Pre-processing of Electromyography Startle Data: a Novel Semi-Automatic Method

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The startle blink response is an eye blink in response to an (acoustic) startle stimulus that is frequently used in psychophysiology research and various clinical settings [1]. There are various methods used to preprocess the data, but these methods are time-consuming, and there is little consensus on which method is best [2]. Here we propose improvements of pre-processing this data.

Human facial surface EMG of the startle reflex is a very dynamic and sensitive measurement. Traditionally, each trial is visually inspected to check whether the measurement is reliable [2]. This method is a very subjective way of checking data and very time consuming. Moreover, when examining a large volume of data, errors are easily made. Visual inspection by two researchers would make it more reliable, however, this is even more time-consuming and the classification would still be subject to subjectivity. Therefore we propose a more objective semi-automatic way of checking the reliability of the trials using the variation of the raw EMG. After rejecting unreliable measurements there is still variation in the baseline across participants, sessions and even within a session due to differences in muscle tension and noise. Therefore, a baseline correction might be important for a good peak amplitude estimation. However, there is no consensus about baseline measurement in EMG experiments [2]. Therefore, we additionally propose an automatic method for determining a baseline.

Data was collected from 37 male combat veterans. The medical ethical board of the University Medical Center Utrecht approved this study. Startle responses were elicited by a sudden acoustic white noise sound of 105 dB while a fixation cross was presented on the screen and were measured by the use of electromyography (EMG). Two electrodes were placed on the skin surface above the orbicularis oculi muscle [1], and the signal was recorded using the Biopac MP150 system with a sampling rate of 1.000 Hz. Data analysis of the raw EMG signal was performed using the software AcqKnowledge version 4.3. The raw EMG signal was filtered offline with two filters. A Finite Impulse Response (FIR) band-pass filter of 28 to 500 Hz (1001 coefficients tapered with Hamming window) was used to filter out the high and low artifacts (such as motion artifacts). This frequency range has a maximum trade-off between suppressing artifacts and retaining the true EMG signal [2, 4]. Next an Infinite Impulse Response (IIR) band stop filter (Frequency 50.38 Hz, Q 30.59) was used to filter out electrical noise [3]. A frequency of 50.38 Hz was used instead of the standard 50 Hz because this was the dominant frequency in our study and a filter centered at 50.38hz was more effective. We used a Q of 30.59 to keep the discarded bandwidth as low as possible. From this signal the root mean square (RMS) was calculated with a sliding mean of 0.3 seconds [5].

For a reliable measurement, an interval of 150 ms before the time window of the startle responses should be stable. Variation caused by, for example, spontaneous blinking, eye movement and disturbance in the lines can contaminate the peak measurement. To check the stability, the variation based on the standard deviation (SD) of the raw filtered EMG signal was calculated in this interval. If the variation of an interval rises above the threshold (0.0115 mV), it is regarded as unstable and therefore the trial was rejected. If the variation stays below the lower threshold (0.0085 mV) it can be assumed that the variation is negligible and the measurement is reliable. Surface EMG is a very sensitive and dynamic measurement and every threshold is to some extent arbitrary, therefore, we propose a semi-automatic method in which the trials between the lower and the upper threshold will be manually classified by visual inspection by two researchers.

We performed both the traditional and the new semi-automatic method on 200 trials. All trials were classified automatically based on the SD and by 2 examiners that compared and discussed their decision till consensus was reached. The classification by 2 examiners was used as the "golden standard" of reliable and unreliable trials. The semi-automatic classification performed well in 200 trials; 99.5% of the trials were correctly classified and only 5% of these trials were classified for further manual inspection.

Other semi-automatic methods for pre-processing of EMG signal are known [6], but these methods focus on detection of the on- and offset of an event rather than checking stability of the baseline. Furthermore, none of these methods are applied to startle eye blink data. Although some of these methods (for example based on wavelet transformation [7]) could, in theory, do the same as the method proposed here, but are much more complex and as the current method proves, this complexity is not necessary for a good classification.

In addition, we propose an automatic method for baseline calculation. The longer the interval of the baseline calculation, the closer the value will be to the true mean. However, this increases the risk of including artifacts such as blinking or eye rolling, thus leading to a higher baseline estimation and therefore a lower peak value. To correct for this effect we calculated the mean of the baseline activity within the baseline interval of 1 second in epochs of 100 ms (10 epochs per baseline, calculated on the RMS data before the startle response window). If in the baseline interval the variation of an epoch was higher than the upper threshold (0.0115mv), this epoch was excluded in the baseline calculation. This baseline correction gives us the advantage of a large interval while constraining the risk of including artifacts. These baseline values were subtracted from the peak values.

In conclusion, we propose a semi-automatic objective method of checking the startle measurements. This can be performed automatically and so decreases subjectivity in the classification, human error and time. Furthermore, an automatic baseline correction method is proposed by using a long interval in which artifacts are removed. With this improved semi-automatic method, we try to increase the quality of startle EMG data.

References

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