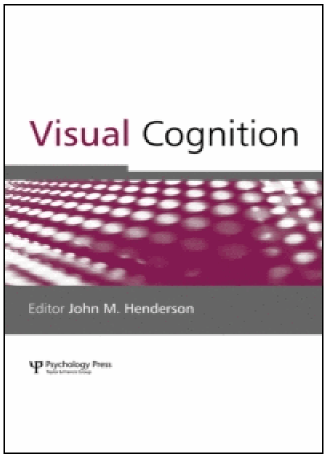

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The processing locus of interference from salient singleton distractors

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The processing locus of interference from salient singleton distractors

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Numerous studies have demonstrated that target processing is slowed in the presence of an irrelevant singleton element. One hypothesis is that these slowed responses are due to disruptions in the early sensory processing of the targets. We replicated this effect in a resource-limited procedure. However, under data-limited conditions (e.g., brief exposure durations and backward masking), the same singleton distractor did not interfere with performance. Following previous suggestions that data-limited procedures should be sensitive to disruptions in early visual processing (Santee & Egeth, 1982), we conclude that slowed response times in the presence of salient singleton distractors may be due to disruptions in a postperceptual stage of processing such as response selection.

In a crowded visual scene, a salient yet irrelevant item may capture spatial attention. According to data-driven models, attentional capture is governed primarily by the properties of stimuli within a display. According to these models, the most salient item in a display automatically captures attention, producing a cost in the observer's ability to process the relevant target item (e.g., Theeuwes, 1991, 1992, 1996; Theeuwes & Godijn, 2001). Such capture is thought to be the result of relatively "hard-wired" perceptual mechanisms that calculate local feature contrasts for each item within a display based on the presence of particular primitive feature dimensions (e.g., shape, colour, etc.) and automatically orient attention to the location of the largest contrast. Further, because of this dependence on basic feature dimensions, capture is assumed to operate at the level of early, preattentive perceptual processing.

Indeed, multiple studies using the "additional singleton" paradigm suggest that a highly salient item is automatically selected by the visual system, regardless of its task relevancy (e.g., Theeuwes, 1991, 1992, 1996). In an

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additional singleton task, observers are asked to search a visual display and respond to a prespecified target defined by a particular feature value. On some trials, an irrelevant, yet salient nontarget item (the "additional singleton") may also be present. Multiple studies have demonstrated that this additional singleton produces a significant cost in the time it takes observers to locate and respond to the target, indicating that this item inadvertently captured observers' attention. In addition, this capture depends on the relative saliency of the additional singleton—a cost obtains only when it is more salient than the target item. This effect is quite robust; evidence of singleton-driven capture has also been obtained in several other paradigms. For example, using a modified additional singleton task, Theeuwes and colleagues (Theeuwes, Kramer, Hahn, & Irwin, 1998; Theeuwes, Kramer, Hahn, Irwin, & Zelinsky, 1999) have shown that an additional singleton may "capture" the eyes by automatically eliciting a saccade to its location. In addition, Theeuwes and Godijn (2002) have recently used inhibition of return (a phenomenon whereby after attention has been oriented to a location, there is a significant delay in responses to stimuli that subsequently appear at that location; e.g., Posner & Cohen, 1984) to show that response latencies to a target are slowed when it appears in the same location previously occupied by an irrelevant singleton.

THE LOCUS OF ATTENTIONAL CAPTURE:[1] EARLY PERCEPTUAL OR POSTPERCEPTUAL?

The studies reviewed above support a data-driven model of attentional capture by demonstrating that in the absence of any particular top-down set, a salient but irrelevant singleton interferes with visual processing. One important question, however, concerns the specific stage(s) of processing that are impaired. On the one hand, it is possible that capture results from interference generated during early perceptual processing. This is the position adopted by data-driven models of capture. On the other hand, it is also possible that capture is the result of inefficiencies that arise during later stages of processing such as response selection. At present, this issue remains unresolved. Each of the studies reviewed above have employed reaction time as the primary dependent measure, and it is known that this variable can be influenced by changes in both early and late stages of processing. On this basis, Santee and Egeth (1982; see also Mordkoff & Egeth, 1993) have drawn a distinction between *data-limited* and *resource-limited* tasks. In a

[1] In the present experiments, we adopt a perspective whereby attentional capture may modulate either perceptual or post-perceptual processing. This seems reasonable given that a variety of attention effects can be shown to occur during either stage (e.g., Awh, Vogel, & Oh, 2006).

resource-limited task, observers are instructed to make a speeded response to a target item that is presented for a relatively long period of time. According to Santee and Egeth (1982), performance costs in such a task might reflect difficulties that arise during either perceptual (e.g., stimulus encoding) or postperceptual (e.g., response selection) processing, since difficulties in either stage of processing could slow responses. However, in a data-limited task, observers are instructed to make an unspeeded response to a target item that is presented for only a brief period. In this case, the brief exposure durations can ensure that the initial encoding of the stimulus identity is a limiting factor for performance. Furthermore, the use of unspeeded responses makes it less likely that errors in response selection (or other processes) will occur. Therefore, because response latency has been the primary dependent measure in the additional singleton task paradigm, the possibility remains that the slowed responses in the presence of the additional singleton are driven by disruptions of postperceptual processes such as response selection.

To identify the stage of processing affected by the irrelevant singleton, it would be necessary to contrast the studies reviewed above with one that employs a data-limited implementation of an additional singleton task. In fact, Theeuwes and colleagues have already reported an accuracy-based version of a typical additional singleton task (Theeuwes & Chen, 2005; Theeuwes, Kramer, & Kingstone, 2004). Theeuwes et al. (2004) presented observers with a "go/no-go" variant of a traditional additional singleton paradigm, and asked them to judge the orientation of a line (horizontal or vertical) within a prespecified target object (defined by shape). On half of all trials, an irrelevant colour singleton was present in the display. All stimuli were masked upon offset. Each subject responded to only one line orientation and was instructed to withhold responses to the alternate orientation. The results of this study suggested that the presence of an irrelevant colour singleton modulated perceptual sensitivity by producing a significant cost in target perceptibility (as indicated by a significantly lower d' on singleton-present trials) on singleton-present trials. Theeuwes et al. interpreted this result as evidence that the presence of an additional singleton biases early perceptual processing. In particular, these authors argue that the cost observed in this experiment was driven by a reduction in the sensory gain at the location of the target.

We reasoned, however, that the d' cost observed in this study could be explained either by singleton-driven reductions in sensory gain or a reduction in observers' response thresholds on singleton-present trials. In line with this possibility, Theeuwes et al. (2004) reported a small, but significantly higher false alarm rate on trials in which an irrelevant colour singleton was present (0.260) than on trials when one was not (0.297). Therefore, it may be that the presence of the irrelevant singleton increased the likelihood of a "go" response. Note that this kind of change in response processing would not necessarily require a change in perceptual processing at the target location (for a discussion of how *d′* effects may not always reflect changes in perceptual sensitivity, see Shiu & Pashler, 1994). Thus, the possibility remains that the cost observed by Theeuwes et al. was not engendered by disruptions in early perceptual processing, but instead reflects interference generated during later stages. In the present experiments, we reexamined whether singleton distractors would influence performance in a data-limited display. To do so, we employed both resource-limited and data-limited versions of a traditional additional singleton task. In addition, our data-limited implementation of this task employed a two-alternative forced choice procedure rather than the go/no-go procedure used by Theeuwes et al. in the hopes of avoiding response threshold effects such as those as described above. Because changes in reaction time can be elicited by disruptions of either perceptual or postperceptual processing, we expected that the presence of an irrelevant singleton would significantly slow observers' response times under resource-limited conditions. In addition, if the presence of an irrelevant singleton biases early perceptual processing by reducing the sensory gain at the location of a target item, then accuracy should also suffer when an irrelevant singleton is presented in a data-limited version of this task. Thus, the absence of such accuracy effects would indicate that the irrelevant singleton influences a postperceptual stage of processing.

EXPERIMENT 1A

Experiment 1 employed a variant of a traditional (i.e., resource-limited) additional singleton task in order to ensure that this procedure would replicate the reaction time costs that are typically observed in this paradigm. The task was similar to those previously employed by Theeuwes (1991, 1992, 1996), and is depicted in Figure 1. Observers viewed an array of eight items (seven circles and one square) presented at equally spaced positions along the perimeter of an imaginary circle centred at fixation.

Observers were instructed to make speeded responses to indicate the location of a gap (e.g., left- or right-hand side) on the perimeter of the square. Thus, the target for which subjects were to search in this task was always a singleton by virtue of shape. In addition, on approximately half of all trials, one of the nontarget items in the display appeared as an irrelevant additional singleton defined by a unique colour (e.g., yellow or white). The remaining six items in the display were red or green circles, with the restriction that on a particular trial, these items shared the colour of the target singleton. Consistent with results obtained in several previous investigations (e.g., Theeuwes, 1991, 1992, 1996) we expected that a singleton

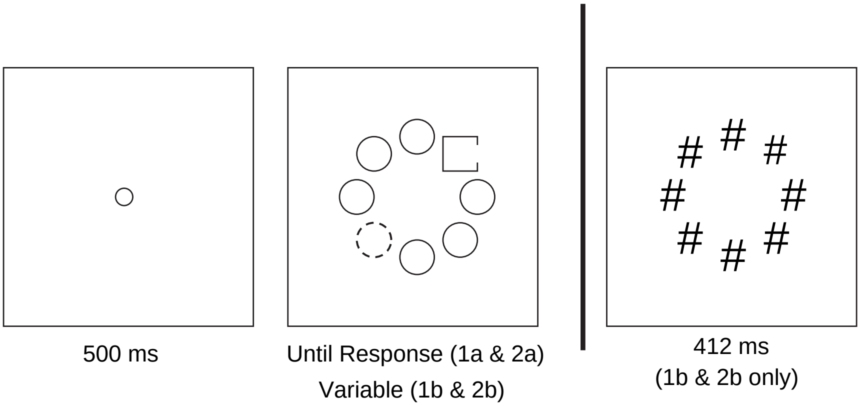

Figure 1. Task design employed in Experiments 1 and 2. In all experiments, the target and nonsingleton items appeared as either green or red on a single trial. The colour singleton (dashed circle), when present, appeared as either yellow or white. The mask displays in the third panel were used only in Experiment 1b and 2b. In Experiments 1a and 1b, the target item was defined as a shape (square) singleton, while the irrelevant colour singleton was always a circle. In Experiments 2a and 2b, the target item was equally likely to be a circle or a square. Thus, the target could only be differentiated from nontarget items by the presence of a small gap.

item would lead to a significant cost in observers' response latencies to the target item.

Method

Subjects. Twelve undergraduates from the University of Oregon human subjects pool participated in a 30 minute experimental session in exchange for course credit. All subjects reported normal or corrected-to-normal vision and ranged from 18 to 30 years in age.

Apparatus and stimuli. Stimuli were presented on a 17-inch colour monitor cycling at 120 Hz driven by a Pentium III processor. Subjects were seated approximately 65 cm from the display. Stimuli appeared against a black background (0.07 cd/m^2) along the perimeter of an imaginary circle (radius = 1.2°) centred at fixation. We chose to use a rather dense display, following previous demonstrations that interference from an additional singleton is especially likely under these conditions (e.g., Kumada, 1999). Each stimulus presented within the array subtended approximately 0.6° in height and width. The centre-to-centre distance between each item was approximately 0.9°, with a spacing of approximately 0.3° between items. The target item was a green or red (8.58 and 7.91 cd/m^2, respectively) square. This item contained a gap of approximately 0.2° on either the left or right hand side. The additional singleton, when present, was a yellow or white (119.1 and 103.0 cd/m^2, respectively) circle. A white fixation dot (0.31° diameter) appeared at the onset of every trial and immediately offset prior to the presentation of the target display.

Design and procedure. The task required subjects to report the position of a gap on either the right or left side of a target square. Subjects were instructed to respond as quickly as possible while maintaining a high degree of accuracy. On any particular trial, the target singleton and all nonsingleton items appeared in the same colour (red or green). The additional singleton, when present, appeared in white or yellow. The position in which both items appeared was randomized across trials. Due to a programming error, 49.2% (instead of 50%) of all trials contained a colour singleton. Subjects performed a total of five blocks of 96 trials each.

Results

The first block of trials for each subject were classified as practice and excluded from analysis. Mean response accuracy was 97.4%. Error trials were excluded from analysis. Mean subject response times for both additional singleton-present and -absent trials are presented in Figure 2a. As is apparent from this figure, mean response latencies to the target were significantly slowed by an additional singleton ($M = 519.7$ ms) relative to nonsingleton trials ($M = 499.2$ ms), $t(11) = 2.59$, $SEM = 7.89$, $p < .05$. These results are characteristic of those typically observed within a traditional additional singleton task (e.g., Theeuwes, 1991, 1992, 1996).

According to data-driven models of attentional capture, the cost of the additional singleton is due to disruptions in early perceptual processing. As such, these models would predict that an additional singleton should also disrupt performance within a data-limited implementation of this task. We tested this prediction in Experiment 1b.

EXPERIMENT 1B

Experiment 1b attempted to replicate the additional singleton-driven cost obtained in Experiment 1a under data-limited conditions. The design of this experiment was identical to that of Experiment 1a, with the exception that display exposure durations were limited, and all stimuli were masked upon offset (see Figure 1, right panel). Observers made unspeeded responses to the location of a gap within the target (again, a square). On approximately half of all trials, an irrelevant colour singleton was present within the display. According a data-driven model of attentional capture, the presence of an

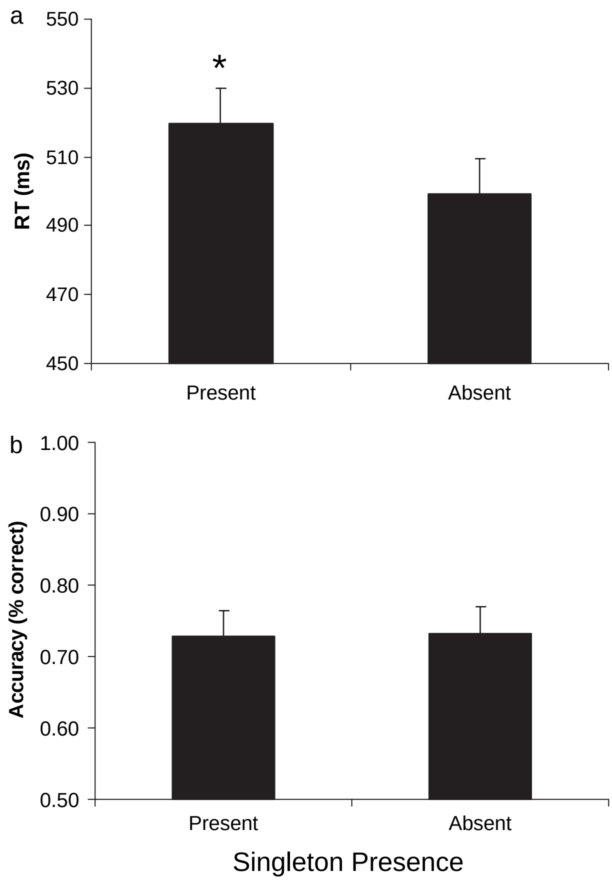

Figure 2. Results of Experiments 1a and 1b. The presence of an irrelevant singleton significantly slowed response latencies in Experiment 1a (panel a; * <.05), but had no effect on response accuracy in Experiment 1b (panel b).

irrelevant singleton reduces the sensory gain at the location of a target item within a display (e.g., Theeuwes et al., 2004). If is the case, we should observe an additional singleton-related cost under these data-limited conditions. However, if no evidence of a cost is obtained, it would suggest that the effect observed in Experiment 1a was driven by disruptions in postperceptual processing.

Method

Subjects. Sixteen undergraduate students from the University of Oregon human subjects pool participated in a single half-hour experimental session in exchange for course credit. All subjects reported normal or corrected-to-normal vision and ranged between 18 and 30 years of age.

Apparatus and stimuli. Displays used in the present experiment were identical to those used in Experiment 1 with the exception that exposure durations were limited and all stimuli were masked upon offset (see Figure 1). The mask display consisted of white number-signs (e.g., "#"; luminance = 103.0 cd/m^2) that occluded each location in the target display.

Design and procedure. The design and procedure of the present experiment were of the same as those used in Experiment 1a, with the following exceptions. (1) Display exposure durations were limited and determined on a subject-by-subject basis via the use of a staircase timing procedure (see Timing Procedure section). In all cases, exposure durations were well below 100 ms. (2) Immediately following the offset of the target display, the mask display appeared for a total of 412 ms. (3) Observers made unspeeded responses as to the location of a gap within the target item. Accuracy was stressed.

Timing procedure. Before beginning the experiment, target display exposure durations were determined on a subject-by-subject basis using a staircase procedure consisting of both additional singleton-present and -absent trials. All observers began with an exposure duration of 250 ms (30 monitor refresh cycles at 120 Hz; an easy setting for all observers tested). This value was adjusted based on the observer's response according to the following specifications: If the target's gap location was reported correctly, the number of refresh cycles for that trial was multiplied by a factor of 0.95. The exposure duration for the subsequent trial was the nearest whole integer to the result of this operation. If, however, the target's gap location was reported incorrectly, the number of cycles for that trial was multiplied by a factor of 1.1. The exposure duration for the subsequent trial was the nearest whole integer to this value. Each subject completed two blocks of 96 trials in this procedure. The exposure duration for target displays within the main experiment were determined by averaging the exposure durations over the last 30 trials of this procedure. Following the timing procedure, observers performed four blocks of 96 trials within the experiment proper.

Results

Mean exposure duration as determined by the staircase timing procedure was approximately 28.0 ms. Mean subject accuracy for both additional singleton-present and -absent trials are presented in Figure 2b. Mean response accuracies on additional singleton-present and absent trials were not reliably different, $t(15) = 0.079$, $SEM = 0.008$, *ns*), suggesting that the additional singleton did not interfere with observers' ability to perceive the target item.

Discussion of Experiments 1a and 1b

In Experiment 1a, the presence of an irrelevant colour singleton caused reliable increases in response latency, indicating that this item captured attention. Experiment 1b examined whether this cost resulted from a disruption of early perceptual processing at the location of a target by employing a data-limited version of the same task. In this experiment, the same additional singleton had no impact on overall performance. This indicates that the additional singleton did not alter the perceptibility of the target item, and suggests that its influence on reaction times in Experiment 1a resulted from disruptions that arose during later, postperceptual stages of processing.

However, there is an alternate explanation for these results. It is possible that the mask display used in Experiment 1b somehow dampened or attenuated the distracting qualities of the additional singleton, preventing it from capturing attention. To examine this possibility, we conducted an additional control experiment that was nearly identical to Experiment 1b (i.e., displays were still masked), with two exceptions: (1) Exposure durations were set at a fixed value for all observers, and (2) the principle dependent measure was RT. We reasoned that if the saliency of the additional singleton was reduced by the mask display used in Experiment 1b, then the RT cost that was observed during Experiment 1a might be eliminated when subjects were required to make speeded responses to the masked display.

EXPERIMENT 1C

Method

Observers. Twenty undergraduate students from the University of Oregon human subjects pool participated in a single half-hour experimental session in exchange for course credit. All subjects reported normal or corrected-to-normal vision and ranged between 18 and 30 years of age.

Apparatus and stimuli. The apparatus and stimuli of this Experiment were identical to those used in Experiment 1b.

Design and procedure. The design and procedure of this Experiment were identical to that employed in Experiment 1b, with two exceptions: (1) All observers were tested at a fixed exposure duration of 58 ms. This duration was selected to be significantly higher than the slowest of those obtained during staircasing in Experiment 1b, so that subjects could make speeded responses while maintaining a high level of accuracy. (2) RT was employed as the principle dependent measure. Observers were instructed to respond as quickly as possible while maintaining a high degree of accuracy. This procedure allowed us to see whether the masking stimuli prevented attentional capture by the additional singleton in Experiment 1b.

Results and discussion

One observer performed at chance levels on both additional singleton-present and -absent trials and was excluded from the analysis. Overall, response accuracy was high and did not differ between singleton-present (0.90) and singleton-absent (0.91) trials, $t(18) = 1.987$, $p > .05$. There was a reliable RT cost on additional singleton-present trials ($M = 522.8$ ms) compared to additional singleton-absent trials ($M = 511.5$), $t(18) = 2.27$, $p < .05$. This result suggests that the mask display used in Experiment 1b did not dampen or attenuate the saliency of the additional singleton. However, there is yet another alternative explanation for the results of Experiment 1b. Bacon and Egeth (1994) have noted that the particular search strategy that a subject employs may have a significant effect on whether an irrelevant singleton engenders a cost within an additional singleton paradigm. For example, observers might adopt a feature search strategy, in which they are set to attend to any item that contains a particular task-relevant feature (e.g., attend only to items of a particular shape) According to these authors, the use of a feature search strategy can effectively attenuate the effect of an irrelevant singleton if this item is defined in cross-dimension from the target. In both Experiments 1a and b, the target element could always be predicted on the basis of a unique shape (e.g., a square amongst circles). It is therefore possible that observers utilized this knowledge and adopted a feature search strategy. This possibility may have contributed to the null effect obtained in Experiment 1b. Experiments 2a and 2b therefore sought to replicate Experiments 1a and 1b under conditions in which the adoption of such a strategy was not possible. According to Bacon and Egeth, this should amplify the cost associated with the additional singleton, thereby providing a more sensitive test of whether early perceptual processing was influenced.[2]

EXPERIMENT 2A

Method

Subjects. Fifteen undergraduates from the University of Oregon human subjects pool participated in a single half-hour experimental session in exchange for course credit. All subjects reported normal or corrected-to-normal vision.

Apparatus and stimuli. The apparatus and stimuli of Experiment 2a were identical to those of Experiment 1a.

Design and procedure

The design of Experiment 2a was similar to that of Experiment 1a, with one exception. To ensure that subjects could not adopt a feature search strategy, the stimulus display used in this experiment was changed such that the target item could no longer be predicted on the basis of shape. In this experiment, the target item could be a red or green circle or square that contained a small gap on either the left- or right-hand side. Subjects were instructed to make speeded responses to the location of this gap. Nontarget items appeared as completed red or green circles or squares with the restriction that these items shared the target item's colour. Thus, the target item could no longer be reliably differentiated from nontarget items on the basis of shape alone. On 49.2% of trials, an additional singleton consisting of a yellow or white circle or square appeared. Subjects completed five blocks of 96 trials within this task.

Results

The first block of trials, as well as error trials in which subjects responded incorrectly or exceeded a 2500 ms response deadline were excluded from further analysis. This resulted in a loss of approximately 4.5% of all trial data. Mean subject response latencies for both additional singleton-present

[2] In Experiments 2a and 2b, we did not entirely remove the possibility that observers employed a feature search strategy. Observers could still adopt an attentional "set" for a gapped item. However, we note that the size of this gap was very small (0.17°), and therefore, it is unlikely that this strategy was useful to observers.

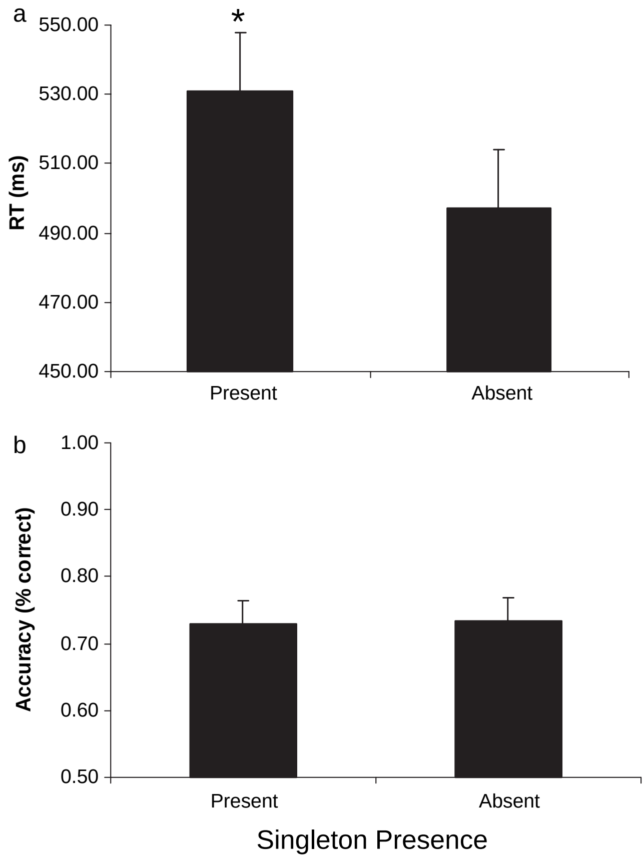

Figure 3. Results of Experiments 2a and 2b. The presence of an irrelevant singleton significantly slowed response latencies in Experiment 2a (panel a; * < .001), but had no effect on response accuracy in Experiment 2b (panel b).

and -absent trials are presented in Figure 3a. Response latencies were significantly longer on trials in which a singleton was present ($M =$ 531 ms) than on trials in which one was not ($M = 497.1$ ms), $t(14) = 4.39$, $SEM = 7.72$, $p < .001$.

EXPERIMENT 2B

Method

Subjects. Sixteen subjects from the University of Oregon human subjects pool participated in a single half-hour session in exchange for course credit. All subjects reported normal or corrected-to-normal vision.

Apparatus and stimuli. The stimuli used in Experiment 2b were exactly like to those used in Experiment 2a. In addition, a mask display identical to that employed in Experiment 1b replaced all stimuli immediately upon offset.

Design and procedure. The design and procedure of Experiment 2b were to the same as those of Experiment 1b. Again, exposure durations were determined on a subject-to-subject basis via the use of a staircase procedure (see Timing Procedure section in Experiment 1b). Subjects performed two blocks of 96 trials in this procedure, followed by four blocks of 96 trials in the main experiment. In the present experiment, subjects were instructed to prioritize accuracy without regard for speed. However, we collected both accuracy and RT data in an attempt to ensure that the mask display did not dampen the saliency of the additional singleton (see Experiment 1c).

Results

Mean exposure duration as determined by the staircasing procedure was approximately 35.9 ms. Mean response accuracy for singleton-present and -absent trials regardless of singleton or target colour is presented in Figure 3b. There was no reliable difference between additional singleton-present and -absent trials, $t(15) = 0.24$, $SEM = 0.018$, *ns*. This result is consistent with the notion that the RT cost observed on additional singleton-present trials in Experiment 2a is due to postperceptual interference rather than any cost in target discriminability.

Discussion of Experiments 2a and 2b

Experiments 2a and 2b replicated Experiments 1a and 1b using a procedure that precluded the use of a top-down filter for a specific colour or shape. According to Bacon and Egeth (1994), this should amplify the probability of obtaining an additional singleton-related cost. Consistent with Experiment 1a, Experiment 2a once again revealed a significant additional singleton effect. However, the results of Experiment 2b replicated the null result obtained in Experiment 1b, again suggesting that under data-limited conditions, the presence of an irrelevant additional singleton did not alter the perceptibility of a target item. This suggests that the cost observed in Experiments 1a and 2a does not reflect disruptions of preattentive target processing. Instead, it would appear that this cost is instead due to disruptions that occur during later, postperceptual stages of processing.

GENERAL DISCUSSION

The present experiments attempted to determine how an additional singleton disrupts perceptual processing. Data-driven models posit that this item biases early perceptual processing by reducing the sensory gain for target items so that observers either miss or misreport some task-relevant feature of the target. According to this logic, the presence of an additional singleton should lead to an accuracy cost in a data-limited implementation of the additional singleton task. In Experiments 1a and 2a, we obtained a typical additional singleton-related cost under resource-limited conditions (e.g., Theeuwes, 1991, 1992, 1996). However, contrary to the predictions of a data-driven model, Experiments 1b and 2b revealed that the presence of an irrelevant additional singleton had no discernable impact on response accuracy, suggesting that this item did not alter the perceptibility of a target item. Because performance costs in data-limited tasks are unlikely to reflect disruptions in postperceptual processing (e.g., Mordkoff & Egeth, 1993; Santee & Egeth, 1982), these results suggest that an additional singleton does not disrupt early perceptual processing.

The present results stand in contrast with those reported by Theeuwes et al. (2004). Recall that these authors found that the presence of an irrelevant additional singleton elicited a significant cost in d', suggesting that this item reduced the sensory gain at the location of the target. Why didn't the present procedures produce a similar result? We can dismiss the possibility that our singleton distractors were not salient enough to influence target processing. Experiments 1a and 2a revealed reaction time costs of 20.45 and 33.93 ms, respectively. These effect sizes are comparable with many previous demonstrations of RT costs in an additional singleton task (Theeuwes, 1991, 1992, 1996; Theeuwes & Godijn, 2001). Thus, we are confident that our procedure was capable of eliciting a singleton-related cost.

However, while the mask displays used in Experiments 1b and 2b appear to have been effective, it remains possible that they may have inadvertently dampened the salience of the additional singleton such that it was no longer capable of summoning attention. While the present experiments cannot exclude this possibility, we think it unlikely for several reasons. First, if the mask display reduced the saliency of the additional singleton, neither the accuracy of discrimination judgments nor response latencies in the task we employed should suffer. However, Experiment 1c yielded a significant RT cost on additional singleton-present trials with an experimental design that was almost identical to that employed in Experiment 1b. Moreover, the additional singleton items used in Experiments 1b and 2b were highly salient relative to the target item (approximately 8 cd/m^2 for target items compared to over 100 cd/m^2 for additional singletons). The mask display used in Experiments 1b and 2b would have to be extremely powerful to negate such a large disparity in contrast values.

The present experiments suggest that an irrelevant singleton may bias a later, postperceptual stage of processing. Such "late selection" effects could take multiple forms. For example, Folk and Remington (1998) have suggested that an irrelevant singleton may influence the efficiency of response selection for a target item by invoking a resource-demanding "filtering" operation that actively suppresses the tendency to respond to information associated with the additional singleton. By this view, the filtering process slows the allocation of attention to the target item during response-related stages of processing. Likewise, we have offered the speculation that the changes in d' observed by Theeuwes and colleagues (2004) were caused by lower response thresholds during the additional singleton trials of the go/no-go procedure. The present data are admittedly insufficient to diagnose exactly what kind of postperceptual interference may be caused by the additional singleton. However, these data do suggest that sensory gain at the target locations is not reduced when an irrelevant singleton is presented. Thus, one important goal for future research will be to further delineate which aspects of postperceptual processing may be influenced by salient distractor stimuli.

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