The Amplitude of the Contingent Negative Variation following Neurofeedback Procedure

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INTRODUCTION
The Contingent Negative Variation (CNV) consists of slow negative potentials that depend on the association or contingency of preparatory and imperative stimuli during a warned reaction task requiring a response (Tecce, 1972). The CNV is classified into early and late components. The early CNV (eCNV) relates to orientation to the preparatory stimulus and expectancy associated with the imperative stimulus. The late CNV (lCNV) relates to the anticipation of processing the imperative stimulus and preparation for a motor response. The amplitudes of the eCNV and lCNV are related to the degree of orientation, expectation, and preparation for the paired preparatory and imperative stimuli (Brunia & Boxtel, 2001). The CNV amplitude is maximal at the central sites (Brunia & Boxtel, 2001, Mackinnon, Allen, Shiratori, & Rogers, 2013) and is attenuated at the Fz site (Lissen, Sambeth, Riedel, & Vuurman, 2013). Neurofeedback (NFB) is a procedure used to affect brain electrical activities that relate to attention and motor performance. In addition to treating ADHD, the non-invasive procedure of NFB has been shown to promote performance and cognitive enhancement (Niv, 2013). The growing practice of neurofeedback has prompted research in its effect on brain activities relating to attention and motor responding. This study examined the immediate effect of NFB on motor preparation as indexed by the CNV.

HYPOTHESES
1. The CNV amplitude is expected to follow a central maximal distribution.
2. The CNV amplitude is expected to have a greater negativity at the central site for the experimental condition than the control condition.

METHODS
Participants
- EEG Data
  - 10 CSUN college students
Stimulus Parameters
- 400 ms duration for each stimulus
Number of Stimuli
- 387 stimuli; 80 Go and NoGo letter sequences

Recording Parameters
- Low frequency filter = 0.1 Hz; High Frequency filter = 100 Hz.
- Vertical (VEOG) and Horizontal (HEOG) eye movements were recorded.

Processing Parameters
- LowPass = 25 Hz; HighPass = 0.1 Hz
- Artifact rejection: Scalp +/- 200 µv; HEOG +/- 100 µv
- Epoch = 2300 ms
- Baseline Correction = method suggested by Semlitsch, et al. (1986)

Peak Identification
- Based on the grand average of the ERPs during both Go and NoGo responses (see Figure 1)

Attention Task
- Participants were administered an AX-CPT while their brain electrical activities were recorded.
- Participants were required to attend to a sequence of letters presented one at a time on a computer screen.

Response Requirements
- Look for the letter “A” and make a button press response as quickly and as accurately as possible if it is followed by an “X”

Experimental Condition (NFB)
- Participants performed an AX-CPT task immediately following a neurofeedback session.

RESULTS
Late CNV Amplitude and Topography
- Interaction Effect (Condition x Lead)
  - Significant interaction effect, F(2,16) = 3.79, p < .05
  - The difference between No-NFB and NFB differs across Fz, Cz, and Pz.

Late CNV Amplitude for conditions across leads
- Significant interaction effect, F(2,16) = 3.79, p < .05
- The difference between No-NFB and NFB differs across Fz, Cz, and Pz.

Table 1. Late CNV amplitude means and standard error for conditions across leads

<table>
<thead>
<tr>
<th>Condition</th>
<th>M (SE)</th>
<th>M (SE)</th>
<th>M (SE)</th>
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<tbody>
<tr>
<td>No-NFB</td>
<td>-3.78 (1.25)</td>
<td>-4.42 (1.58)</td>
<td>-3.23 (1.29)</td>
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<tr>
<td>NFB</td>
<td>-5.80 (0.50)</td>
<td>-8.89 (0.84)</td>
<td>-6.85 (1.19)</td>
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The difference between Fz and Cz is significant for the NFB condition.

CONCLUSION
The present study examined the amplitude of the late CNV following neurofeedback procedures. The findings on the CNV topography followed the expected central maximal distribution. The CNV amplitude was greatest at the central site compared to parietal and frontal sites. The analysis on the CNV amplitude further yielded a significant interaction effect. A greater CNV amplitude was produced for the NFB condition than for the No-NFB condition at the central site. The results show that neurofeedback produced a greater negativity for the preparation to make a response. This finding suggests that the processing of imperative stimuli and for motor preparation is enhanced by neurofeedback.

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