ABSTRACT

Neural underpinnings of walking under cognitive and sensory load: a Mobile Brain/Body Imaging approach

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Dual-task walking studies, in which individuals engage in an attentionally-demanding task while walking, have provided indirect evidence via behavioral and biomechanical measures, of the recruitment of higher-level cortical resources during gait. Additionally, recent EEG and imaging (PET, fNIRS) studies have revealed direct neurophysiological evidence of cortical contributions to steady-state walking. However, there remains a lack of knowledge regarding the underlying neural mechanisms involved in the allocation of cortical resources while walking under increased load. This dissertation presents three experiments designed to provide a greater understanding of the cortical dynamics implicated in processing load (top-down or bottom-up) during locomotion. Furthermore, we seek to investigate age-related differences in these neural pathways. These studies were conducted using an innovative EEG-based Mobile Brain/Body Imaging (MoBI) approach, combining high-density EEG, foot force sensors and 3D body motion capture as participants walked on a treadmill.

The first study employed a Go/No-Go response inhibition task to evaluate the long-term test retest reliability of two cognitively-evoked event-related potentials (ERPs), the earlier N2 and the later P3. Acceptable levels of reliability were found, according to the intraclass correlation coefficient (ICC), and these were similar across sitting and walking conditions.

Results indicate that electro-cortical signals obtained during walking are stable indices of neurophysiological function. The aim of the second study was to characterize age-related changes in gait and in the allocation of cognitive control under single vs. dual-task load. For young adults, we observed significant modulations as a result of increased task load for both gait (longer stride time) and for ERPs (decreased N2 amplitude and P3 latency). In contrast, older adults exhibited costs in the cognitive domain (reduced accuracy performance), engaged in a more stereotyped pattern of walking, and showed a general lack of ERP modulation while walking under increased load, all of which may indicate reduced flexibility in resource allocation across tasks. Finally, the third study assessed the effects of sensory (optic flow and visual perturbations) and cognitive load (Go/No-Go task) manipulations on gait and cortical neuro-oscillatory activity in young adults. While walking under increased load, participants adopted a more conservative pattern of gait by taking shorter and wider strides, with cognitive load in particular associated with reduced motor variability. Using an Independent Components Analysis (ICA) and dipole-fitting approach, neuro-oscillatory activity was then calculated from eight source-localized clusters of Independent Components (ICs). Significant modulations in average spectral power in the theta (3-7Hz), alpha (8-12Hz), beta (13-30Hz), and gamma (31-45Hz) frequency bands were observed over occipital, parietal and frontal clusters of ICs, as a function of optic flow and task load. Overall, our findings demonstrate the reliability and feasibility of the MoBI approach to assess electro-cortical activity in dual-task walking situations, and may be especially relevant to older adults who are less able to flexibly adjust to ongoing cognitive and sensory demands while walking.