Movement-Modulation Of Local Power And Phase Amplitude Coupling In Bilateral Globus Pallidus Interna In Parkinson Disease

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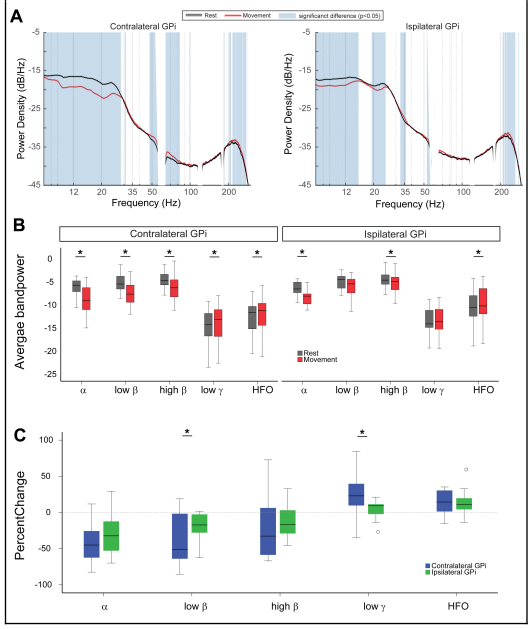
Introduction

The execution of daily manual tasks involves the coordination of bihemispheric cortical and subcortical motor areas. However, the extent and manner in which bilateral basal ganglia motor networks are coordinated for lateralized movement is unclear. While exaggerated ß (13-35 Hz) power and ß phase-encoded Phase amplitude coupling (PAC) have been implicated in the pathophysiology of Parkinson disease, there is emerging evidence that they also subserve interhemispheric motor processes for coordinating bilateral basal ganglia networks. In this study, we directly compared local beta oscillatory power and beta phase-encoded PAC within bilateral globus pallidus interna (GPi) to identify frequency-specific symmetries and asymmetries that would respectively support interhemispheric coupling and hemispheric lateralization during unilateral movement.

Methods

Bilateral GPi local field potentials (LFP) were recorded simultaneously during rest and cued left hand movement (finger tapping) in nineteen subjects with idiopathic PD, while undergoing awake deep brain stimulation (DBS) implantation. We assessed unilateral movement-related changes to pallidal ß oscillations and ß phase-encoded PAC in comparison to rest.

Fig 1. Unilateral hand movement modulates oscillatory power in bilateral GPi.

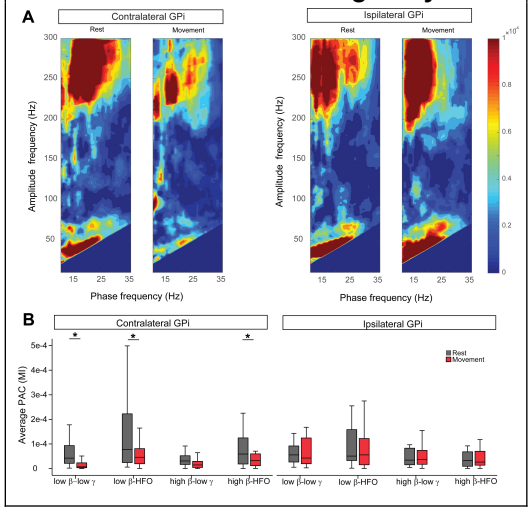


Results

With unilateral hand movement, high ß (21-35 Hz) oscillations were symmetrically attenuated in bilateral GPi while low ß (13-20 Hz) power was significantly attenuated only in the contralateral GPi (P=0.009, paired t-test). Despite these significant differences, the overall ß spectral profile were largely symmetrical between hemispheres (see Fig. 1). In comparison, marked asymmetry was observed between bilateral GPi ß phase-encoded PAC during unilateral movement behavior (see Fig. 2), with significant ß-low gamma (40-80 Hz) PAC attenuation occurring only in the contralateral GPi (P=0.004, Wilcoxon signed-rank test).

(A) Average power spectral densities across the cohort during rest (black curve) and unilateral finger tapping (red curve). Blue vertical shade indicates significant difference between resting and movement conditions as tested by two group test of spectra and corrected for multiple comparisons. (B) Comparing average power for different frequency bands between rest (gray) and movement (red). (C) Comparison of percent change in the spectral power between the two GPi ipsilateral (green) and contralateral (blue) to the moving body side ((Power during movement - Power during rest)/Power during rest ×100). In panels B and C, asterisk signs (*) indicate statistical significance of the difference between the two conditions as tested by paired t-test and corrected for multiple comparisons (P<0.05).

Figure 2. Unilateral hand movement modulates PAC only at the GPi contralateral to the moving body side.



(A) Average comodulogram (MI values) for the cohort at bilateral GPi during rest and movement conditions. (B) Comparison of average PAC values at different frequency bands during rest (gray) and movement (red) indicates significant suppression of the PAC only at the GPi contralateral to the movement side. Asterisk signs (*) indicate statistical significance of the difference between the two conditions as tested by Wilcoxon signed-rank test and corrected for multiple comparisons (P<0.05).

Conclusions

These findings indicate that ß oscillatory power and ß phase-encoded PAC subserve distinct motor operations. The high-degree of symmetry between bilateral GPi ß power with unilateral movement is most consistent with global behavior state where as lateralizing ß phase-encoded PAC, reflecting alterations in large-scale effective connectivity, more specifically represents motor behavior.

Learning Objectives

1) The symmetical expression of GPi ß power in bilateral GPi is most consistent with global behavior state.

2) Lateralization of ß phase-encoded PAC with unilateral movement behavior more specifically represents motor behavior.