Dopaminergic medication and the ERN in Parkinson's disease

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SUMMARY

A negative deflection in the electroencephalogram (EEG) that occurs in response to errors made in choice reaction time tasks has been related to the dopaminergic system. More specifically, it has been hypothesized that this error-related negativity (ERN) is generated when an error signal is relayed via the cortical projection of the mesencephalic dopamine system to the anterior cingulate cortex [3]. The hallmark of Parkinson's disease (PD) is a degeneration of dopaminergic neurons, particularly targeting nigro-striatal projections. This has led to the hypothesis that the ERN is attenuated in PD patients. Two previous studies investigating the ERN in medicated patients with PD reported contradictory findings. One study found an amplitude reduction in the ERN [1] while another did not find such a reduction [2]. Comparing medicated and non-medicated (drug naïve) PD patients we recently showed that the ERN occurred in both PD groups with a reduced amplitude at frontal sites compared to healthy controls [4]. In order to see whether effects of medication are more easily seen *within* subjects, we studied the ERN in individual PD patients over time who were off and on medication. We found a decrease of ERN amplitude over time and an increase of ERN amplitude after PD patients had started medication.

WHAT WE DID

Eriksen flanker task: A visual letter paradigm was presented on a computer screen. Subjects pressed a button with the right index finger if the central letter was an H and with the left if the central letter was an S.

Stimulus presentation: 480 trials, stimulus duration 190ms, ISI 1243ms. Stimuli were letter strings SSSSS, HHHHH, SSHSS, and HHSHH.

EEG recording and analyses: 64 electrodes, sampling rate 512Hz. Re-referenced offline to averaged mastoid, band-passed at 1-20 Hz, epochs from 400 ms before to 800 ms after response, occular correction (Gratton & Coles), artifact reduction for signals > +/- 100 µV, baseline -400 ms to -200 ms. The epochs were time-locked to the response on each trial and averaged separately for correct and error trials.

Response times were calculated from stimulus onset to button press.

WHO PARTICIPATED

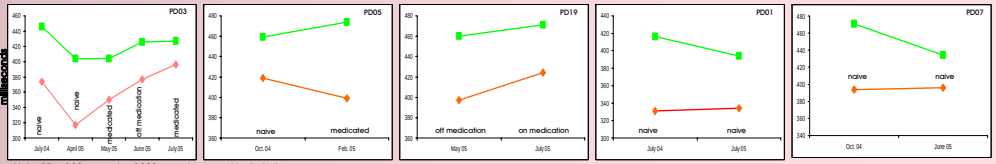
5 patients clinically diagnosed with Parkinson's disease (PD), four of whom were recorded at two points in time and one at five points in time. Gender: 1 male, 4 female. Average age: 64.4 yrs. (range 52 – 72 yrs), average education: 17.2 yrs.

PD03	July 04	April 05	May 05	June 05	July 05
UPDRS (motor)	25	23.5	17.5	25.5	22
Hoehn & Yahr	2	2	2	2.5	2.5
Medication	None	None	Amantadine	off Amantadine	Artane

	PD01		PD05		PD07		PD19	
	July 04	July 05	Oct. 04	Feb. 05	Oct. 04	June 05	May 05	July 05
UPDRS (motor)	33	46	28.5	16	6	17	26.5	11.5
Hoehn & Yahr	2.5	3	2	2	1	2.5	2.5	2.5
Medication	none	none	none	Apotrihex	none	none	off Permax+Amantadine	on Apo-Levocarb

WHAT WE FOUND

Behavioral results: Response times (RTs) for error and correct trials in medicated and non-medicated PDs

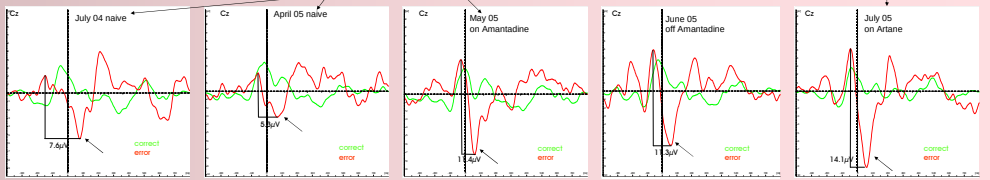


Note: RT < 100 ms and > 1000 ms not were not included

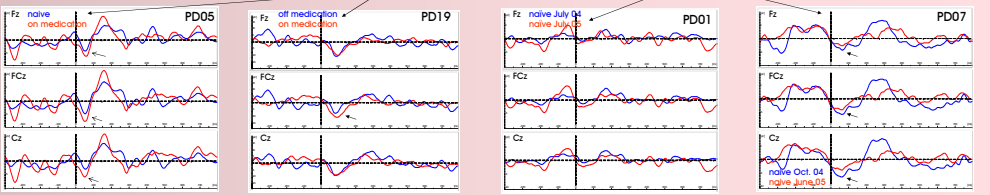
➔ Response times (RT) faster for errors than for corrects in all PDs.
➔ Tendency for a reduction in RTs over time in non-medicated condition (e.g."naïve" at two points in time in PD03,PD01, PD07) and an increase when going on medication (e.g. PD03, PD19 and PD05 (correct).

ERP results

Patient PD03 at five points in time: naïve and medicated



Four PD patients at two points in time (on/off medication or naïve but 12 and 8 months apart)



➔ Tendency for ERN to decrease as disease progresses (PD03-naive, PD07) and increase when dopaminergic medication is given (PD03, PD05, PD19. Note that PD01 does not follow this pattern.

WHAT WE THINK

In individual patients we found a decrease of ERN amplitude in two of three cases when the disease progressed and an increase of ERN amplitude in all three cases with medication that directly or indirectly influenced the availability of dopamine. This supports the hypothesis that ERN generation is linked to the dopaminergic system. Compared to previous PD studies, our findings also indicate that *within* patient comparisons are better suited than *between* group comparisons to observe such differences. However, caution is warranted: More individual PD patients are necessary to corroborate these findings. In addition, it is currently unclear whether different dopaminergic agents influence the ERN differently.

In previous work we found that non-medicated PD patients showed faster RTs [4]. The current work showed an overall reduction in RTs over time in individual cases. Whether this is due to progression of disease or a practice effect still needs to be determined. We also observed an increase in RT when individual patients went on medication. This is counter to most reports in the literature [5] and needs further investigation.

[1] Falkenstein et al., (2001) *Neuroreport, 12*:157-161.
[2] Holroyd et al., 2002. *Neuropsychologia, 40,* 2116–2124.
[3] Holroyd & Coles (2002). *Psychological Review, 109*:679-709.
[4] Stemmer et al. (2005). ICON, Havana, Cuba, 05. – 10. September, 2005.
[5] Gauntlett-Gilbert & Brown (1998). *Neurosc Biobehav Rev, 6*, 865-881.

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