Imaging the Mobile Brain

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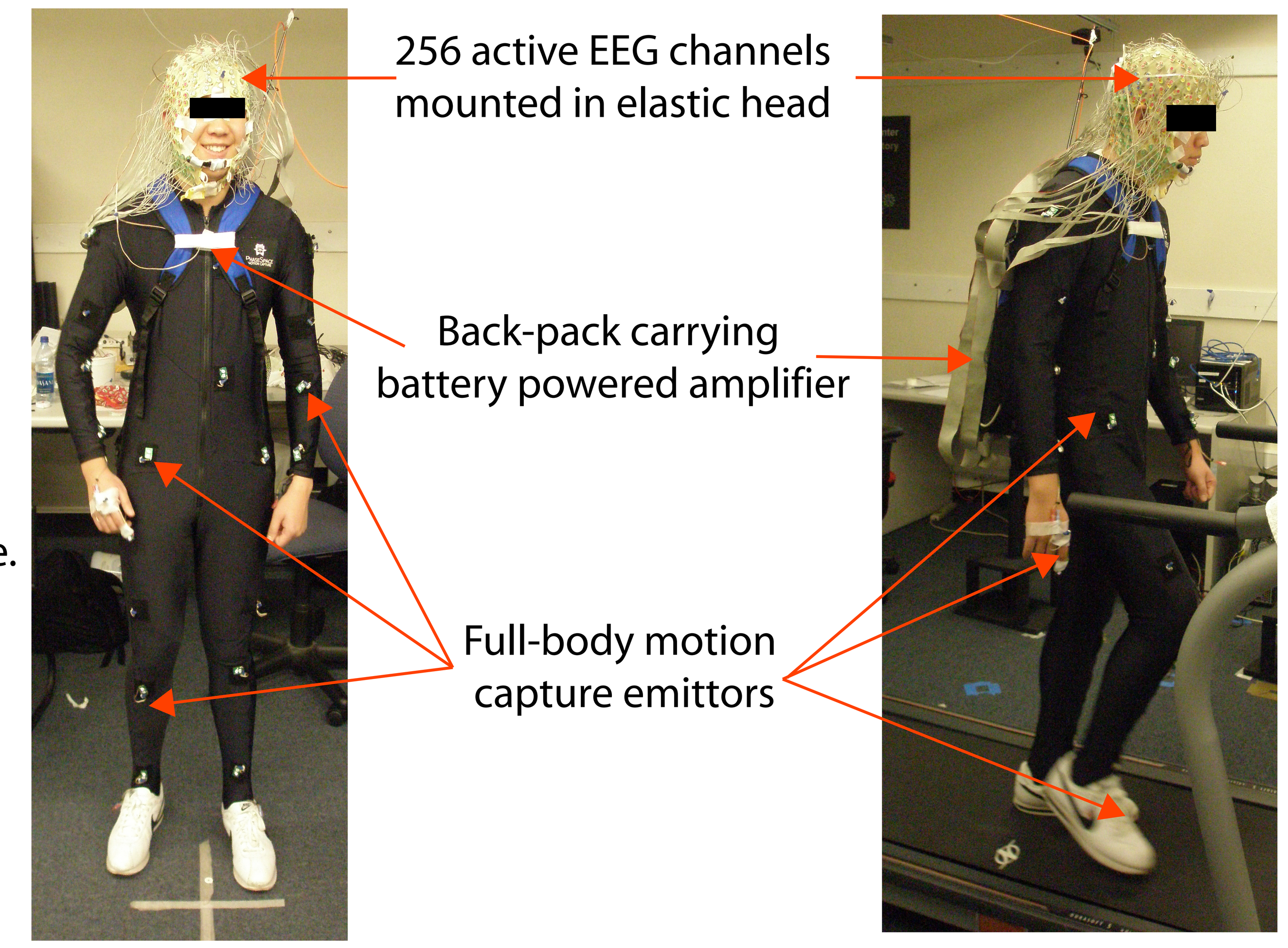
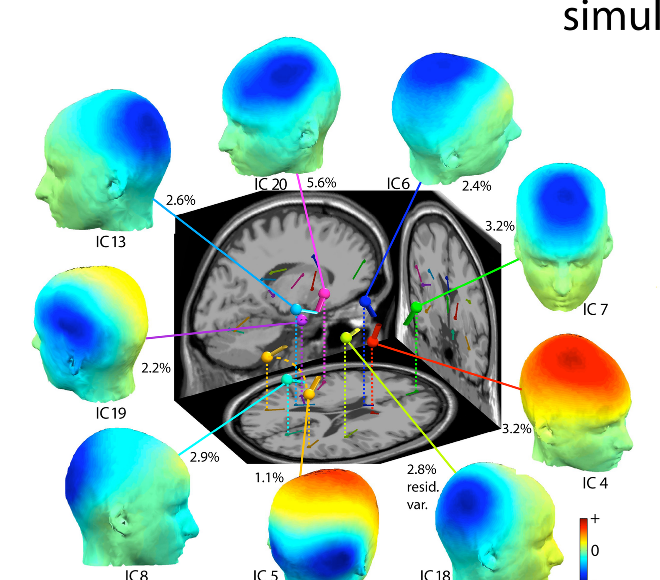
Traditional Brain Imaging of 'Passive Cognition'

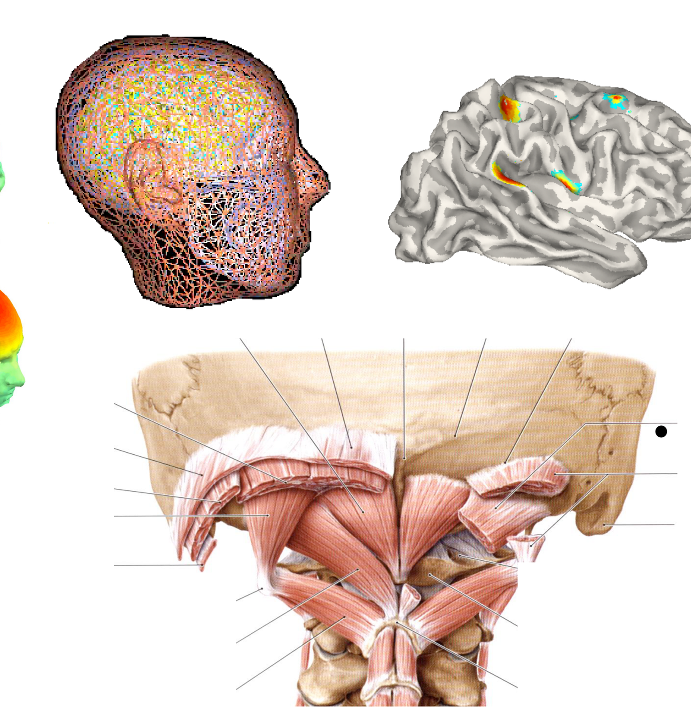
- The primary purpose of perception and cognition is to control our behavior in an ever changing environment. Moreover, sensory input accompanying motor behavior is directly used for cognitive ends, e.g.
  - vestibular information on head/body rotations leads to an automatic updating of egocentric bearing and allocentric heading representation (Farell & Robertson, 1998 JEP:HPP).
- Thus, imaging the brain dynamics subserving cognitive processes controlling our behavior will give valuable insights into the human cognitive architecture.
- However, traditional imaging methods such as fMRI, PET, and EEG/MEG record complex brain dynamics associated with only minimal behavior (button presses) for fear of introducing artifacts.
- Besides EEG, sensors of traditional imaging approaches are too heavy to follow subject movements.



Mobile Brain/Body Imaging (MoBI) Records Embodied Cognition

- We developed a software architecture(Data River) that allows synchronous recordings of multiple brain and behavioral data-streams by multiple network processors and realtime processing with simultaneous generation and control of one or more streams of stimulus generation.

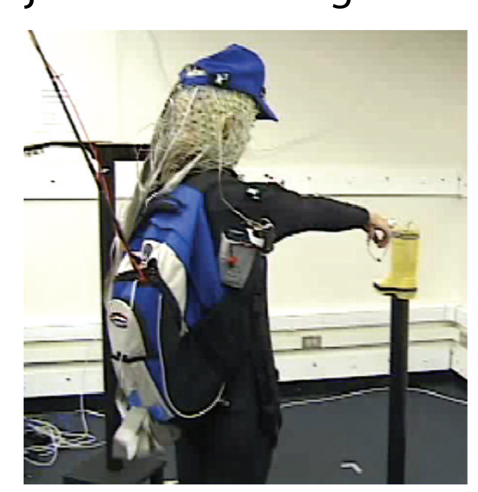


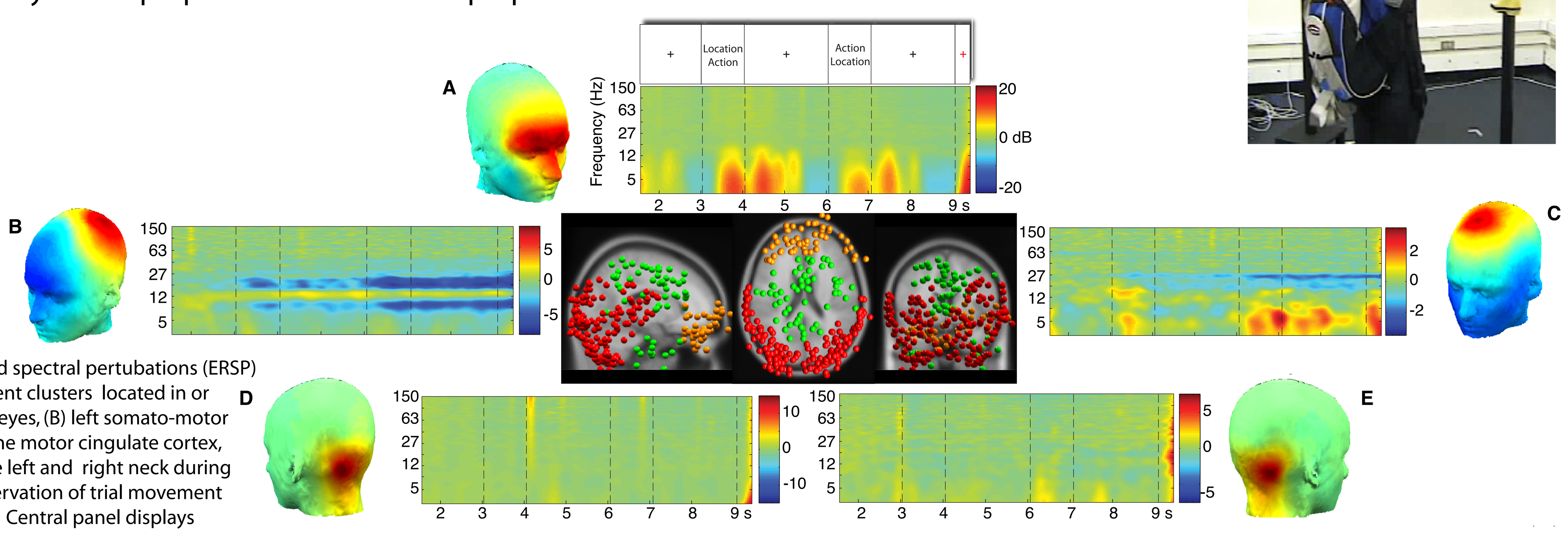


- MOBI includes a 64-256 channel Biosemi Active II EEG system and a PhaseSpace motion capture system with up to 50 sensors.
- EEG is recorded with SR of 512 Hz, motion capture with a SR of 480 Hz.
- Further hardware and recording modalities (e.g., eye movements, ECG) will be included in the near future.
- A dry wireless EEG sensor system is under deveopment.

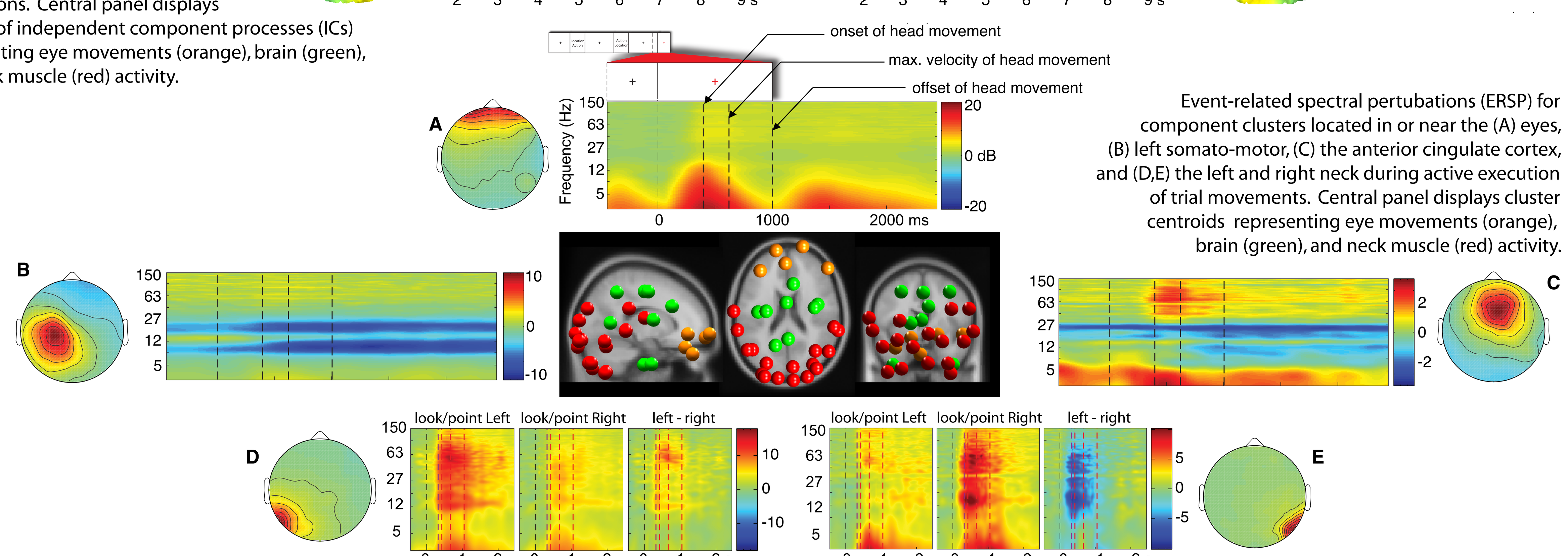
Imaging Mobile Cognition

- In a first experiment we investigated the brain and body dynamics while subjects oriented towards objects surrounding them in space (6 objects centered around a LCD monitor displaying instructions).
- Participants received delayed complementary action/location instructions (which object to orient to and which kind of orienting movement) and had to look to, point to, or walk towards and subsequently point to 1 out 6 objects.
- This way action preparation and location preparation can be dissociated.





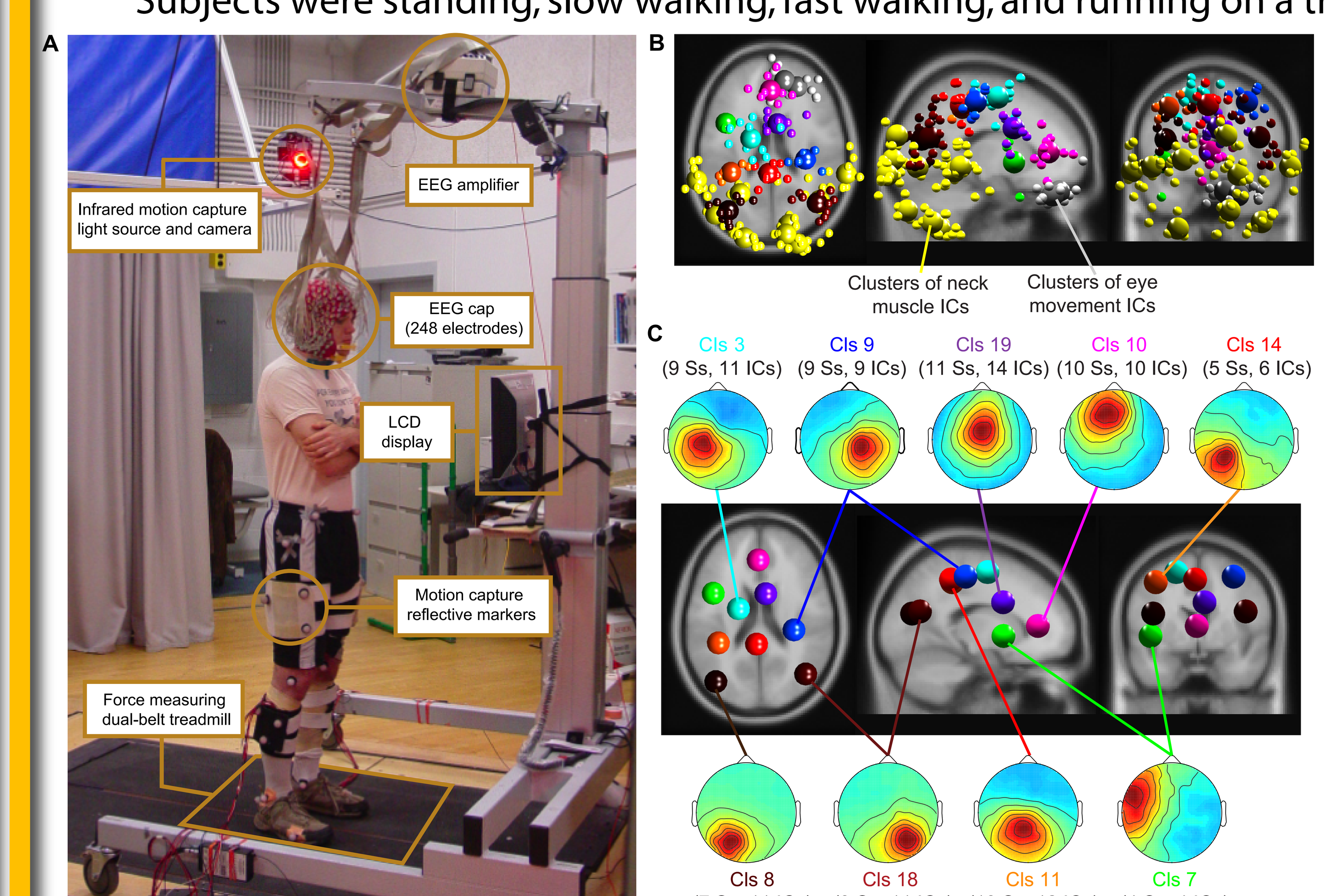
Event-related spectral pertubations (ERSP) for component clusters located in or near the (A) eyes, (B) left somato-motor cortex, (C) the motor cingulate cortex, and (D,E) the left and right neck during passive observation of trial movement instructions. Central panel displays clusters of independent component processes (ICs) representing eye movements (orange), brain (green), and neck muscle (red) activity.



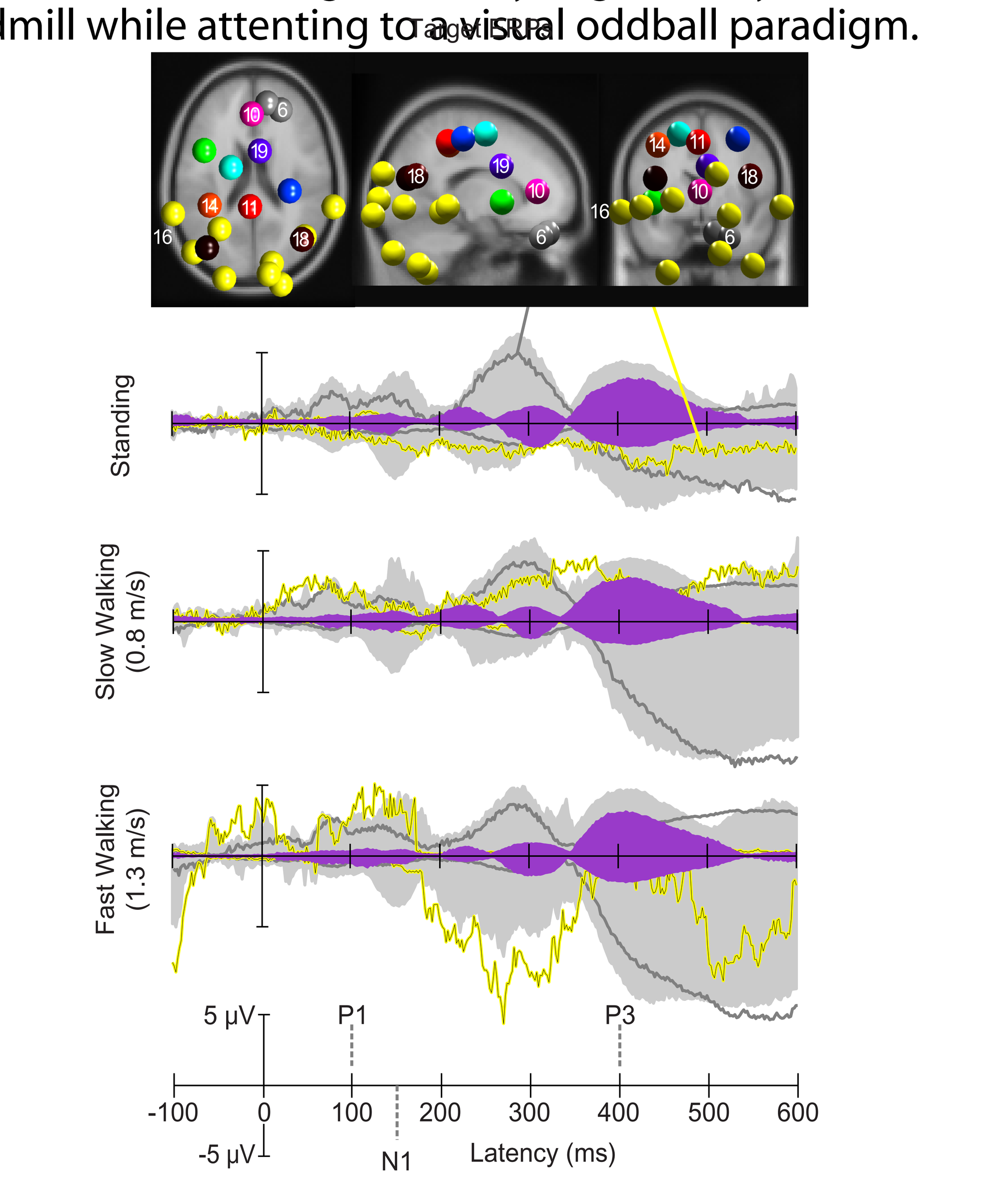
Event-related spectral pertubations (ERSP) for component clusters located in or near the (A) eyes, (B) left somato-motor, (C) the anterior cingulate cortex, and (D,E) the left and right neck during active execution of trial movements. Central panel displays cluster centroids representing eye movements (orange), brain (green), and neck muscle (red) activity.

Testing the Limits of MoBI

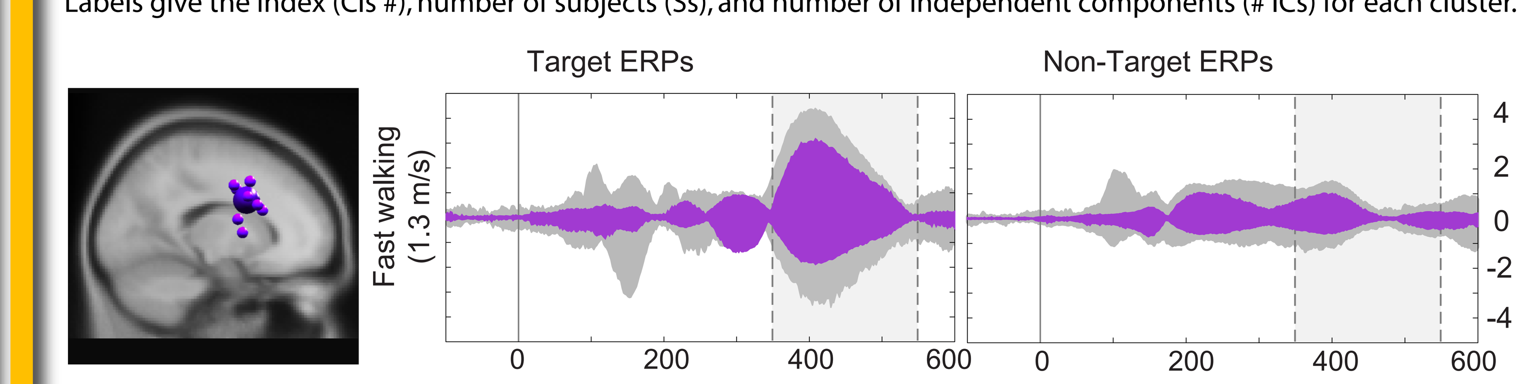
- In a feasibility study we investigated the range of movements that would allow for recording and analyzing brain dynamics. Subjects were standing, slow walking, fast walking, and running on a treadmill while attenting to a visual oddball paradigm.



(A) Experimental setup: subject standing on the dual-belt treadmill facing the LCD display. Components of the experimental setup are highlighted and described in the linked text boxes. (B) Equivalent-dipole locations of independent component (IC) processes (small spheres) and IC cluster centroids (large spheres) projected on horizontal, sagittal, and coronal views of the standard MNI brain. (yellow) Neck-muscle ICs; (grey) eye-movement ICs; (other colors) brain-based ICs. (C) (Scalp maps) Mean projections to the scalp of the indicated brain-based IC clusters. Labels give the index (Cls #), number of subjects (Ss), and number of independent components (# ICs) for each cluster.



Centroids of IC clusters (colored spheres) visualized in the MNI brain volume in horizontal, sagittal, and coronal views. Grey and yellow spheres represent eye and neck muscle activity clusters, respectively. Other-colored spheres mark centroids of brain IC clusters. Traces display grand-mean ERP envelopes (maximum and minimum channel ERP values at each latency) summing back-projections of all IC clusters (light grey areas), envelopes of one representative neck muscle cluster (Cluster 16, yellow traces) and a representative eye movement cluster (Cluster 6, dark grey traces). Filled purple envelopes show the back-projected contribution of one IC cluster (19) with equivalent dipoles in or near cingulate cortex. Left column: visual target stimulus responses in the three movement conditions.



(A) Centroid (bigger sphere) and individual ICs of the IC cluster (19) contributing most strongly to the P3 peak. This cluster comprised 13 ICs from 11 subjects (here displayed as smaller spheres) in or near anterior cingulate cortex (BA32, here shown in the standard MNI brain volume). (B) Target and non-target stimulus ERPs (middle and right columns) in the (dashed/shaded) P3 latency range. Grey-shaded 'ERP envelopes' enclose the bundle of spatially-filtered scalp channel ERP values. Magenta-filled envelopes enclose the ERP contributions to the scalp channel data