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The transitions of time-dependent performance in a task

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For prolonged cognitive tasks the efficiency of an observer, as a function of test period, is often illustrated as a downward-sloping curve. This deterioration is called the vigilance decrement and is due to a shift in attention during a task. We have investigated the temporal features of attention by using an RSVP task. We focused on transient performance in a trial, in addition to prolonged performance throughout the experiment. Throughout the experiment a vigilance decrement occurred. During a trial however, the detection of a target at the beginning of a sequence was dramatically low and recovered as it appeared later. This result has been shown neither in the vigilance studies, which predict high performance after the task onset, nor in the RSVP studies, which predict high and fair detection of only target in the sequence. This result would reflect a gradual modulation of temporal attention to a rapid sequence.

Key words: preparation cost, vigilance decrement, RSVP

Vigilance studies investigate the ability of observers to maintain their focus of awareness and remain alert to stimuli for prolonged periods of time (Davies & Parasuraman, 1982). These studies have found that the efficiency of observers is highest after the onset of a task and declines over time. This is called the vigilance decrement. However, previous studies have rarely focused on transient changes in performance. Instead they have compared performance at several periods of time, generally at the beginning of an episode and then during some time later. Indeed it is known that preparation for a task is only completed by observers after the onset of the task. This suggests that performance is hindered just after the onset of the task, due to the cost of this preparation (Rogers & Monsell, 1995).

The present study investigated the temporal profiles of attention during a task. By focusing on the preparation cost the state of attention during this brief period of the trial could be understood. But focusing only on the vigilance decrement would not represent the overall state of attention in the experiment. In our study, we used a rapid serial visual presentation (RSVP) task in which stimuli were presented serially and rapidly at the same spatial location on a display. The observers were required to detect a target defined by a certain feature. By manipulating when the target appeared in the RSVP stream we could observe the brief transitions of attention during the task performance. We predicted that a vigilance decrement would occur throughout the experiment: the efficiency of an observer would decline as the trials continued. In particular during a trial, because of the preparation cost, observers would often miss a target inserted into the beginning (or preparation period) of an RSVP stream.

Method

Twelve naive students participated in the experiment. After the presentation of a fixation point (500 ms), an RSVP stream of upper-case letters began (SOA = 100 ms, ISI = 80 ms). In the RSVP stream 20 different letters were sequentially presented for a total of 2500 ms. The task of each observer was to report a white target letter which was presented among light-blue distractor letters by pressing the corresponding key on a keyboard after the finish of the RSVP stream. The position of the target in the stream was varied between the second and nineteenth frames. A response was recorded if it occurred within the response period of 2500 ms after the termination of the sequence. Following the response period the fixation point reappeared and the next trial began, regardless of whether an observer made a response or did not. Each trial therefore lasted for 5000 ms. The experiment consisted of 432

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trials (4 sessions of 108 trials, for a total of 9 minutes). The first and second sessions of the trials were conducted sequentially as one block, and the third and fourth trial sessions were conducted as another. The duration of each block was therefore 18 minutes. Because the observers were allowed to have a 5-minute break between each block the entire experiment took 41 minutes.

There were 2 experimental factors (Time Frame and Target Part). The Time Frame had 2 conditions (the first-half and last-half conditions), in which the first and third sessions (the first 9 minutes of a block) were the first-half condition, and the second and fourth sessions (the last 9 minutes of a block) were the last-half condition. The Target Part had 6 parts (the first to sixth parts), which were based on the primary target positions. We integrated every 3 primary target positions in a sequentially order as one part. That is, we treated the primary second to fourth target position as the first part, the fifth to seventh as the second part, and so on (a total of 6 parts were set).

Results and Discussion

The mean percentages of correct detection of the target, for each condition of Target Part and Time Frame, are shown in Table 1. A two-way ANOVA with the Time Frame (the first-half and last-half conditions) and Target Part (the first to sixth parts) revealed significant main effects of the Time Frame [$F(1, 11) = 6.55, p < 0.05$] and of the Target Part [$F(5, 55) = 32.59, p < 0.001$]. A significant interaction between the factors was not revealed [$F(5, 55) = 1.13, n.s.$]. A Ryan's multiple comparison analysis, which collapsed the Time Frame factor, revealed that the correct detection rates in the first and second parts of the target positions were significantly lower than those in any other part [$ts(55) > 3.33, p < 0.05$].

The present study demonstrated the changes of time-dependent efficiency in the experimental tasks. Because the correct detection rates were lower in the last-half condition than in the first-half condition, a

Table 1
The mean correct detection rate (%)

Time frame	Target part					
	1st	2nd	3rd	4th	5th	6th
First-half	53	66	72	78	81	74
Last-half	50	58	70	72	78	74

vigilance decrement occurred throughout the experiment. In the present experiment, the vigilance decrement occurred within 9 minutes, which is almost consistent with other vigilance studies.

On the other hand, we found a preparation cost in a single trial: in both the first- and last-half conditions the correct detection of a target in the earlier positions was dramatically low, and gradually increased as the target appeared later. This result has not been reported in previous vigilance studies, which have focused on the changes during prolonged performance in an experiment. This result is also a new finding for RSVP tasks because the earlier RSVP studies have predicted a fair and high detection of only one target, whenever it appears. We assumed that the reduction in detection of a target that was early in a sequence would reflect a gradual modulation of temporal attention to a rapid sequence. At the beginning of an RSVP stream the temporal attention of an observer may have difficulty in adjusting to a rapid sequence and detecting a target. Then, the observer might begin to modulate their temporal attention in order to accurately extract a target from the temporally congested stream. The preparation cost observed in the present study would reflect this modulating process of attention to the task.

References

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