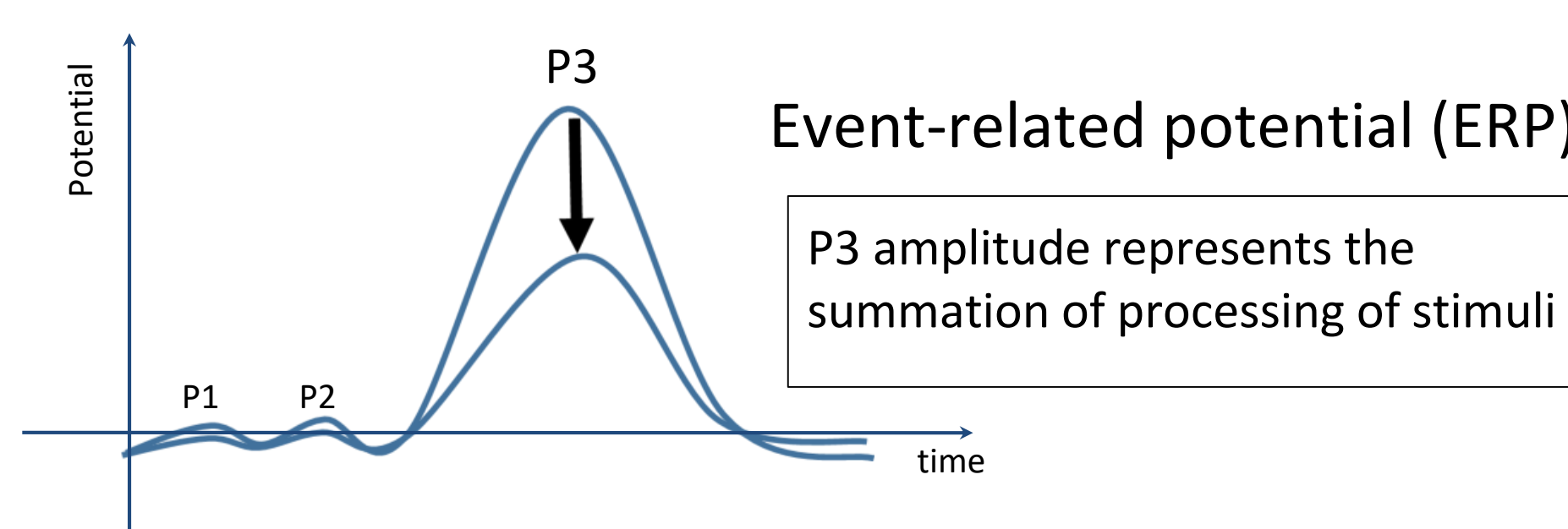


## Introduction

- **Cognitive load**, or mental effort, is important in the evaluation of assistive technologies (e.g., prostheses<sup>1,2</sup>, powered wheelchairs<sup>3</sup>).
- Prosthesis wearers experience mobility limitations that lead to:
  - Difficulty in challenging environments (e.g. uneven terrain, hills, stairs)<sup>4-7</sup>
  - Restricted walking ability<sup>8,9</sup>
  - High incidence of falls<sup>7,8,10-12</sup>
- **Cognitive load** during walking is poorly understood, and a *better understanding of cognitive load could inform prosthetic interventions*.<sup>13</sup>
- Oddball paradigms in electroencephalography (EEG) elicit event-related potentials (ERP) which provide a measure of attentional resources.
  - The **P3 event-related potential** (i.e. the 3<sup>rd</sup> positive peak in ERP) decreases and its onset is delayed as cognitive load increases, as shown in complex mobile tasks such as cycling<sup>14</sup>.



**Fig. 1** Example of a P3 peak in the ERP.

## Setup

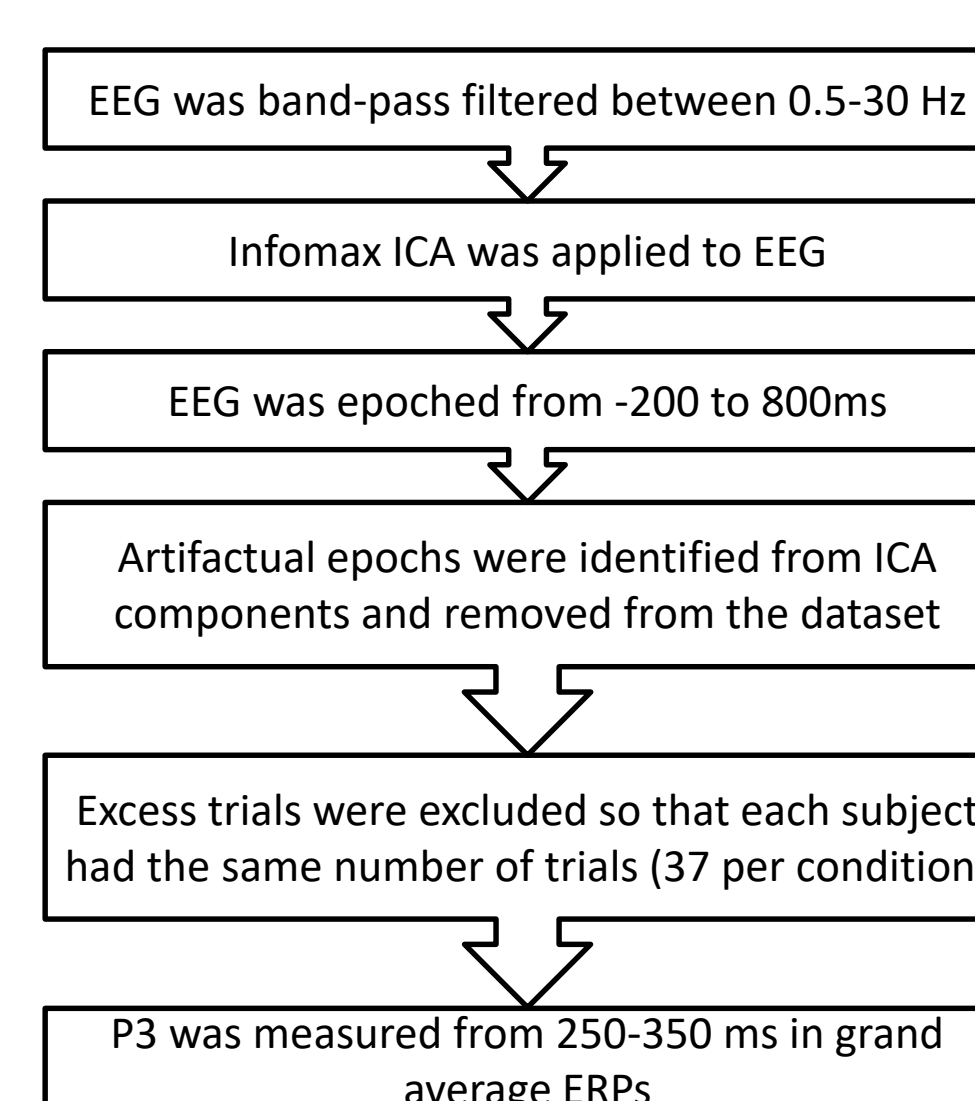


**Fig. 2** EEG electrode placement used in the DSI-7 (left) and participant during treadmill walking (right).

## Procedure

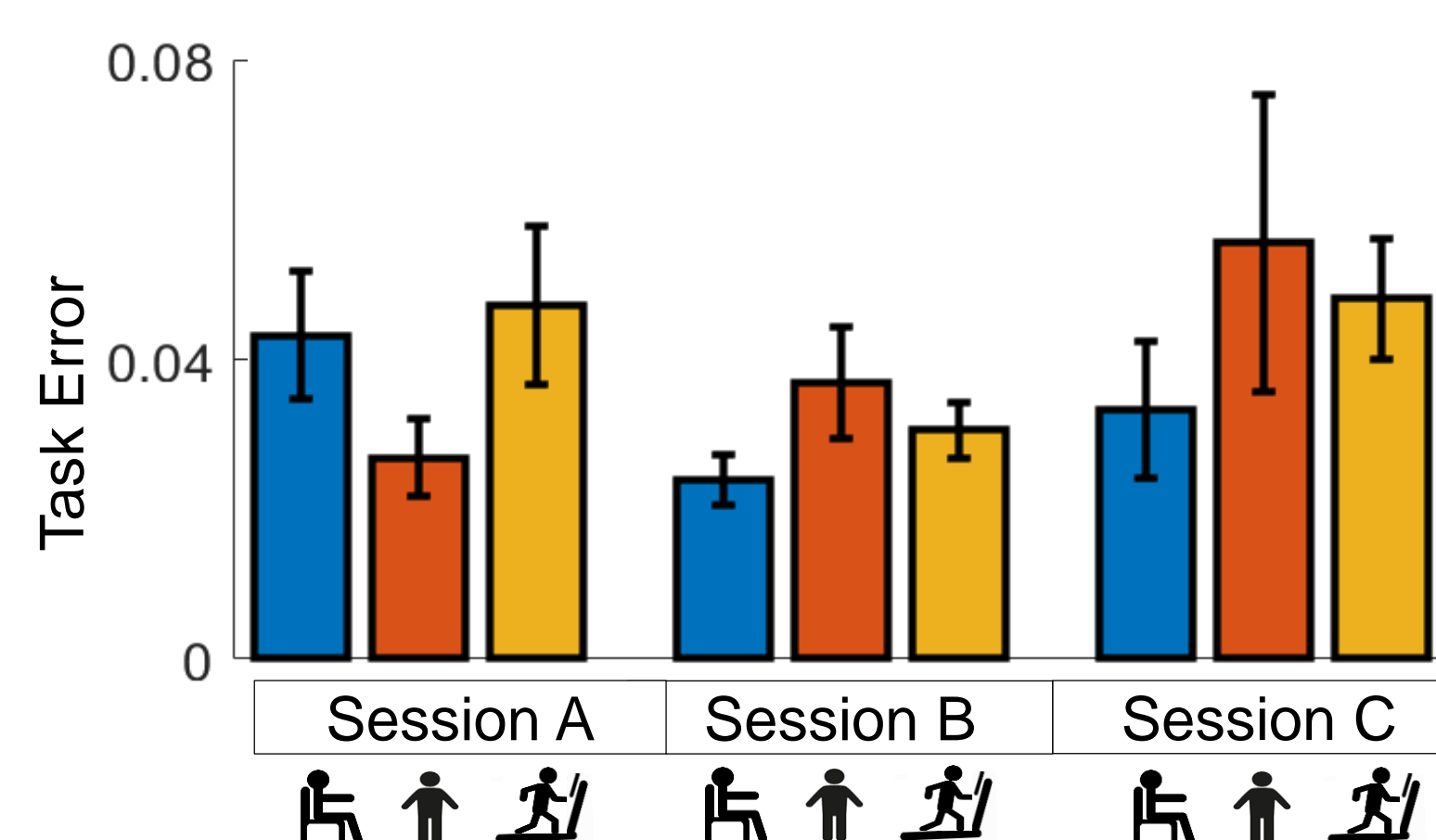
- EEG collected via a 7-channel dry EEG (DSI-7, Wearable Sensing) from 10 participants ( $22 \pm 3$  years), in accordance with Northwestern IRB. One subject was excluded from the analysis due to cardioballistic artifacts in the EEG ( $N = 9$ ).
- **Auditory stimuli** included 10% oddball tones (1200 Hz) and 90% standard tones (900 Hz) in approx. 1-sec intervals (675-1365 ms).
- **P3 amplitude** was measured from ERP to determine the cognitive load at each timepoint<sup>15,16</sup>

## EEG Processing Pipeline

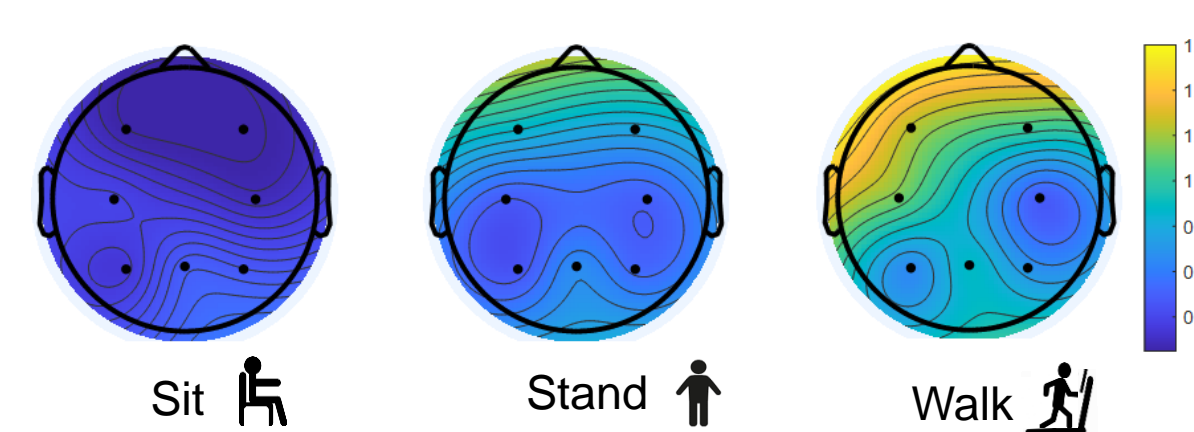


## Results

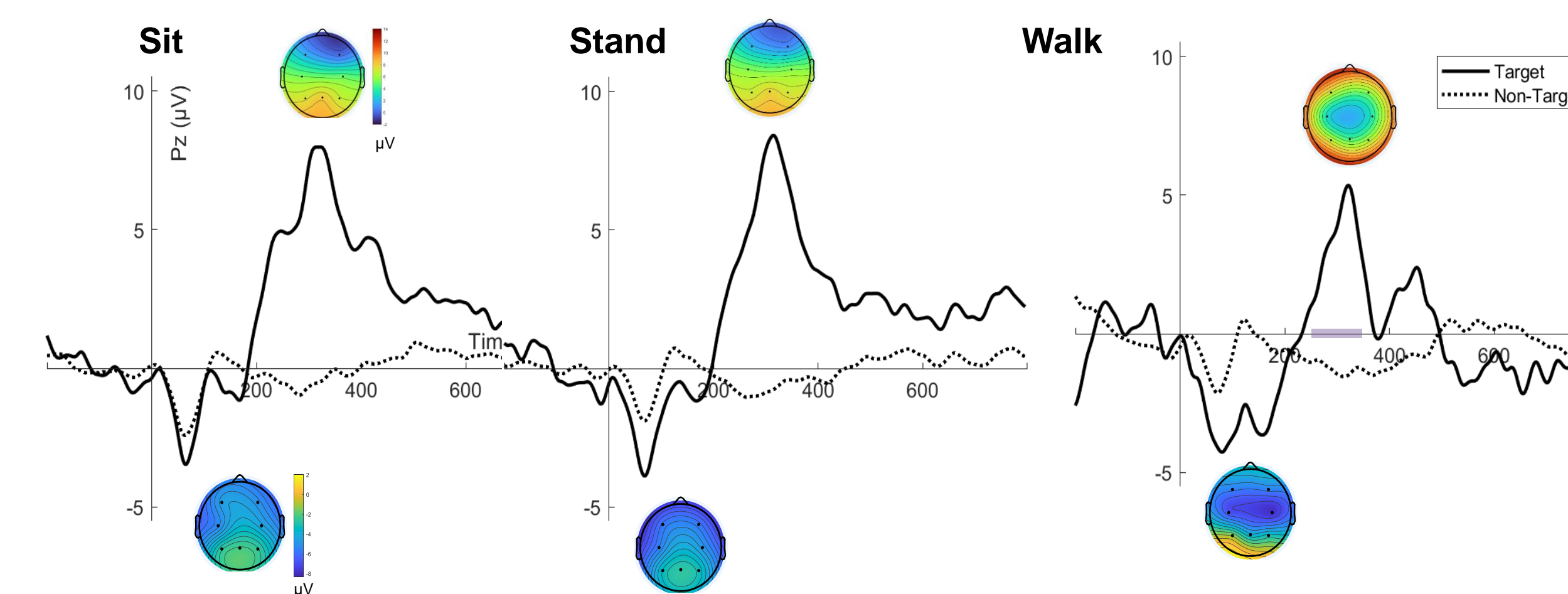
Dry-EEG measurement of cognitive load during sitting, standing, and walking was not correlated with head motion.



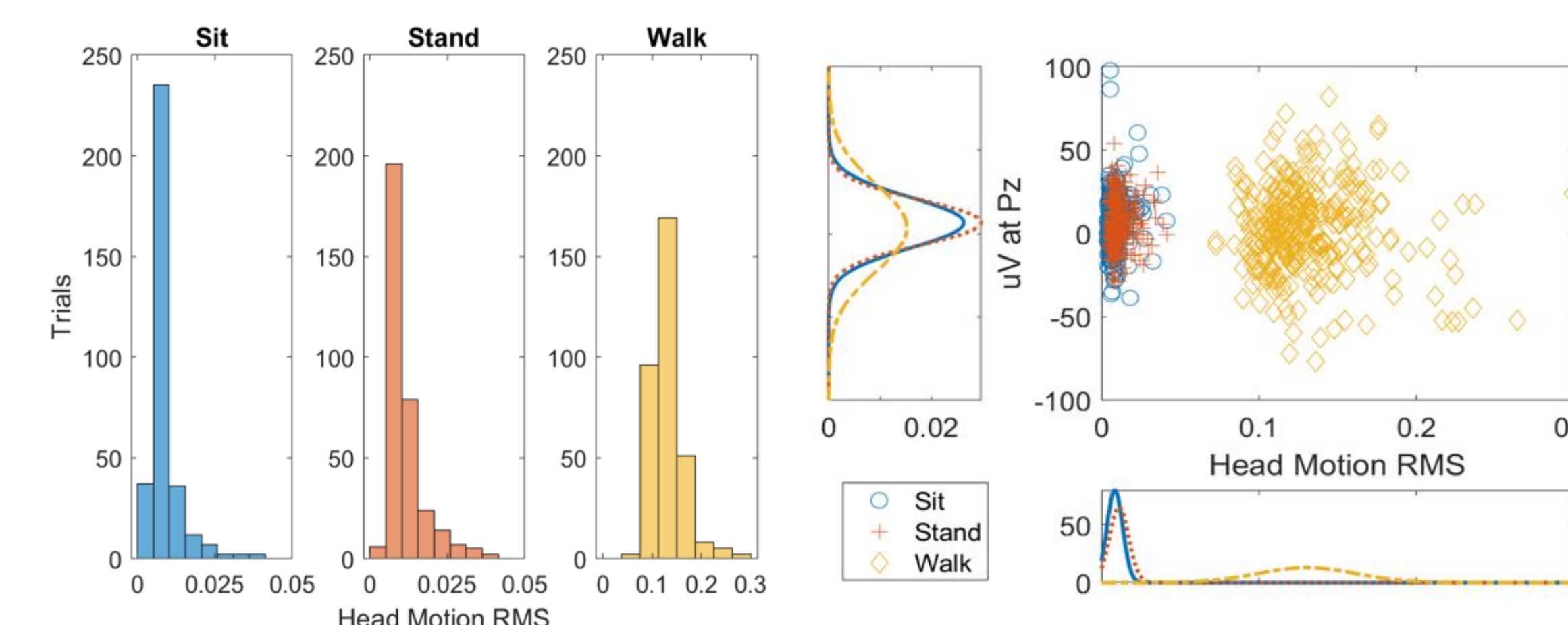
**Fig. 3** Task error was not significantly different across condition or session.



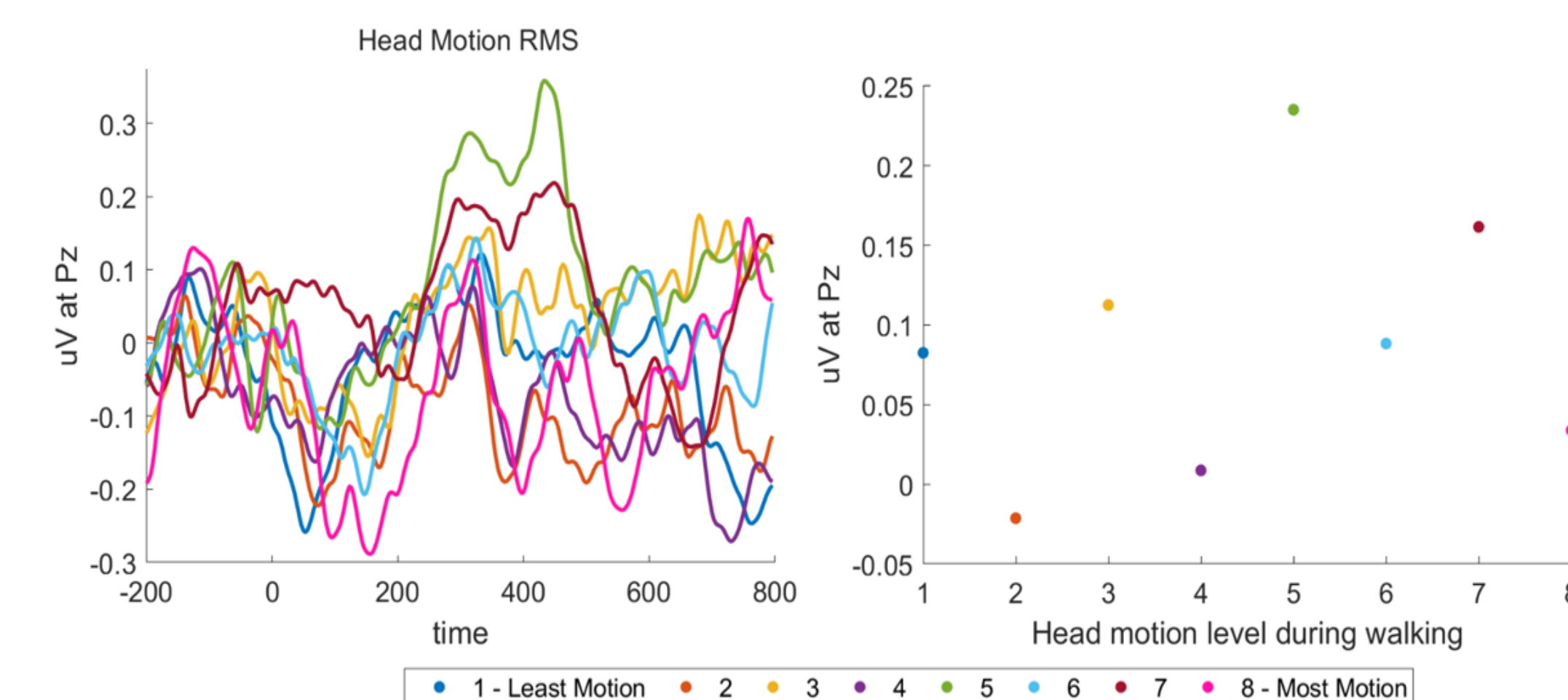
**Fig. 4** Baseline EEG activity for each condition.



**Fig. 5** Grand average ERP across all sessions



**Fig. 6** (left) Accelerometer RMS magnitude. (right) Individual trials RMS plotted against P3 with Gaussian probability distributions along axes.



**Fig. 7** (left) Averaged ERP for each motion level during walking. (right) Mean P3 voltage plotted against motion level.

## Discussion

**Main findings:** P3 amplitude was lowest during walking, indicating that walking was the most cognitively burdensome task. P3 amplitude was not correlated to head motion.

- Agreement with previous P3 during walking and sitting<sup>17-21</sup>.
- Walking had the lowest P3 amplitude, as in Protzak et al.<sup>19</sup>
- No significant difference in P3 amplitude for sitting and standing, in contrast to a dual-task study that found slower reaction times during standing compared to sitting<sup>22</sup>

## Future Work

- More difficult auditory task.
- Identify gait events that are more cognitively burdensome.

