Temporal Analysis of Visual Search Task by Transcranial Magnetic Stimulation

Sheng Ge\(^1\), Shoogo Ueno\(^2\), and Keiji Iramina\(^1\)
\(^1\)Graduate School of Information Science and Electrical Engineering, Kyushu University, Japan
\(^2\)Faculty of Engineering, Engineering, Kyushu University, Japan

Abstract — In this study, we examined the temporal aspects of the right posterior parietal cortex in easy feature “pop-out” visual search using transcranial magnetic stimulation (TMS). The transcranial magnetic stimulations were applied over the right posterior parietal cortex of subjects. Subjects received 4 tests which the TMS onset times were set as 100, 150, 200 and 250 msec after visual stimulus presentation. We found that, when SOA = 150 msec, compared to no-TMS condition, there was a significant elevation in response time when the TMS pluses were applied. However for the other SOA cases, there was no significant difference between TMS and no-TMS conditions. Therefore, we considered that “pop-out” visual search was processed in the right posterior parietal cortex at about 150 msec after stimulus present.

DOI: 10.2529/PIERS060906045142

1. INTRODUCTION

The use of transcranial magnetic stimulation (TMS) in the investigation of neurological deficits provides an important method for human cognitive processes. Visual search, as a traditionally visual neglect sensitive measure, was studied by many researches. Much is already known about the involvement of right posterior parietal cortex \([1, 2]\). However, the study of temporal aspect of the posterior parietal cortex in visual search was not sufficient. In this study, to examine the temporal aspect of the posterior parietal cortex in “pop-out” visual search using TMS, we used different TMS stimulus onset asynchrony (SOA) and measured the visual search reaction times. The relationship between the SOA and reaction time was investigated.

2. MATERIALS AND METHODS

TMS Equipment:
The stimulator was a MagStim Super Rapid Stimulator (Magstim comp., Whitland, UK). Stimulus strength was set as the subjects’ individual threshold for the motor evoked potential which under 55% of the maximum output. A figure-of-eight 70 mm coil was used.

TMS Stimuli:
2 pulses (20 ms interval) transcranial magnetic stimulations were applied over the right posterior parietal cortex of subjects.

Visual Search Task:
An easy feature “pop-out” search task was used in this study (Fig. 1). The target was a black backslash, and the distractor was black slash. The background was always gray. All the experiments were executed in a darkroom. The subject’s head and sagittal midline was aligned with the centre of the monitor, and their head position was controlled by a chinrest. A visual search stimulus was consisted of 8 items, which were presented on a 5.7 × 5.7 mm square range (4.7° × 4.7°) on the center of PC monitor at a distance of 70 cm from the subject. The square range was divided into a 5 column × 5 row array of 25 virtual boxes. On any trial, each target or distractor could appear randomly in any one of 8 of these boxes. The target was present on 50% of trials and the target was unique among distractors.

Subjects:
5 subject, aged 21–31 years, all right hand, one female, four males.

Procedure:
The time sequence of experiment is shown in Fig. 2. Each trial was preceded by a central fixation cross (0.9° × 0.9°) for 1500 msec, followed immediately by the visual search stimuli, which would be presented for 1500 msec. Subjects were asked to respond as quickly and as accurately as possible on a mouse button to indicate the presence or absence of the target (left button for target present
and right button for target absent). The time from the visual search stimuli presentation till the button click was recorded as the response time. Transcranial magnetic stimulations were applied over the right PPC of subject at different time intervals after the visual search stimuli presentation. These time intervals were called as TMS stimulus onset asynchronies (SOA).

![Figure 1: Examples of visual search stimuli.](image)

![Figure 2: The time sequence of experiment.](image)

Each subject received 60 trials for 2 times for TMS and no-TMS conditions respectively as one test. Subjects received 4 tests which the TMS stimulus onset asynchronies (SOA) were set as 100, 150, 200 and 250 msec after visual search stimuli presentation.

3. RESULTS AND DISCUSSION

The average of target-present response times of each subject in the TMS condition was normalized to the no-TMS condition (set as the baseline = 1). The subtraction between the average of normalized response times of all the subjects and the baseline was taken to demonstrate the TMS effect.

The subtraction between the average of normalized response times of all the subjects and the baseline is shown in Fig. 3. In order to investigate the influence of TMS effect, one-way analysis of variance (ANOVA) was used to analyze the difference between TMS and no-TMS conditions. We found that, when SOA = 150 msec, compared to no-TMS condition, there was a significant elevation ($p < 0.05$) in response times when the TMS pluses were applied. However for the other SOA cases, there was no significant difference between no-TMS and TMS conditions.

Corbetta et al.’s PET study reported activation of the PPC during feature conjunction search, but not during easy visual searches for single features [3]. Ashbridge et al.’s TMS study reported that TMS had detrimental effect on the performance of conjunction search but not on the feature search [2]. Whereas, both neuroimaging in humans [4] and single-unit recordings in monkeys [5] have revealed that the PPC subregions controlling spatial selection are also implicated in the selection of nonspatial features, suggesting that the involvement of the PPC in the visual search may not
be binding-specific but rather reflect more general attention mechanisms. Furthermore Leonards et al. [6] and Donner et al. [7] also reported the PPC activations during the feature search task.

In the present study, when SOA = 150 msec, compared to the no-TMS condition, a significant elevation in response time was measured for easy feature search. Based on the past researches [2] and present study, it seems reasonable to support that the right PPC plays a dominant role not only in the conjunction search but also in the “pop-out” visual searches.

Furthermore, since a significant elevation in response time was only measured when SOA = 150 msec, we considered that “pop-out” visual search was processed in the right posterior parietal cortex at about 150 ms after stimulus presentation.

This TMS study opens up several new possibilities for understanding not only the role of the PPC in visual search but also the temporal aspect of the PPC involved in the “pop-out” visual search. The contribution to theories about the visual search dynamics is expected.

REFERENCES