Auditory target detection in real life settings: insights from mobile electroencephalography (EEG) recordings

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Background

Brain dynamics operate differently during movement than when stationary [1]. EEG measures have identified brain areas associated with the cognitive control of gait [2-8], which overlap those associated with executive functions [9,10]. While gait control is largely automated [11], the level of cortical control engaged to produce movement has variable effects on motor ERPs [12]. Mobile EEG assessment of auditory target detection processes when seated and walking in real-life settings found **attenuated attentional responses during walking** with a counting task that suggests depleted availability of attentional resources [13,14].

In appraisal of this, we examined the effect of **environment** (indoors/outdoors) and **action** (seated/walking) on auditory target detection using two response tasks: **1. Button press** (motor process), **2. Counting** (cognitive process)

We hypothesised that :

I. Executive processes monitoring the motor system during walking will be further **loaded by selection of a within-modality response** (button press), and result in **greater attenuation** of attentional processing abilities than a modality-independent response (counting).

II. Environmental effects would be greater when **counting**, and **action** effects greater with a **button press**.

Method

Three tone auditory oddball task

- 900Hz standard (72% probability) 600Hz distractor, 1200Hz target (each 14% probability).
- Binaural earphone presentation

Exp 1: **Press button to acknowledge target (motor response)**

Exp 2: **Count target tones (cognitive response)**

Four conditions (repeated measures, randomised):

1. **Indoor seated**
2. **Indoor walking**
3. **Outdoor seated**
4. **Outdoor walking**

Participants:

Exp 1: N = 18, 15 F, mean 21.78 years , 16 right handed

Exp 2: N = 16, 10 F, mean 19.94 years , 13 right handed

EEG recording:

14 Ag/AgCl electrodes (10-20 system) Bluetooth enabled adapted Emotive amplifier (49x44x25 mm, 48g),

128 Hz sampling rate, 0.16-45 Hz band-pass filter

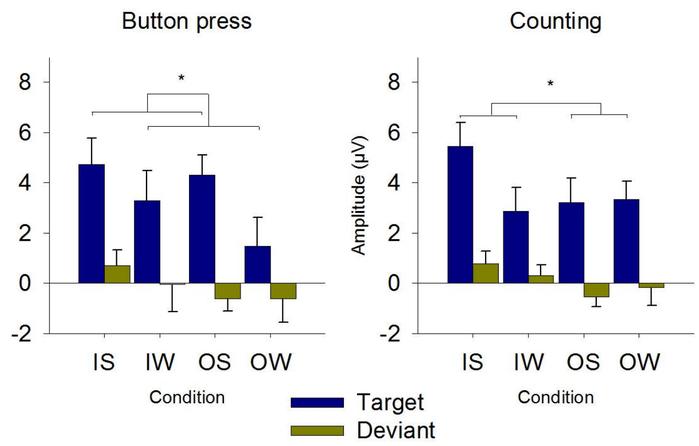
Acquired via small laptop (Toshiba Portege Z830-10N, 316x227x8.3 mm, 1.12kg) running OpenViBE software

Data processing:

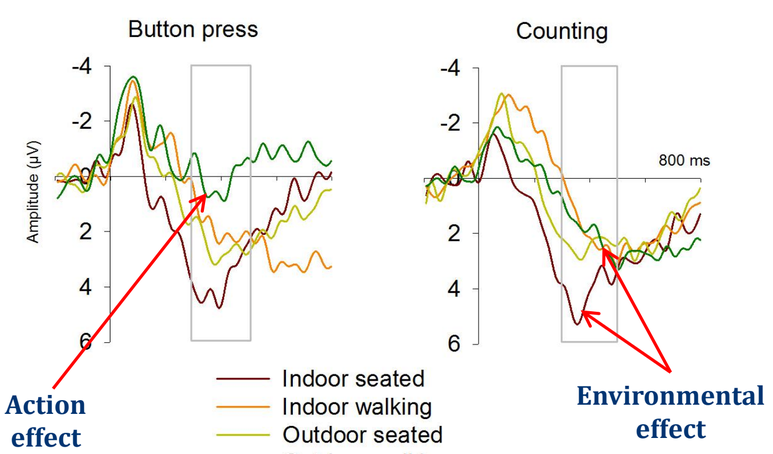
- ICA to attenuate eye blinks only
- 20Hz low pass filtered
- Epochs extracted -200ms-800ms around each stimulus onset, baseline corrected and averaged together
- Peak surrounding means (86ms) for each stimulus in each condition calculated for P3 ERPs and analysed in ANOVA

Are there variable **environmental/action** effects from **response modality** on attentional processes as measured by the P3 ERP component for auditory target detection in real-life settings?

Peak mean amplitudes for stimulus tones in each condition 300-500 ms at Pz



ERPs to target tone stimuli in each condition



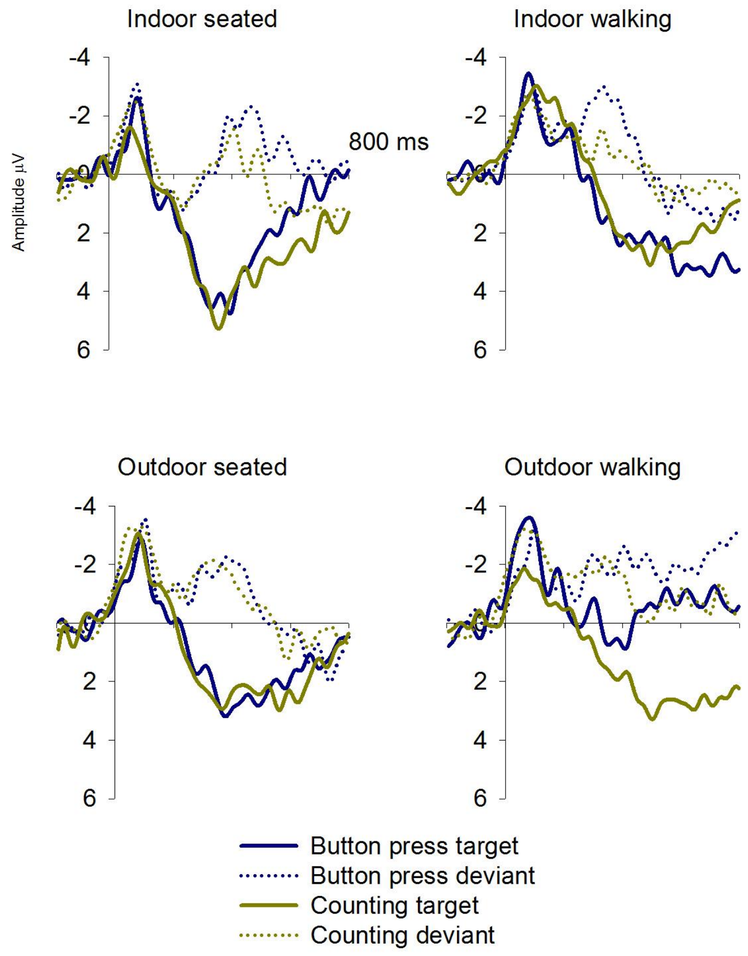
Yes.

Environmental: Reduced and comparable attentional effects out with indoors seated condition when using a counting response.

Action: Walking attenuates attentional effects when using a button press response.

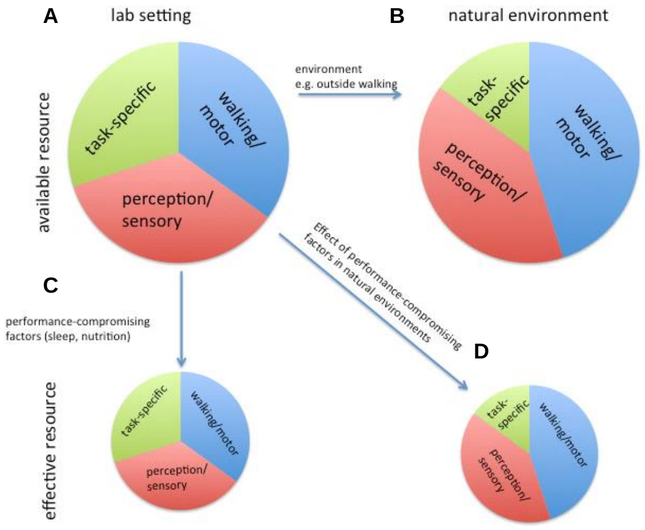
Increase in perceptual and motor demands out with the 'laboratory-like' indoors seated condition results in a **cost of task on the processing** of auditory stimuli.

Target and deviant ERPs by condition for button press and counting tasks



Discussion

The resulting difference in patterns of attentional allocation across tasks is inline with a dynamic resource allocation model which predicts that the **cognitive processes normally employed** are **differentially allocated** when perceptual and motor demands are multi-level and multi-sensory (i.e. involving the whole body movement control and all-sense perception).



Conclusion

A cognitive response (counting) resulted in global reduction of attentional resources available when perceptual stimulations are increased, independently of walking behaviour.

A motor response (button press) resulted in specific attenuation of attentional resource availability during walking, and more so when walking behaviour takes place outdoors.

Active locomotion requires executive function involvement. A model of dynamic resource allocation may help explain future studies of cognition in natural settings.

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