



Executive Control Deficit in Depression: Event-Related Potentials in a Go/Nogo Task

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Background

Depressive patients show cognitive and particularly attentional deficits. Growing evidence suggests an impairment at the level of executive control (Channon and Green 1999). Executive control is involved in cognitive processing when learned routines are ineffective for task performance (Norman and Shallice 1986). A typical situation requiring executive control is the inhibition of a dominant response tendency, which can be tested in go/nogo tasks.

The aim of this study was to examine if depressive patients show an impairment of executive control in a response inhibition task and to investigate its neurophysiological correlate using event-related potentials. Our group has previously investigated healthy controls in a go/nogo task (Kiefer et al 1998). As an effect of response inhibition an increase of fronto-temporal N2 amplitude was found as well as an increased frontal P3, which was lateralized to the left hemisphere.

Regarding the comparison of depressive patients with normal controls our hypotheses were: (1) Patients perform worse in the nogo-condition, reflecting a deficit in executive control. (2) In the ERPs patients show a modification of the nogo-effects found in healthy subjects in the N2 or P3 time window.

Methods

Subjects: 16 patients diagnosed with major depression and 16 controls matched for gender, age and education participated in the study.

Task: The go/nogo paradigm used was a modified auditory oddball task. Subjects heard frequent low-pitched and rare high-pitched tones. In the go condition a response to rare tones was required. In the nogo condition subjects responded to the frequent tones, which made inhibition of response to the rare tones necessary. Each task was performed in a simple as well as a difficult condition.

ERPs: EEG and EOG were recorded continuously using 64 scalp electrodes. Offline, the EEG was segmented into epochs 100ms prestimulus to 1000ms poststimulus. After removal of segments with difference between minimum and maximum value exceeding 200 μ V in any EEG/EOG electrode, blinks and eye movements were corrected separately (Gratton et al 1983). The average-reference transform was applied and trials with correct responses were averaged synchronously to onset of stimulus.

Statistical Analysis: The sensitivity index d' was used as a behavioral measure for task performance. An ANOVA was performed with group as between subject factor and task and difficulty as within subject factors.

On the ERP data we calculated mean amplitudes for the N2 time window (225-285ms) over fronto-temporal regions and for the P3 time window (366-486ms) over fronto-central regions. An ANOVA was performed for both time windows with group as between subject factor and task, difficulty, hemisphere and electrode site as within subject factors. Newman-Keuls tests were used for post-hoc comparisons.

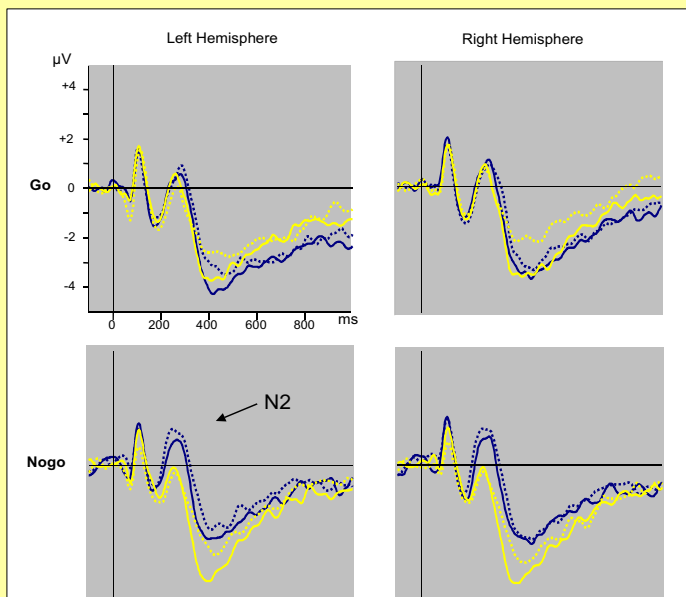


Figure 1: Grand Averaged ERPs over fronto-temporal regions for controls (blue lines) and patients (yellow), showing simple (solid lines) and difficult (broken) conditions. N2 is visible as a positive peak in the time window 225-285ms poststimulus. N2 mean amplitude is similar for both groups in the Go-condition (upper panels), but clearly differs in the Nogo-condition (lower panels).

Results

Behavioral Data: Overall, patients performed worse than controls ($p < 0.05$). This was modified by a group \times task interaction ($p < 0.05$) [see Figure 2]. Post-hoc tests revealed that patients performed significantly worse in the nogo condition than controls ($p < 0.001$), while groups did not differ in the go condition.

ERP Data: In the N2 time window there was a main effect of group over fronto-temporal regions ($p < 0.05$), with mean amplitude over all conditions being larger in controls than in patients. This effect was modified by a group \times task interaction ($p < 0.01$) [see Figure 3]. Post-hoc tests revealed that groups did not differ in the go condition, while controls had a larger amplitude than depressive patients in the nogo condition ($p < 0.001$). Regarding within group effects, controls showed increased activation in the nogo compared to the go condition ($p < 0.05$), while patients showed the opposite pattern: a decreased activation in the nogo condition ($p < 0.05$).

There were no differences between groups in the P3 time window.

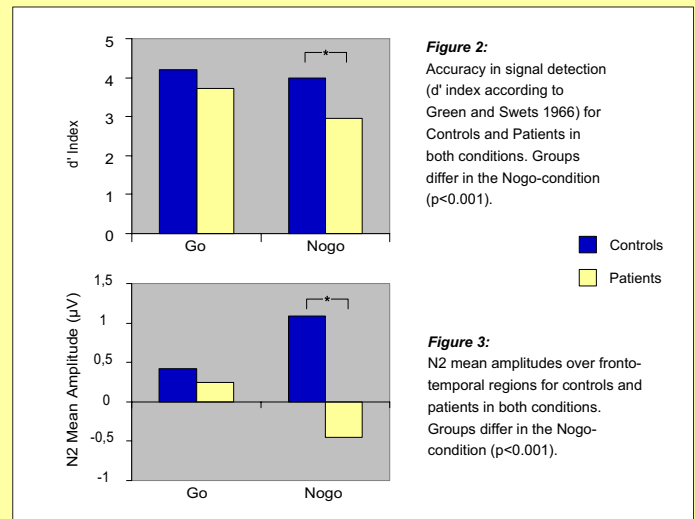


Figure 2: Accuracy in signal detection (d' index according to Green and Swets 1966) for Controls and Patients in both conditions. Groups differ in the Nogo-condition ($p < 0.001$).

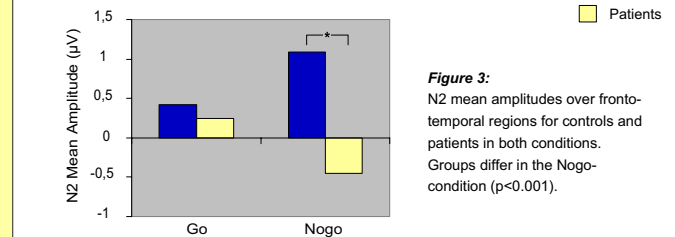


Figure 3: N2 mean amplitudes over fronto-temporal regions for controls and patients in both conditions. Groups differ in the Nogo-condition ($p < 0.001$).

Conclusions

Regarding our first hypothesis, behavioral data demonstrated that depressive patients have a performance deficit in the nogo condition, which requires inhibition of a prepotent response. Since there was no effect of task difficulty on this interaction, this result is unlikely to be due to an increased difficulty of the nogo compared to the go task. This result supports the view of a specific deficit in response inhibition as a function of executive control.

Regarding our second hypothesis, this deficit of inhibitory control was reflected in the ERP data. While both groups had similar mean N2 amplitude in the go condition, nogo N2 amplitude was larger in controls than in patients.

Increased N2 amplitude is a known ERP-Correlate of response inhibition (Jodo and Kayama 1992). Source analysis (Kiefer et al 1998) and neuroimaging findings (Konishi et al 1999) have suggested that generators for this N2 effect are located in the inferior prefrontal cortex. Therefore, our results suggest that depressive patients show a disturbance during an early stage of the cortical processing for response inhibition. In line with evidence for hypofrontality in depression (George et al 1994), these results may reflect dysfunction in inferior frontal areas.

Acknowledgements

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References

- Channon S, Green PS (1999): Executive function and depression: the role of performance strategies in aiding depressed and non-depressed patients. *J Neurol Neurosurg Psychiatry* 66:162-171.
- George MS, Ketter TA, Post RM (1994): Prefrontal cortex dysfunction in depression. *Depression* 2:59-72.
- Gratton G, Coles MGH, Donchin E (1983): A new method for off-line removal of ocular artifact. *Electroencephalogr Clin Neurophysiol* 55:468-484.
- Jodo E, Kayama Y (1992): Relation of a negative ERP component to response inhibition in a Go/No-go task. *Electroencephalogr Clin Neurophysiol* 82(6):477-82.
- Kiefer M, Marzinzik F, Weisbrod M, Scherg M, Spitzer M (1998): The time course of brain activations during response inhibition: evidence from event-related potentials in a go/no go task. *Neuroreport* 9(4):1-6.
- Konishi S, Nakajima K, Uchida I, Kikyo H, Kameyama M, Miyashita Y (1999): Common inhibitory mechanism in human prefrontal cortex revealed by event-related functional MRI. *Brain* 122:981-991.