Priming of pop-out depends upon the current goals of observers

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What you have seen before helps you see it again. This effect has been shown in visual search studies looking at the consequence of the previous trial: Reaction times are shorter when the features defining a target and distractors are repeated. Here, I explore whether this bias in attentional selection occurs automatically or whether it depends upon the current goals of observers. Participants performed a visual search task, in which both a color singleton and a shape singleton appeared in the search array. The observers were instructed at the beginning of every trial as to which singleton was relevant. The data show that repeating the color or shape from the previous trial benefits performance only when this information is relevant to the observers’ current goals.

Keywords: priming of pop-out, goal, mental or task set, automatic, implicit


Introduction

The complexity of the visual world exceeds the processing capacity of the human brain (Tsotsos, 1990), which forces us to select one (or a few) object(s) in the scene for more detailed analysis at the expense of other items (James, 1890). This act of selection provides us with a succinct definition of the term visual attention. One central question in the field of visual attention is how do we choose which object to select next?

On the basis of decades of research, we know that the top–down goals of observers and the bottom–up salience of objects in the scene govern this selection process (see, e.g., Egeth & Yantis, 1997; Fecteau & Munoz, 2006; James, 1890; Posner, 1980; Posner & Petersen, 1990; Wolfe, 1994; for reviews). It is important to note that there are some mechanisms that bias this selection process further. These biases are automatic in nature, occurring outside of the conscious control of the observer (e.g., Egeth & Yantis, 1997; Fecteau & Munoz, 2006; Klein, 2000; Nakayama, 2004; Posner et al., 2001; Theeuwes, 2005; for reviews).

Priming of pop-out is one good example of an automatic bias in attentional selection (Maljkovic & Nakayama, 1994, 1996, 2000). In the typical priming of pop-out study, observers perform an oddball visual search task, in which the target is defined by way of its unique color (a red target among green distractors or a green target among red distractors). The observers indicate whether a gap on the target item faces toward the left or right side. The data are then analyzed based on what happened on the previous trial (see Fecteau & Munoz, 2003)—did the color of the target stay the same or did it change? This analysis reveals that observers respond faster when the color stays the same (Maljkovic & Nakayama, 1994, 2000; reviewed in Nakayama et al., 2004).

Several critical features of this priming of pop-out phenomenon have been established: Complex objects (Hillstrom, 2000; Kristjánsson, Wang, & Nakayama, 2002; Wang, Kristjánsson, & Nakayama, 2005) and the position of the previous target (Maljkovic & Nakayama, 1996) also produce priming effects; priming can be observed for features of the target that are irrelevant to the task (Huang, Holcombe, & Pashler, 2004; Kristjánsson, 2006); the magnitude of priming is greater when the task is more ambiguous (Meeter & Olivers, 2006; Olivers & Meeter, 2006); and priming is unaffected by knowledge of an upcoming switch (Hillstrom, 2000; Maljkovic & Nakayama, 1994). As surmised by Nakayama et al. (2004), priming of pop-out “consist(s) of a passive association of isolated characteristics of previously attended sites and the ‘response’ of attentional deployment…. The effects of (priming) are not overcome by knowledge, expectancy, or intention” (p. 403).

Is it true that the intentions, or mental set, of observers play no role in priming of pop-out? Accumulating evidence indicates that many “automatic” biases are affected by and, in some instances, depend upon the current goals of an observer. For example, the benefits of a salient object are enhanced when the salient item helps the observer solve the task (Fecteau, Bell, & Munoz,
and the costs of a competing salient object are eliminated with foreknowledge of the target’s location or features (Caputo & Guerra, 1998; Yantis & Jonides, 1990). Neither outcome should be obtained if salient objects are processed passively and automatically by the visual system. Indeed, some research indicates that observers automatically orient to the location of a salient object only when this object is consistent with their current goals (Folk, Remington, & Johnston, 1992; Folk, Remington, & Wright, 1994; see also Most, Scholl, Clifford, & Simons, 2005; Most et al., 2000).

Might priming of pop-out be influenced by the current mental state of observers in a similar fashion? Some evidence suggests that it is. For example, several studies have reported that the magnitude of repetition priming is greater when the repeated feature is used to identify the target than when it is a feature possessed by the target but not used to identify it (Hillstrom, 2000; Huang et al., 2004; Kristjánsson, 2006). Simply put, the automatic priming of features from the previous trial is stronger when the feature is task relevant than when it is task irrelevant.

How should this be interpreted? According to Kristjánsson (2006), repetition priming from the previous trial is first dedicated to the features that defined the target and then spreads to irrelevant features that are also possessed by the target, provided the capacity of priming has not been exhausted. One point regarding this issue must be made very clear. Kristjánsson emphasizes the role of our viewing history in affecting what we attend to next. He has shown that task-irrelevant features, sometimes, facilitate responding.

Here, I addressed the opposite question—how do our current goals affect the consequences of history? Or, put another way, what happens when the relevance of our previous experiences changes? Until now, every investigation exploring priming of pop-out has required observers to adopt the same mental set during the course of the task: They must either respond to the unique item in the display (singleton detection) or focus upon one unique feature in the display (e.g., color). The mental set of observers has never been manipulated during the course of a session to see how their current goals affect automatic priming from the previous trial.

I made a few modifications to the typical priming of pop-out paradigm to manipulate the goals of observers on a trial-by-trial basis (see Figure 1; see also Meiran, 1996). Each display contained two singletons, one defined by way of its unique color and one defined by way of its unique shape. An instruction at the beginning of the trial indicated which singleton was relevant for that trial: “C” indicated that the color singleton was relevant and “S” indicated that the shape singleton was relevant. The observers reported the direction of a gap (left vs. right) contained in the relevant singleton.

The data were coded to reveal the relationship of the previous target to the current target. Did the color of the target remain the same across trials, or did it change? Did the shape of the target remain the same across trials, or did it change? The relationship between the previous task and the current task was also assessed. Finally, these stimuli and task-dependent consequences of history were compared to the task the observers currently performed to assess the primary purpose of this study—do our current intentions affect the consequences of history?

The “automatic bias” and “goal-dependent” hypotheses yield different predictions. If priming of pop-out is an automatic bias, then repeating the color or shape of the previous target should facilitate performance, irrespective of the current task being performed. This outcome might occur because both color and shape are noncompeting features—conditions

![Figure 1](https://jov.arvojournals.org/pdfaccess.ashx?url=/data/journals/jov/933524/)
under which priming should extend to the task-irrelevant features of the target (Huang et al., 2004; Kristjánsson, 2006). Alternatively, priming might be limited to the features possessed by the previous target and not the previous salient distractor (see Maljkovic & Nakayama, 2000; Nakayama et al., 2004). In this case, observers will respond faster whenever the features defining the previous target remain the same across trials. The noteworthy prediction of these automatic bias accounts is that the current goals of observers should not affect performance.

By contrast, if priming of pop-out depends upon the current mental set of observers, then repeating the color of the target from the previous trial will facilitate performance only when the observers perform the color task, and repeating the shape of the target from the previous trial will facilitate performance only when the observers perform the shape task.

### Methods

All experiments in this study obtained ethical approval through the Psychonomic Ethics Commission at the University of Amsterdam.

Fifteen university students, with normal or corrected-to-normal vision, participated in the experiment for course credit or monetary compensation.

Participants were seated comfortably at a table, facing a 19-in. computer monitor located 57 cm away. Each trial began with the presentation of a fixation marker. A single letter (1° of visual angle) appeared 600 ms later. The letter was a capital “C” or “S,” and it instructed the participants as to which singleton was relevant on the upcoming trial. After 600 ms, this instruction letter was replaced by the fixation marker, and after an additional 600 ms, the search array appeared. The search array consisted of six objects (each subtending 2.5° of visual angle) that were evenly distributed around an imaginary circle with a radius of 8.5°. Two singletons appeared in every display: a color singleton, which was defined by way of its unique color (red among green or the reverse), and a shape singleton, which was defined by way of its unique shape (circle among squares or the reverse). The observers indicated the direction of the gap by pressing “g” for a leftward-facing gap and “h” for a rightward-facing gap. The color and shape of the target and salient distractor were equally probable and randomly selected, as were the gap directions for all stimuli and the task performed on every trial (report gap for color or shape singleton). Speed and accuracy were equally stressed. Every observer performed 10 blocks of 84 trials, preceded by 40 practice trials, for which the data were not recorded.

Matlab, using the Psychophysics Toolbox extensions (Brainard, 1997; Pelli, 1997), was used to present the stimuli and collect the data.

### Results

The reaction times for this experiment are shown in Figures 2, 3, and 4, with the percentage accurate data for each condition represented in its corresponding bar. As shown in Figure 2, this experiment replicated the important features of typical priming of pop-out investigations: Reaction times were 40 ms faster when the target maintained the same shape across consecutive trials, $F(1, 14) = 25.3, p < .05$, and 16 ms faster when the target maintained the same color across consecutive trials—this later difference was marginally significant, $F(1, 14) = 3.2, p = .097$. Also evidenced in this figure, reaction times were 44 ms faster when observers performed the same task across consecutive trials, $F(1, 14) = 14.4, p < .05$, and 320 ms faster when they responded to the color singleton compared to the shape singleton, $F(1, 14) = 127.5, p < .05$.

It is important to note that these advantages for the previous color and shape of the target were modified by the current task that the observers performed. Figure 3
illustrates the importance of the current task in eliciting priming of pop-out for color (Figure 3, left), $F(1, 14) = 26.8$, $p < .05$, and shape (Figure 3, right), $F(1, 14) = 18.4$, $p < .05$. Repeating the color of the target benefited performance when the observers performed the color task, $F(1, 14) = 63.5$, $p < .05$, but not the shape task, $F(1, 14) < 1$, $p > .1$. Likewise, repeating the shape of the target benefited performance when the observers performed the shape task, $F(1, 14) = 30.2$, $p < .05$, but not the color task, $F(1, 14) < 1$, $p > .1$.

This dependence of priming on the current task was not affected by the previous task the observers performed—the same degree of priming was obtained, $F$ values $< 1$, $p$ values $>.1$. No other statistical comparisons were significant in this analysis—all $F$ values $< 2.3$, all $p$ values $>.1$.

In summary, repeating the features of a target across trials facilitates performance only when this feature is relevant to the current task: Repeating the color of the previous target facilitates performance when the observers perform the color task, and repeating the shape of the previous target benefits performance when the observers perform the shape task. Otherwise, there is no benefit.

Up to now, no consideration has been given as to how the repeated feature of the target was represented on the previous trial: Was the feature unique (a singleton) or not? This is an important question because the uniqueness of an object defines whether or not it is a target, and potentially, only these unique features are primed across trials. Alternatively, perhaps repetition priming is spread among all elements sharing the same feature. If repetition priming is dissipated under these conditions, then it might weaken the benefit. To address these issues, the data were recoded to reveal how the features of the previous color and shape

![Figure 2](https://jov.arvojournals.org/pdfaccess.ashx?url=/data/journals/jov/933524/) Mean correct reaction time showing the reaction time differences between the color task and the shape task (far left) and reaction time differences originating from the previous trial: the previous task, the previous color, and the previous shape (left to right). Numeric values in bars represent the percentage accurate data. Error bars represent ±1 SEM.

![Figure 3](https://jov.arvojournals.org/pdfaccess.ashx?url=/data/journals/jov/933524/) Mean correct reaction time data for the color task (left) and the shape task (right) when the color of the target was the same as or different than the previous target (leftward bars) and when the shape of the target was the same as or different than the previous target (rightward bars). Numeric values in bars represent the percentage accurate data. Error bars represent ±1 SEM.
singleton affected performance: The variable color singleton represented whether the color singleton possessed the same color or different colors across trials and the variable shape singleton indicated whether the shape singleton possessed the same shape or different shapes across trials. These consequences of the previous singletons were contrasted to the task the observers performed on the current trial (color or shape task) and the task the observers performed on the previous trial (same as or different than the current task).

As shown in the previous analysis, performance was better when observers performed the color task (Figure 4, top) compared to the shape task (Figure 4, bottom; be watchful of the y-axes) and when the task remained the same compared to when it changed across trials (left vs. right bars in each quadrant). What is most critical is how the color or shape singleton affected performance depending upon its relevance on the previous trial and its relevance on the current trial. The three-way interaction of these factors was significant for both color singletons, $F(1, 14) = 15.7, p < .05$, and shape singletons, $F(1, 14) = 6.6, p < .05$. This interaction originated from three theoretically important effects.

First, the singleton that is irrelevant to the current task does not affect performance. For the color task, repeating or changing the shape singleton did not affect performance alone or as part of an interaction, $F$ values < 1. Similarly, for the shape task, repeating or changing the color singleton did not affect performance alone or as part of an interaction, $F$ values < 1. Simply put, repeating a singleton has no consequence on performance when it is not relevant to the current task—even when it was the target on the previous trial.

Figure 4. Mean correct reaction time data for the color task (top) and the shape task (bottom) when the color singleton (left) was the same as or different than the previous color singleton and when the shape singleton (right) remained the same as or was different than the previous shape singleton. This is shown depending upon whether the current task was the same as (leftward bars) or different than (rightward bars) the previous task. Numeric values in bars represent the percentage accurate data. Error bars represent ±1 SEM.
A very different pattern was obtained for singletons that were relevant to the current trial. In this case, the consequences of the task-relevant singleton depended on the task the observers performed on the previous trial. This interaction was observed for the color task, $F(1, 14) = 29.7$, $p < .05$, and the shape task, $F(1, 14) = 10.0$, $p < .05$. There are two facets of this interaction worth mentioning. First, changing the feature possessed by the task-relevant singleton across trials eliminates the costs involved in switching tasks. That is, for the color task, performance was equivalent when the task changed, provided that the color singleton also changed, $F(1, 14) < 1$. Similarly, for the shape task, performance was equivalent when the task changed, provided that the shape singleton also changed, $F(1, 14) < 1$. It is important to note that this same comparison for the task-irrelevant singleton (shape singleton, color task; color singleton, shape task) yielded significant task-switching costs, $F$ values $> 4.5$, $p$ values $< .05$. Thus, when the task-relevant singleton changes its feature from one trial to the next, this change appears to reset the system—all consequences of switching tasks are eliminated.

Second, keeping the feature defining the task-relevant singleton the same across trials reveals a pattern of facilitation or inhibition depending on its role in the previous task. When the observers performed the same task across trials, repeating the feature of the relevant singleton facilitated responding. This repetition advantage was significant for the color task, $F(1, 14) = 14.6$, $p < .05$, and the shape task, $F(1, 14) = 5.5$, $p < .05$. By contrast, when the observers performed a different task on the previous trial, repeating the feature of the now relevant (and previously distracting) singleton inhibited performance. This repetition disadvantage was significant for both the color task, $F(1, 14) = 15.1$, $p < .05$, and the shape task, $F(1, 14) = 4.6$, $p = .05$.

In summary, the influence of a singleton depends upon whether it is relevant to the current task and its role in the previous task. In general, repeating the features of a singleton has no impact on performance when this singleton is irrelevant to the current task. Although this statement may seem somewhat obvious, consider this—if priming of pop-out is an automatic process facilitating the attended feature on the previous trial and is uninfluenced by intentions of observers, then performance should be slower when the singleton is repeated and the task is changed. This pattern was not obtained.

A fundamentally different pattern is observed when the singleton is relevant to the task. When the feature defining the singleton changes between trials (e.g., red singleton on previous trial and green singleton on current trial), it acts as a “reset” button: All the benefits of performing the same task across trials are eliminated. By contrast, when the feature defining the singleton remains the same, then responding is facilitated when observers perform the same task across trials and responding is inhibited when observers performed a different task on the previous trial.

### Discussion

Repeating the same features of a target across trials facilitates performance. This benefit, called priming of pop-out, is thought to be an implicit bias that encourages observers to attend to features in the scene that were attended in the past. Although there are competing views of what priming of pop-out represents (Hillstrom, 2000; Huang et al., 2004; Nakayama et al., 2004; Olivers & Meeter, 2006; Wolfe, Butcher, Lee, & Hyle, 2003; Meeter & Olivers, 2006), all descriptions focus on the same basic issue—how do our recent experiences affect ongoing performance? Here, I asked a different question: Do our current goals or intentions affect our recent experiences? In short, the answer is yes! The data show that the current intentions of observers dictate whether a repeated feature (color and shape) affects ongoing performance.

Consider the evidence.

First, repeating a feature possessed by the previous target (color or shape) benefited performance only when this feature was relevant to the observers’ current task. If the repeated feature was irrelevant, all evidence of priming was eliminated (see Figure 3).

Keep in mind that this analysis only considered whether the target on the current trial possessed the same features as the target on the previous trial. It is important to note that this is all that should matter based on recent evidence showing that all (or most) features of the target are primed from one trial to the next (Huang et al., 2004; Kristjánsson, 2006). Perhaps, however, priming is limited to unique objects (the singletons) because only unique features are relevant within the context of this task. Alternatively, perhaps priming is dissipated among all items sharing the same feature. To address these issues, a second analysis explored how repeating or changing the features of the singletons affected performance. This analysis revealed three critical outcomes that were not apparent before.

First, repeating a salient feature across trials does not affect performance when this feature is irrelevant to the observers’ current task. This statement might seem obvious from the outset—how could this irrelevant singleton affect performance when it must be ignored on the current trial?

Based on previous investigations, there are two conditions in which the salient distractor should modify performance, if the current mental set of observers’ plays no role.

1. Numerous studies have shown that the presence of an irrelevant singleton interferes with responding to a target (see, e.g., Caputo & Guerra, 1998; Pinto, Olivers, & Theeuwes, 2005; Theeuwes, 2005). In general, this influence is greatest when the characteristic defining the salient distractor has changed or the distractor appears infrequently (Caputo & Guerra, 1998; Pinto et al., 2005). If we assume that the
singleton presented in this study acts in the same manner as in these previous studies, then we should expect that repeating the irrelevant distractor across trials will weaken its influence and facilitate responding to the target. This outcome was not obtained: Reaction times were equivalent when the features defining the singleton distractor remained the same and when the features defining the singleton distractor changed across trials.

2. According to all theories of priming of pop-out, the feature defining the target on the previous trial should attract attention on the next trial. This prediction reflects the basic mechanism by which priming of pop-out operates, and yet, this prediction was not borne in the data. The feature defining the target on the previous trial did not affect performance when this feature was inconsistent with the participants’ current goals. Once again, no theory of priming of pop-out can account for this outcome. If history affects performance and this influence occurs automatically (and implicitly), then repeating the previous target singleton should attract attention and disrupt performance when the observers must attend to a new feature. This pattern was not obtained.

The next two insights originating from the analysis of the singletons came from trials in which the singleton was relevant to performance on the current trial (i.e., color singleton during color task). If the feature defining the singleton changed across trials (e.g., a red singleton on the previous trial and a green singleton on the current trial), then this change appeared to reset the system—the task performed on the previous trial no longer affected performance. This is an important observation: It shows that the “task” defined in this simple paradigm depends upon the specific features possessed by the target (see also Koch & Allport, 2006; Rogers & Monsell, 1995; Rubin & Koch, 2006, for stimulus-based effects in task-switching experiments; and Monsell, 2003, for a general review). This occurs even though the actual color and the actual shape of the target are irrelevant—the target is defined through its uniqueness with respect to the other items in the display, not the particular features it possesses. The abstract task of “color singleton” or “shape singleton” should outweigh the specific “red color singleton task” or “square shape singleton task.” Yet, the consequences of maintaining the same task set or switching task sets were linked entirely to the specific stimuli used on the previous trial (see Fecteau & Munoz, 2003).

Finally, when the relevant singleton remained the same from one trial to the next, its influence changed depending upon its role on the previous trial. When this singleton was also the target on the previous trial, responding was facilitated. By contrast, when this singleton was the distractor on the previous trial, responding was inhibited. It is important to reiterate that this pattern of facilitation or inhibition was observed only when the singleton was relevant to the observers’ current goals. If the singleton was not relevant on the current trial, then it did not affect performance.

Taken together, the data indicate that our intentions, or current goals, govern which properties of the previous trial influence performance. Over the next few paragraphs, I describe what these findings mean for our theoretical views of priming of pop-out and how we can reconcile these findings with the observations made in previous studies.

**Present goals dictate the consequences of previous experiences**

This take-home message appears to contradict other findings reported in previous investigations: For example, task-irrelevant features from the previous trial aid responding sometimes (Kristjánsson, 2006; see also Huang et al., 2004). Yet, the data presented here reveal that task-irrelevant features do not affect performance. How should we reconcile these apparently conflicting results? It is simple, if we consider an important methodological difference across these investigations. Previous investigations explored the consequence of a repeated feature that was never relevant to the observers’ task (during the experimental session, at least). Under these circumstances, the repetition of a task-irrelevant feature aids performance. In this study, repeating a task-irrelevant feature does not aid responding; it is important, though, that this same feature dimension was relevant on the remaining trials. Perhaps when a feature is relevant some of the time, its influence is gated—it is allowed to affect performance when the feature is relevant and it is not allowed to affect performance when the feature is irrelevant. Assessing the veracity of this claim will be a fruitful avenue for future research.

A second apparent conflict with previous investigations is the ability of the observers’ intentions, or mental set, to influence priming from the previous trial. Consider the evidence. Nakayama et al. have demonstrated, quite convincingly, that priming of pop-out is unaffected by the expectations or explicit memory of observers. For example, Maljkovic and Nakayama (1994) conducted an experiment in which the color of the target remained the same or changed on every trial (several intermediate probabilities were tested as well). Although both conditions provided observers with perfect knowledge of what to expect next (see also Hillstrom, 2000), reaction times were much longer when the color of the target switched. In a second study, Maljkovic and Nakayama (2000) obtained evidence of priming of pop-out in reaction time, although the observers did not remember which features defined the target on the previous trial. Simply put, neither knowing the characteristics of the upcoming trial nor remembering the characteristics from the previous trial is responsible for priming of pop-out.
To address these apparent conflicts, we do not need to question the validity of these data; rather, we need to examine the assumption inherent in the interpretation of these data. The assumption is that automatic processing and the goals of observers are mutually exclusive phenomena. Implicit processing is automatic, reflexive, and stimulus driven—factors that are not affected by the current goals of observers and operate outside of conscious awareness. By contrast, explicit processing is synonymous with voluntary, goal-directed actions, all occurring within conscious awareness. Here, I argue that this distinction may be oversimplified. What is automatic may depend upon how the brain is configured to solve a task.

This basic notion is not new. For example, when evaluating the capture of attention by salient objects in the visual scene, Folk and Remington have shown that objects capture attention only when the properties of the salient object are consistent with the participants’ goals (Folk & Remington, 1998; Folk et al., 1992, 1994). One important feature of their theoretical arguments is that, within the appropriate mental set, the salient objects are processed automatically. Analogous findings have been observed in inattentional blindness investigations (see also Most et al., 2005, 2000; reviewed in Ambinder & Simons, 2005; Most & Simons, 2001).

With regard to priming of pop-out, the same basic phenomenon may be at play—priming of pop-out occurs automatically and independently of the conscious control of the observer—it is an automatic process that, nevertheless, requires the participant to be in the appropriate mental set to be observed.

**Remembering everything but acting on little: A two-tiered system**

One feature of this study cannot be stressed strongly enough—this study reveals a dissociation between what is “remembered” from the previous trial and how this memory affects performance. The repeated feature only affects responding when it is relevant to the observers’ current goals. Otherwise, there is no consequence.

Here, I describe a simple system, which may account for the findings obtained in this study. It builds upon ideas of salience and priority, which have been described in detail elsewhere (e.g., Koch & Ullman, 1985; Treisman, 1986; Treisman & Gelade, 1980; Wolfe, 1994; Wolfe et al., 2003; see also Fecteau & Munoz, 2006). The basic concept is that the specific features of an object (its color, shape, etc.) are processed in regions of the brain specialized for this purpose (ventral visual pathway; Milner & Goodale, 1995). By contrast, the priority of an object (see Fecteau & Munoz, 2006)—its relative salience (physical distinctiveness) and its relevance (relationship with current goals)—is represented in the dorsal stream (Milner & Goodale, 1995), which uses this information to direct attention and to guide action. In this basic scheme, the relevance of an item may be determined by changing the weighting of the feature-based information feeding into the priority map (see Wolfe et al., 2003)—relevant features are given a greater weighting than irrelevant features. One important facet of this simple two-tiered system is that regions processing feature-specific information may not be weighted to the same degree, and, as such, these ventral visual areas may “remember” the salient features from the previous trial, although this memory may not always be visible in the behavioral responses governed by the dorsal pathway. Simply put, under some conditions, a dissociation between perceptual processing and action processing might be obtained—the factors affecting perception may not be observable in action (see Milner & Goodale, 1995, for many additional examples).

Of course, history has shown (and will continue to show) that this distinction between automatic priming and task-contingent priming is less clear-cut than this offering would suggest. As mentioned above, what happens when perceptual information is not weighted? Based on published evidence (see above), it appears that unweighted input is permitted to gain access to action centers and facilitate responding—perhaps only the features relevant within the experimental session are gated in the manner described here. Also, what happens when more complex objects or features of an object are used? Chances are, less information will be remembered (outside of the goals of observers), perhaps paralleling the “early” and “late” bottlenecks described elsewhere (see, e.g., Lavie, 2001; Lavie & Tsal, 1994; see Dobbins, Schnyer, Verfaellie, & Schacter, 2004, for related evidence). Finally, what of the experimental parameters that seemingly eliminate all evidence of repetition priming when brief displays are used? Huang and Pashler (2005) argued that the elimination of repetition priming with masked displays occurs because masked priming only permits “perceptual” processing, and without masking, “postperceptual” processing also occurs. Accordingly they argued that priming of pop-out is not perceptual because no repetition advantage is observed in accuracy measures after masking. Although the neurophysiological correlates of repetition priming in neurophysiological measures (Bichot & Schall, 2002) are the same as those disrupted through masking (Lamme, Zipser, & Spekreijse, 2002), I am uncertain of how these measures map onto perceptual and postperceptual stages of processing considering that these correlates have been attributed to many different stages of processing—stages that cannot be encapsulated through this perceptual and postperceptual framework. At this stage, it is fair to indicate that masking disrupts repetition priming, for reasons that we do not yet understand. Understanding how these theoretical labels of perceptual and postperceptual processing map onto neurophysiological substrates is an important area for future research.
Taken together, it appears that our goals change what we process automatically (see also Folk & Remington, 1998; Folk et al., 1992, 1994). Albeit a counterintuitive idea if we consider traditional views of automatic or implicit processing, this outcome is much less surprising if we consider the organization of the nervous system, in general, and the visual system, in particular—there is more input from late visual areas to early visual areas than from early visual areas to late visual areas (Lamme & Roelfsema, 2000). This feedback helps to configure the brain, allowing it to efficiently process the information that is relevant to the task.

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### Footnotes

1 Although this outcome may appear to imply that the current goals of observers define whether an irrelevant item captures attention (see also Folk & Remington, 1998; Folk et al., 1992, 1994; Most et al., 2005, 2000; reviewed in Ambinder & Simons, 2005; Most & Simons, 2001; but see Pinto et al., 2005), I do not wish to interpret this outcome in this manner at this time. A directed study is needed to assess the relationship of the capture of attention by a salient singleton and priming of pop-out before such conclusions should be drawn because of the many differences between the studies exploring the capture of attention by a salient distractor and this study, which has merely made use of a salient distractor.

2 One apparent discrepancy between this model and the theoretical advances of Milner & Goodale, (1995) is where the “smarts” of the brain originate: The dorsal stream is “automatic” and operates outside awareness, whereas the ventral stream is more closely related to our conscious perception and goal-directed behavior. The simple model described here suggests that the opposite relationship may be true—the dorsal stream reflects goal-directed behavior, whereas the ventral stream produces automatic priming. While a full explanation of this discrepancy would require a full paper in and of itself, there are three points that one may wish to consider. (1) Rather than splitting the functioning of the pathway as automatic (dorsal) and goal directed (ventral), perhaps it is more accurate to consider that both dorsal and ventral streams possess smart and automatic processing—action can be smart (e.g., Jeannerod, 1997) and perception can be automatic (e.g., Merikle & Daneman, 2000; Schacter, Dobbins, & Schnyer, 2004). (2) The imperative role of action in the arena of smart cognitive processing has gained much attention recently (and previously), through the recognition that visual perception and visual cognition are contingent upon sensorimotor interactions (Jeannerod, 1997; Noë, 2004). Simply put, smart behavior (in general) depends on the interactions of the dorsal and ventral visual pathways. (3) Finally, consider that the critical insight of Milner and Goodale’s theory is to show the functional division of the dorsal and ventral visual pathways—visual information for action and for perceptual processing, respectively. Focusing on this feature requires us to keep in mind how the information is used rather than where more complex cognitive processes originate in the brain. The question of where does complex cognitive behavior originate is a difficult question that should be approached with great humility considering the expansive interconnectedness of the brain and the recognition that the smarts of the brain are reflected virtually everywhere in neurophysiological recordings (see, e.g., Fecteau & Munoz, 2006).

### References


