Perceptual load effects on pre-attentive processing in everyday activities: mismatch negativity (MMN) assessment using mobile electroencephalography (EEG)

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Background

Attenuated ERPs indexing attentional selection have been found during natural walking in comparison to seated conditions [1,2], suggesting resources available to attentional focus are reduced when walking. However, several walking studies carried out on a treadmill have found no modulation in ERPs [3,4]. The ERP attenuation found in natural studies may not be attributable to walking alone. **Perceptual load theory** [5,6], suggests that this discrepancy may be a consequence of greater perceptual load induced by naturalistic surroundings (e.g. attentional resources dedicated to a task varies dependent on the volume of competing stimuli). Working under the assumption that low task loads will result in low attentional allocation and high task loads will result in high attentional allocation, we examined the mismatch negativity (MMN) (an ERP component signalling pre-attentive capture) in typical daily activities in natural settings in three typical postures; **Seated**, **Standing** and **Walking** during two tasks, (1) **active distraction** (goal-oriented), and (2) **passive distraction** (no-goal).

We predicted that with increased perceptual load, there would be greater capacity for attentional capture reflected in the magnitude of the MMN.

Method

Task:
Ignore two-tone oddball (deviant, 16%, standard 84 % presented through headphones)

Exp 1: Active distraction
Goal oriented: beat score on app game, reading and comprehension, count footsteps and navigation

Exp 2: Passive distraction
watch video/observe surroundings

3 Conditions
SEATED, STANDING & WALKING

Participants:
Exp 1 **ACTIVE**: N = 12, 6 F, *M* = 21.9 years; Exp 2 **PASSIVE**: N = 12, 9 F, *M* = 23.5 years

EEG recording:
24 Ag/AgCl electrodes (10-20 system) Bluetooth enabled SMARTING amplifier (82 x 51 x 12 mm, 50g), 500 Hz sampling rate, 0 - 250 Hz band-pass filter

Acquired via small laptop (Toshiba Portege Z830-10N, 316 x 227 x 8.3 mm, 1.12kg) running Presentation® software and LSL

Data processing:
- Epochs extracted -200ms-600ms around each stimulus onset, baseline corrected and averaged together
- 40 ms MMN mean peak from electrode Fz extracted for each stimulus in each condition and analysed in condition X experiment ANOVA

Do increased perceptual loads modulate the MMN component in everyday tasks due to the involvement of executive control?

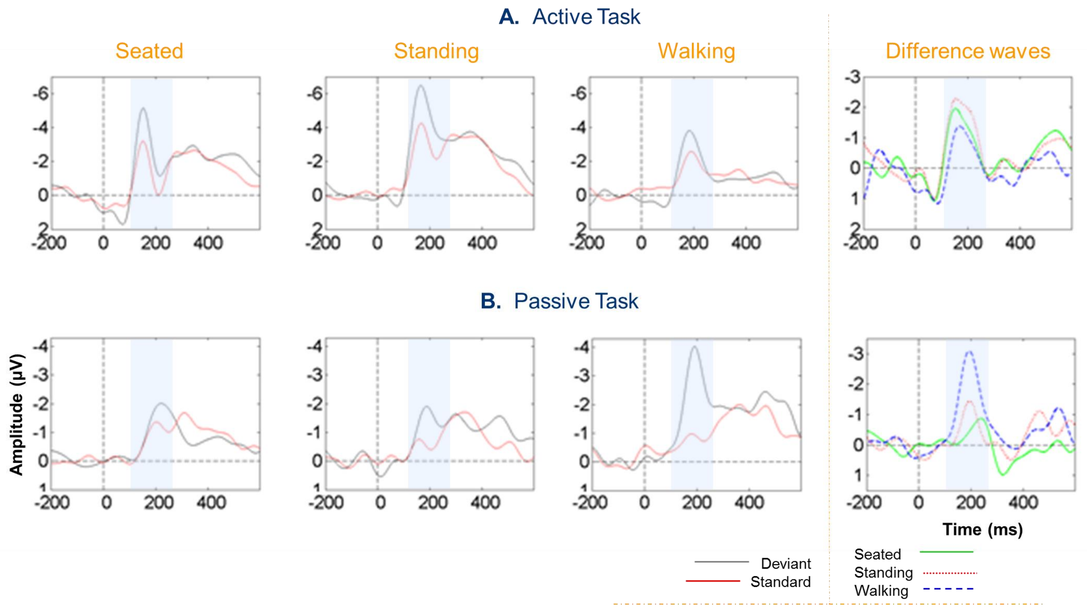
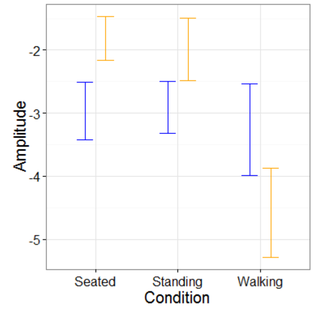


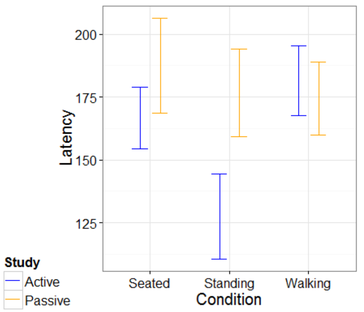
Figure 1. ERPs to deviant and standard stimuli in each conditions, and difference waves isolating the MMN (highlighted in grey). **A.** Active task, walking amplitudes are attenuated in comparison to seated and standing conditions but MMN amplitudes are similar. **B.** Passive task, seated and standing amplitudes are attenuated in compassing to walking conditions, with MMN resultantly larger.

Yes
The MMN varies dependent on task (active or passive) and condition (seated standing and walking)

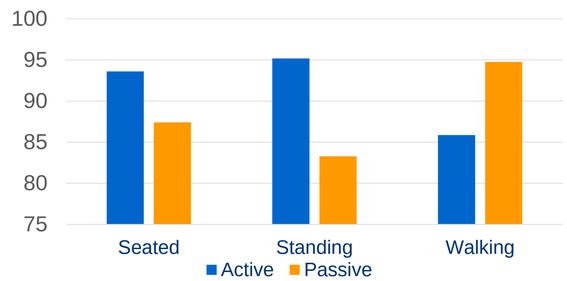
- **A & B. ERPs** show different presentation in each task in each experiment.
- **C. MMN amplitudes** calculated in the active task (blue) show little variation. Passive amplitudes (orange) are similar in the seated and standing conditions, and are increased in the walking conditions.
- **D. MMN latency** is similar across conditions in the passive task, and more variable in the active experiment. Overall, latencies are later in the passive task.
- **E. Estimated resources available** for attentional capture in each condition in each experiment. A certain level of distraction increases pre-attentive orienting, but, too much causes reduction (e.g. walking during active distraction).



C. MMN amplitudes (*SE*)



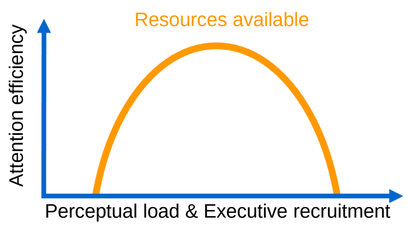
D. MMN latency (*SE*)



E. Estimated % of attentional capture (illustration based on normalised data)

Discussion

For seated and standing conditions, MMN amplitudes are smaller in the passive task in comparison to the active task, thus supporting the concept that under increased perceptual loads (goal-oriented active task), the pre-attentive processes (indexed by the MMN) are enhanced. This suggests that under passive, low perceptual conditions where executive resource requirements are minimal, attentional function is less efficient (as predicted by perceptual load theory), evidenced by reduced amplitudes and later latencies in comparison to the active task. **Increasing perceptual loads by walking in natural settings increased pre-attentive processing in the passive task. But, further increasing the perceptual load in this same condition by performing a goal-oriented task resulted in attenuated resource availability.** This suggest that attentional resource allocation functions like an inverted U (**F**). With increased executive engagement (stimulated by perceptual loads) functional attention resources increases to maximal efficiency before decreasing with increased demands.



F. Model of attentional function in natural settings

Conclusion

MMN presentation differs under active and passive distraction tasks, and under different postures (seated, standing and walking).

Variable ERPs found in natural settings are not necessarily a result of competition with the motor system (e.g. walking), but may be due to interacting effects from perceptual loads.

Effectively managing perceptual loads requires differing degrees of executive resources, depending on tasks demands.

Attention-related processes may be more efficient with increased loads, but are subject to limits on resource availability.

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