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Error-negativity and positivity as they relate to other ERP indices of attentional control and stimulus processing

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Abstract

We compared individual differences in the ERP associated with incorrect responses in a discrimination task with other ERP components associated with attentional control and stimulus discrimination (N2, P3, CNV). Trials with errors that are detected by the subject normally produce a negativity (N_E) immediately following the response followed by a positivity (P_E). The morphology of the N_E and the P_E is similar to that of the standard N2–P3 complex on correct discrimination trials. Our findings suggest that the P_E is a P3 response to the internal detection of errors. The N_E , however, appears to be distinct from the N2. Finally, even though both the contingent negative variation (CNV) and the N_E are associated with prefrontal cortex and the allocation of attention to response accuracy, the N_E and CNV did not relate to one another. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Error negativity; N_E ; ERN; Error detection; ERPs; CNV; N2; P3

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1. Introduction

The error-negativity (N_E , or error-related negativity, ERN) is a recently documented component of the event-related potential (ERP) and has been associated with acknowledged incorrect responses that occur in target discrimination tasks (e.g. Falkenstein et al., 1991; Gehring et al., 1993; Dehaene et al., 1994; Scheffers et al., 1996). The error waveform is time-locked to the behavioral response, as opposed to stimulus onset, and consists of a negative deflection (N_E) followed by a positive deflection (P_E). The N_E has engendered much interest because examining the parameters within which it occurs may enrich our understanding of the processes involved in the monitoring and evaluation of response tendencies (Gehring et al., 1993; Luu et al., 2000). However, both the N_E and the P_E share functional and morphological similarities with other ERP components. The purpose of this paper is to compare individual differences in the N_E – P_E with other ERP components associated with attentional control and stimulus discrimination, specifically the contingent negative variation (CNV) and the N2–P3 complex.

1.1. Error-negativity (N_E)

The N_E is time-locked to the execution of an incorrect response, is absent for trials on which the correct response is made when the subject is certain of the correctness of that response (Coles et al., 2001), and does not seem to be dependent on the type of error made. Scheffers et al. (1996), using a simple Go/NoGo task, found that both errors of choice (incorrect responses on go-trials) and errors of action (uninhibited responses on NoGo trials) were associated with an N_E of similar morphology, latency, and scalp distribution. Tasks used to elicit the N_E are usually not difficult (e.g. the flanker task of Eriksen and Eriksen, 1974; the letter discrimination task of Falkenstein et al., 1991) so that errors are usually caused by quick or impulsive responding rather than by the inability of the individual to discriminate the stimuli or choose the correct response.

On tasks in which individuals are unable to determine correct or incorrect responses on their own, an N_E occurs only when error-feedback is provided. Miltner et al. (1997), presented feedback 600 ms following behavioral response and found that an N_E was produced only when feedback indicated that an incorrect response had been made. These data indicate that the elicitation of the N_E is not dependent on whether the detection of the error is internally driven or signalled by external cues, typically as long as there is awareness that an error has occurred (Miltner et al., 1997). In addition to its error detection role, N_E has been associated with the magnitude of individuals' response to their own error, as well as with error correction and compensation mechanisms (Gehring et al., 1993). In fact, we have found the N_E to be related to individual differences in the impulsivity of response style on the task (Pailing et al., 1999). However, there is still some question as to whether the N_E is more directly related to the processes involved in the generation of an error signal or to the processes following it, such as emotional or remedial reactions (Bernstein et al., 1995; Stemmer et al., 2000, for evidence that the N_E follows error detection rather than being generated simultaneously with it).

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