Temporal properties of multiple target consolidation: A ERP study

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When two targets (T1 and T2) are embedded in a rapid serial visual presentation, T2 is often missed if it appears within 500 ms after T1 (attentional blink, AB). However, a T2 report is not impaired if it immediately follows T1 (Lag-1 sparing). Furthermore, in a three-target AB paradigm, the third target is also easily identified when the targets are presented successively (Lag-2 sparing). The present study examined how targets were consolidated in working memory when Lag-2 sparing occurred, by observing the P3 component of the event-related potential. Multiple P3 components elicited separately by each target were observed when Lag-2 sparing occurred, suggesting that the trailing targets can be consolidated independently.

Key words: attentional blink, Lag-1 sparing, electrophysiology, P3, consolidation

When two targets and a dozen distractors are presented in a rapid serial visual presentation (RSVP) at the rate of 10 Hz, observers often miss the second target (T2) if it is presented between 200 and 500 ms after the first target (T1). This phenomenon is known as attentional blink (AB; Shapiro, Arnell, and Raymond, 1997). It is generally accepted that attentional blink reflects the failure of consolidation of T2 into working memory. However, the temporal dynamics governing the critical period of consolidation of T1 and T2 is still unclear.

The purpose of this study was to explore whether multiple targets during RSVP would be consolidated into working memory simultaneously or separately. Investigating the mechanism of Lag-1 and Lag-2 sparing, which are phenomena that the performance is unimpaired if the targets are presented successively, should provide important insights about this issue (Di Lollo, Kawahara, Ghorashi, and Enns, 2005). To achieve this goal, we investigated P3 component(s) in a three-target AB paradigm. We measured the P3 component of the event-related potential (ERP) as an index of the target consolidation process. It is well known that P3 reflects the updating of working memory. Indeed, it has been reported that the P3 for T2 was eliminated when AB occurred (i.e., failure to consolidate T2; Vogel, Luck, and Shapiro, 1998). Thus, it is reasonable to suppose that the simultaneous consolidation of multiple targets would elicit a single P3 component. On the other hand, if each target is consolidated independently, multiple P3 components should be elicited for each target.

Method

Participants Ten participants were recruited. All gave informed consent and were paid for their time.

Stimulus and procedures Each RSVP item was presented for 100 ms and subtended approximately 1 x 1 degrees of visual angle. The distractors were selected randomly from uppercase letters. The targets were selected randomly from digits. The length of the RSVP stream was varied randomly between 15 and 21. After the stream, participants were instructed to identify all of the targets.

Design There were four conditions: TTT, TTD, TDT, and TDD. In the TTT condition, three targets were presented successively. In the TTD condition, two targets were presented successively. In the TDT condition a distractor was presented between two targets, and in the TDD condition a single target appeared in the RSVP stream. Each condition consisted of 8 blocks of 25 trials. Before each block was presented the instructions for the number of targets (i.e., one, two, or three) were presented on the screen.

EEG recording Electroencephalograms (EEGs) were measured from the midline parietal site (Pz).

1) The results of the experiment were reported in Neureport (Kihara, Kawahara, & Takeda, 2008).

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Based on visual inspection, trials containing artifacts (4.4% of trials) were removed from the data analysis. In addition, eye movement artifacts were removed by the independent component analysis procedure.

To obtain the ERP waveforms, EEG epochs time-locked to the onset of T1 were averaged separately for each condition. For averaging, the error response trials were excluded.

**Results and Discussion**

**Behavior** The percentage of correct targets for each condition, as a function of lag, is shown in Figure 1A. We referred to the target which appeared at the first, second, and third target positions as Lag 0, Lag 1, and Lag 2, respectively. A paired t-test demonstrated a significant difference between T1 (Lag 0) and T2 (Lag 2) in the TDT condition ($t(9)=6.63, p<.001$), suggesting that AB occurred. The T2 (Lag 1) accuracies were not lower than the T1 (Lag 0) accuracies in both the TTT and TTD conditions, indicating the occurrence of Lag-1 sparing. A paired t-test revealed a significant difference of accuracy between T3 in the TTT condition and T2 in the TDT condition at Lag 2 ($t(9)=2.70, p<.025$), indicating the occurrence of Lag-2 sparing.

**Electrophysiology** The P3 waveforms at Lag 0, Lag 1, and Lag 2, were calculated by TTD+TDT-TTT, TTT-TDT and TTT-TTD, respectively (Figure 1B). The results of the ERPs suggest that the three targets are consolidated independently even if they appeared successively. A one-way ANOVA was performed on these waveforms, yielding a significant main effect of the onset latency ($F(2, 18)=3.98, p<.04$).

Our data provide the first evidence of discrete consolidation of the trailing targets by observing the P3 components in the AB paradigm. The present findings are consistent with recent AB models, assuming that the AB deficit occurs not because the delay of T1 consolidation directly blocks T2 consolidation, but rather because an attentional mechanism triggered by distractors intervened between T1 and T2 (Di Lollo et al., 2005; Olvers and Meeter 2008).

**References**


