Cortical Activation During Visual Masking in Migraine With Aura

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Introduction: A briefly displayed visual stimulus (target) can be rendered less visible or invisible if it is immediately preceded or followed by another stimulus (mask), called visual masking. Multi-unit recording from V1 in monkeys demonstrated that a forward mask suppressed the transient on-response of neurons to the target and a backward mask inhibited the transient after-discharge of neurons that occurred right after the disappearance of the target [1]. Our recent study showed that the decreased visibility of a visual target is associated with a reduction in cortical activation [2]. A recent psychophysical study reported that in migraine patients with aura the effect of backward-mask suppression on the visual target was significantly less than in both migraine patients without aura and the non-headache controls [3]. In this study, we investigated cortical activation during visual masking in migraine patients with aura.

Methods and Materials: Ten patients with migraine with aura (MwA) (9 female, 1 male, aged 24-50 years, mean ± SD = 37.6 ± 8.9) and ten age- and sex-matched non-headache controls (NHC) (9 female, 1 male, aged 24-51 years, mean ± SD = 36.4 ± 9.8) participated in a psychophysical test outside of the magnet and an fMRI study. During the psychophysical test, the subject was presented a stimulation sequence consisting of a fixation, forward mask (M_f), time delay (t), target (T), time delay (t), backward mask (M_b), and fixation ($M_f tT t M_b$) (Fig. 1). FMRI: The fMRI scan included three protocols: (1) retinotopic mapping to determine the V1 boundary [4], (2) corticotopic mapping to identify the cortical regions activated by the visual target, and (3) visual masking protocol consisting of five different conditions: T, $M_f M_b$, $M_f T M_b$, $M_f t M_b$, $M_f t T t M_b$. Images were acquired on a GE 3T scanner using GE-EPI. The BOLD signals obtained during visual masking were averaged over the voxels defined by corticotopic mapping with ccc > 0.35 ($p<0.001$) [5]. The area under the time course of BOLD signals was integrated as a metric for cortical activation.

Results and Discussion: *Visual Masking Effect*: Without the masks, all subjects could detect the target correctly with an error rate 5.3±3.2 % for MwA and 4.0±1.1 % for NHC, indicating the target clearly visible (Fig. 2, left). The effect of the forward- and backward-masks on the target depends upon the delay time (t) between the target and the masks. Without a time delay, visibility of the target was reduced, rendering an increase in errors for detection of the target with an error rate 48.0±2.3 % for MwA and 43.3±3.4 % for NHC (50% error rate for random choice). An increase in the delay time reduced the masking effect. With 500ms time delay, the masking effect was diminished as reflected in the error rate reduced to 14.3±14.0 % for MwA and 9.8±1.9 % for NHC. No significant difference was observed between MwA and NHC ($p>0.2$). *Activation in V1*: T only produced significant activation (3.8±0.5 %xs for MwA and 3.6±0.4 %xs for NHC). For NHC, the difference of cortical activation between $M_f tT t M_b$ (unmasking) and $M_f t M_b$ was significantly greater than zero ($p<0.002$), but not between $M_f T M_b$ (masking) and $M_f M_b$, indicating that the target produces cortical activation during unmasking but almost no activation during masking. The first finding was associated with almost fully visibility of the target during unmasking and the latter one with almost invisibility of the target. No significant difference was observed between MwA and NHC during masking or unmasking (Fig. 2, right). This result is self-consistent with the psychophysical test (Fig. 2, left). It showed that MwA was not less susceptible to visual masking than NHC, and does not support the conclusion made in [3].

Fig. 1 The stimulus sequence of $M_f tT t M_b$. T=84ms; M_f =100ms; M_b=84ms; t=0, 34, 100, or 500ms. Prior to testing, the gray level of the light gray bar in T was selected for each subject, as the target without masks could be detected correctly with an error rate 10% or less. During testing, the subject was instructed to detect whether the two bars were at the same gray level or not.

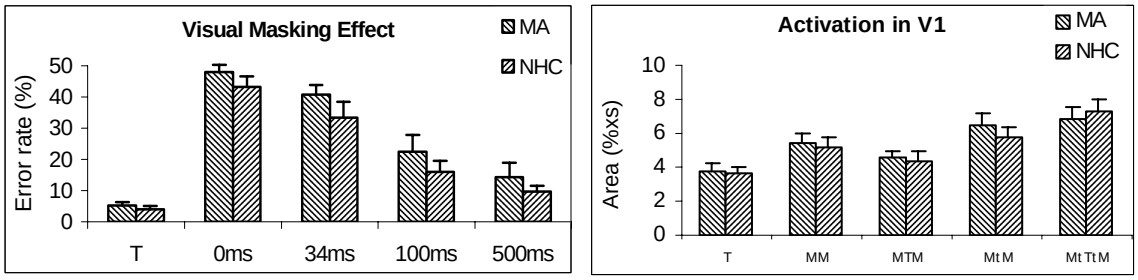

Fig. 2 Left: psychophysical results; T: target only; delay time: 0, 34, 100, and 500 ms; Right: cortical activation results.

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