Processing Stages of Visual Stimuli and Event-Related Potentials

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Abstract

Event-evoked potentials (ERP) in electroencephalograms reflect various visual processing stages according to their latencies and locations. Thus, ERP components such as the N100, N170 and the N200 which appears 100, 170 and 200 ms after the onset of a visual stimulus correspond respectively to a selective attention, the processing of color, shape and rotation (e.g. processing of human faces) and a degree of attention.

Event Related Potential (ERP)

Event-Related Potentials (ERPs) are electrical changes in electroencephalographic (EEG) recordings that are time-locked with sensory or cognitive events. These deflections in the signal are more vlongnamesfirst isible when responses are averaged. The ERP components (figure 1) are a useful tool to track the temporal brain dynamics to understand the neural processing. The ERP components are peaks whose names are designated by their negative (N) or positive (P) polarity and their approximate latency in ms. Thus the P100 component reflects a positive deflection of the signal with a peak approximatively around 100 ms.

Until now it is unclear how ERPs are generated. Two hypotheses are the most suitable. The first one establishes that ERPs are generated due to an event-related activation of neural assemblies with the stimulus (evoked response) [1], meaning that the ERP is added to the ongoing EEG. The second hypothesis states that ERPs are generated by “phase resetting”, meaning

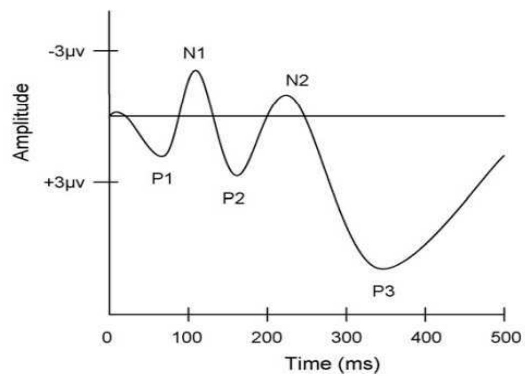

Figure 1: Event-related potentials main components, Note that the ERP is plotted with negative voltages upward. This convention is common but not widespread.

that there is an enhanced alignment of the EEG activity, caused by a stimuli, resetting the phase of the ongoing oscillatory activity [4]. To better understand these hypotheses see figure 2.

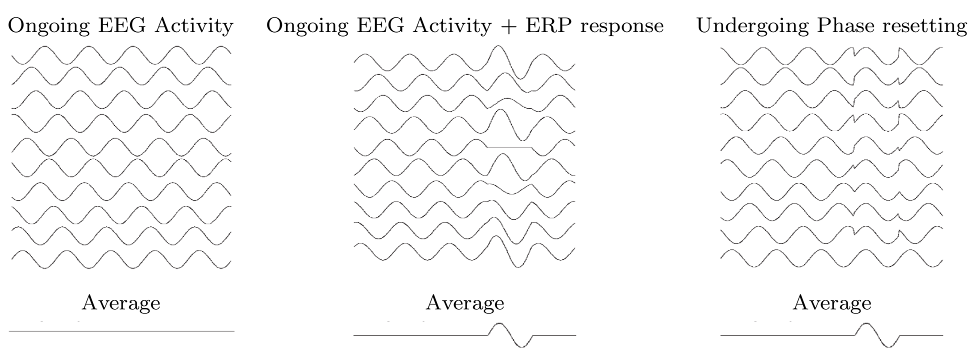

Figure 2: The left figure shows the ongoing single-trial EEG signals, the middle one the evoked response model and the right one the phase-resetting model (Figures taken from [14]).

Many different stimuli could elicit reliable ERPs. In this short review, we concentrate on ERPs evoked by visual stimuli. ERPs have been used to study visual awareness [5], attention [10], perception of color and form [11], facial expression processing [7], affective processing [8].

Peaks within 90-200 ms latency are associated with rapid selective attention processes.

- C1 is the first major visual evoked potential (VEP) component generated in the primary visual area (striate cortex; area 17) with an onset around 50 ms and a peak around 90 ms [12, 6, 10]. The C1 component is sensitive in amplitude and polarity to the spatial location of the stimulus in the visual field. C1 has negative polarity when the stimulus is in the upper visual field and positive when is presented in the lower visual field [10]. For this reason, the standard nomenclature (N or P) about polarity is not applied to C1. This component is usually used to study attention and learning processes [10] and is sensitive to contrast [6]

- P1, also called P100, is the first positive component with an onset within 60-80 ms and a peak normally observed around 100-130 ms in the lateral occipital cortex [6, 5, 7]. The early phase of P1 overlaps with C1, making difficult to identify its onset in time. It is a mandatory response elicited by a visual stimuli (exogenous response) because they are influenced by external stimulus, such as luminance [6]. P1's amplitude is larger for unpleasant target stimuli than pleasant stimuli, showing a relation between the P1 component and the affective processing [8]. A correlation between P1 and face expression has also been found [7].

- N1 is usually called visual N1 to differentiate it from the auditory version. This potential responds to manipulations of attention. This component has a peak around 100-150 ms in the parietal cortex when influenced by spatial attention (attended vs. unattended locations) and a latter peak around 150-200 ms in the lateral occipital cortex sensitive to a discrimination process [6]. N1 is also sensitive to lexical processing, having an increased amplitude in response to pleasant words during silent reading [3].

- N170 is a negative component sensitive to face perception [2]. The N170 source is still controversial but in the lateral occipito-temporal cortex [7].

Peaks within 200-300 ms latency range are associated with the stimulus discrimination stage and response selection processes [13]

- N200 can be decomposed into two VEP subcomponents: the N2b which is evoked during conscious stimulus attention (visual discrimination tasks) and the N2c which arises during classification tasks [9]. Furthermore, some stimuli may evoke a N2pc ("pc" stands for "posterior–contralateral" cortex), produced when the attention is focus on one object while ignoring others [5].

Conclusion

Event-evoked potentials (ERP) have been studied for 40 years. Even if their neural origins are still unclear, in recent studies, scientists have been able to better identify their locations and latencies making easier to relate them to visual processing. According to the increase of the latency, the locations of the ERP components are larger starting in the primary visual area, passing through the lateral occipital cortex and ending to the pariental cortex and the lateral occipito-temporal cortex. Thus, the first ERP components when elicited by visual stimuli are correlated to selective attention, processing of color, shape, rotation and degree of attention. As well, the last components are related to discrimination tasks revealing more complex cognitive processes.

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