MSc in Computational Cognitive Neuroscience

Goldsmiths UNIVERSITY OF LONDON

Characterising brain-body interactions underlying expert performance in video games

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Introduction & Background

Neuroplasticity and mental flexibility in gamers, along with immersive graphics that engage somatosensory and higher-order cortices, make video games a promising tool in research and therapy (1-3).

Greater post-stimulus α power attenuation correlated with faster visual information processing, specifically in gamers (4).

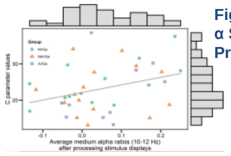

Figure 1. α Suppression Predicts Visual Speed

(Hilla et al., 2020)

During flow in shooter games, increased β-band activity in the anterior cingulate and temporal pole, aligned with better performance (5).

Early exhalation aligned with faster reaction times in sensory-cognitive paradigms (6).

Figure 2. Early Exhalation Speeds Reaction Times in Sensory Tasks

(Johannknecht & Kayser, 2022)

Rationale

While neural correlates of gaming expertise are known, the brain–body interactions, particularly respiratory-neural coupling and cardiac dynamics underlying expert performance and the flow state, remain understudied. We address this gap by integrating EEG, ECG, respiration, in-game event, and controller data in a single protocol.

Hypotheses

Gaming performance can be predicted by α/β-band dynamics.

Greater coupling between brain oscillations and bodily rhythms, along with balanced autonomic activity, predicts better gaming performance.

Greater variability in the modulation of bodily signals is associated with increased enjoyment and reaching the flow state during gameplay.

Experimental Design

Participants: 22 frequent gamers (16 men and 6 women, aged 18–31 years, each playing at least one hour per day).

Figure 3. Experimental Setup and Gameplay Environment

Measurements: Self-Report (Demographics; Body Perception Questionnaire (BPQ) (7); Video Game Experience Questionnaire; Player Experience Inventory (PEI) (8); Temporal Experience Tracing (TET) (9)• Neural data (64-channel ANT Neuro EEG at 500 Hz) • Cardiac data (standard two-lead ECG for heart rate variability) • Respiratory data (thoracic respiration belt) • In-game event logs (developer build of *Outriders* game) • Controller input logs (button presses via AntimicroX) (10)

Procedure: After consent and completion of gaming-experience and BPQ questionnaires, participants were fitted with neurophysiological sensors and instructed to breathe nasally. A 5-minute eyes-open fixation served as a baseline recording. They played for 90 minutes, aiming to reach the first raid boss, “Gauss”. Lastly, all equipment was removed and participants completed the PXI and TET questionnaires before debriefing.

Data Analysis

EEG data underwent continuous artefact rejection, ICA, band-pass filtering and denoising in EEGLAB. All neurophysiological signals were resampled to 250 Hz in FieldTrip. Respiratory-phase extraction followed Kluger et al. (2025) (12): thoracic-belt trace was z-scored, outliers removed, and missing data spline-interpolated. MATLAB’s findpeaks detected inspiratory peaks and labelled 0 rad; the minima (expiration troughs) between consecutive peaks were labelled ±π rad. Instantaneous phase was computed via linear interpolation between these anchors.

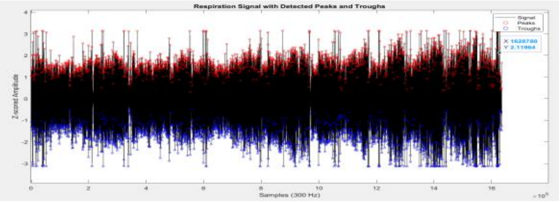

Figure 4. Cleaned Respiration Signal With Peaks and Troughs

Time-resolved EEG spectral features were extracted via short-time Fourier transform; aperiodic 1/f slope estimated using SPRiNT indexed cortical excitability (13). Slopes were phase-tagged to respiration (60 bins, $\Delta\omega = \pi/30$) to compute phase-locked modulation indices. ECG metrics (RMSSD, LF, HF, LF/HF) will be used to assess brain–autonomic coupling. Group-level effects will be tested using cluster-based permutation tests and linear mixed-effects models, with predictors including α/β-band and cardiorespiratory dynamics. Outcomes included performance (kills, deaths) and flow ratings (PXI, TET), with participant ID as a random intercept. Analyses were performed in MATLAB R2022b using EEGLAB 2023, FieldTrip 20230812, SPRiNT 1.2, and SPM12.

Preliminary Results

Preliminary analyses linked greater post-failure β suppression with faster learning and better performance. Bodily signals arousal also predicts performance variations and is positively correlated with enjoyment.

Future Directions

Implications: Findings support future interoceptive and biofeedback interventions to help athletes and video gamers break records, ADHD individuals regain focus, patients with affective disorder regulate emotions, and boost cognition in the general population.

Limitations & Next steps: Sample size, heterogeneity in gaming expertise, and the cross-sectional nature may limit generalizability. Future studies should include diverse game genres, larger and gender-balanced samples, and examine causal mechanisms through interventions such as breathing training or neurofeedback.

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