# Attentional Blink 課題中の脳波位相同期現象: δ、θ、α、β、及びγ波帯域での検討

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Attentional Blink 現象と脳波位相同期現象の関連を複数周波数帯域で検討した。課題は 100ms ごとに連続提示される視覚刺激中の２標的（T1、T2）について T1 属性判断及び T2 検出を課した二重課題と、T2 検出の単一課題であった。T1 - T2SOA は 100、300 及び 700ms であった(Lag1, 3, 7 条件)。単一課題より二重課題条件で位相同期が高い電極ペアを各周波数帯域ごとに検出し、位相同期の頭皮上・時間的変動を、T1 正答 - T2 正答試行と T1 正答-T2 誤答試行で比較した。Lag1、Lag3 条件の T1 正答 - T2 正答試行ではほぼ全頭を覆う大規模同期が見られたが、Lag7 条件では見られなかった。大規模同期タイミングは周波数帯域で異なり、T1 以前ではδを除くすべての帯域、T1T2 近傍ではβ、T2 後はδ、θ、α帯域で大規模な位相同期が見られた。Keywords: Attentional blink, EEG.

## Intruduction

A target presented in a rapid stimulus sequence (~10 items/sec) usually is detected easily. However, when two targets (T1 and T2) are presented in sequence, T2 is often missed when the two are 200-500 ms apart. This phenomenon is called attentional blink (Broadbent et al., 1987; Raymond et al., 1992).

Brain activities that correlate with attentional blink (AB) phenomenon were reported before, around, and after the targets. Before T1 onset, EEG phase synchronization in the γ band increases when T2 is detected (Nakatani et al. 2005). Around T1 and T2, β band MEG phase synchronization and γ band EEG phase synchronization increased when T2 is detected (Gross et al., 2004; Nakatani & van Leeuwen, 2004). After T2, amplitude of P3 for T2 decreases (Vogel at al., 1988). Sergent et al. (2005) suggested that temporal overlap between P3b of T1 and N2 of T2 leads to decrease in T2-P3 amplitude.

To integrate these varieties of results, we investigated the time course of AB effects on EEG whole-head, cross-lag phase synchronization in five frequency bands.

## Method

**Participants:** Four male and four females (mean age: 23.75 years-old) participated to the experiment. All had normal or corrected-to-normal vision.

**Task:** On each trial, a rapid sequence of visual stimuli was presented (RSVP) at a rate of 100 ms each (stimulus presentation duration was 25 ms, followed by 75 blank). T1 (blue character) occurred in 100 % and T2 (“O”) in 50 % of the trials. T2 occurred 100, 300, or 700 ms after T1 (Lag-1, Lag-3, Lag-7, respectively). Trials were presented in experimental and control blocks; Experimental conditions require both categorization of T1 (whether the blue stimulus was letter or digit) and detection of T2 (if letter “O” was present); control conditions require detection of T2 only.

**EEG recording:** 62 EEG and 2 EOG channels, 1000 Hz sampling rate. Linked ears were used as reference and re-referenced with averaged activity of the 62 channels (cf. Guevara et al., 2005).

**Analysis:** Five frequency bands were chosen to represent δ, θ, α, and γ band activity. The respective central frequencies were 3, 6, 10, 20 and 40 Hz; bandwidth was ±2.5 %. Instantaneous phase was computed using Hilbert transform. A dynamic phase synchronization index (dcPSI) was computed between 10 base-electrodes: FP1, FP2, F3, F4, C3, C4, P3, P4, O1 and O2 and 61 other electrodes distributed evenly across the brain (See Nakatani et al., 2005, for the computation details of dcPSI).

## Results

**Behavioral results:** AB and Lag 1 sparing were obtained.

**EEG results:** Fig. 1 shows the number of electrode pairs that showed higher dcPSI in experimental than in control conditions plotted against time. The higher the value, the more brain regions synchronized in the experimental condition than in the control condition. When T1 and T2 were correctly reported, prominent peaks (> 150) appeared in Lag 1 and Lag 3 conditions, but not in Lag 7 condition. These peaks appeared pre-T1 in all except the δ band, between T1 and T2 in the β band, and 400-500 ms post T2 in the δ and θ band.

*Delta band:* A peak appeared about 400 ms after T2 in Lag 3 condition. This timing coincides with latency of P3 ERP component for T2. In the peak, occipital, parietal and frontal pole electrodes showed synchrony to each other and with other electrodes spread over the head.

*Theta band:* A pre-T1 (-400ms) and a post T2 (+300 ms) peaks appeared in Lag 1 condition. The pre-T1 peak was mostly due to synchronization among occipital and parietal electrodes, while the post-T2 peak involved

synchronization of frontal pole and frontal electrodes as well.

*Alpha band:* Peaks appeared in Lag 1 (post T2, +500 ms) and in Lag 3 (pre-T1, -500 ms) conditions. Electrode pairs in the Lag 1 peak spread over the head (more or less) evenly. In the Lag 3 peak, electrode pairs with frontal pole, frontal and central electrodes are slightly more prominent than other locations.

*Beta band:* Multiple peaks were observed. In the largest post-T1 peak in Lag 1 condition, electrode pairs with anterior loci (frontal pole, frontal and central) were dominant. The post T1 peak in Lag 3 did not show such bias in scalp distribution.

*Gamma band:* Pre-T1 peaks were observed in Lag 3 condition. Electrode pairs involved in the parks spread over the whole head.

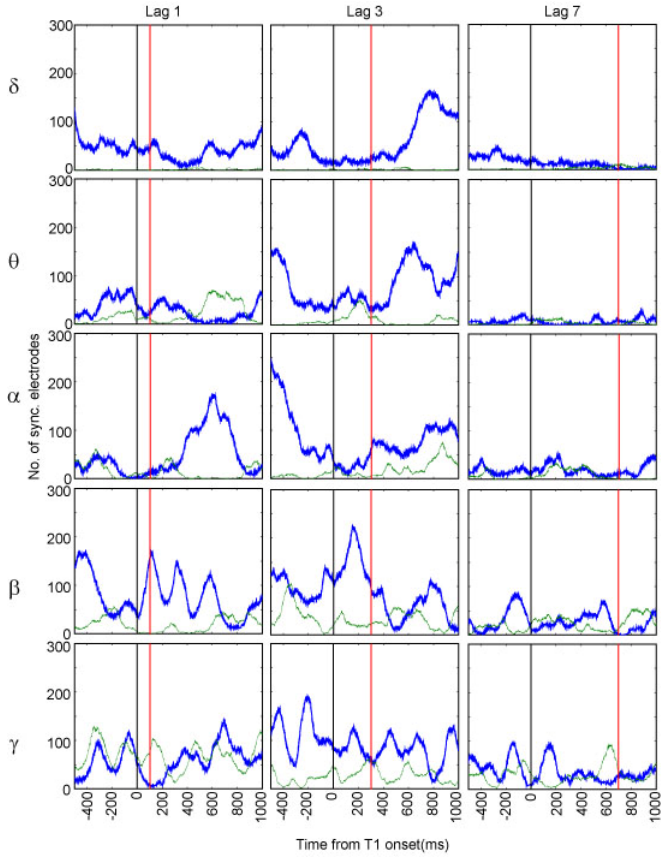


Figure 1. Dynamic EEG phase synchronization during AB task

Rows: δ, θ, α, β and γ band frequencies. Columns: Lag 1, 3 and 7 conditions. T1 and T2 onset are indicated by vertical lines. Time plots for T2 hit (blue) and T2 miss (green) trials shows the number of electrode pairs with increased synchrony compared to control conditions.

## Discussion

Peaks in large-scale synchronization occur prior to, during, and after target onset in conditions of high perceptual load, when the target is reported successfully. In Lag 3 condition, post T2 peaks were observed in theta and delta bands. These two peaks may relate to ERP components (e.g., N2 and P3b for T2 in Sergent et al.,2005). In Lag 1 condition, such peaks were not observed. This suggests that T2 process in Lag 1 condition requires less neural resources in post T2 period than that in Lag 3 condition.

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