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Attentional control and competition between episodic representations

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Abstract The relationship between attentional control and episodic representation was investigated in six experiments that employed a variant of the classic attentional blink paradigm. We introduced a task-irrelevant (unpredictive) color match between the first and second target stimulus in a three-stream rapid serial visual presentation task. When this match was present, the first target reliably elicited a priming benefit to the identification of the second, lateralized target. However, this was only the case when the identities of the targets did not belong to the same category (digits, letters, or symbols). When targets did belong to the same category, interference was observed instead of priming, particularly at Lag 1. Furthermore, when color was the target-defining feature, interference at Lag 1 gave way to priming at longer lags. The interference effect is attributed to partial overlap between competing episodic target representations, which affects the availability of their overlapping features for successive attentional selection in rapid serial visual presentation.

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Introduction

Attentional processes have often been characterized as either voluntary or automatic, the idea being that voluntary processes reflect purely endogenous, top-down processes that gate incoming information according to current needs and goals, whereas automatic processes are stimulus-driven and impact processing in a purely bottom-up fashion. There is however increasing evidence that this binary contrast is too simplistic and fails to capture the apparently dynamic interaction between bottom-up and top-down processes in the service of attention. On the one hand, evidence has been obtained that stimulus salience has a rapid (if short-lived) effect on attention, regardless of current task relevance (Theeuwes, 1991; 1994; Theeuwes & Burger, 1998; van Zoest, Donk, & Theeuwes, 2004). On the other, as argued by Folk, Remington, and colleagues, phenomena that appear to indicate stimulus-driven processes can be shown to depend on current attentional control settings (Folk, Leber, & Egeth, 2002; Folk & Remington, 1998; Folk, Remington, & Johnston, 1992; Folk, Remington, & Wright, 1994). Comparable observations have also been made in other research areas, such as stimulus–response compatibility and perception–action coupling, where seemingly automatic processes (i.e., processes that do not require cognitive resources and are difficult or impossible to inhibit) are very sensitive to the task context and current intentions (Hommel, 2002). Thus, even stimulus-driven processes could be considered as "prepared reflexes" (Hommel, 2002) that reflect (goal-) "contingent automaticity" (Bargh, 1989).

Furthermore, it has been shown that (spatial) attention can be guided by concurrently active representations, including the content of short-term or working memory. For instance, Downing (2000) showed that maintaining a

stimulus representation in working memory biased attention towards task-irrelevant stimuli that perceptually matched the memorized item. Along the same lines, Pratt and Hommel (2003) demonstrated that keeping the shape of a stimulus in mind biased attention towards task-irrelevant stimuli that happen to share the color in which the memorized shape stimulus was presented. Work by Soto, Humphreys, and colleagues has furthermore shown that search for a target stimulus was facilitated if the target matched a previously memorized cue (e.g., by having the same shape), while search was impaired when the memory cue matched a distractor shape instead (Soto, Heinke, Humphreys, & Blanco, 2005; Soto, Humphreys, & Heinke, 2006; see Soto, Hodsoll, Rotshtein, & Humphreys, 2008 for a review).

It must be noted that items represented in memory do not always affect control of spatial attention. Downing and Dodds (2004) asked participants to maintain a shape stimulus in memory, while searching for another shape target. Critically, the memorized shape could appear as a distractor item in the search array, which was expected to impair search. Instead, search was not impaired at all by memory-distractor matches. A similar result was obtained by Woodman and Luck (2007), who even observed slight benefits in search performance when a distractor stimulus matched the content of working memory. However, these somewhat contradictory findings may be explained by subtle differences in task characteristics. Olivers (2009) showed that while potential differences between visual and verbal working memory, and search display heterogeneity or difficulty, did not account for the observed discrepancy (i.e., the presence or absence of memory effects on attention), the variability of the search template did. Olivers argued that a variable target template demands active representation itself, thereby diminishing (or de-prioritizing) the representation of the memorized item and reducing its effects on selection (for a review see also Olivers, Peters, Houtkamp, & Roelfsema, 2011).

Taken together, the evidence suggests that representation and maintenance of (perceptual) information and selection of relevant input in spatial attention tasks are intertwined. This idea is compatible with the assumption made by models of attention that stimulus selection occurs through a top-down, biased competition process (Bundesen, 1990; Desimone & Duncan, 1995; Duncan & Humphreys, 1989). The representation of a specific searched-for object or its characterizing features may bias this competition so that stimuli matching the representation of the object, or its features, receive support. The stimulus that wins the competition then determines the location towards which attention will be allocated.

Memory maintenance effects on temporal attention

In temporal attention tasks that require the successive selection and storage of items, interaction between currently active representations and attentional selection may also be expected. Specifically, the maintenance of representations of earlier items may affect the selection of later ones. Selection may suffer if task-irrelevant information was previously selected (and maintained), which may consume resources needed to deploy attention successfully (Pashler & Shiu, 1999). Detrimental effects may also be expected when a previously selected, maintained item is dissimilar to, or incompatible with the current target. Conversely, selection may be facilitated when an item that is similar or compatible with the current target was selected and maintained. In support of such effects, it has been shown that featural similarity within working memory can enhance recall performance (Lin & Luck, 2009).

However, the possible consequences for target selection may also depend on how it is accomplished, and in particular whether it is based exclusively on type information, or also on token information (Kanwisher, 1987; 1991; see also Shapiro, Driver, Ward, Sorensen, 1997). Type information can be thought of as a collection of semantic and visual features pertaining to a target item (e.g., "the number 9", and "blue"). By contrast, token information implies an instance-specific combination of features of an item (e.g., "the blue 9 that came first"), so that tokens can be considered episodic bindings of type information (Bowman & Wyble, 2007; Treisman, 1996). The (e)STST model of temporal attention has explicitly linked the creation of such token representations (i.e., tokenization) to the building of "attentional episodes" to represent targets (Bowman & Wyble, 2007; Wyble, Bowman, & Nieuwenstein, 2009; Wyble, Potter, Bowman, & Nieuwenstein, 2011). Attentional episodes may be loosely described as intervals during which attention is engaged. Accordingly, within such episodes, target encoding is facilitated, but this comes at the expense of episodic distinctiveness. This trade-off leads to the counter-intuitive prediction that featural similarity between targets may not always enhance performance (as might have been expected from feature priming): highly similar targets may also become increasingly difficult to dissociate, with reduced performance (e.g., increased repetition blindness, order errors) as a result. As argued by Wyble et al. (2011), the attentional system may actually be geared to prevent such difficulties, and might consequently suppress input momentarily to increase distinctiveness.
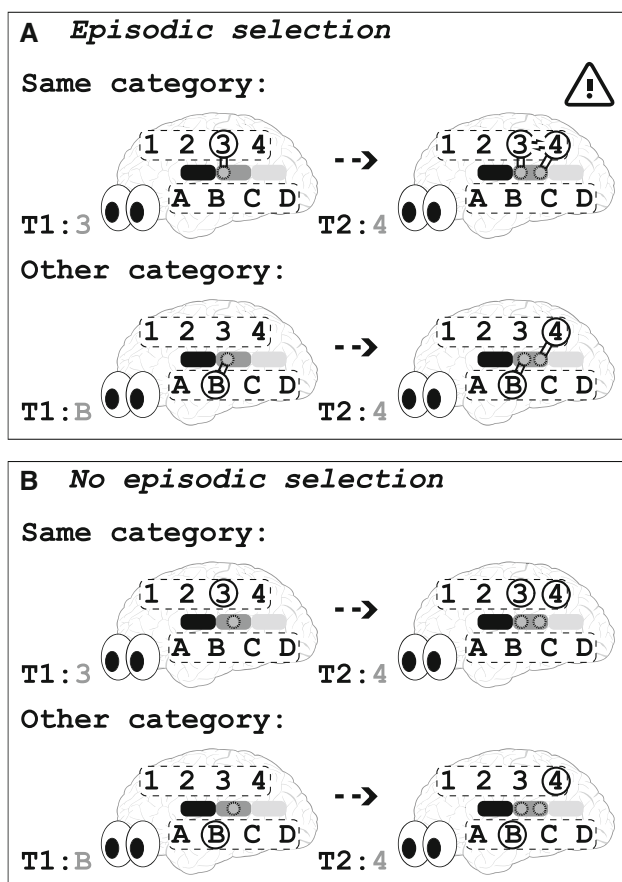
To date, episodic contingency effects between targets in temporal attention tasks have not been systematically studied, but a preliminary prediction of potential episodic

effects may be generated. Consider a task with trials in which two successive target stimuli (T1 and T2) have to be selected for identification from a set of (asynchronous) distractors over time (Fig. 1). The targets in this example have a particular identity; a digit number or letter and a certain level of brightness (lighter/darker), which the observer has to represent in some way to allow the selection and report of targets but not distractors. Hypothetically, once T1 has been selected, identified, and is thereby represented in some form (though possibly short of being fully consolidated in memory), its representation may affect the subsequent selection of T2. In other words, the selection of T2 may reflect changes due to items that were previously selected—T1 in this case. There are two possible ways in which selection of T2 may be affected, which

Fig. 1 **a** The consequences for selection of the second of two targets if selection is assumed to be sensitive to episodic representation. The *top row* shows the partial overlap created if the targets share the same category, without being identical. The *bottom row* shows the situation when targets do not share category (no overlap). **b** The consequences for selection of the second target if selection is not sensitive to episodic representation, but only to individual features. Features activated by the first target do not pose an overlap problem for the second target in both same and different target categories. The *background picture* of the brain is for illustration only and is a reproduction of a lithograph from the 20th US edition of Gray's Anatomy (1908), which is in the public domain

are depicted in Fig. 1. The first possibility is that episodic, token representations affect selection (Fig. 1a; the links between identity and brightness features constituting a target). The second is that only type information matters (Fig. 1b; the absence of specific links between features and identities).

Figure 1a illustrates the episodic option. The representational space is depicted as consisting of (dashed) rectangles containing possible target identities and feature values (brightness levels). As the trial proceeds (from perceiving T1 on the left to T2 on the right in the figure), an episodic representation enters the system when T1 is selected. Let us first consider the top row of Fig. 1a. In this case, T1 is a "3" of medium brightness, and its identity and brightness level are bound episodically, which is indicated by the link drawn between them in the left part of the panel. T2 is a "4" of the same brightness, and is thus from the same category of items as T1 (i.e., numbers). Note that because the targets are from the same category, they are prone to errors arising from failures to dissociate them; an undesirable outcome that the attentional system may try to avoid by temporarily suppressing input (Wyble et al., 2011). The episodic representation of T2 calls for the binding of the feature "medium bright" and "4", as depicted in the right part of the panel. As indicated by the exclamation mark and the colliding identity circles of T1 and T2, this creates a situation of partial overlap between the competing episodic representations of the targets. Partial overlap between items has been observed to incur cognitive costs, which have also been attributed to a storage or consolidation problem: The occupation of features (codes) by one item or event may prevent a second item from being encoded effectively if its representation relies on the same features (Hommel, 2004; Hommel, Müsseler, Aschersleben, & Prinz, 2001; Stoet & Hommel, 1999). Importantly, this difficulty may also be related to the need to minimize confusion between separate, but confusable items. A similar negative effect may thus occur in the present paradigm with respect to the efficiency of T2 selection, particularly when the targets fall into the same attentional episode, because the attentional system must try to keep the targets separate.

Compare this partial overlap situation with one in which T1 and T2 are not of the same category. This situation is depicted in the bottom row of Fig. 1a. In this trial, T1 is a letter while T2 remains a digit. The selection of T1 and that of T2 now require different target templates (i.e., one involving letters and the other digits). Even when these dissimilar targets would fall into the same attentional episode, confusion between them is very unlikely (i.e., it would require mistaking a letter for a digit or vice versa). The fact that the episodic representation of T1 shares a feature with T2 is less problematic, as the attentional system does not

need to devote effort into minimizing confusion between these targets. Thus, in this scenario, the only remaining effect that might be expected from the selection of T1 on that of T2 (or its storage) is a possible consequence of re-activating the previously activated brightness feature; a case of straightforward feature priming.

Figure 1b shows an alternative possibility, namely that selection is not affected by episodic representation at all. In these scenarios, only individual features and identities are activated and binding does not occur at this stage (and no links are drawn between them). Once a target is encountered, its features may affect later selection (by means of feature priming), but they do so independently, so that binding does not contribute to the selection template. In this case, no partial overlap has to be resolved between targets, even if they share the same category, as shown in the top row of Fig. 1b. At most, feature repetition benefits may be obtained in all conditions, regardless of whether the targets share a category or not (the latter is depicted in the bottom row of the panel). Partial overlap costs would not be observed.

The time-course of episodic representation

In the context of temporal attention, specific consideration has to be given to the time-course of episodic representation. Because the target stimuli may follow each other quickly, it is conceivable that the representation of T1 is still in the process of taking definite shape, and possibly not yet fully encoded when T2 appears. In such cases the episodic integration or binding might still be ongoing, which may create specific problems. When an episodic link is not yet fully established, newly incoming T2-related input may interfere with this process, and compete for integration. It is also possible that the T1-related integration process "occupies" the features involved (cf. Stoet & Hommel, 1999), thereby inhibiting, or at least suppressing their ability to bias their subsequent attentional selection.

There is evidence that visual input is temporally integrated across intervals up to 200 ms, an interval that pertains to Lag 1 in rapid serial visual presentation (RSVP) tasks, in which T1 and T2 follow each other directly. RSVP studies have indeed shown that participants become increasingly unable to correctly report the temporal order of targets at such short intervals (Hommel & Akyürek, 2005; Potter, Staub, & O'Connor, 2002). This loss of order information has been attributed to the tendency to create a singular event representation that contains both targets, in contrast to two separate representations that can be more clearly delineated in time (Akyürek et al. 2012; Akyürek, Toffanin, & Hommel, 2008; Bowman & Wyble, 2007; for a contrasting view see Olivers, Hilkenmeier, & Scharlau, 2011; Wyble et al. 2009, 2011).

Thus, it is conceivable that episodic effects may occur during successive selection of targets, by virtue of their joint integration specifically. The predictions are nonetheless comparable to the attentional suppression account described above. If partial overlap is particularly problematic when temporal integration occurs, and because temporal integration is more likely when targets are more similar (Akyürek & Hommel, 2005), interference should be strongest for same-category targets sharing the same color, and might even be absent for targets from different categories altogether, as this clear discrepancy between targets renders their integration much less likely.

The present study

In order to test the hypothesis that attentional selection of an item can be affected by episodic representations of previously selected items, we used an RSVP paradigm, which is known to produce the attentional blink (AB). The AB occurs when participants are trying to identify two successive target stimuli that appear within an interval of about 500 ms. In such cases, identifying the second target is problematic (Broadbent & Broadbent, 1987; Duncan, Ward, & Shapiro, 1994; Raymond, Shapiro, & Arnell, 1992). The AB reflects a limit to attentional processing over time, which has traditionally been modeled as a consequence of the processing of T1. For instance, two-stage theories assume that the consolidation of T1 in memory stalls that process for T2, causing its fleeting representation to decay or suffer from interference (Chun & Potter, 1995; Jolicœur & Dell'Acqua, 1998). Others have pointed to bottlenecks in an executive function hypothesized to maintain an attentional set (Di Lollo, Kawahara, Ghorashi, & Enns, 2005), or to an interplay between a slow attentional boost function and an attempt to inhibit distractors (Olivers & Meeter, 2008).

We chose the AB task to provide an online assessment of attentional allocation over time rather than relying on offline, 'memory-only' retrieval effects. The standard AB task of a single, central RSVP with two arbitrary targets was modified in two ways. First, the two targets randomly appeared in either the same color or in different colors. Given that the task was to identify the two (letter or digit) targets, color was not a feature that was part of the report that was asked for. Nevertheless, we expected that the relatively salient colors would be processed more or less automatically, and thereby should have the potential to affect the efficiency of selection. Second, rather than using the common RSVP of a single stimulus stream, we used a version with three such streams. The middle stream held T1, while either the left or the right stream held T2. The reason for this paradigmatic choice was that the three-stream version allowed us to use location-based priming, so that a property of T1 (i.e., color) acted as a

prime to T2, which appeared at another location (cf. Juola, Botella, & Palacios, 2004). This way, T1 feature-location binding should not contribute to the difficulty of representing T2, which might play a role at the intervals we considered (e.g., Logie, Brockmole, & Jaswal, 2011; for an example of single-stream T1–T2 priming see Akyürek & Hommel, 2007).

We conducted a series of experiments that systematically contrasted conditions in which partial overlap interference between targets was expected, and conditions in which it was not. In all experiments color (mis-)match as well as temporal distance (lag) between targets were varied. In the first experiment, the two targets belonged to different categories, and the selection criteria that applied were different from each other: T1 was a letter while T2 was a digit (cf. bottom rows of Fig. 1a, b). Regardless of whether episodic binding of T1 could affect subsequent selection of T2, it would not be expected to occur here as targets were from different categories. Accordingly, this experiment was meant to chart the baseline effect of a color match between targets. As explained previously, feature priming might be expected to occur. In the second experiment, we used targets that belonged to the same category (cf. top rows of Fig. 1a, b). If episodic representation does affect selection, it would be expected to occur here, and identification performance of T2 should suffer due to the partial overlap problem. Experiments 3 and 4 reinstated the different-category targets condition of Experiment 1, but controlled for possible alternative selection strategies that might have affected the degree to which color was able to guide attention. Experiment 5 replicated the same-category targets (partial overlap interference) condition of Experiment 2, but controlled for the possible effects of task switching between targets. Finally, Experiment 6 investigated whether the degree to which color was critical for finding the targets might have affected the difficulty elicited by partial overlap between same-category targets.

Experiment 1

The purpose of Experiment 1 was to establish the 'baseline' effect of a color match between successive targets, using a condition in which episodic effects should not come into play. In Experiment 1, participants were presented with three streams of black letter stimuli and were asked to detect a letter T1 in the central stream and a digit T2 in one of the other two streams (whether it was the left or the right stream on any given trial was unpredictable). The color of T1 was either bright green or bright purple. The color of T2 could either match that of T1, or not. In order to balance the visual display, the distractor stimulus presented at the same time as T2 in the opposing stream

had the other color. If, for example, a green T2 was shown in the left stream on a particular trial, then the distractor letter appearing at the same time in the right stream would have been purple. The colors of the target stimuli were presented equally often, and were otherwise randomly selected. Similarly, the chance of a color match between T1 and T2 was 50 %, and such matches occurred randomly. In other words, the color of the targets was not predictive with regard to the location of T2, and was not part of the task of identifying either target (though color did signal the presence of T1). Nevertheless, as indicated previously, a benefit from feature priming in case of a color match between targets might be expected.

Method

Participants

Sixteen students (11 female, 5 male) gave informed consent to participate in the experiment for course credit or monetary compensation. Mean age was 23.7 years (range 20–31). None of the participants were aware of the purpose of the study and all of them reported normal color vision, and normal or corrected-to-normal acuity.

Apparatus and stimuli

The program was written in PST E-Prime© (version 1.2) and run on a computer equipped with an Intel Core 2 Duo® processor and a discrete graphics board. The stimuli were presented on a 20″ CRT monitor in a resolution of 800 by 600 pixels in 16-bit color, refreshing at 100 Hz. Responses were recorded using a wired USB keyboard (125 Hz). Participants were individually seated in a sound-attenuated testing chamber, which was dimly lit. The viewing distance was approximately 100 cm (not fixated). An 18 pt. size ($\sim$0.43° visual angle) black plus sign ("+") presented at the center of the screen on a white background served as the fixation cross. The background color was constant throughout the trial. The three stimulus streams were centered on the screen and drawn in the center of virtual, invisible boxes of 60 pixels width ($\sim$0.86° visual angle) that were laid on the horizontal axis. Distractors were randomly drawn from the full alphabet without replacement, which was done separately for each stream. T1 was also a letter, which was again not repeated within the stream, resulting in a chance level of 3.85 %. T2 was a digit and was chosen randomly from 2, 3, 4, 5, 6, 8, and 9, which meant a chance level of 12.5 %. The first target was presented in the middle stream, and the second target was presented in either the left or the right stream. The location of T2 varied randomly, but was constrained by the prerequisite that it should appear equally often on each side

within each block of trials (48). All characters in the RSVP stream were presented in 36 pt. bold Courier New font (visual angles of ∼0.86° wide and ∼1.34° high). The color of T1 and T2 varied between bright purple ("magenta") and bright green ("lime"). The color was randomly selected, but again limited by the constraint that the frequency should be equally distributed (i.e., 50 % for each color and 50 % chance of a color match between T1 and T2 across all trials).

Procedure and design

Figure 2 shows a schematic representation of an experimental trial. Each trial was initiated by the participant by pressing the Enter key. After a 100 ms delay, the fixation cross came on for 300 ms. Then the three RSVP streams started. Each of the 20 frames in these streams was presented for 60 ms, and was followed by a 30-ms blank (90 ms SOA). T1 was either the fifth or the seventh stimulus in the stream, and T2 followed T1 at lags 1, 3, or 8. After the streams had ended, two successive prompts were given for participants to enter the identities of the targets at leisure (5-s timeout). There were 480 experimental trials, with an optional pause halfway through. In addition, there were 24 practice trials to familiarize participants with the task, which were not considered for analysis. Participants were asked to identify the colored letter (T1) and the following digit (T2). To prevent false expectations, the instructions stated that the actual color of the targets did not need to be reported, and as such was not of importance for the task. An experimental session lasted for approximately one hour, depending on the participant's response and trial initiation speed. The experimental design used in the repeated measures analysis of variance (ANOVA) had two independent variables: T1–T2 lag and color match. Lag reflected the delay between T1 and T2, with three levels as T2 appeared as the first, third, or eighth item after T1. Color match indicated whether T1's color matched that of T2 or not. For all analyses, the standard significance level of 5 % was used. Degrees of freedom were Greenhouse–Geisser adjusted (and rounded to one decimal) whenever appropriate.

Results and discussion

Table 1 shows performance (accuracy) on T1, which was affected by lag only, $F_{(2, 30)} = 5.02$, MSE = 0.003, $p < 0.01$, $\eta^2 = 0.25$. Performance was relatively low overall, presumably reflecting the difficulty of identifying a letter amidst letter distractors, reaching its peak at Lag 1 (59.6 %) and dropping to 55.5 % at Lag 3, and 56.8 % at Lag 8. Although the differences were relatively small, they might be taken to indicate improved performance on T1 in
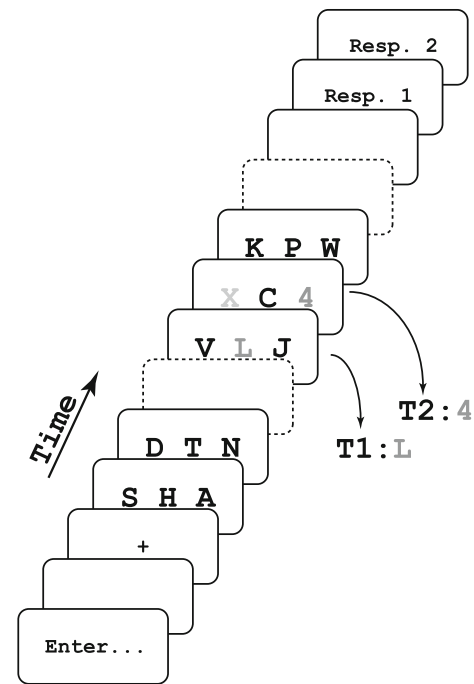
Fig. 2 Schematic overview of the experimental paradigm. Three concurrent streams of stimuli (90 ms each) were shown, in which letters were distractors. T1 was shown in the central stream, after which T2 appeared in either the left or the right stream. T1 either matched the color of T2, or it matched the color of the distractor appearing simultaneously with T2 in the opposite stream. A Lag 1 trial from Experiment 1 is shown in which T1 and T2 matched color

exchange for a loss of T2 accuracy, at least for the case of Lag 1. By virtue of its somewhat special status in that both targets follow each other without intervening distractors, Lag 1 may have provided the unique opportunity for such a trade-off. More specifically, joint integration of targets into a single event episode, rather than two, may have facilitated this competitive process (Akyürek, Riddell, Toffanin, & Hommel, 2007; Akyürek et al., 2008; 2012; Hommel & Akyürek, 2005; Potter et al. 2002). No further effects were significant, $Fs < 1$.

Figure 3 shows performance (accuracy) on T2 given that T1 was correct (T2|T1). T2 performance showed an effect of lag, $F_{(2, 30)} = 27.12$, MSE = 0.014, $p < 0.001$, $\eta^2 = 0.64$. As expected for an AB task with spatial separation of the targets (Visser, Bischof, & Di Lollo, 1999), performance was quite low at Lag 1, at 66.0 %, as well as Lag 3 (63.6 %), compared to Lag 8 where it reached 83.4 %. Color match also had a significant effect, $F_{(1, 15)} = 19.18$, MSE = 0.018, $p < 0.001$, $\eta^2 = 0.56$: when T1 and T2 had the same color, performance on the latter was much higher (77.0 %) than when they had not (65.0 %). Finally, lag and color match interacted, $F_{(2, 30)} = 4.86$, MSE = 0.004, $p < 0.05$, $\eta^2 = 0.25$. Post hoc Tukey tests showed that color match had a beneficial effect at Lags 1 and 3, $q_{(6, 15)} = 4.05$, $t = 3.34$, and $t = 5.10$,

Table 1 Mean performance on T1 (percent correct) in Experiments 1-6

| | Experiment 1 | | | Experiment 2 | | | Experiment 3 | | | Experiment 4 | | | Experiment 5 | | | Experiment 6 | | |
| | Lag | | | Lag | | | Lag | | | Lag | | | Lag | | | Lag | | |
Color	1	3	8	1	3	8	1	3	8	1	3	8	1	3	8	1	3	8
Match	59.8	55.6	57.5	85.6	93.1	92.8	95.5	95.1	95.7	85.7	85.9	86.4	90.9	93.0	92.0	64.3	65.8	67.6
No match	59.5	55.3	56.2	86.5	92.1	93.3	94.9	95.5	95.9	86.4	86.1	86.5	91.6	92.6	92.4	65.6	64.5	66.0

Columns represent different lags, and rows represent color match
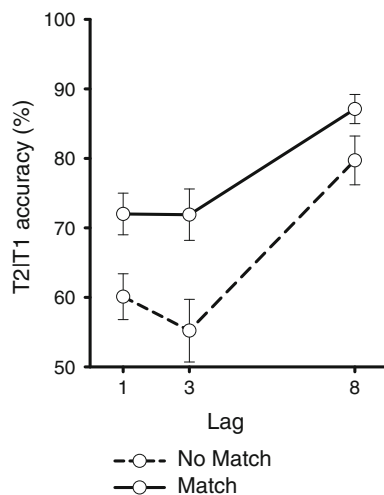
Fig. 3 Percentage of correctly identified T2s in Experiment 1, given that T1 was correct (T2|T1), plotted as a function of lag. *Solid lines* represent trials in which the color of T1 matched that of T2, and *dashed lines* those in which it did not

respectively, but not convincingly so at Lag 8, $t = 2.60$. Further Tukey tests to compare matching effects across lags revealed that the benefit of a color match was reliably larger at Lag 3 than at Lag 8, $q(3, 15) = 3.67$, $t = 3.48$. This may be taken to indicate an interaction with blink magnitude: when the AB was largest, the color match provided the biggest benefit, by compensating for the poor performance to a greater degree.

Overall, the outcome of this experiment was clear: a task-irrelevant color match between targets induced a strong priming effect. The priming effect was in line with expectations. Even though the color of T1 (and T2) was not part of the required report of target identities, its featural representation seems to have been activated to a degree that it primed a color-matching T2. Thus, these results confirm that the present paradigm can produce reliable priming by T1 across different T2 locations.

Experiment 2

In Experiment 2, we tested whether attentional selection is affected by episodic representations established in the

course of processing earlier events. We did so by making one critical change compared to Experiment 1: T1 was now a digit. The predictions regarding this modification were as follows. If episodic representation of T1 has an effect on the subsequent selection of a same-category T2, partial overlap costs would be expected to emerge (cf. top row of Fig. 1a). In particular, one would predict that the binding of the color feature to the identity of T1 would hinder effective selection or encoding of T2. Alternatively, if episodic representation has no effect on subsequent selection, then the priming effect observed in Experiment 1 should be replicated (cf. top row of Fig. 1b).

Method

Another 20 students (15 female, 5 male; mean age 23.3 years, range 19–33) participated in this experiment after having given informed consent. They met the same criteria as in Experiment 1. The experiment was identical to Experiment 1, except that T1 was a digit like T2, but never the same digit within one trial.

Results and discussion

Performance on T1 (see Table 1) was again affected by lag, $F(1.2, 23) = 15.27$, MSE = 0.007, $p < 0.001$, $\eta^2 = 0.45$. This effect was unlike the one observed in Experiment 1, however. Accuracy was lowest at Lag 1 (86.0 %), and recovered to 92.6 % at Lag 3, and 93.0 % at Lag 8. Instead of a small benefit of T2 proximity, T1 performance now suffered at the shortest lag, suggestive of competition between targets. The means showed that the task of identifying a digit was much easier than identifying a letter, as in Experiment 1. There were no further effects, all Fs < 1.8.

Figure 4a shows conditional T2 performance plotted over T2 lag in Experiment 2. Lag had a pronounced effect, $F(2, 38) = 16.35$, MSE = 0.007, $p < 0.001$, $\eta^2 = 0.46$. Performance was relatively poor at Lags 1 and 3 (78.3 and 77.0 %) as compared to Lag 8 (87.1 %). In contrast to Experiment 1, there was no effect of color match, $F < 1.8$, indicating that the priming effect had disappeared. In an additional ANOVA across Experiments 1 and 2, this

Fig. 4 **a** Percentage of correctly identified T2s in Experiment 2, given that T1 was correct (T2|T1), plotted as a function of lag. **b** Percentage of order reversals as a function of lag. Line conventions in this and subsequent figures are as in Fig. 3
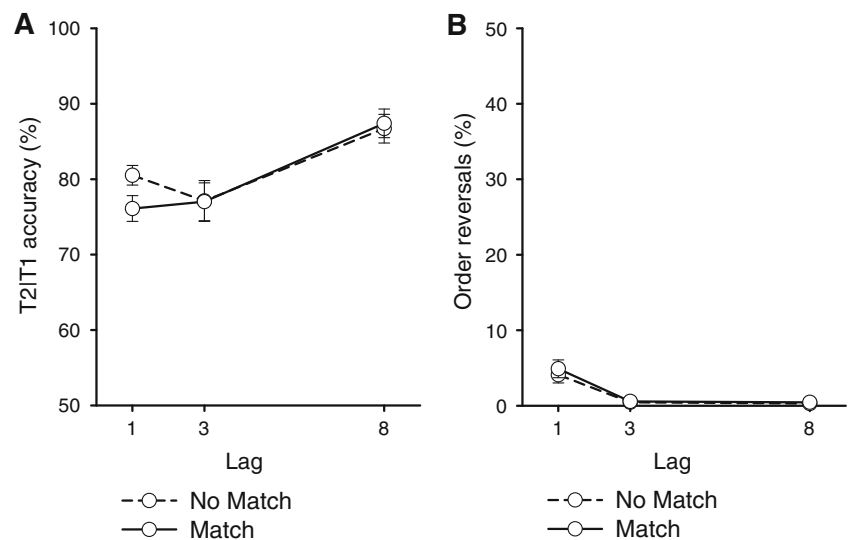
difference was also reliable (color match × experiment), $F(1, 34) = 24.62$, MSE = 0.01, $p < 0.001$, $\eta^2 = 0.42$.

However, the interaction of lag and color match was significant in Experiment 2, $F(2, 38) = 4.91$, MSE = 0.001, $p < 0.01$, $\eta^2 = 0.21$. Importantly, this interaction was in the opposite direction of that of Experiment 1. A difference between match and mismatch trials was only apparent at Lag 1, where a color match actually reduced performance (76.1 % compared to 80.5 %), $q(3, 19) = 3.59$, $t = 2.60$.

A color match could be detrimental to performance in this experiment if it encouraged order reversals between targets at Lag 1. These are trials in which T2 is named as the first target, and T1 is named as the second target; target identities are preserved, but order information is lost (Hommel & Akyürek, 2005). There might be several mechanisms causing these effects (see Akyürek et al., 2008; 2012; Olivers, Hilkenmeier, et al. 2011), but all theories predict that increased similarity between targets should increase order reversals. It should be noted that spatial distance between targets, as in the present paradigm, strongly reduces the frequency of order reversals (for related considerations concerning Lag 1 sparing, see Visser et al., 1999; Yamada & Kawahara, 2007). Nonetheless, an analysis of the frequency of these errors (see Fig. 4b) showed that they were affected by lag, $F(1.1, 20) = 14.83$, MSE = 0.002, $p < 0.001$, $\eta^2 = 0.44$. As expected, reversals were most frequent at Lag 1 (4.2 %), and virtually absent at Lag 3 (0.4 %) and Lag 8 (0.3 %). Color had a marginal effect, $F(1, 19) = 4.04$, MSE = 0.001, $p < 0.06$, $\eta^2 = 0.18$, with increased frequency when a color match was present (1.4 % absent vs. 1.9 % present; at Lag 1 alone these came to 3.7 and 4.6 %). The interaction was unreliable ($F < 1.2$). Thus, this analysis could not fully confirm that increased order reversals were found when target color matched, but a trend in this direction was visible.

Taken together, the results showed a clear contrast to those of Experiment 1. Instead of priming, a short-lived interference effect was observed. This pattern of data was predicted by the hypothesis that episodic representations can affect attentional selection, since it predicts that partial overlap costs could have such negative consequences for selection. Conversely, the idea that attentional control could be immune to episodic effects was not supported by these findings; priming was not observed, even at longer lags.

Experiment 3

Experiment 2 showed how priming benefits were completely eliminated and even reversed to a more short-lived interference effect, which we attribute to the introduction of shared category membership of the targets. However, before this claim can be made conclusively, it is necessary to consider an alternative explanation of our results. Namely, changing T1 to a digit may have led participants to establish a search template on the basis of categorical identity only (i.e., looking for a digit amidst the letter distractors), which would have allowed them to more easily ignore their colors despite their salience. In other words, the selection utility of color was low in Experiment 2, which may have eliminated priming. Even though this would not account for the interference observed at Lag 1, we decided to conduct a new experiment to address this alternative account directly. Accordingly, in Experiment 3 we replicated Experiment 2, with the only modification that T2 was now a letter. If the search for T1 was indeed performed on the basis of categorical identity, and if this was indeed the cause of the lack of a priming effect in Experiment 2, then one would expect a replication of that result with the present configuration.

Method

Another 25 students (19 female, 6 male) participated in this experiment after having given informed consent. These met the same criteria as in Experiment 1. Mean age was 24.3 years (range 20–32). The data from three female participants were discarded because their T2 performance approached chance level, indicating that the task was too difficult for them. The experiment was identical to Experiment 2, except that T2 was a letter, and that the color of the distractor in the opposite stream was blue. This color change was necessary to allow participants to determine which of the colored letters was T2. Although this modification might have increased the importance of the actual T1 and T2 colors (i.e., as a means to find the actual targets), such an increase would boost overall performance on T2—while for our predictions only differential effects within these colors and in particular between T1 and T2 color match mattered.

Results and discussion

Performance on T1 (see Table 1) was not affected by any experimental variable ($Fs < 1$), and was close to ceiling (95.4 %). The absence of effects on T1 was expected, as T1 enjoyed the dual benefits of being relatively easy to discern as a digit amongst letters, and of having no categorical overlap with T2.

Figure 5 shows the performance on T2 (given T1) in Experiment 3. T2 performance was affected by both experimental variables as well as their interaction. The AB was observed as a function of lag, $F(2, 42) = 79.89$, $MSE = 0.007$, $p < 0.001$, $\eta^2 = 0.79$. The lowest performance was attained at Lag 1 (12.7 %), with a slight improvement at Lag 3 (16.0 %), before recovering more fully at Lag 8 (34.2 %). It is evident that the letter identification task was extremely challenging, as was also seen to a lesser degree with T1 performance in Experiment 1, where that target was a letter. Note that, if anything, this difficulty would work against our hypothesis that priming should be taking place in this experiment, since it pushed performance towards a floor level. Nonetheless, color priming was reliable, $F(1, 21) = 8.09$, $MSE = 0.004$, $p < 0.01$, $\eta^2 = 0.28$, with higher performance associated with a color match (22.5 %) than without a match (19.5 %). Color match furthermore interacted with lag, $F(2, 42) = 3.93$, $MSE = 0.002$, $p < 0.05$, $\eta^2 = 0.16$, which showed that the color match effect was limited to Lags 3 and 8 (3.2 and 5.8 %), and was not visible at Lag 1 (−0.1 %). The interaction must be interpreted with caution, however, because the absence of the match effect at Lag 1 might also have been due to a bottom effect. Beyond that, a possible reason for the absence of priming at Lag 1 (which was found in Experiment 1) could be that the target
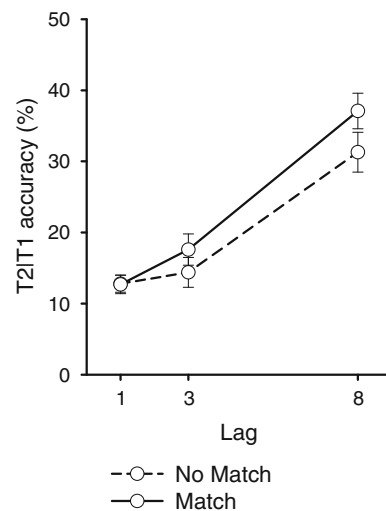
Fig. 5 Percentage of correctly identified T2s in Experiment 3, given that T1 was correct (T2|T1), plotted as a function of lag

template for T1 might have been more specific in the present experiment (i.e., category) than it was in Experiment 1 (color). The use of a more specific template may have reduced the strength of the color match priming effect, particularly at short lags.

Overall, the results of this experiment nonetheless mostly replicated those of Experiment 1, and did not lend support to the idea that the differences between Experiment 1 and 2 were due to a different selection strategy (i.e., based exclusively on categorical identity or not).

Experiment 4

Some of the results so far might still be explained by differences in the degree of selection utility of color. Despite the fact that the color of the targets was not part of the report the observers were asked to give, color could nonetheless be used as a means to find the targets, and to dissociate them from distractors. In Experiments 1 and 3, color was the only property of one of the targets that distinguished it from the distractors (T1 and T2, respectively). In Experiment 2, this was not the case, as both targets were uniquely identifiable by virtue of being a digit rather than a letter. Thus, color might have had higher selection utility overall in Experiments 1 and 3, and thereby caused priming. Conversely, because color had less selection utility in Experiment 2, interference might have emerged. Moreover, targets and distractors were easily discriminable in Experiment 2 (digits vs. letters), while at least one target in Experiments 1 and 3 shared the identity of the distractors, that is, it was a letter too. The absence of target-distractor similarity might also have contributed to the interference effect in Experiment 2. Experiment 4 was designed to test

this possibility by replicating Experiment 1 with a symbol character T1 (T2 remained a digit). This change had two consequences: color was no longer the only property defining either target, since watching for symbols and digits only could accomplish successful selection, and targets and distractors no longer shared identities. If these aspects of the task caused the differential results obtained so far, the present replication should produce interference. However, if they did not, the experiment should show priming, as in Experiment 1.

Method

Twenty-two new students (12 female, 10 male; mean age 20.7 years, range 18–27) participated. They met the same criteria as in Experiment 1. The experiment was identical to Experiment 1, except that T1 was now a symbol character; "@", "#", "$", "%", "^", "*", "(", or ")". As in Experiment 3, the color of the distractor opposite to T2 was blue. This choice was made so that T1–T2 priming could be dissociated from interference between T1 and the distractor shown simultaneously with T2.

Results and discussion

Performance on T1 (see Table 1) was unaffected by the experimental variables, $Fs < 1$, as might have been expected, even though accuracy was not entirely perfect (86.2 %).

Figure 6 shows performance on T2 (given T1), which was affected by both lag, $F(1.4, 30) = 16.35$, MSE $= 0.021$, $p < 0.001$, $\eta^2 = 0.44$, and color, $F(1, 21) = 6.03$, MSE $= 0.006$, $p < 0.05$, $\eta^2 = 0.22$. The two variables did not interact ($F < 1$). Accuracy averaged 73.2 % at Lag 1,
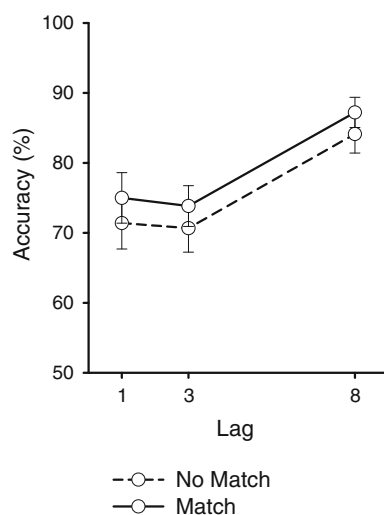
Fig. 6 Percentage of correctly identified T2s in Experiment 4, given that T1 was correct (T2|T1), plotted as a function of lag

72.2 % at Lag 3, and 85.7 % at Lag 8. Without a color match between T1 and T2, average T2 identification performance was 75.4 %, compared to 78.7 % with a match. The results thus showed that lag-independent priming was obtained. Thus, color does not need to have unique selection utility, and targets and distractors do not need to be from the same category, to obtain priming effects or, by extension, to avoid interference (but see Experiment 6 for a direct test of the latter).

Experiment 5

Experiment 5 was conducted to address another remaining concern. Experiment 2 was the only experiment in which targets shared the same category and interference was observed. It was also the only experiment in which there was no task switch between T1 and T2; both required the identification of a digit. Thus, it cannot yet be concluded that the interference was caused by the shared category of the targets; it could also have been caused by the lack of a task switch. In order to test the task switch hypothesis, Experiment 5 was conducted. It was designed to replicate Experiment 2, but introduced a task switch between T1 and T2, while keeping the category of the targets constant. The task for T1 was no longer to identify the digit (as it remained for T2), but rather to determine whether it was odd or even. If the introduction of this task switch reduces or even eliminates interference, shared category membership cannot be held (entirely) responsible for the interference effect. If interference remains unchanged, however, then a lack of task switching cannot have contributed to the interference between targets.

Method

Another 22 new students (17 female, 5 male; mean age 20.8 years, range 19–23) participated. They met the same criteria as in Experiment 1. The experiment was identical to Experiment 2, except that the task for T1 was no longer to identify it, but rather to judge whether it was odd (key "O") or even (key "E").

Results and discussion

As in Experiment 2, performance on T1 (see Table 1) was affected by lag, $F(2, 42) = 3.44$, MSE $= 0.001$, $p < 0.05$, $\eta^2 = 0.14$. Neither the color main effect nor the interaction term was reliable ($Fs < 1$). Accuracy averaged 91.3 % at Lag 1, 92.8 % at Lag 3, and 92.2 % at Lag 8.

Figure 7 shows performance on T2 (given T1), which was affected by lag, $F(2, 42) = 25.14$, MSE $= 0.007$, $p < 0.001$, $\eta^2 = 0.55$, and color, $F(1, 21) = 11.35$, MSE $= 0.003$, $p < 0.005$, $\eta^2 = 0.35$. The interaction was
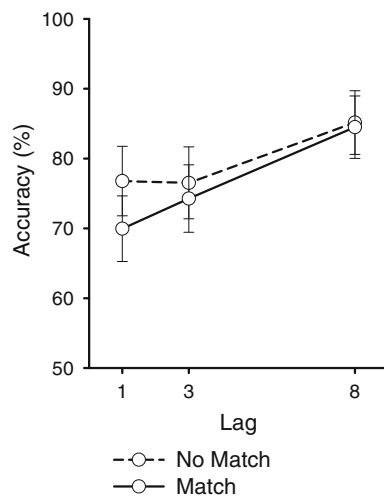
Fig. 7 Percentage of correctly identified T2s in Experiment 5, given that T1 was correct (T2|T1), plotted as a function of lag

also significant, $F(2, 42) = 8.68$, MSE $= 0.001$, $p < 0.001$, $\eta^2 = 0.29$. Identification was poorest at Lag 1 (73.4 %) and Lag 3 (75.4 %), and improved at Lag 8 (84.8 %). Replicating Experiment 2, accuracy averaged 79.5 % without a color match, and 76.2 % with a match, indicative of an interference effect. The interference effect was strongest at Lag 1, at 6.9 % difference, compared to 2.2 % at Lag 3, and 0.7 % at Lag 8. The replication of the interference effect demonstrates that the presence or absence of a task switch cannot account for the pattern of priming and interference effects observed in the present study.

Experiment 6

So far, interference between T1 and T2 was only observed in experiments in which both targets could be selected by color, but also by category (e.g., because the targets were digits amidst letter distractors). Even though these two selection criteria were also available in Experiment 4, which showed T1–T2 priming instead, it cannot yet be ruled out that the interference effect might be eliminated if color has comparatively higher selection utility. This can be accomplished by making color the single feature allowing target selection, and thus removing category as a means to dissociate a target from distractors. Experiment 6 was carried out to test whether interference between targets from the same category continues to occur if their matching feature (i.e., color) is critical to target selection.

Method

A new group of 18 students (17 female, 5 male; mean age 20.8 years, range 19–23) participated. They met the same criteria as in Experiment 1. Half the participants were to

identify colored letters amidst black letter distractors, while the other half were to identify colored digits amidst black digit distractors. Thus, in both cases, color was the only feature dissociating a target from a distractor. The two versions of the task were implemented to make sure any effects presently observed could not be attributed to potential stimulus-specific peculiarities.

Results and discussion

Performance on T1 (see Table 1) was not affected by either variable ($Fs < 1.4$).

Figure 8 shows performance on T2 (given T1). Lag predictably affected performance, $F(2, 32) = 35.17$, MSE $= 0.008$, $p < 0.001$, $\eta^2 = 0.69$. Presumably because of the similarity between distractors and targets in this experiment (cf. Experiment 3), performance was relatively low, averaging 22.8 % at Lag 1, 21.3 % at Lag 3, and 37.1 % at Lag 8. Although color did not have a main effect ($F < 1.7$), it did interact with lag, $F(2, 32) = 16.37$, MSE $= 0.003$, $p < 0.001$, $\eta^2 = 0.51$. The interaction was due to two opposing differences in the means. First, at Lag 1, color match produced interference (7.1 %), $q(3, 32) = 3.48$, $t = 3.7$. Second, at Lag 8, color match produced priming (7.7 %), $q(3, 32) = 3.48$, $t = 3.12$. At Lag 3, the priming effect (4.3 %) was not reliable enough to pass the Tukey criterion, $q(3, 32) = 3.48$, $t = 2.26$.

The results thus indicated that the degree of selection utility provided by color does modulate the interference effects previously observed for targets of the same category. Specifically, interference continued to occur at Lag 1, but gave way to a priming effect at longer lags. This possibly adaptive change might reflect the dynamics of
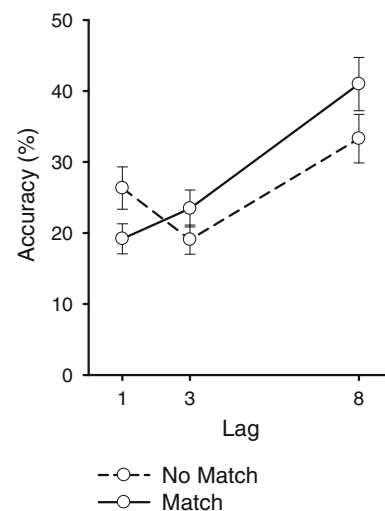
Fig. 8 Percentage of correctly identified T2s in Experiment 6, given that T1 was correct (T2|T1), plotted as a function of lag

forming episodic representations with features that are critical to target selection.

General discussion

The experiments in the present study set out to investigate the possible consequences of episodic representation on successive attentional selection of items. Such consequences were indeed observed, as summarized in Table 2. The results demonstrated that episodic representation of T1 can interfere with the selection of T2 if the collection of its features has partial overlap with that of T1 (see Fig. 1a). Interference seemed to be particularly strong when time between targets was shortest. In the absence of partial overlap, and when targets did not share the same category, robust feature priming was observed across almost all lags. The long-lasting nature of this effect is consistent with previous work showing that location-based cueing effects can be somewhat independent of the AB bottleneck, as long as no identification of the cue (in this case the critical target feature) was necessary (Ghorashi, Spalek, Enns, & Di Lollo, 2009).

Experiment 1 showed that a color match between T1 and T2 facilitates T2 report. This suggests that selecting a target includes the coding of all its features, those that are part of the required report as well as those that are not. This is consistent with Duncan's (1980) claim that attentional selection is based on objects but not features, so that attending to some features of an object necessarily implies attention to other features of this object as well. It is also consistent with Pratt and Hommel's (2003) finding that storing the shape of a stimulus in working memory implies that all features of that stimulus are stored, so that both relevant and less relevant features provide top-down support for feature-overlapping stimuli. In the present study, storing the identity of a digit or letter was sufficient to bias attention towards stimuli sharing the color of that stimulus. This bias was observed across all lags, which suggested that only briefly coding a target was sufficient to induce a lasting top-down bias.

At first sight, these findings may seem to be at odds with results reported by Woodman and Vogel (2008), which showed that task-irrelevant features of to-be-memorized objects are not necessarily encoded in visual working memory. However, a crucial difference lies in the attentional nature of the current task. While the participants of Woodman and Vogel were simply asked to remember items from an unmasked visual array, in the present study the targets had to be selected from an ongoing stream of distractors. Encoding of color may thus have been encouraged in the present task because color had selection utility.

The effect of a color match in Experiment 1 was furthermore strong even at short lags. This provided evidence against the idea that memory consolidation of T1 needs to be completed before its features can affect incoming information, as this would imply a stronger priming effect as time passes. Hence, it seems that relatively little T1 processing is needed for the attentional bias to occur. The interaction with blink magnitude found in Experiment 1 in particular points to the idea that memory-related biases have the strongest impact if few attentional resources are available, as in the case with short lags. If attentional control is resource-hungry, an assumption made by most of the available attentional-control models (e.g., Logan & Gordon, 2001; Norman & Shallice, 1986; Wolfe, 1998), resource-demanding processing situations should make attentional control particularly vulnerable and sensitive for influences unrelated to the current task. Indeed, findings from task-switching studies support that conclusion. Waszak, Hommel, and Allport (2003) have shown that switching from one task to another is more difficult if the present stimulus has been encountered earlier in the context of the old task. This suggests that stimuli are automatically integrated with the task in which they occur, so that reviewing the stimulus primes the associated task. Most interesting for our purposes, however, is that such priming effects only occur if people are in the process of switching to a new task but not if they are cued to repeat the current task. As Waszak et al. (2003) have suggested, switching to a new task is likely to be more resource demanding thus

Table 2 Summary of T1–T2 color match effects on T2 performance in Experiments 1–6

Experiment	Distractors	T1 identity/task	T2 identity/task	Main result
1	Black letters	Color letter (identify)	Color digit (identify)	Priming
2	Black letters	*Color digit (identify)*	*Color digit (identify)*	Interference (Lag 1)
3	Black letters	Color digit (identify)	Color letter (identify)	Priming
4	Black letters	Color symbol (identify)	Color digit (identify)	Priming
5	Black letters	*Color digit (odd/even)*	*Color digit (identify)*	Interference (Lag 1)
6	Black letters/digits	*Color letter/digit (identify)*	*Color letter/digit (identify)*	Interference (Lag 1), priming

Italics represent same-category targets

rendering control functions more vulnerable and open to priming effects.

Experiment 2 provided evidence for episodic modulation of the priming effect observed in Experiment 1. When the targets shared the same category (i.e., both were digits), the priming effect completely disappeared, even to the point of a performance decrement at Lag 1. The crucial difference between these experiments was that Experiment 2 introduced a competitive relationship between the targets. The elimination of the priming effect and the interference of the color match between targets can be interpreted as an attentional mechanism, as proposed by Wyble et al. (2011). According to this account, episodic distinctiveness is threatened when confusable (i.e., same-category) targets have similar properties, which could elicit a suppression of input and result in decreased T2 identification performance. An alternative interpretation that is also to an extent compatible with the present results is that targets from the same category are more likely to become jointly integrated. Assuming that competition for features between targets that are part of the same event representation is particularly severe, this would also result in reduced performance.

At longer T1–T2 lags, the interference apparently weakened, but was nonetheless capable enough to counteract any potential priming effect, as compared to Experiment 1. The weakening of the suppression over time might be taken as evidence for an early locus of this effect (see Olivers, 2009, for similar considerations), more likely to correspond to the first stage of several models of the AB (Chun & Potter, 1995; Jolicœur & Dell'Acqua, 1998), rather than to memory consolidation (or retrieval). The early locus of the interference effect can also be taken to support models that assume a special role for temporal integration at Lag 1. Presumably, at Lag 1 integration associated with T1 might still be ongoing when T2 arrives, which is less likely at longer lags. The lack of priming at longer lags is not directly predicted by this account, however, although one may assume that interference is reduced once episodic representations have matured (at longer lags).

Experiment 3 showed that priming was again observed without category sharing, when T1 could be identified on the basis of its digit identity alone (amidst letter distractors), as had been the case in Experiment 2 (in which interference was observed). Thus, the degree to which the color was critical to find the first target cannot be held responsible for the contrast between the presently observed priming and interference effects. This finding also argues against a possible account of the present effects in terms of contingent attentional capture, which can have subtle, long-lasting effects also in RSVP (Folk et al., 2002; Folk, Leber, & Egeth, 2008; Thompson, Underwood, & Crundall, 2007). While the present results do not rule out the existence of contingent capture, the observation that the effects of priming and interference mirror each other cannot be accounted for in terms of varying levels of capture that might have been elicited in the experiments.

Experiment 4 extended these results, showing that even when both T1 and T2 could be found without necessarily relying on color, and when both targets belonged to a different category than the distractors (cf. Experiment 2), priming was still obtained. One caveat is justified here, since Experiment 4, like Experiment 3, used a different nontarget color for the distractor appearing simultaneously with T2, and priming effects were comparatively weaker than those observed in Experiment 1, in which a target color was used. This might indicate that part of the priming effect might be attributed to interference caused by the distractor, when it matched the color of T1 (and thus T2 did not). There is indeed some evidence for detrimental effects on task performance when items in working memory match distractors in a search task (Balani, Soto, & Humphreys, 2010). In any case, the survival of the effect with a neutral baseline (i.e., with a distractor in a nontarget) color did prove that T1–T2 priming was indeed obtained.

Experiment 5 replicated Experiment 2, demonstrating interference between targets in the presence of a task switch. Thus, differences in the need to switch tasks between targets cannot account for the observed contrast between priming and interference. This finding is in line with previous claims made by Kawahara, Zuvic, Enns, and Di Lollo (2003), who found no evidence for an AB due to task switching when the stimuli were overlearned symbols (i.e., letters and digits). Finally, Experiment 6 showed that when color was the single target-defining feature, interference continued to be observed at Lag 1 for target from the same category. However, at longer lags, a priming effect emerged instead. This might indicate that features that are critical to the selection of the target (but not the report thereof) might be released sooner, or more fully, from episodic processing than features that are less, or not exclusively critical (cf. Experiments 2 and 5). Such adaptive release suggests that there may be a degree of control over the time-course of episodic representation.

Taking together the results of these experiments, one might surmise that differences in overall performance between experiments might account for the pattern of results. First, however, it is important to note that T2 performance was calculated contingent on correct T1 report in all experiments, which makes it unlikely that baseline T1 performance mattered for the effects that were observed. Second, the general level of identification performance does not offer a satisfactory account of the results. Regarding the first two experiments, if anything, T1 and its color were perceived better in Experiment 2, yet that did not lead to any measurable priming effect. T2

performance in Experiment 2 was also higher than in Experiment 1, which might have reduced the presence of modulations if it were approaching a performance ceiling. Yet, the data do not favor this interpretation either. The AB was still clearly visible, which makes it unlikely that the relatively strong priming effect would be hidden. Indeed, the small but reliable interference at Lag 1 pointed to a fundamental change rather than ceiling-induced suppression. In Experiment 3, despite the high difficulty of the task, and signs of performance reaching a bottom plateau, priming was still observed. Similarly, difficulty in Experiment 6 did not prevent the emergence of both interference and priming effects. Third, in Experiments 4 and 5, performance was comparable—yet these experiments showed opposite effects.

Overall, the results thus support the idea that attentional selection is sensitive to episodic information. Put differently, not just the T1 type, but the T1 token affects the selection of T2. This finding seems to fit with the "simultaneous type, serial token" (STST) model of the AB, and its derivatives, in that it supports their basic type/token organization of attentional selection (Bowman & Wyble, 2007; Wyble, et al., 2009, 2011). However, since the 2009 iteration of this model (eSTST), attentional selection takes place on the basis of type information, and stimuli are bound to unique tokens. These features of the model seemingly render it less likely that the content of one token should interfere with that of another, as would be predicted by the temporal integration account.

Conclusion

The data can be taken to support a direct link between episodic representation and attentional control, as depicted in Fig. 1a. This is in line with established models of attention (Bundesen, 1990; Desimone & Duncan, 1995; Duncan & Humphreys, 1989). Reliable T1–T2 (location-based) priming effects were observed when no direct competition between these targets existed, that is, when there was no partial overlap between them, and when they were not hard to dissociate by virtue of being from a different category. Conversely, when targets shared the same category, and overlap did occur, feature matching between targets produced an interference effect on successive attentional selection. The early locus of interference furthermore suggests that (temporal) integration processes may play a role therein.

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