"Imagine while you watch": The neurophysiology of combined action observation and motor imagery of a hand movement in people with Parkinson's

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Background & Aims

- Parkinson's is a neurodegenerative disease that results in debilitating movement symptoms including slowness of movement (bradykinesia), tremor and rigidity. There is no known cure for the condition
- Parkinson's is characterised by a loss of dopamine neurons in the basal ganglia, primarily in the substantia nigra (Figure 1). The gold standard treatment is dopaminergic drug therapy, but long-term use can cause unpleasant side effects

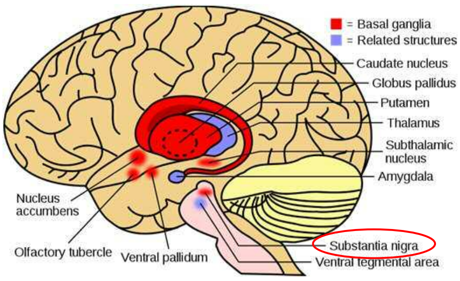


Figure 1. Depiction of the basal ganglia and related structures in the brain. The substantia nigra is circled as the key area associated with dopamine depletion in Parkinson's

- Action observation (deliberately watching movement; AO) can improve physical movement in people with Parkinson's (PwP) (Ryan et al., 2021). Emerging evidence suggests this could be further improved by combining AO with motor imagery (imagining oneself move; MI; Bek et al., 2019)
- This study aims to replicate findings of improved hand movement amplitude following combined AO and MI (AO+MI) compared to AO alone (Bek et al., 2019), as well as collect neurophysiological data to illuminate the neural processes underlying AO+MI in people with Parkinson's
- If a positive impact of AO+MI is found in Parkinson's, this could prove to be a useful accompaniment therapy to drug-based treatments

Hypotheses

EEG

1. Greater event-related desynchronisation (ERD) over the motor areas in the alpha and beta frequencies for controls compared to PwP
2. Alpha and beta ERD over the motor areas will be influenced by condition: AO+MI > MI alone > AO alone
3. Greater alpha and beta ERD over the left rostral prefrontal cortex (rPFC) during AO+MI compared to MI or AO alone
4. Greater frontal theta event-related synchronisation (ERS) during MI and AO+MI compared to AO and movement execution in controls
5. Greater frontal theta ERS in all conditions for controls compared to PwP

Behavioural

6. Greater hand amplitude for elevated trials in the AO+MI condition compared to AO or MI for both groups

Design & Measures

- 15 people with Parkinson's and 15 age-matched controls will be recruited, screened for cognitive impairment (MoCA) and imagery ability (KVIQ-10)
- EEG and motion tracking data will be simultaneously recorded during 3 X conditions: AO+MI, MI alone and AO alone (within-subjects, fully randomised)

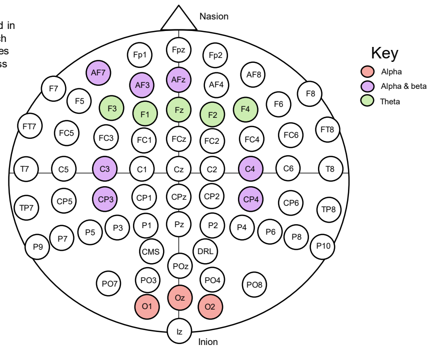
EEG Data

- Alpha and beta ERD will be recorded over the central electrodes as an indication of activation of the motor/premotor cortices (Neuper & Pfurtscheller, 2010). See Figure 2
- Alpha and beta ERD will be recorded over the frontal electrodes, particularly over the left rPFC, which is thought to be involved in switching between self-other states (Burgess et al., 2007; Eaves et al., 2016)
- Theta ERS will be recorded over the frontal electrodes, which may relate to cognitive effort or movement-related inhibition (Lubbe et al., 2021; Pscherer et al., 2019)

Behavioural data

- Motion tracking of the participant's right index finger will record hand movement on x, y and z axes to calculate movement amplitude and duration

Figure 2. Depiction of the 64-electrode system that will be used in this study. The key shows at which electrodes the different frequencies of interest will be compared across conditions



Method

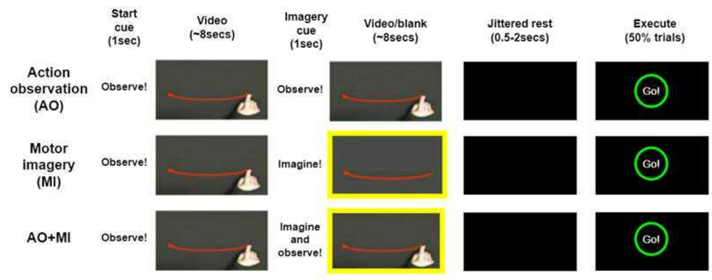


Figure 3. Main experiment procedure. Each row shows a single trial in each of the 3 conditions

- The videos will show either an elevated or direct hand movement, or a 'filler' movement to provide variability (not analysed)
- Participants will practice trials in all conditions prior to the main experiment. They will also practice engaging in imagery with detailed instructions emphasising kinaesthetic imagery (KI), which is the internal simulation of the **sensations** associated with a movement (as opposed to the visual image of a movement). This is because KI is associated more with the motor areas of the brain than visual imagery (Guillot et al., 2009)
- A baseline EEG recording will be taken when participants are at rest for comparison and to determine ERD/S

Proposed Analyses

EEG Data

- Pre-processing will include artefact removal, baseline correction and filtering (frequencies > 60Hz will be removed and mains interference will be notch filtered between 49-52Hz)
- ERD/S will be calculated as a % of power relative to each participant's baseline at the frequencies and electrodes of interest, which will be averaged across trials for each condition
- 1 X 3 ANCOVAs will be run on the above data, with each condition as a different level, and participants' KVIQ-10 scores included as a covariate

Behavioural Data

- Both peak movement amplitude (y axis; mm) and movement duration (ms) will independently be added into linear mixed models, with condition and movement type (elevated/direct) as fixed effects, and the random effect of participant included as a random intercept and slope. KVIQ-10 score will also be included as a covariate

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