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Attention Blinks for Selection, Not Perception or Memory: Reading Sentences and Reporting Targets

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In whole report, a sentence presented sequentially at the rate of about 10 words/s can be recalled accurately, whereas if the task is to report only two target words (e.g., red words), the second target suffers an attentional blink if it appears shortly after the first target. If these two tasks are carried out simultaneously, is there an attentional blink, and does it affect both tasks? Here, sentence report was combined with report of two target words (Experiments 1 and 2) or two inserted target digits, Arabic numerals or word digits (Experiments 3 and 4). When participants reported only the targets an attentional blink was always observed. When they reported both the sentence and targets, sentence report was quite accurate but there was an attentional blink in picking out the targets when they were part of the sentence. When targets were extra digits inserted in the sentence there was no blink when viewers also reported the sentence. These results challenge some theories of the attentional blink: Blinks result from online selection, not perception or memory.

Keywords: selective attention, dual-task performance, attentional blink, sentence processing, RSVP

Accounts of visual attention distinguish between continuous attention in a whole-report task such as reading and reporting a sentence and selective attention in a visual search task such as looking for a specific word (e.g., Pashler, 1998). Can viewers engage both of these modes of processing simultaneously? In search, the chance of noticing the thing you are looking for is enhanced, often at the cost of missing other things. For example, when viewers search for two targets among distractors in a rapid serial visual presentation (RSVP) of 10 items/s, the first target may be easy to detect, whereas the second target shows an attentional blink if it appears about 200–400 ms after the onset of the first target (e.g., Chun & Potter, 1995; Raymond, Shapiro, & Arnell, 1992). That is, successful selective attention momentarily diminishes the capacity to report a second target. In contrast, in whole-report tasks such as perceiving and then recalling a string of items, there are primacy and recency effects but nothing that looks like an attentional blink. Would there be an attentional blink for target selection if a viewer combined target selection and whole report?

The difficulty of reporting the second of two targets that appears shortly after the first target is surprising, given that adult readers have no trouble reading and reporting a sentence presented word by word at this same rate of 10 item/s (e.g., Potter, Kroll, & Harris, 1980). In a direct comparison of whole report and partial report (Nieuwenstein & Potter, 2006), a short stream of letters was presented and participants either reported two blue target letters or all the letters, in separate blocks. When the first and third items were targets, the third item suffered an attentional blink in partial report. Report of that item was actually better in whole report even though more total items had to be recalled. In other recent studies, the attentional blink has been reduced or eliminated by presenting several targets in sequence, preceded and followed by distractors (Di Lollo, Kawahara, Ghorashi, & Enns, 2005; Nieuwenstein, Potter, & Theeuwes, 2009; Olivers, Van der Stigchel, & Hulleman, 2007). Together with the Nieuwenstein and Potter study, these results suggest that it is the continuous nature of whole report that prevents the attentional blink.

A recent study (Potter, Nieuwenstein, & Strohminger, 2008) asked whether the attentional blink would be eliminated if targets were embedded in an easy-to-remember sequence such as a sentence. They presented 10-word RSVP sentences for 93 ms/word, and participants either reported the whole sentence or, in a different block, reported just two red words. Most of the words, including the target words, could be reported in whole report. However, as Figure 1 shows, the second target word in the partial report condition suffered an attentional blink at a stimulus onset asynchrony (SOA) of 187 ms (lag 2, the second item after the initial target). Another experiment with targets in uppercase rather than red letters produced similar results. In a further experiment, scrambling the sentences with red words reduced whole report accuracy but had no effect on partial report, which showed the same attentional blink seen with normal sentences. That suggested that participants did not process the sentence when instructed to select just the two red words, perhaps because they could not do both.[1]

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[1] In a subsequent unpublished experiment using uppercase targets and scrambled sentences, the effect of scrambling the sentence was similar to that with red targets, with an attentional blink only in partial report, and a stronger negative effect of scrambling on whole than on partial report. There was, however, some negative effect of scrambling the sentence on partial report, unlike the null effect with red targets.

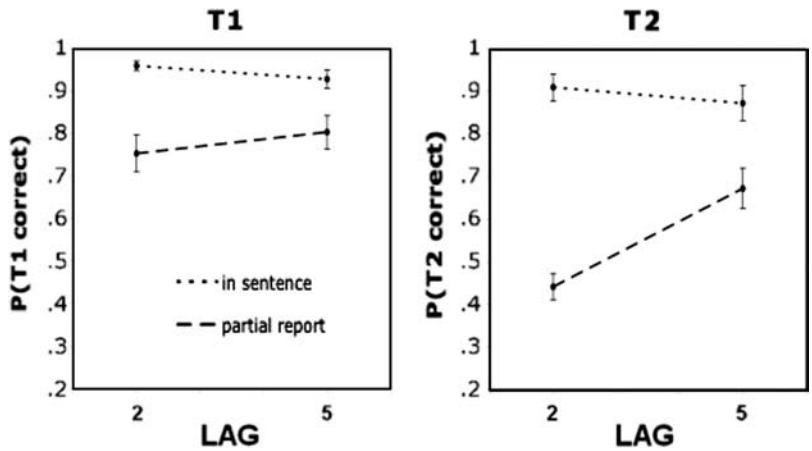

Figure 1. Correct report of T1 and T2 at lags 2 and 5, separately for whole report of the sentence and partial report of just the red target words (from Figure 1 of Potter, Nieuwenstein, & Strohminger, 2008).

If processing the sentence as a whole is incompatible with selecting targets, then attempting to do both tasks simultaneously should produce interference with one or both tasks. On the other hand, it might be the case that subjects are able to maintain selective and continuous modes of processing simultaneously. Such a result would have serious consequences for our understanding of the attentional blink as a process that restricts or limits the encoding of information into memory. In the present study we ask what happens to partial report when it is combined with whole report on the same trial. In the first two experiments the target words were marked by an extra feature: red font in Experiment 1 and uppercase in Experiment 2. In subsequent experiments the targets were digits that were inserted between the words of the sentence.

Experiment 1: Red-Letter Targets

As in Potter et al. (2008), in Experiments 1 and 2 we presented 10-word sentences at 93 ms/word with two targets (words in a red font in Experiment 1 and in upper case in Experiment 2). The second target was presented at lag 2 or lag 5, SOAs of 187 or 467 ms, respectively: a decrement in target report at lag 2, relative to lag 5, would indicate an attentional blink. There were two conditions, blocked within subjects: report only the two target words (partial report), or report the sentence and mark the two target words (whole report plus target marking, which will be referred to as whole report). If selection of the targets requires participants to ignore distractors, correct report of the targets should interfere with report of the words of the sentence and there should be an attentional blink for the second target when it appears at lag 2, creating an error in sentence report.

Method

Participants. The 16 participants were paid volunteers from the MIT Community. All were native speakers of English.

Materials. Table 1 shows an example of a stimulus sentence in Experiment 1. The stimuli were 80 10-word sentences on a wide variety of topics and using diverse syntactic structures, used originally in Potter et al. (2008). There were eight practice sentences, four before each block. Words were one to eight letters in length, and no words in the sentence were repeated. The initial word and all proper names were capitalized. There was no punctuation; the font was Courier, size 22. Words were presented in black on a light gray background, centered on the monitor. The red words were R, G, B 255, 0, 0.

Apparatus. The experiment was programmed using Matlab 5.2.1 and the Psychological Toolbox extension (Brainard, 1997; Pelli, 1997), and was run on a PowerMac G3. The Apple 17" monitor was set to a 1024 × 768 resolution with a 75 Hz refresh rate and 32-bit colors.

Design. The first target (T1) was in one of four serial positions (first, second, third, or fourth word) and the SOA between T1 and T2 (187 or 467 ms, i.e., lag 2 or lag 5) was counterbalanced within subjects and within sentences across subjects, in each of two 40-trial blocks. The last word in the sentence was never a target. The order of the trials was randomized, and that order was used for all participants. The two tasks, partial report of only the two red words or report of the whole sentence, marking the two red words, were blocked; the order of the tasks was counterbalanced between subjects. Thus, the 4 × 2 × 2 design was completed with 16 participants.

Procedure. All participants were told that they would be seeing sentences presented rapidly, one word at a time, and that two of the words would be red. In the partial-report block partic-

Table 1
Examples of a Sentence in Each Experiment

Experiment 1: Our tabby cat **chased**[a] a **mouse** all around the backyard
Experiment 2: Our tabby cat **CHASED** a **MOUSE** all around the backyard
Experiment 3: Our 6666 tabby cat 2222 **chased** a **mouse** all around the backyard
Experiment 4: Our six tabby cat two **chased** a **mouse** all around the backyard

Note. Just one lag condition is illustrated; see text for the lag and serial positions in each experiment.
[a] The critical words in Experiment 1 were red but in the same font as the other words; here they are shown in bold.

ipants were instructed to report only the two red words, putting a hyphen after each word. In the whole-report block they were instructed to report the whole sentence, marking the two red words with a hyphen. Participants were asked not to abbreviate words.

When the participant pressed the space bar to begin a trial, a black fixation cross appeared for 400 ms, followed by a blank screen for 213 ms and then the sentence, presented one word at a time at the same location, for 93 ms/word. After the last word a dialog box appeared. In the whole-report block there was one large entry field into which the sentence was typed, marking the red targets with a hyphen; in the selective-report block there were two smaller entry fields into which the two targets were typed. When the participant had typed his or her response and had clicked on a button labeled "OK," the dialog box was replaced by the words "press space bar."

Scoring. The initial scoring was done by computer, by searching for the two target words in the response; order of report was ignored. This was followed by a hand check, so that spelling errors could be counted as correct. Aside from obvious spelling mistakes, all letters had to be correct and for the response to be counted as correct. In the whole report condition, target responses were scored in two ways: (1) inclusion of the target word in report of the sentence, and (2) inclusion with a hyphen to mark it as a target. In the partial report condition report of the target was counted as correct whether or not it was marked by a hyphen, because adding a hyphen was redundant. In a further analysis of the whole report results, the total number of correct nontarget words was scored, regardless of order.

Results

Participants were able to carry out both tasks together, but at some cost to target detection. Strikingly, there was an attentional blink for the target detection task, whether or not participants also recalled the sentence. The main results for both T1 and T2 are shown in Figure 2. When participants typed the sentence, the red words were recalled just like other words, as part of the sentence. However, when participants marked the red words in the sentence, or recalled just the red words, they showed an attentional blink for identifying the second target at lag 2, relative to lag 5. Analyses of variance (ANOVAs) were carried out on the proportion of correctly identified (marked) targets, separately for T1 and T2. For T1, with serial position of T1, lag, and task (whole vs. partial report) as variables, there were significant main effects of whole (M = .49) versus partial report (M = .73), $F(1, 15) = 40.380$, Mse = .0859, $p < .001$, and T1 serial position, $F(3, 45) = 7.823$, Mse = .0569, $p < .001$, with T1 reported more accurately when it was the first word in the sentence. There were no other significant effects.

In an analysis of T2 responses (conditional on a correct T1), lag and task were variables. There was a main effect of the whole report task (M = .30) versus partial report (M = .55), $F(1, 15) = 64.196$, Mse = .0161, $p < .001$, and a main effect of lag (for lag 2, M = .37, for lag 5, M = .48), $F(1, 15) = 6.186$, Mse = .0315 $p < .05$, showing an attentional blink. There was no interaction, $F < 1.0$.

In summary, there was an attentional blink in marking or reporting the second target at lag 2 whether participants were reporting just the targets or were reporting the whole sentence and marking the targets. In contrast, there was no blink of the target words in writing the sentence: performance was actually slightly higher at lag 2 than at lag 5, as seen in Figure 2.

Finally, the accuracy of report of the eight noncritical words in the whole-report condition was analyzed. The mean proportion reported was .77. Overall, including the red words whether or not they were correctly marked, .79 of the words were recalled, somewhat lower than the .86 words recalled in Potter et al. (2008) when participants recalled the sentence without reporting targets (see Figure 1).

Discussion

Surprisingly, even though participants had to select target words in the whole report condition, recall of the sentences was good, although somewhat lower than recall without a simultaneous

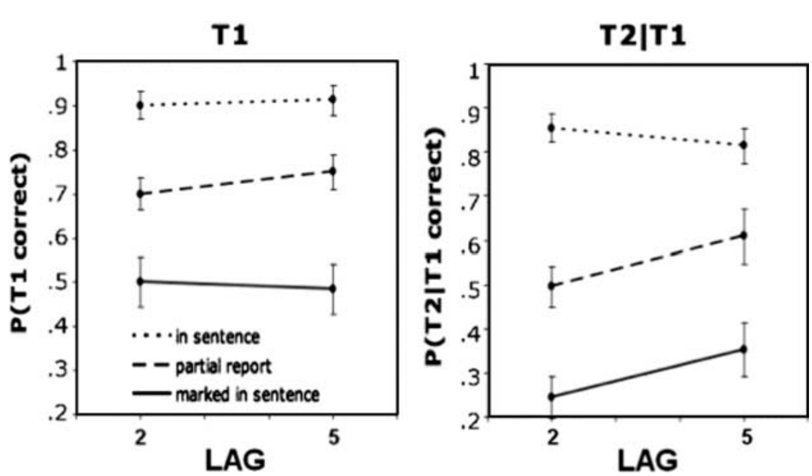

Figure 2. Experiment 1: Correct report of targets T1 and T2|T1 (T2 report conditional on correct T1 report) at lags 2 and 5 in recall of the sentence in whole report (whether or not marked), marked as targets during whole report of the sentence, or in partial report of just the red target words. Error bars depict *SEM*.

search task (Potter et al., 2008).[2] Target detection was, however, substantially worse when the sentence had to be recalled, indicating that the two tasks did compete for resources. However, it is crucial that there was an attentional blink for correctly identifying the second target at lag 2 whether or not the sentence had to be reported, and its magnitude (the difference between lags 2 and 5) was the same in both conditions. The same red target words showed no evidence of an attentional blink during sentence report. That is, attention blinked for selection of the red word, but not for perception and memory for the word.

Was that because selection required binding color to a word? Partial report in Experiment 1 required that the target feature (red) be bound to a word, whereas that feature was irrelevant when reading and then writing the sentence. In Experiment 2 we replicated Experiment 1, using a target feature that is more relevant in reading, the case of the word. Targets were written in uppercase letters, as in Experiment 2 in Potter et al. (2008).

Experiment 2: Uppercase Targets

The method was like those of Experiment 1, except that targets were uppercase words rather than red words; an example is shown in Table 1. To avoid confusion, no other words in the sentence (including the first word and proper names) were capitalized. Participants wrote the sentence in lowercase letters, marking targets with hyphens. The 16 participants were from the same pool as those in Experiment 1, but none had participated in that experiment. One participant who misunderstood the instructions was replaced.

Results

The main results, shown in Figure 3, were highly similar to those in Experiment 1. ANOVAs were carried out on the proportion of correctly marked responses, separately for T1 and T2. For T1, with serial position of T1, lag, and task (whole vs. partial report) as variables, there were significant main effects of whole ($M = .50$) versus partial report ($M = .68$), $F(1, 15) = 13.667$, $Mse = .1538$, $p < .01$, and T1 serial position, $F(3, 45) = 13.024$, $Mse = .0688$, $p < .001$, with T1 reported more accurately when it was the first word in the sentence. There were no other significant effects.

In an analysis of T2 responses (conditional on correct T1), there was a main effect of the whole report task ($M = .25$) versus partial report ($M = .47$), $F(1, 15) = 53.343$, $Mse = .0146$, $p < .001$, a main effect of lag (lag 2, $M = .27$, lag 5, $M = .44$), $F(1, 15) = 20.784$, $Mse = .0218$, $p < .001$, and an interaction, $F(1, 15) = 5.708$, $Mse = .0170$ $p < .05$. As shown in Figure 3, the size of the attentional blink was larger in partial report than in whole report. We followed up the interaction with separate analyses of partial and whole report of T2, conditional on correct report of T1. Both showed a significant effect of lag: for partial report, $F(1, 15) = 18.682$, $Mse = .0229$, $p < .001$; for whole report, $F(1, 15) = 5.090$, $Mse = .0128$, $p < .05$.

Finally, an analysis was carried out on accuracy of report of the eight noncritical words in the whole-report condition. The mean proportion reported was .75. Overall, including the uppercase words whether or not they were correctly marked, .77 of the words were recalled.

In analyses comparing performance in Experiments 1 and 2, with experiment as a between subjects factor, the same main effects and interactions were obtained. There was no significant difference between the experiments and there were no significant interactions with experiment.

Discussion

Taking the results of Experiments 1 and 2 together, it is notable that participants could carry out report of the sentence quite accurately (76% of the words were correct, vs. 85% when only the sentence had to be recalled, in our earlier study). At the same time, participants correctly marked about 50% of the T1 words when recalling the sentences, compared with 70% report of those same words in partial report. Strikingly, T2 reports showed an attentional blink at lag 2 without any effect on report of T2 as part of the sentence. Although targets were more difficult to recall when the sentence had also to be recalled, the magnitude of the attentional blink was similar in both tasks. Thus, the blink was only observed for target selection, and the two tasks were largely independent.

Was the requirement to bind an irrelevant feature to a word responsible for the attentional blink? As noted earlier, in Experiments 1 and 2, the target-defining feature (red or uppercase) was attached to a word in the sentence, although the feature was irrelevant to processing that word as part of the sentence. In search tasks, a critical feature will frequently shift position and become attached to an earlier or later item (e.g., Lawrence, 1971). Several studies of the attentional blink (e.g., Chun, 1997) have noted that such misbindings are increased under conditions that produce an attentional blink, so that the failure to report T2 is sometimes because of the report of T2 + 1 or T2 − 1 instead. Such misbindings do not account for the whole of the attentional blink effect in those studies, however (e.g., Botella, Privado, Gil-Gomez de Liano, & Suero, 2011; Vul, Nieuwenstein, & Kanwisher, 2008). Nonetheless, we carried out analyses in which report of the T2 + 1 or T2 − 1 word was counted as correct, along with report of the correct word. If the attentional blink is entirely because of an increase in such errors at lag 2 compared with lag 5, counting these errors as correct should eliminate the blink. With condition (whole vs. partial report) and SOA between T1 and T2 as variables, and analyzing any of three responses (correct, the + 1 or − 1 word) as correct, conditional on a correct (hyphenated) T1, in Experiment 1, there was a main effect of whole versus partial report, $F(1, 15) = 66.290$, $Mse = .0167$, $p < .001$, and a main effect of SOA, $F(1, 15) = 12.354$, $Mse = .0258$, $p < .01$, with no interaction ($F < 1$). In Experiment 2, there was again a main effect of whole versus partial report, $F(1, 15) = 34.704$, $Mse = .0304$, $p < .001$, and of SOA, $F(1, 15) = 18.359$, $Mse = .0234$, $p = .001$, with a significant interaction, $F(1, 15) = 5.793$, $Mse = .0234$, $p < .05$. In a separate analysis of the whole report

[2] Because the two experiments were carried out at different times with different conditions, the apparent difference in performance may not be reliable.

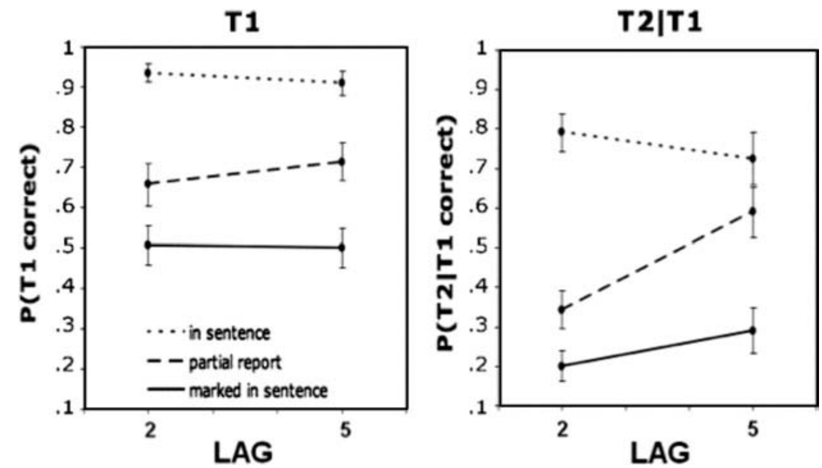

Figure 3. Experiment 2: Correct report of targets T1 and T2|T1 at lags 2 and 5 in recall of the sentence in whole report (whether or not marked), marked as targets during whole report of the sentence, or in partial report of just the uppercase target words. Error bars depict *SEM*.

condition in Experiment 2, the effect of SOA was not significant, $F(1, 15) = 1.701$, Mse $= .0185$, $p = .212$, although the means were .36 and .42 for SOAs of 2 and 5, respectively. Thus, in Experiment 2 the blink effect in whole report was weakened when we included binding errors as correct responses, showing that some (but not all) of the blink effect did take the form of misbinding as others have reported.

The dual role of target words. Quite apart from the question of binding an extraneous feature to a target is the question of the two roles a target word played in the task: the red or uppercase word was a target item to be selected, and a word to fit into the sentence. Would the two tasks—reporting the sentence and reporting the targets—no longer show mutual interference if items did not play a dual role? To separate the target completely from the words of the sentence, in Experiment 3 the targets were Arabic digits that were inserted as extra items in the RSVP sentence. Our intent was to avoid the dual role of the target words in Experiments 1 and 2, while combining the two tasks of sentence processing and target selection.

Experiment 3: Digit targets. In Experiment 3, targets were strings of four identical Arabic digits (e.g., 5555) inserted between words, lengthening the sequence to 12 items, the 10 words of the sentence plus the 2 digit strings. Four-digit strings were used to match the length of an average word. An example is shown in Table 1. In one block participants were required to report only the digits (partial report), and in the other block to report the digits and then the whole sentence (whole report). As before, the order of the two blocks was counterbalanced between participants.

Method

The 16 participants were from the same pool as that of the earlier experiments, but none had participated in those experiments. The words of the sentence were presented for 93 ms, and the digit strings for 80 ms. Unlike the earlier experiments, we used four different lags between digit targets, 1, 3, 6, and 9, with SOAs of 80, 267, 547, and 827 ms, respectively. T1 was always presented immediately after the first word of the sentence; T2 then appeared as the third item in the sentence (lag 1 with respect to T1), or followed after two, five, or eight intervening words (lags 3, 6, and 9); an example is shown in Table 1. In both blocks participants were instructed to report the two digits first, by typing them in. (They typed single digits, not the whole string.) In the whole report block they then typed the sentence, without the digits.

Results and Discussion

Report of the sentence (shown as a horizontal dotted line in Figure 4) was at least as accurate (82% of the words) as in Experiments 1 and 2 (79 and 77%, respectively, including the target words). Report of the digit targets turned out to be surprisingly easy, especially in partial report. There was, nonetheless, an attentional blink for the second target at lag 3 in the partial report condition. Contrary to the results of Experiments 1 and 2, however, there was no blink for target report when participants also reported the sentence.

The ANOVA of correct responses to T1 showed a main effect of whole (M = .90) versus partial report (M = .94), $F(1, 15) = 4.576$, Mse $= .0098$, $p < .05$, and an effect of lag, $F(1, 45) = 5.410$, Mse $= .0146$, $p < .01$, attributable to a lower report of T1 when T2 followed at lag 1. This pattern has frequently been reported in attentional blink experiments, and is attributed to competition between T1 and T2 at lag 1. There was no interaction between condition and lag.

An ANOVA on the proportion of correct responses to T2, conditional on a correct response to T1, showed a main effect of condition, $F(1, 15) = 4.63$, Mse $= .0279$, $p < .05$, with partial report (M = .94) more accurate than whole report (M = .88); a marginal effect of lag, $F(3, 45) = 2.092$, Mse $= .0126$, $p = .12$; and an interaction between lag and partial or whole report, $F(3, 45) = 5.870$, Mse $= .0105$, $p < .01$. There was an attentional blink at lag 3 for partial report, and an apparent enhancement at lag 1 termed lag 1 sparing (Potter, Chun, Banks, & Muckenhoupt, 1998;

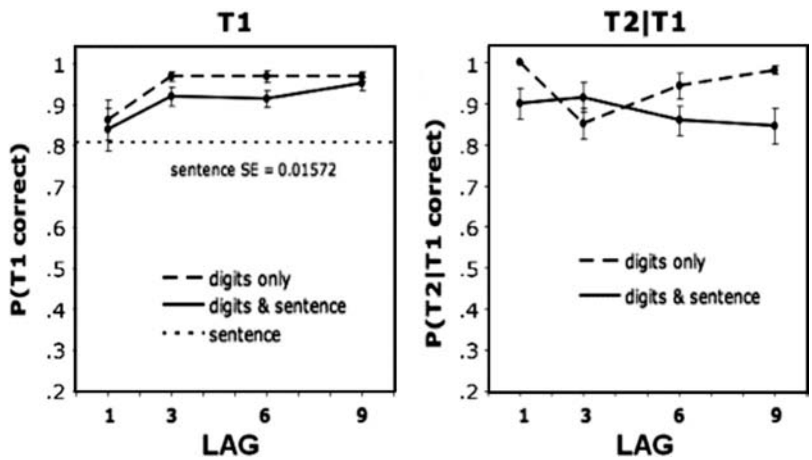

Figure 4. Experiment 3: Correct report of digit-string targets T1 and T2|T1 at lags 1, 3, 6, and 9 when also recalling the sentence in whole report, or in partial report of just the digit strings. Accuracy of sentence recall is shown for comparison. Error bars depict *SEM*.

Visser, Bischof, & Di Lollo, 1999).[3] Lag 1 sparing is often associated with a slight deficit to T1 at lag 1, as found in the present experiment.

Critically, there was no attentional blink and no lag 1 sparing in report of the digits when participants also recalled the sentence. A planned analysis of correct T2 responses conditional on a correct T1 response, including only lags 3 and 6, showed an interaction between lag and whole or partial report, $F(1, 15) = 11.706$, Mse = .0073, $p < .01$, consistent with an attentional blink for partial report only; a separate analysis of partial report with the same two lags was significant, $F(1, 15) = 7.641$, Mse = .0088, $p < .05$.

The results of Experiment 3 suggest that when the viewer must report both the sentence and two sentence-irrelevant targets defined by their distinct category–Arabic digits—there is no attentional blink for the second target, and no lag 1 sparing. When the task was to report only the digits, overall performance was better, but there was an attentional blink at lag 3, as well as lag 1 sparing. The results show that an attentional blink is seen whenever the task is simply to select two targets, even when they are embedded between words in an RSVP sentence. Selection of targets for specific processing, not binding of the color cue or uppercase cue, creates an attentional blink.

However, why was there no selection cost when viewers reported both the sentence and the digit targets? The Arabic digits were conspicuously different, visually, from the words of the sentence. Possibly, participants who were trying to read the sentences were able to register the digits as they appeared, without selecting them as targets until the end of the trial. Subjectively, the sentence seemed to form itself immediately around the visually distinct digits. In contrast, when reporting only the digits, the words of the sentence could be ignored, turning the task into a standard attentional blink task with the expected blink at lag 3.

An alternative possibility is that the digits were easy to segregate not only because they were visually distinctive, but also because they were in a specified category (digits) and because they did not fit into the meaning of the sentence, allowing them to be retained separately. If so, they should also be easy to report if they were written as digit words, again appearing in arbitrary, inappropriate places in the sentence. To distinguish between the roles of visual distinctiveness and of misfitting meaning, we carried out Experiment 4.

Experiment 4: Digits as Words

To test the hypothesis that the visual distinctiveness of the digit targets allowed the targets to be represented easily along with the sentence in the whole report condition, while still creating an attentional blink in partial report, in Experiment 4 we repeated the design of Experiment 3 with one major change: instead of Arabic numerals as the targets, we presented the digits as words (zero, one, two, . . . nine). Thus, they were no longer visually distinguishable from the words of the sentence, and could only be distinguished by their semantic category and their misfit to the sentence.

Method

Participants. The 24 participants were from the same pool as those in the earlier experiments; all but 8 of the participants saw the same sentences used in Experiment 3, and 8 participants saw new sentences. Of these, 3 had seen the old sentences in an earlier experiment, but no other participants had been in any of the earlier experiments.

Design and Procedure. The method was the same as that of Experiment 3 except for the following. The inserted digit was

[3] One theory of the attentional blink that accounts for lag 1 sparing proposes that targets can be readily detected in a first stage, but must then be consolidated into short-term memory in a second stage, before they can be reported (e.g., Chun & Potter, 1995; Shapiro, 2001). The second stage is serial, capable of handling just one stimulus at a time, so that if T2 arrives while T1 is occupying the second stage, T2 may be detected but then must wait until Stage II is free. When stimuli are shown in sequence at a rapid rate, T2 will be masked by the following stimulus and may be forgotten before it can be consolidated. In this model, presentation of T2 at lag 1 allows both targets to move together into the second stage, although there may be some competition between them that decreases report of T1 at lag 1 (Potter, Staub, & O'Connor, 2002), as seen here.

written as a word rather than a string of Arabic numbers; as before, the target was reported by typing the relevant digit as an Arabic number. An example is shown in Table 1. As in Experiment 3, the words of the sentence were presented for 93 ms, but unlike Experiment 3, the digit words were also shown for 93 ms (not 80 ms). A new set of 80 10-word sentences was used with eight of the participants.

Results and Discussion

As shown in Figure 5, which can be compared with Figure 4, the target task was much more difficult when the digits were presented as words than as Arabic digits. There was a substantial attentional blink in the digits-only condition, but none in the report-both condition. Report of the sentence was also worse: 72% of the words were reported, compared with 82% in Experiment 3.

In an ANOVA of correct reports of T1, with whole or partial report and lag as variables, there were no significant main effects (both *F*s less than 1.11), but there was a suggestion of an interaction, $p = .11$: when only the digits needed to be reported, there was a lower performance on T1 when T2 appeared at lag 1. Overall, T1 was reported correctly on .73 of the trials, compared with .92 in Experiment 3. In the ANOVA of T2 responses, conditional on correct report of T1, the advantage of digits-only over report of both was marginally significant, $p = .08$; the main effect of lag was significant, $F(3, 69) = 5.71$, Mse $= .0406$, $p = .001$, and the interaction was significant, $F(3, 69) = 3.526$, Mse $= .0343$, $p < .05$. In a planned comparison to assess the significance of the attentional blink effect, we compared T2 report at lags 3 and 6 (conditional on correct report of T1). The main effect of condition was not significant, $F < 1$, but the effect of lag was significant, $F(1, 23) = 7.827$, Mse $= .0539$, $p = .010$. The interaction with condition was marginally significant, $F(1, 23) = 3.564$, Mse $= .0417$, $p = .072$. Separate planned analyses indicated a significant effect of lag for the digits-only condition, $F(1, 23) = 9.281$, Mse $= .0577$, $p < .01$, but not for the report-both condition, $F < 1.0$.

Thus, there was an attentional blink for the second target when reporting only the digits, but not when reporting both the sentence and the digits—just as when the targets were distinctive Arabic numerals (in Experiment 3). Although both tasks were more difficult with digit words than with Arabic digits, having to report both the digits and the sentence eliminated the attentional blink of the second digit. Why the results of Experiments 3 and 4 differed from those of Experiments 1 and 2 is considered in the general discussion.

General Discussion

Selective report of targets (partial report) and whole report are two modes of processing that have usually been studied separately. In a study comparing these two ways of processing RSVP sequences (Potter et al., 2008), participants viewed a sentence presented rapidly, one word at a time, and reported either the sentence or only two targets (red words or uppercase words), in separate blocks. Partial report produced an attentional blink for the second target at lag 2, whereas the same two words (along with the other words of the sentence) were readily recalled in whole report. The purpose of the present studies was to investigate whether these two ways of processing can be engaged simultaneously.

In the first two experiments we combined the two tasks used by Potter et al. (2008), asking participants to write down the sentence and mark the red or uppercase words (Experiments 1 and 2, respectively). In a separate block, participants simply reported the two red or uppercase words (partial report). In the partial report block there was an attentional blink for the second target at lag 2, replicating that condition in the earlier experiments. In the block in which participants both recalled the sentence and marked the target words, there was an attentional blink for correct marking of T2, even though both target words were readily recalled as part of the sentence with no sign of the blink. The attentional blink was a problem of selection, not of perception or storage capacity.

The dual task did reduce overall accuracy in each task. Recall of the sentences was somewhat less accurate than in the whole report condition in our earlier study, although because of many differences between the two studies we could not test the reliability of this observation. Partial report was significantly worse when combined with whole report than when it was the sole task, although

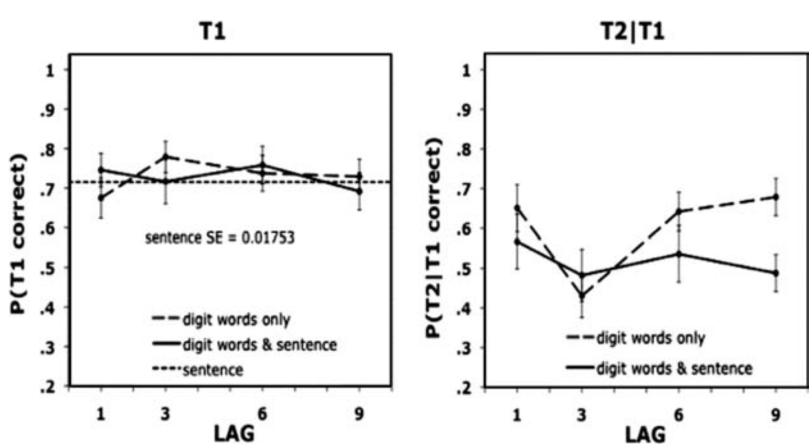

Figure 5. Experiment 4: Correct report of digit-word targets T1 and T2|T1 at lags 1, 3, 6, and 9 when also recalling the sentence in whole report, or in partial report of just the digit words. Accuracy of sentence recall is shown for comparison. Error bars depict *SEM*.

the blink effect for target report was present whether or not the sentence had to be recalled.

Selection in Experiments 1 and 2 required participants to bind the target feature (red or uppercase) to a word, which might account for the difficulty in detecting a second target at a short lag. In Experiment 3 the targets were rows of identical digits (e.g., 3333) inserted between words in the RSVP sentence, so the targets had to be identified but did not require binding of an incidental feature, and targets were not part of the to-be-reported sentence. Again, the sentences were relatively easy to report, but so were the digits, even though they were presented for only 80 ms. There was an attentional blink for report of the digits—but only in the digits-only block, not the block in which participants reported both the sentence and the digits.

Thus, having to encode the sentence spared the digit targets from an attentional blink, perhaps because they were visually distinct from the words of the sentence, which seems to have made the task very easy, In Experiment 4 the easily seen digit strings were replaced by a written digit word. Now, both digit detection and report of the sentence were markedly more difficult than in Experiment 3, but there was again no attentional blink when both the sentence and the digits had to be recalled. Thus, in both experiments there was an attentional blink when only the digits had to be reported, but not when both the digits and the sentences had to be reported.

However, why did having to report the sentence eliminate the attentional blink only in Experiments 3 and 4, not in Experiments 1 and 2 with targets that were part of the sentence? A possible explanation is that the dual role of the target words in Experiments 1 and 2 forced participants to encode them in two ways, remembering them in relation to the sentence and selecting them as to-be-reported targets. Moreover, the selection of targets in these experiments had to be done online, to bind the target feature (color or uppercase) to the correct word. In Experiments 3 and 4, participants had only one encoding for each stimulus, so that in sentence-processing mode they simply had to note the targets as they arrived, along with the words of the sentence. Having to process the sentence forced participants to consider all the items in turn, without pausing to select targets, but simply retaining them along with the sentence and selecting them afterward. This shift in processing may have deactivated the mechanisms that would otherwise have led to a blink, as has been shown in previous RSVP whole report studies (Nieuwenstein & Potter, 2006).

Still another explanation of the failure to find an attentional blink when the participants were also required to report the sentence is that the sentence task diffused attention as suggested by Olivers and Nieuwenhuis (2005), reducing attentional focus on T1 and thereby eliminating an attentional blink.

That leaves another question: Why did subjects use selective attention (resulting in an attentional blink) in the partial report condition of Experiments 3 and 4 if target detection is so easy and blink-free in whole report? The data show that there is an overall improvement in target identification for T1 in the partial report condition, relative to whole report. This suggests that while the operation of selective attention in these experiments comes at the cost of an attentional blink, performance on target detection is improved on average.

Lag 1 Sparing. The present studies have shown that two distinct modes of attending to and processing visual stimuli, selective detection of targets and unselective processing of a sentence, can be carried out simultaneously by novice participants. In Experiments 1 and 2 selective processing continued to generate an attentional blink while sentence processing and report of the same stimuli on the same trial exhibited no attentional blink. Conditions that produce an attentional blink at lags 2 or 3 often produce relatively good performance on T2 when it directly follows T1, an effect termed lag 1 sparing (see Footnote 3). This effect can be seen in Experiments 3 and 4 in the partial report condition (Experiments 1 and 2 did not include lag 1). A recent theory of the attentional blink (Bowman & Wyble, 2007) ties lag 1 sparing to the attentional blink: sparing occurs because the attentional episode initiated by T1 extends for about 150 ms, benefiting T2 if it appears in that interval. At longer lags between targets there is a delay in processing T2 while the first target episode is consolidated, producing an attentional blink. Furthermore, the conditions that produce lag 1 sparing also come with a cost to T1 report at lag 1. The present results are consistent with this account of the attentional blink, inasmuch as whenever there was an attentional blink (defined by lower report at lags 2 and 3 than at lags 5 or 6) there was always an indication of lag 1 sparing. The absence of lag 1 sparing when the sentence had to be remembered is a further indication that there was no online selection of targets in that condition, in Experiments 3 and 4.

Relation to Existing Theories of Attention

These results are broadly congruent with models that suggest that the attentional blink is primarily the result of changes in attentional control, rather than limited processing resources (Di Lollo et al., 2005; Martens & Wyble, 2010; Olivers & Meeter, 2008; Wyble, Bowman, & Nieuwenstein, 2009; Wyble, Potter, Bowman & Nieuwenstein, 2011). If limited resources were the primary cause of the attentional blink, then processing of words in a sentence during the blink should have been impaired and it was not (Experiments 1 and 2). Furthermore, adding the task of encoding the words of the sentence should have decreased the accuracy of T2 at lag 3, and it did not (Experiments 3 and 4).

However, these data also raise important new challenges for such models by illustrating that the presence of an attentional blink does not necessarily impede the ability to consciously report stimuli within its time window. The difficulty in attentionally selecting two temporally proximal targets in these experiments occurs at the same lags that words in an RSVP task are being actively encoded into memory (Experiments 1 and 2). Furthermore, the results indicate that RSVP sentence processing can occur alongside the encoding of irrelevant target numbers in Arabic (Experiment 3) or written (Experiment 4) form.

To conclude, two modes of processing can occur simultaneously but largely independently: the continuous mode required for sentence processing and the selective mode required for target detection, identification, and report. In all conditions there was an attentional blink for target selection when the sentence could be ignored. When participants did both tasks, there was still an attentional blink for selection (but not for sentence memory) when targets were words in the sentence, but the blink was eliminated when the targets were interleaved with the sentence, suggesting that they were processed in the continuous mode, along with the sentence, and selected later. In summary, attention blinks for online selection, not for perception or memory.

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Correction to Potter et al. (2011)

The article "Attention Blinks for Selection, Not Perception or Memory: Reading Sentences and Reporting Targets," by Mary C. Potter, Brad Wyble, and Jennifer Olejarczyk (*Journal of Experimental Psychology: Human Perception and Performance*, 2011, Vol. 37, No. 6, pp. 1915–1923) contained several production-related errors.

In Table 1, the critical words should have been shown in bold for Experiment 1 only. A corrected table appears below.

Table 1
Examples of a Sentence in Each Experiment

Experiment 1: Our tabby cat **chased**[a] a **mouse** all around the backyard
Experiment 2: Our tabby cat CHASED a MOUSE all around the backyard
Experiment 3: Our 6666 tabby cat 2222 chased a mouse all around the backyard
Experiment 4: Our six tabby cat two chased a mouse all around the backyard

Note. Just one lag condition is illustrated; see text for the lag and serial positions in each experiment.
[a] The critical words in Experiment 1 were red but in the same font as the other words; here they are shown in bold.

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