

Classification of Correct and Incorrect Responses based on Error-Related Negativity

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Abstract

The development of systems that automatically classify a response as correct or incorrect, based on the error-related negativity (ERN) associated with incorrect responses, might enable the implementation of devices that automatically check the correctness of responses in a variety of critical tasks. In the present study we investigate the classification performance that can be achieved using averaged recordings of 15 subjects who were performing the execution condition of a modified Eriksen flanker task [3]. The feature used for the classification process was the minimum amplitude of the ERP. Logistic regression models provided 93.3% overall classification performance, indicating the possibility to extend the research using combinations of classification methods with the perspective of applying the classification to single-trial data.

Introduction

Error-related negativity (ERN) is a component of human Event-Related Potentials (ERPs) elicited by errors [1]. Its study may elucidate neural mechanisms related to action monitoring [2]. In a more applied perspective, the development of systems that automatically classify a response as correct or incorrect, based on the ERN, might enable the implementation of devices that automatically check the correctness of responses in a variety of critical tasks.

As a first step towards this direction, in the present study we have investigated the classification performance that can be achieved using averaged recordings of subjects performing a choice-reaction task.

Materials and Methods (continued)

The global minimum amplitude was extracted for each electrode recording for time window 0 to 200 ms (TW1 in the following), representing the ERN peak. This was the feature used as input to the classifier. For comparison reasons concerning the classification performance, the global minimum was also extracted for time window 0 to 700 ms (TW2) and time window -100 to 700 ms (TW3, i.e. the whole recording length).

The classification was implemented using a forward conditional logistic regression model. The probability for entry was 0.05 and for removal was 0.1. The process was monitored for rejecting cases when overfitting occurred.

Materials and Methods

Averaged ERPs of 15 subjects who were performing the execution condition of a modified Eriksen flanker task [3] were processed. ERPs had been digitized at 250Hz. The full length of recordings was 800 ms, including a baseline 100-0 ms before response. From the original 47 Ag/AgCl recordings, for the present analysis recordings at electrodes Cz, Fz, Pz, F1, F2, C3, C4, P3, P4, O1, O2 were used.

For each subject both the correct and the incorrect response average curve at each of the above electrodes was processed.

Results and Discussion

The features were tested for statistical normality using the Kolmogorov-Smirnov goodness-of-fit test and were found to be consistent with the normal distribution. The application of the logistic regression model for classifying correct and incorrect responses, for TW1 resulted in an equation including only electrodes Cz and P3, reflecting high correlations between the amplitudes at the different leads. Overall classification reached 93%, with one subject being misclassified in each of the two classes of responses. In Table 1 the sensitivity, specificity and the negative and positive predictive values are given.

Table 1: Classification performance for TW1 (0 to 200 ms)

| | Predicted Correct response | Predicted Incorrect response | Accuracy | |
|-----------------------------|----------------------------|------------------------------|----------|---------------------|
| Observed Correct response | 14 | 1 | 93.3 | Specificity |
| Observed Incorrect response | 1 | 14 | 93.3 | Sensitivity |
| Accuracy | 93.3 | 93.3 | 93.3 | Overall Performance |
| | Negative predictive value | Positive predictive value | | |

Table 2: Classification performance for TW2 (0 to 700 ms)

| | Predicted Correct response | Predicted Incorrect response | Accuracy | |
|-----------------------------|----------------------------|------------------------------|----------|---------------------|
| Observed Correct response | 13 | 2 | 86.7 | Specificity |
| Observed Incorrect response | 3 | 12 | 80.0 | Sensitivity |
| Accuracy | 81.25 | 85.7 | 83.3 | Overall Performance |
| | Negative predictive value | Positive predictive value | | |

Results and Discussion (continued)

For TW2 and TW3 the application of the method resulted in an equation containing electrodes Cz and Pz, and classification performance deteriorated to 83.3%. Results for TW2 are given in Table 2. No overfitting was observed in any case.

The above results indicate the possibility to extend the research using combinations of classification methods [4] with the perspective of applying the classification to single trial data and also extend the classification to the observer's ERPs.

References

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