

# Impaired Cortical Control of Voluntary Saccades in Parkinson Disease (PD)

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**Rationale:** Gamma range EEG is associated with cognition such as volition, perception and memory. Volitional saccades and visuospatial attention are linked. We previously reported that there is an increase of perisaccadic posterior gamma range (35-45 Hz) EEG power, temporally linked to saccade initiation. This gamma synchrony may represent realignment of visual space to the predicted saccade end-target location (Bodis-Wollner et al 2002, Forgacs et al 2008). PD patients have hypometric voluntary saccades with steps. We compared the perisaccadic scalp EEG in PD from healthy subjects (HS). Each perisaccadic EEG window comprised of a pre- (500 ms), intra- (saccade duration itself) and a postsaccadic (500 ms) EEG time segment.

## **Purpose:**

- 1\_To quantify perisaccadic gamma power over frontal and posterior-parietal (PP) scalp sites in PD and HS.
- 2\_To quantify fronto-parietal; theta-gamma and alpha-gamma phase amplitude coupling (PAC) in HS.
- 3\_To investigate inter-regional cortical gamma power correlation in PD and HS in relation to voluntary saccades.

**Method:** Perisaccadic EEG was recorded with an electro-cap over the frontal and the posterior-parietal scalp sites in 15 PD patients (55-71 years, 4 females) and 44 healthy subjects (27 young HS; 19-27 years, 6 females and 17 old HS; 54-72 years, 8 females). Saccades were recorded with electro-oculogram and infra-red ISCAN camera. Subjects executed horizontal voluntary saccades to a mark; 15 degree distance rightwards or leftwards (centrifugal CF) from the central fixation, then back to the center (centripetal CP) and so on, for 2 minutes. Perisaccadic EEG segments were wavelet transformed followed by Hilbert transformation to obtain gamma (35- 45Hz) powers for the three time windows/epochs; pre-, intra- and postsaccadic EEG. Epoch powers were trial-averaged, separately for the 4 possible saccade types; CP and CF, rightwards R and leftwards L. ISG power and gamma modulation index (GMI) variables were used for statistical analysis; where  $GMI = \text{epoch2} / (\text{avg. of epoch1 and 2})$ .

## **Results:**

- 1\_fronto-parietal analysis: GMI was higher over posterior parietal scalp sites ( $p < 0.05$ ). The power increase was absent frontally. Alpha-gamma and theta-gamma PAC was present fronto-parietally in HS.
- 2\_lateralization with saccade direction: GMI difference between L and R directed saccade movements existed over posterior parietal sites (left PP  $p=0.001$  and right PP  $p=0.004$ ), not frontally. We labeled it as lateralization with saccade direction. Lateralization was absent in PD (left PP  $p=0.3546$  and right PP  $p=0.2901$ ). Both GMI and fronto-parietal PAC lateralized with saccade direction in HS.
- 3\_inter-regional ISG power correlation: Correlation between frontal and posterior parietal ISG power are higher in PD (correlation coefficient  $> 0.06$ ) while low in age matched older HS (correlation coefficient  $< 0.02$ ).

**Discussion:** Posterior parietal ISG power is reduced in PD (Javaid et al 2010) patients who had hypometric saccades with steps. Bold activity in the perisaccadic frontal eye field is hypoactive in PD (Rieger et al 2008). Fronto-parietal phaseamplitude coupling could relay voluntary saccade related corollary information to posterior brain. We interpret high fronto-posterior power correlation as lack of modulatory coupling between frontal and posterior parietal intrasaccadic mechanisms in PD. Potentially impaired fronto-parietal PAC may underlie impaired cortical control of voluntary saccades in PD.