Video Article

A Dual Task Procedure Combined with Rapid Serial Visual Presentation to Test Attentional Blink for Nontargets

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Abstract

When viewers search for targets in a rapid serial visual presentation (RSVP) stream, if two targets are presented within about 500 msec of each other, the first target may be easy to spot but the second is likely to be missed. This phenomenon of attentional blink (AB) has been widely studied to probe the temporal capacity of attention for detecting visual targets. However, with the typical procedure of AB experiments, it is not possible to examine how the processing of non-target items in RSVP may be affected by attention. This paper describes a novel dual task procedure combined with RSVP to test effects of AB for nontargets at varied stimulus onset asynchronies (SOAs). In an exemplar experiment, a target category was first displayed, followed by a sequence of 8 nouns. If one of the nouns belonged to the target category, participants would respond 'yes' at the end of the sequence, otherwise participants would respond 'no'. Two 2-alternative forced choice memory tasks followed the response to determine if participants remembered the words immediately before or after the target, as well as a random word from another part of the sequence. In a second exemplar experiment, the same design was used, except that 1) the memory task was counterbalanced into two groups with SOAs of either 120 or 240 msec and 2) three memory tasks followed the sequence and tested remembrance for nontarget nouns in the sequence that could be anywhere from 3 items prior the target noun position to 3 items following the target noun position. Representative results from a previously published study demonstrate that our procedure can be used to examine divergent effects of attention that not only enhance targets but also suppress nontargets. Here we show results from a representative participant that replicated the previous finding.

Video Link

The video component of this article can be found at http://www.jove.com/video/52374/

Introduction

Rapid Serial Visual Presentation (RSVP) has been used to show that there is an attentional blink (AB) when two targets are presented sequentially within about 500 msec[1]. If the second target is presented within about 150 msec, however, there is enhancement in the processing of both targets (*e.g.*, lag-1 sparing)[2]. A similar phenomenon has been found in spatial attention studies. Both the biased competition model of selective attention[3] and the normalization model of attention[4] suggest that attention enhances the processing of items presented in the attended location but suppresses the processing of nearby items. Could this spatial proximity suppression also explain the temporal AB of subsequent items, both nontargets and targets?

Past studies have looked at memory of a presentation of items and found AB when participants were instructed to partially report the sequence of items, but not when participants were instructed to report the entire sequence[5,6]. These results suggest that when attention is allocated over all the words in a sequence, there is no AB, and the span of attention is large. Since the above experiment included all or half of the words as targets, what would happen if participants were told to only look for one target, and all other words were nontargets? Is there AB for nontargets?

Loach and Mari-Beffa published a study about the influence of target detection on memory for distractors, and found the memory for a distractor was inhibited based on its proximity to the target[7]. This indirect design, however, was limited to using only four letters (X, H, S, and O), with any of the letters being a target, critical distractor, or probe. Letters that were never presented as targets or probes would be the remaining distractors.

To overcome the limitations in previous studies, a novel dual-task procedure was developed by Meng and Potter to investigate whether the detection of a target would suppress processing of nearby nontargets[8]. This paper describes this procedure in detail. First, participants searched a sequence of RSVP words for a categorical target word. Second, there was a memory task involving words that were present in the RSVP task, but were not the target. In this procedure, the nontarget words were distractors. The nontarget words, which would be tested in the memory task, had to be attended and remembered by the subject. In each trial, new words would be used; therefore nontarget words were never presented as a target.

Protocol

NOTE: All subjects must give informed written consent before the experimental protocol. All procedures, consent forms, and the experimental protocol must be approved by the local Committee for the Protection of Human Subjects.

1. Preparing the Subject for the Experiment

1. Recruit participants from the local area and compensate them for their time. The participants must have normal or corrected-to-normal visual acuity and English as their first language.

2. Stimuli

1. Choose at least seven different categories from Battig and Montague[9] to use in the target detection task explained below.
2. Choose nouns from the category norms you selected in Battig and Montaque[9] to use as targets as well as other words from separate categories to use as decoys in the target detection task explained below. Make sure the set of words collected in this step is large enough so each subject can be tested with many trails without repeatedly using the same target.
3. Choose nouns from the Penn Treebank corpus, with frequency higher than 1 per million[10] to use as nontargets and distractors to be tested against the nontarget nouns in the memory task explained below. Make sure the set of words collected in this step is also large enough so that repeatedly using a word can be avoided for a given subject.
4. Choose words 4 or 5 letters in length. Trials can be divided into 4-letter words trials and 5-letter words trials. Use only 4-letter words for 4-letter words trials, and 5-letter words for 5-letter words trials.
5. For each trial, randomly select 1 target and 1 decoy that are prepared in step 2.2; from the set that are prepared in step 2.3, randomly select 7 words as nontargets and 5 words as memory task distractors. Make sure the words are never repeated in a given trial.

3. Collect Information from the Participant

1. Before the actual experiment begins, add a section into your experiment, or create a piece of paper to record information about the participant (name, age, handedness, gender).

4. Display Instructions

1. Make sure the participants understand and fully read the instructions.
2. Clearly state that there are two tasks in the experiment, first the participants have to detect the presence or absence of a target noun in a displayed category. Second, participants will be tested on other words in the sequence, so participants must try to remember all the words in the RSVP task described below.
3. Make the response keys clear and easy to remember.

5. Rapid Serial Visual Presentation (RSVP)

1. Use A 21-inch CRT monitor, or equivalent (refresh rate = 85 Hz, resolution = 1,280 x 1,024 pixels) to display the stimuli. Use standard scientific software and a stimuli presentation toolbox to run the experiment. Present the words in black and Courier font (size 14) on a white background.
2. Start each trial with a display of the target category for 1.2 sec, followed by a fixation cross for 500 msec and a blank screen for 200 msec. Next, present 8 nouns using SOAs of either 120, 240, or 360 msec/item making sure distractor nouns are never used as target nouns across trials. Each trial takes about 10 sec.
   NOTE: in total, there were 96 trials and 8 practice trials in the exemplar experiment 1, including 16 repetitions for each condition. A typical session with this experimental design will take a subject 15–20 min to complete.

6. Target Detection Task

1. Prepare two nouns, one belonging to the target category and the other not belonging to the target category (a decoy noun), for every trial. In half of the trials, present the target noun. And in the other half of the trials, present the decoy noun. Ensure the target position is never one of the first or last positions in the presentation.
2. After the RSVP, give participants 2 sec to respond “Yes” or “No” to indicate whether the presentation contained a word from the target category.

7. Recognition Memory Task for Nontargets

1. Present the first recognition memory task for nontargets after the 2-sec interval for response to the categorical task.
   NOTE: this first memory task is always a word either immediately before or immediately after the target word in the sequence, or in the middle of the sequence for trials not containing a target word.
2. Show the test word randomly on the right or left side of the screen next to a word that was not in the sequence, acquired from protocol step 2.2.

3. Keep these words on the screen until participants make a response using the left or right arrow key, corresponding to the position of the word that was displayed in the sequence.
4. Present the second memory test after the response, using a word in the sequence not directly before or after the target, to keep participants from paying extra attention to the words around the target. Use the same procedure as the first memory task.
5. To avoid fatigue or eye strain, encourage participants to take rests between experimental trials. Participants usually do not need more than a few seconds to rest between consecutive trials.

8. Counterbalanced SOA Memory Task

1. If interested in examining AB effects on more nontarget items, in a second experiment, use the same RSVP procedure with a counterbalanced, between-subject design.
   NOTE: In the demonstrative study, the SOAs of 120 or 240 msec were counterbalanced between participants. Other SOAs can be tested as well. This experiment does not need to be conducted with the same participants or in the same sessions as the first experiment.
2. Use three memory tests after the detection task for this experiment. Make sure that the test words are equally likely to be from positions 2 through 7 around the target for target present trials, or around the decoy noun in the target absent trials.
   NOTE: the procedure and button press is the same as the first experiment.

9. Wrapping up

1. De-brief with the participants if they are interested in the purpose of the study. To protect participant's privacy, identifying information about participants (*e.g.*, name) should be removed and replaced with number coding to be affiliated with the data file.
2. If needed, when data from multiple participants are collected, use ANOVAs or planned contrast t-tests to compare memory performances in target present versus target absent conditions.
   NOTE: We suggest to focus on the data from correctly answered trials of the target detection task, as participant's attention may be unfocused in incorrectly answered trials of the target detection task.

Representative Results

For experiment 1, the representative subject's accuracy for detecting a noun in the target category over SOAs was 72% at 120 msec, 91% at 240 msec, and 94% for 360 msec. For the memory task, only correctly answered trials of the target detection task were used, and trials were separated based on the presence or absence of a categorical target noun and then split into subsets based on their positions corresponding to the target noun, or their serial positions corresponding to the decoy target noun in target absent trials. **Figure 1** shows the results of the first memory task for the representative subject. The subject showed difficulty remembering targets immediately after the category noun for both 120 and 240 msec SOAs, but fairly high accuracy with encoding at 360 msec SOA. Words that were immediately before the category noun were all remembered with fairly high accuracy. When there was no target present in the RSVP sequence at 120 and 240 msec SOAs, memory was better for words later in the sequence than early in the sequence, while all nontarget words were easily remembered with 360 msec SOA. **Figure 2** shows the results of the second memory task. The words were put into subsets based on whether they were presented before or after the target serial position in RSVP.

For experiment 2, category noun detection accuracy was 80% for the 120 msec SOA condition and 93% for the 240 msec SOA condition, where the serial positions of the target noun were the same as in experiment 1. **Figure 3** shows results for the 120 msec SOA condition. Note that the tested words were equally likely to be from any position 3 words before the target noun (or at the corresponding serial position in the target absent trials) to 3 words following the target noun (or at the corresponding serial position in the target absent trials), excluding the first and last word in the sequence. All items from lag -3, -2, and -1 were remembered around 70% of the time independent of whether the target was present or absent. At lag 1, 2, and 3 in target absent trials, nontarget words were remembered more accurately, while memory for nontarget words at lag 2 was hindered the most in target present trials. **Figure 4** shows results for the 240 msec SOA experiment. Again, memory for nontarget words at lag 2 was worse if there was a target present in the trial.

These results largely replicate a previously published paper[8] that used the same experimental protocol, suggesting robust effectiveness of the present experimental paradigm.

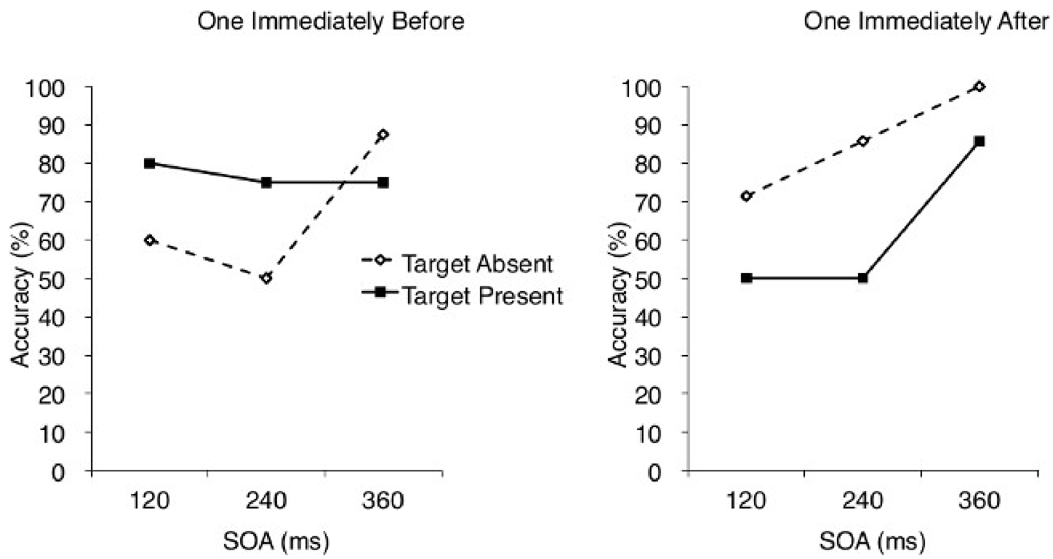

Figure 1. Results of exemplar experiment 1, first memory test for one representative subject: two-alternative forced-choice recognition of the word immediately before the target or control (left) and immediately after the target or control (right).

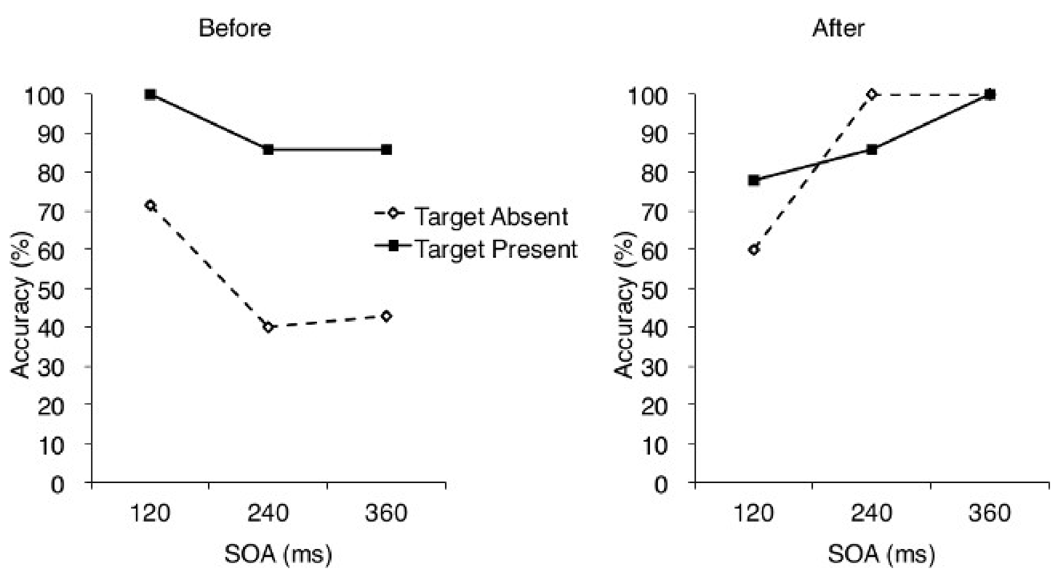

Figure 2. Results of exemplar experiment 1, second memory test for one representative subject: two-alternative forced-choice of a word before (left) or after (right) the target or control, excluding the two words adjacent to the target.

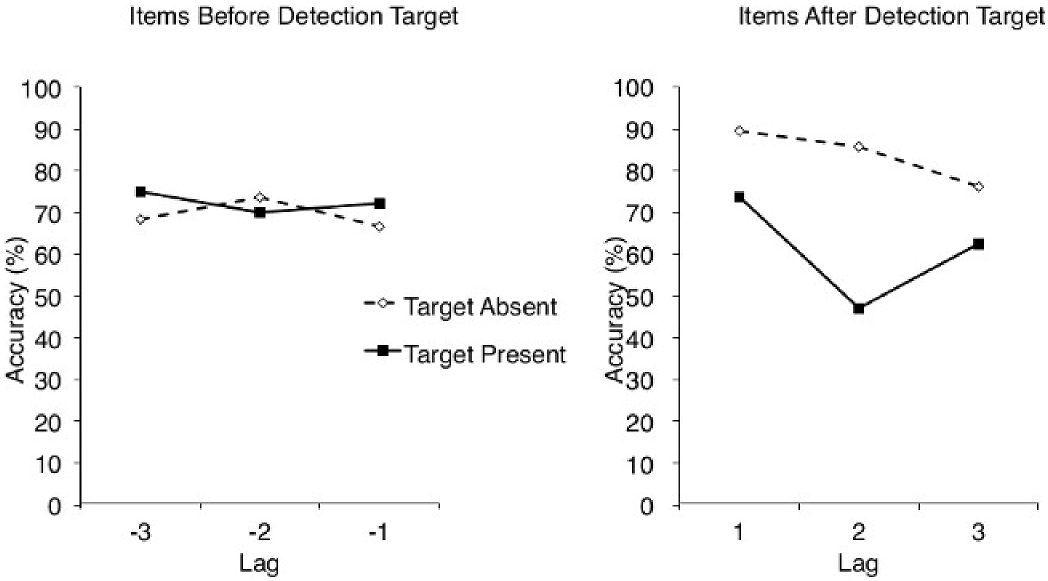

Figure 3. Results of exemplar experiment 2, memory test for one representative subject in the 120 msec SOA condition: accuracy as a function of lag relative to target or control position in RSVP.

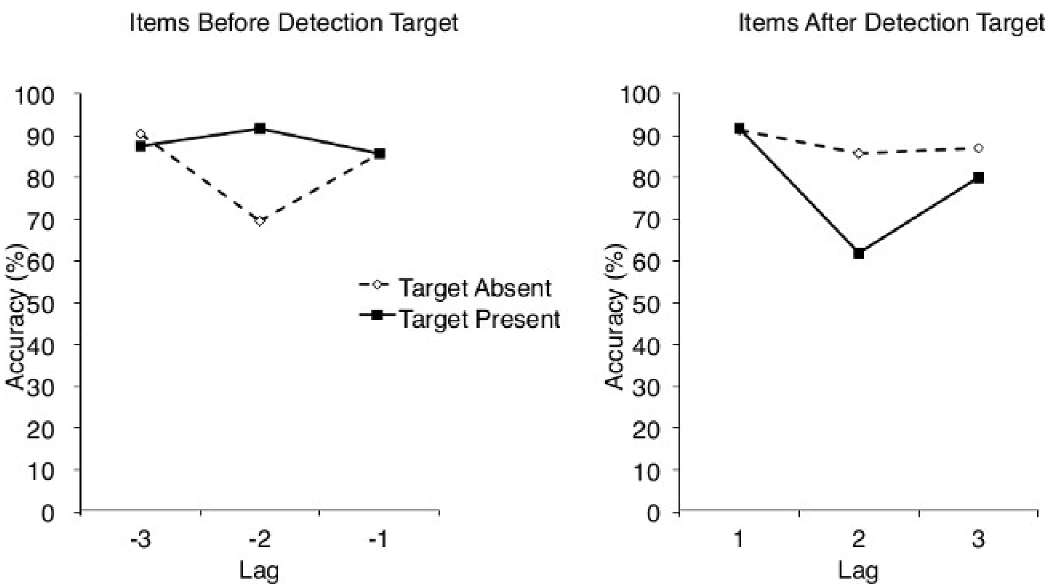

Figure 4. Results of exemplar experiment 2, memory test for one representative subject in the 240 msec SOA condition: accuracy as a function of lag relative to target or control position in RSVP.

Discussion

This novel dual-task approach combined a categorical RSVP detection task with two-alternative forced choice memory tasks immediately following the detection task. Our representative results replicate a previously published study[8], showing that target detection may impair memory encoding of nontargets that are presented after the target, especially at the lag-2 position in RSVP. At a glance, this is an effect similar to AB with lag-1 sparing that suggests transient attention modulated by target detection[8]. However, conventional AB paradigm can only test the effect of attention on targets. Using the conventional AB paradigm, as participants need to maintain the description of targets in working memory, it would be impossible to tease apart any effects caused by transient attention versus effects of working memory. By contrast, our paradigm allows investigations of the temporal properties of visual attention by probing the encoding of nontargets, therefore independent of target-to-target interactions. Using this paradigm, experimenters can test whether theories of spatial attention can be extended to temporal proximities.

Counterbalancing the order of testing and the exact lags in the two-alternative forced choice memory task will allow experimenters to interpret their results with confidence. Researchers should be careful about the selection of the words in RSVP sequence. The length and familiarity should be kept roughly the same among the words; otherwise the results may be biased. On the other hand, SOA and the number of words in RSVP can be changed to allow flexibility in testing effects of attention across various temporal ranges. These changes should not bias experimental results as long as experimental conditions are all otherwise counterbalanced.

This dual-task paradigm is very demanding for the attention of participants. Participants should practice before the real experiment, in order to be able to look for a target word in the RSVP sequence and try to remember the words in the sequence at the same time. In addition, the verbal ability of participants needs to be controlled for to avoid introducing confounding factors. For example, in our exemplar experiments, participants were native English speakers recruited from a university in the US. This requirement of the verbal knowledge of English limits our paradigm in testing English native speaking populations. If a different population is tested, stimulus words must be created in the native language of that population.

Using the current design, more studies can be done to test the importance and specificity of attentional blink as well as periods of transient attention following targets. Future applications of this technique include looking more closely at temporal properties of attention that may complement the current attentional models noted previously that only focus on spatial attention. This technique may also be used for other categories besides nouns, such as pictures and sounds, and can be easily combined with fMRI and MEG techniques to examine neural correlates of attentional effects.

Disclosures

The authors have nothing to disclose.

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