AN ERP APPROACH TO MEASURING MIND WANDERING DURING LEARNING MULTIMEDIA USE

Colin Conrad and Aaron Newman | NeuroCognitive Imaging Lab | Dalhousie University | Halifax, Canada | Colin.Conrad@dal.ca

BACKGROUND

There is growing awareness that interactive learning technologies can be improved by incorporating user context. For example, research by Wammes and Smilek (2017) suggest that decreased mind wandering could lead to better educational outcomes. Ideally, we could identify mind wandering in real time, as it happens. Event-related brain potentials (ERPs) allow us to measure indices of attention without the conscious intervention of the individual, and so are a good candidate for measuring mind wandering.

In two experiments we examined event-related potentials (ERPs) in response to task-irrelevant tones, while people watched e-learning videos. In both experiments, the amplitudes of early sensory components (P1, N1, P2, P3) were modulated during periods of self-reported mind wandering. These studies lay the foundation of a ERP protocol that can be used to measure mind wandering in learning technology contexts.

Research Objective: Identify event-related potential correlates of mind wandering and on-task states during e-learning use.

STUDY 1 DESIGN

16 participants (7 female; age 19-29 years, mean 23.6) were recruited to watch a 51-minute video while having EEG recorded from 32 electrodes (ActiCap, BrainProducts Gmbh, Munich, Germany & ANT-Neuro amplifier, The Netherlands).

Throughout the video, auditory stimuli were presented at randomized intervals (m= 1.25s +/-0.25s) at either 500 Hz (80% of trials) or 1000 Hz (20% of trials). Participants were told to ignore these and pay attention to the video. They were also instructed to press a button whenever they detected themselves mind wandering.

EEG data were bandpass filtered (0.1–40 Hz), artifacts removed with ICA, and ERPs (-200–1000 ms) were extracted to each auditory stimulus occurring 10 s before, and 10 s after, each self-reported mind wandering event. Six participants' data were excluded due to having too few analyzable mind wandering reports.

ERP amplitudes in time windows corresponding to the P1, N1, P2, and P3 components were analyzed using linear mixed effects, on a region of interest including electrodes Pz, Cpz, POz, CP3, CP4, P3 and P4.

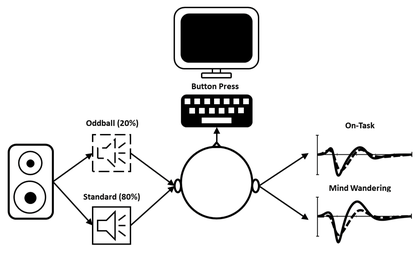


Figure 1 – An illustration of the design of Study 1. Based on Braboszcz and Derlorme (2011), participants were asked to press a button to report moments they perceived their mind starting to wander.

STUDY 1 RESULTS

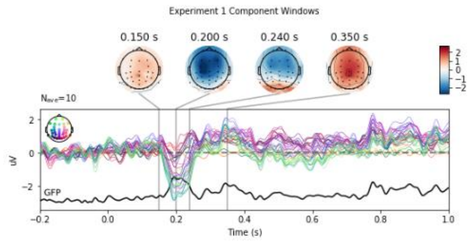


Figure 2 – A topographic illustration of the grand average of responses to oddball stimuli during reported mind wandering across all 32 channels observed in Study 1. Grand average waveforms revealed four distinct components corresponding to P1 (125 to 175 ms), N1 (175-225 ms), P2 (225-275 ms) and P3 (275-375 ms).

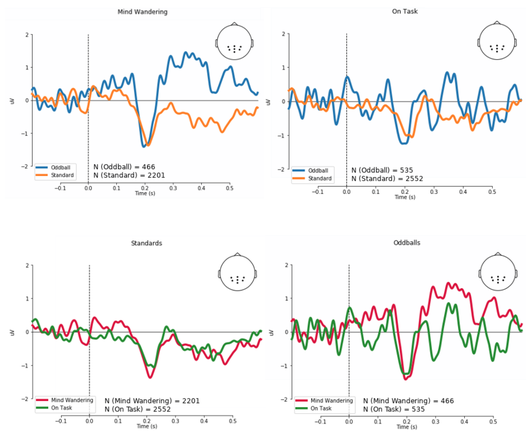
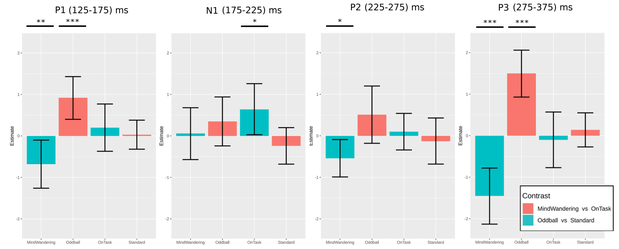


Figure 3 – Study 1 grand average waveforms in a region of interest including electrodes Pz, Cpz, Poz, CP3, CP4, and P4. Given that this was an exploratory study, component windows were selected by visual inspection.



* Significant at α = 0.05; ** Significant at α = 0.01; *** Significant at α = 0.001; N=10.

Figure 4 – Contrasts of study 1 amplitudes modelled using linear mixed effects, following Tremblay and Newman (2015). Results consist of differences between conditions with 95% confidence intervals; comparisons significantly different from the baseline are illustrated with asterisks. We observed a significant difference in P3 response to oddball stimuli during reported mind wandering and on-task states.

STUDY 2 DESIGN

52 participants (36 female; age 17-28 years, mean 20.6) were recruited to watch a 75 minute video.

Participants reported mind wandering through pseudo-random experience samples while auditory stimuli were presented at randomized intervals (m= 1.25s +/-0.25s) at either 500 Hz (80% of trials) or 1000 Hz (20% of trials).

EEG data were recorded and analyzed as in Study 1. Eight participants' data were excluded due to having too few analyzable mind wandering reports.

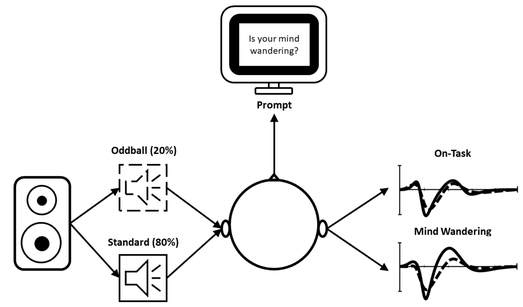


Figure 5– An illustration of the design of Study 2. Based on Wammes and Smilek (2017), participants were prompted pseudo-randomly to report whether their mind was wandering.

STUDY 2 RESULTS

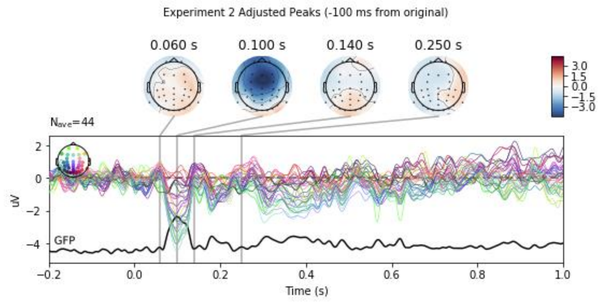


Figure 6 – A topographic illustration of the grand average of responses to oddball stimuli during reported mind wandering across all 32 channels observed in Study 2. Grand average waveforms revealed four distinct components corresponding to P1 (25 to 75 ms), N1 (75 to 125 ms), P2 (125-175 ms) and P3 (175-275 ms). Component timings occurred much earlier than expected due to a combination of differences in the experiment and corrected errors in audio timing recording.

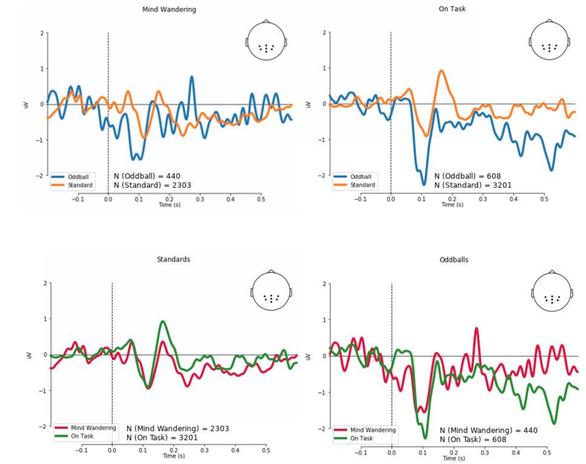


Figure 7 – Study 2 grand average waveforms in a region of interest including electrodes Pz, Cpz, Poz, CP3, CP4, and P4. We observed an absence of a P3 component, which suggests that it was an artifact of the mind wandering reporting method employed.

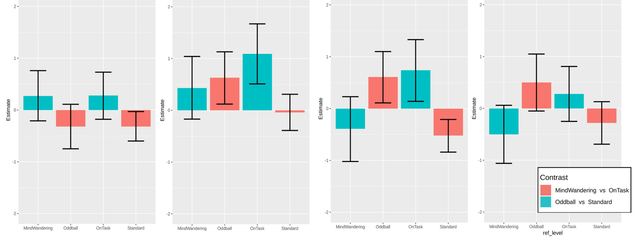


Figure 8 – Contrasts of Study 2 component amplitudes using linear mixed effects, following Tremblay and Newman (2015). Results consist of differences between conditions with 95% confidence intervals and comparisons significantly different from the baseline are illustrated with alpha values. We observed a significant difference in P2 response to standard stimuli during reported mind wandering and on-task states.

CONCLUSIONS

- Differences in P2 & P3 ERP responses to auditory tones can distinguish mind wandering from on-task states.
- The paradigm described in Study 2 might be employed as a passive measure of mind wandering during e-learning or IT use broadly.
- Future work should replicate these results in a different IT use context.

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