses

EEG was derived from 23 scalp electrodes according to the 10-10 system against linked ears (32 channel Synamp Neuroscan amplifier, 500 Hz sampling rate, online band-pass filter 0.1 - 100 Hz).

Artifact rejection was performed using Vision Analyzer (Brain Vision). Eye blink related electric activity has diminishing influence from frontal to parietal sites [6]. Focusing on parietal electrodes, the amplitude artifact criterion in the EOGV channel was set to  $\pm 500 \mu V$ .

### References

[1] Jackson, P.L., Decety, J. (2004) Motor cognition: a new paradigm to study self-other interactions. *Current Opinion in Neurobiology*, 14, 259-263.  
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[3] Ruby, P., Sirigu, A., Decety, J. (2002) Distinct areas in parietal cortex involved in long-term and short-term action planning: a PET investigation. *Cortex*, 38, 321-339.

[4] Stockwell, R.G., Mansinha, L., Lowe, R.P. (1996) Localization of the complex spectrum: The S transform. *IEEE Trans. Signal Processing*, 44 (4), 998-1001.  
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