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Intentional Forgetting Reduces Color-Naming Interference: Evidence From Item-Method Directed Forgetting

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In an item-method-directed forgetting task, Chinese words were presented individually, each followed by an instruction to remember or forget. Colored probe items were presented following each memory instruction requiring a speeded color-naming response. Half of the probe items were novel and unrelated to the preceding study item, whereas the remaining half of the probe items were a repetition of the preceding study item. Repeated probe items were either identical to the preceding study item (E1, E2), a phonetic reproduction of the preceding study item (E3), or perceptually matched to the preceding study item (E4). Color-naming interference was calculated by subtracting color-naming reaction times made in response to a string of meaningless symbols from that of the novel and repeated conditions. Across all experiments, participants recalled more to-be-remembered (TBR) than to-be-forgotten (TBF) study words. More importantly, Experiments 1 and 2 found that color-naming interference was reduced for repeated TBF words relative to repeated TBR words. Experiments 3 and 4 further found that this effect occurred at the perceptual rather than semantic level. These findings suggest that participants may bias processing resources away from the perceptual representation of to-be-forgotten information.

Keywords: selective rehearsal, semantic inhibition, intentional forgetting, perceptual inhibition

What do people do when they try to forget something? One method that psychologists have used to examine this question in the laboratory is the directed forgetting paradigm. Although several variants of the directed forgetting paradigm have been developed, we focus on item-method-directed forgetting. In an item-method-directed forgetting task, words are presented successively, each followed by an instruction to remember or forget the preceding word. Memory instructions are typically presented after (as opposed to concurrent to) the study item to ensure that each item receives the same amount of initial encoding (although for concurrent presentation, see Paller, 1990). During a subsequent test participants typically demonstrate impaired memory for forget (F) instructed relative to remember (R) instructed items (see MacLeod, 1998, for a review). The occurrence of directed forgetting in the item method has long been attributed to rehearsal differences between to-be-remembered (TBR) and to-be-forgotten (TBF) items at encoding. Following each study item, it is believed that all items receive maintenance rehearsal to refresh the representation of that item in working memory in anticipation of the pending memory instruction (Woodward, Bjork, & Jongeward, 1973). According to the selective rehearsal account, after the presentation of the memory instruction, rehearsal of TBR items continues and becomes elaborated, whereas TBF items do not receive such elaboration. As a result, memory for TBF items is impaired because they have received less rehearsal than TBR items.

The idea of selective rehearsal has been prevalent in the directed-forgetting literature from the beginning (e.g., Bjork, 1972; MacLeod, 1975; Wetzel, 1975) and has received substantial empirical support. Studies have found that the time and resources available for postcue encoding has a larger effect on TBR than on TBF items (e.g., Davis & Okada, 1971; MacLeod, 1989; Wetzel & Hunt, 1977). Moreover, memory is typically impaired for TBF items on tests of both recognition and recall (Basden & Basden, 1998; Basden, Basden, & Gargano, 1993; MacLeod, 1999; Wilson & Kipp, 1998) as well as on certain implicit memory tests, such as word-fragment and word-stem completion (MacLeod, 1989). In recognition tests using the remember-know paradigm, participants make more "remember" responses for TBR items than for TBF items, but make a similar number of "know" responses regardless of the associated memory instruction (e.g., Gardiner, Gawlik, & Richardson-Klavehn, 1994). Taken together, these results support the view that TBR items received more elaborative rehearsal than TBF items, resulting in a stronger, recollective memory trace.

Some researchers have instead suggested that inhibition is involved in item-method-directed forgetting (e.g., Geiselman & Bagheri, 1985; MacLeod, 1989; Weiner & Reed, 1969). For example, Weiner and Reed (1969) found lower recall following an instruction to actively forget the study item relative to an instruction not to rehearse the study item. Their findings suggested that intentional forgetting was not the result of mere nonrehearsal. Roediger and Crowder (1972) nonetheless suggested that Weiner and Reed's (1969) findings resulted from covert rehearsal in the nonrehearsal condition. In addition, Geiselman and Bagheri (1985) found greater memory gains for TBF items than TBR items fol-

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lowing a second study and test procedure, and proposed that this was evidence for the release of retrieval inhibition from the TBF items. Results from directed forgetting on indirect memory tests are also consistent with the notion of retrieval inhibition (MacLeod, 1989). However, Basden et al. (1993) suggest that MacLeod's (1989) results may have been contaminated by explicit retrieval, and the evidence from Geiselman and Bagheri (1985) was not compelling; thus, the role of inhibition in item-method-directed forgetting remains inconclusive for methodological reasons (Basden et al., 1993; Hauselt, 1998; Roediger & Crowder, 1972).

If item-method-directed forgetting is mediated only by processes that enhance the rehearsal of TBR items and not by processes that discourage the encoding or retrieval of TBF items, TBF items ought to be ignored after the memory instruction. As a result, increasing the interval between the presentation of the R or F instruction and the presentation of the next study item (the postcue interval) should improve memory only for TBR items and not for TBF items. However, when the postcue interval was increased, correct recognition and "remember" responses were found to increase for both TBR and TBF items, suggesting that the participants did not stop processing the study item following an F instruction (Lee, Lee, & Tsai, 2007). One interpretation of these findings is that each F instruction enacted an active mechanism tasked with suppressing the rehearsal or representation of the study item—and that this suppression becomes more difficult over an extended period because of the continued demands of attentional control.

Electrophysiological studies have also provided evidence consistent with an active account of forgetting in this paradigm. Event-related brain potentials recorded during the recognition phase showed that TBF items had a more pronounced late right-frontal effect that was associated with postretrieval processing. This was allegedly because the retrieval of TBF items was suppressed until testing, at which time this suppression was released through the active involvement of frontal brain regions (Paz-Caballero & Menor, 1999; Ullsperger, Mecklinger, & Müller, 2000). Ullsperger et al. (2000) further demonstrated that the difference between TBF and TBR items in the spatiotemporal pattern of the event-related potentials was not equivalent to the difference between shallow and deep encoding conditions, suggesting that the item-method-directed forgetting effect they observed could not be accounted for by selective rehearsal alone. Instead, they argued that TBF items were somehow less accessible than TBR items. Both electrophysiological (Nowicka, Jednoróg, Wypych, & Marchewka, 2009; Paz-Caballero, Menor, & Jimenez, 2004; Van Hooff, Whitaker, & Ford, 2009) and functional magnetic resonance imaging (Wylie, Foxe, & Taylor, 2008) findings that frontal and prefrontal control mechanisms were triggered after the presentation of study phase F instructions also suggest the involvement of active control processes in item-method-directed forgetting at the time of encoding.

On the basis of the inhibitory deficit hypothesis of aging, Zacks, Radvansky, and Hasher (1996) suggested an attentional inhibition account of item-method-directed forgetting. According to their view, inhibition occurred at encoding to stop the activation associated with TBF items and at test to suppress the retrieval of TBF items. They argued that these mechanisms combined to reduce the likelihood of TBF items gaining access to working memory or interfering with later recall of TBR items. Moreover, Taylor (2005; see also Fawcett & Taylor, 2010; Taylor & Fawcett, 2011) examined whether an intervening R or F instruction would impact the inhibition of return (IOR) arising from the peripheral presentation of the study item. The results revealed that the magnitude of the IOR effect was reliably greater following F than R instructions, indicating that attention was more readily withdrawn from the representation of TBF items relative to TBR items.

Fawcett and Taylor (2008, 2010) similarly showed that participants were slower to detect centrally presented visual targets following F relative to R instructions within the study phase. Importantly, slower response times within their secondary response task were predictive of successful intentional forgetting (but not intentional remembering). Taylor (2005; see also Taylor & Fawcett, 2011) and Fawcett and Taylor (2008, 2010) concluded that following an F instruction, an active mechanism was enacted withdrawing processing resources from the representation of the study item in working memory, including its spatial representation (see Hourihan, Goldberg, & Taylor, 2007). They also predicted that participants may bias attention away from the source of the irrelevant information (potentially including its spatial, physical, or semantic representation) in the period immediately following the memory instruction (Taylor & Fawcett, 2011). Unlike Zacks et al. (1996), they believed this effect to be short-lived and made no predictions as to the accessibility of the study items at test.

In the present study, we provide further evidence for the suppression of TBF items at encoding and examine the nature of this suppression. We addressed this question by presenting colored probe items requiring a speeded color-naming response following each memory instruction within the study phase of an item-method task. Half of the probe items were words and the remaining items were meaningless symbols. Whereas the word trials were of experimental interest, the symbol trials served as a baseline against which to evaluate interference during the word trials. Our study was based on the assumption that (a) the content of the probe item would interfere with the color-naming portion of our task and (b) the magnitude of this interference could be quantified by subtracting the mean response time to name the color of a symbol from the mean response time required to name the color of a word. In past research, researchers have found that the meaningfulness of a colored word is directly related to the speed with which participants can name the color of that word (e.g., Klein, 1964; Monsell, Taylor, & Murphy, 2001). As such, changes in color-naming interference (word trial reaction times–symbol reaction times) may be used to gauge the degree to which the representation of the probe item gains access to working memory—with greater interference implying relatively greater allocation of processing resources to the probe item as opposed to the color-naming task itself (although see Burt, 2002).

Due to our interest in determining the fate of the TBR or TBF study items presented within each trial, we manipulated the content of the colored probe item for word trials such that it was either (a) a novel word unrelated to the preceding study word or (b) a repetition of the study word. We argue that color-naming interference would be reduced if the study item were suppressed (e.g., Zacks et al., 1996) or otherwise denied access to limited capacity working memory resources (e.g., Fawcett & Taylor, 2008, 2010; Taylor & Fawcett, 2011). As noted above, color-naming interference was calculated by subtracting color-naming reaction times

(RTs) for the symbol trials from that of the repeated or novel word trials. Insofar as TBF items were less likely than TBR items to be allocated further processing resources, the degree to which a TBF item interfered with the color-naming task should be relatively reduced for repeated versus novel items, and this effect should be item specific. Therefore, in addition to predicting a directed forgetting effect as measured by the mean proportion of the study items recalled at test, within the study-phase probe task, we predicted an interaction between instruction (R, F) and repetition (novel, repeated). Specifically, we expected equivalent color-naming interference for novel items regardless of the preceding memory instruction, but we expected relatively diminished color-naming interference for repeated probe items presented following F instructions compared with R instructions. Importantly, an explanation based purely on selective rehearsal would not predict the reduction of the color-naming interference for TBF items.

Experiment 1

In Experiment 1, we used a typical item-method-directed forgetting paradigm in which a sequence of words was presented individually, each followed by an R or F instruction. Immediately after that instruction, the participants were asked to name, as quickly and as accurately as possible, the color of a visual probe item. Each probe item was either a meaningless symbol, a novel word unrelated to the study item, or a repetition of the study word. If TBF items were less likely to be allocated processing resources than TBR items, then the interference effect observed for repeated TBF items should be smaller than for repeated TBR items.

Method

Participants. The participants were 40 university students enrolled in an introductory psychology course; they participated voluntarily to fulfill part of their course requirements. Participants had not participated in any of our other experiments. All the participants in this study were native Mandarin Chinese speakers.

Design. The study phase of this experiment was conceptualized as a 2 × 2 within-subjects design. The independent variables for this task were the memory instruction (R vs. F) that followed each study item and whether the probe item was a repetition of the study item (repeated vs. novel). Trials containing a symbol were used to calculate a baseline RT that could be subtracted from the word-trial RTs to produce a measurement of color-naming interference. The test phase of this experiment was conceptualized as a 2 × 3 within-subjects design. The independent variables for this task were the memory instruction (R vs. F) that followed each study item and the nature of the probe item on that trial (symbol vs. repeated vs. novel).

Materials. A set of 120 two-character medium and high-frequency Chinese words (materials used in all experiments are provided in the Appendices) was selected from 10 taxonomic categories (based on Jeng, Lai, & Liu, 1973), with 12 words in each category. Two words from each of the 10 categories were selected to form a total of six sets of 20 words each that were balanced across each factor of interest. For the purpose of presentation, each set contained 10 colored words and 10 colored nonsense symbols. The "ox ox" symbol was used to mimic the physical structure of a two-character Chinese word. To counterbalance memory instruction (R vs. F), repetition condition (repeated vs. novel), and probe type (word vs. symbol), eight versions of the task were created differing only in the specific assignment of the lists detailed above.

The studied words were always printed in black. The probes were presented in one of five colors (red, green, blue, brown, and purple). Each probe item was assigned a color at random, and the same random assignment was applied to all participants. The character size was 4 cm × 3.5 cm. The memory instruction was read by a male voice for a duration of 1,000 ms. A built-in computerized "beep" lasting 500 ms was used in both the study and practice phases to alert participants of the upcoming target stimulus. All the items were presented on a 17-in. PC computer screen running E-Prime. The viewing distance was approximately 60 cm. Responses and their latencies were recording within E-Prime (Schneider, Eschman, & Zuccolotto, 2002) using a standard computer microphone.

Procedure. Participants were tested individually. Each experimental session consisted of a practice phase, a study phase, and a test phase.

Practice phase. During the practice phase, the participants were first required to name the colors of five color patches. The purpose of this initial task was to screen participants for color blindness and to otherwise ensure that they could name each color correctly. A 4 cm × 8 cm color patch appeared on the screen following a 500-ms beep; the participants had to name the color of the square aloud as quickly and as accurately as possible. In the second practice task, the procedure was the same, except that the colored patch was replaced by a two-character Chinese word, which occupied an area similar to that of the color patches. Ten practice trials were performed using 10 different Chinese words. These words were not used in the following study phase. The purpose of the second practice task was to familiarize the participants with color-naming itself. The third practice task, consisting of five trials, used a procedure that was identical to the subsequent study phase (see below), except that different words were used and that participants were only asked to recall the TBR words at the end of the practice trials.

Study phase. During the study phase, the participants studied 80 words (four sets of 20 words) that were presented sequentially in an order randomized on a subject-by-subject basis. All independent variables were equally distributed throughout this phase. As depicted in Figure 1, each trial sequence consisted of the presentation of (a) a fixation cross ("+") for 500 ms, (b) a blank computer screen for 300 ms, (c) the study item for 2,000 ms, (d) the memory instruction ("remember" or "forget," read by a male voice) for 1,000 ms, (e) another blank screen for 1,500 ms, (f) a beep for 500 ms, and (g) the colored probe (either a symbol, a repetition of the study word, or a novel word), which remained on-screen until a response was made. Participants were instructed to silently attend to each study item in anticipation of the memory instruction that was to follow. They were instructed that TBR but not TBF items would be subject to a subsequent memory test. Participants were also told that, in addition to this primary task, each memory instruction would be followed by the appearance of a colored probe item. The onset of each probe item would be preceded by a warning beep. Participants were to name the color of that probe item as quickly and as accurately as possible. Par-

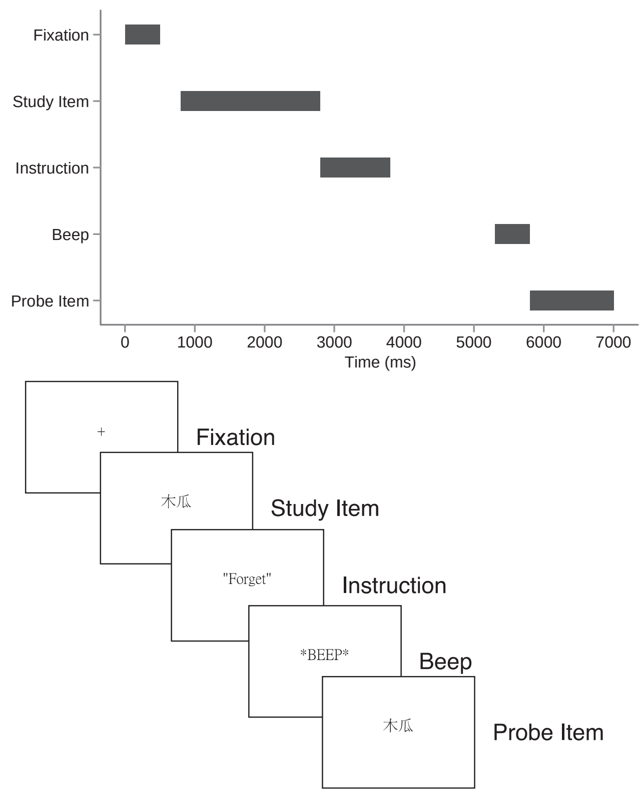

Figure 1. A schematic representation of the study-phase trial events and their respective timings for the repeated condition within Experiments 1 and 2. Experiments 3 and 4 used the same timings and basic procedure with slight changes to the nature of the probe item. In all experiments, the probe item required a speeded color-naming response and was presented until such a response was recorded.

ticipants were notified that sometimes the study item and the probe item would be the same, that sometimes they would be different, and that sometimes the probe would be composed of symbols as opposed to a word.

Test phase. Following the presentation of all study items, participants completed a 30-s backward counting task before beginning the test phase to minimize any recency effects; counting was completed aloud to ensure compliance. To minimize the possibility of a floor effect, a cued as opposed to a free-recall task was used. During this task, 10 category names were presented sequentially in the center of the screen to serve as retrieval cues. The presentation of these cues was randomized, and after the onset of a given cue, participants had to recall as many of the TBR and TBF study items pertaining to that cue as they could. The cue stayed on the computer screen for a minimum of 1 min. Once they could not recall any further study items, participants pressed the space bar for the next cue. Upon completion, participants were instructed not to discuss the experiment with any other potential participants and were permitted to leave.

Results

Table 1 provides the color-naming interference (RT for colored words – RT for colored symbols) calculated following a log-transformation to correct for nonnormality; Table 2 and Figure 2 provide the same data back-transformed into milliseconds. Table 3 contains the mean proportion of study items recalled as a function of memory instruction and probe type.

Naming latency. Prior to performing any analyses, we conducted a log-transformation on color-naming RTs to correct for nonnormality; any values greater or less than three standard deviations from each condition mean were then rejected as outliers. The primary intent of the following analysis was to evaluate whether an F instruction reduced the degree of color-naming interference caused by repeated probe items. We calculated interference by subtracting the mean color-naming RTs for meaningless symbols from the color-naming RTs for repeated or novel words for both TBR and TBF trials. We then analyzed this difference score using a 2 (memory instruction: R vs. F) × 2 (repetition condition: repeated vs. novel) repeated measures analysis of variance (ANOVA). Both the main effect of memory instruction, $F(1, 39) = 12.72$, $MSE = 0.010$, $p < .001$, $\eta_g^2 = .071$, and the main effect of repetition condition, $F(1, 39) = 5.42$, $MSE = 0.007$, $p =$

Table 1
Log-Transformed Mean Latencies for Color Naming Presented as a Function of Memory Instruction (Remember, Forget) and Probe Type (Repeated, Novel, Symbol) Within Experiments 1–4

	Remember			Forget		
Experiment	Repeated	Novel	Symbols	Repeated	Novel	Symbols
Experiment 1						
Raw scores	6.67 (0.02)	6.65 (0.03)	6.50 (0.02)	6.57 (0.03)	6.65 (0.03)	6.51 (0.02)
Interference	0.17 (0.01)	0.15 (0.01)		0.06 (0.01)	0.14 (0.02)	
Experiment 2						
Raw scores	6.66 (0.02)	6.68 (0.02)	6.52 (0.02)	6.62 (0.02)	6.67 (0.02)	6.51 (0.02)
Interference	0.14 (0.01)	0.16 (0.01)		0.11 (0.01)	0.16 (0.01)	
Experiment 3						
Raw scores	6.74 (0.02)	6.68 (0.02)	6.48 (0.02)	6.69 (0.03)	6.65 (0.02)	6.48 (0.02)
Interference	0.26 (0.01)	0.20 (0.02)		0.21 (0.01)	0.17 (0.01)	
Experiment 4						
Raw scores	6.63 (0.04)	6.60 (0.03)	6.47 (0.03)	6.56 (0.03)	6.59 (0.03)	6.46 (0.03)
Interference	0.16 (0.02)	0.13 (0.02)		0.10 (0.02)	0.13 (0.01)	

Note. Interference = naming latencies for colored words − naming latencies for colored symbols. Standard errors appear in parentheses.

Table 2
Back-Transformed Mean Latencies (in Milliseconds) for Color Naming Presented as a Function of Memory Instruction (Remember, Forget) and Probe Type (Repeated, Novel, Symbol) Within Experiments 1–4

	Remember			Forget		
Variable	Repeated	Novel	Symbols	Repeated	Novel	Symbols
Experiment 1	789	773	665	714	774	672
Experiment 2	777	794	679	749	787	672
Experiment 3	846	795	652	806	773	652
Experiment 4	756	732	645	708	731	639

.025, $\eta_g^2 = .021$, were significant. These effects were qualified by a significant Memory Instruction × Repetition Condition interaction, $F(1, 39) = 21.22$, $MSE = 0.005$, $p < .001$, $\eta_g^2 = .058$. Within the repeated condition, the interference caused by the probe item was significantly smaller following F instructions ($M = 0.06$, $SE = 0.01$) than following R instructions ($M = 0.17$, $SE = 0.01$), $F(1, 39) = 50.38$, $MSE = 0.004$, $p < .001$, $\eta_g^2 = .266$. No such difference was found for the novel condition, $F(1, 39) = 0.06$, $MSE = 0.010$, $p = .803$, $\eta_g^2 < .001$. Furthermore, the interference generated by the probe item was reduced for repeated ($M = 0.06$, $SE = 0.01$) relative to novel ($M = 0.14$, $SE = 0.02$) items following F instructions, $F(1, 39) = 16.99$, $MSE = 0.008$, $p <$ .001, $\eta_g^2 = .111$, whereas no difference was observed between these conditions following R instructions, $F(1, 39) = 2.21$, $MSE =$ 0.004, $p = .144$, $\eta_g^2 = .013$.

Cued recall. We analyzed recall accuracy using a 2 (memory instruction: R vs. F) × 2 (probe type: repeated vs. novel vs. symbols) repeated measures ANOVA. The main effect of the memory instruction was significant, $F(1, 39) = 117.31$, $MSE =$ 0.026, $p < .001$, $\eta_g^2 = .370$. Participants recalled more TBR items ($M = 0.37$, $SE = 0.02$) than TBF items ($M = 0.14$, $SE = 0.02$). None of the other effects or interactions was significant (all Fs < 1). Overall, recall performance is lower than observed in past item-method experiments: For example, Basden and Basden (1998) found that participants recalled .72 of the TBR items and .46 of the TBF items in their study (see, e.g., Lee et al., 2007). It is probable that performance is lower in the present investigation relative to past investigations due to the relatively large number of study-phase trials in the present experiment (80 trials) as compared with past experiments (e.g., 24 trials; Basden & Basden, 1998). It

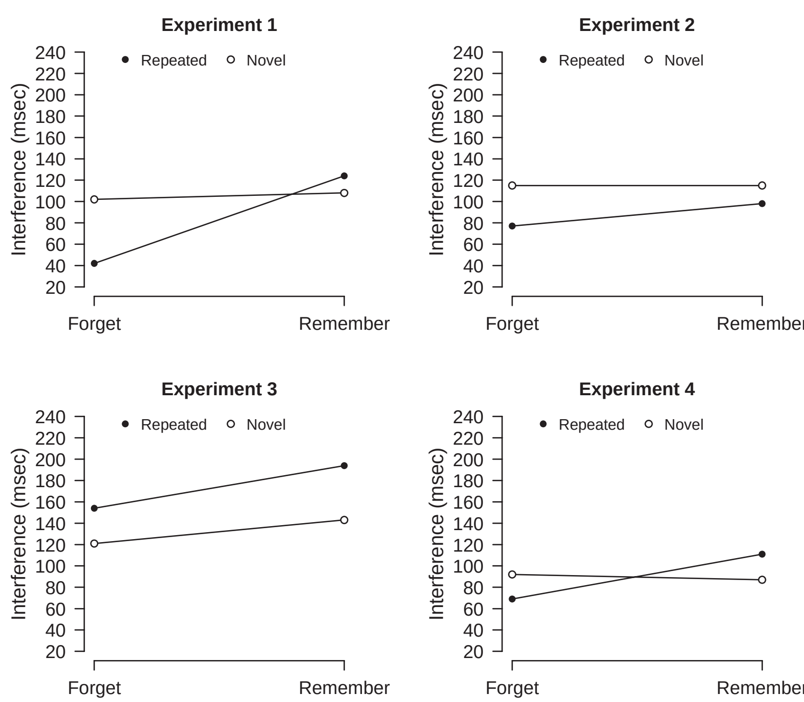

Figure 2. Back-transformed mean interference (in milliseconds) for color naming presented as a function of memory instruction (Remember, Forget) and repetition (Repeated, Novel); interference was calculated as the back-transformed-naming latencies for colored words minus the back-transformed-naming latencies for colored symbols.

Table 3
Mean Proportion of Study Items Recalled Presented as a Function of Memory Instruction (Remember, Forget) and Probe Type (Repeated, Novel, Symbol) Within Experiments 1–4

	Remember			Forget		
Variable	Repeated	Novel	Symbol	Repeated	Novel	Symbol
Experiment 1	.37 (.03)	.38 (.03)	.36 (.02)	.14 (.02)	.14 (.02)	.14 (.02)
Experiment 2	.37 (.02)	.36 (.02)	.36 (.01)	.17 (.01)	.15 (.01)	.18 (.01)
Experiment 3	.48 (.03)	.37 (.04)	.39 (.03)	.23 (.03)	.17 (.03)	.19 (.02)
Experiment 4	.39 (.03)	.41 (.04)	.44 (.04)	.16 (.03)	.10 (.02)	.13 (.02)

Note. Standard errors appear in parentheses.

is further possible that the inclusion of a secondary color-naming task reduced overall performance by burdening participants during the postcue period. Nevertheless, the present directed forgetting effect ($M = 0.23$) is similar in magnitude to past research ($M = 0.26$; Basden & Basden, 1998) and is consistent across probe type.

Discussion

The purpose of the present experiment was to evaluate whether an instruction to intentionally forget a study item would impact the subsequent allocation of processing resources to that item in the context of a secondary color-naming task. Recall performance indicated a directed forgetting effect, suggesting that the participants followed the instructions to remember or forget the study items. Importantly, repeated TBF items were found to produce less interference on the secondary color-naming task than either repeated TBR items or novel items presented following an F instruction. Repeated TBR items produced the same amount of interference as novel items. In the present task, the interference value we calculated was believed to reflect the automatic activation of the probe item. Such activation would draw on limited capacity-processing resources and slow the color-naming response. The present experiment demonstrated that, following the receipt of an F instruction, the study item was less likely to be reactivated in this manner, reducing the degree to which the probe item interfered with the color-naming task.[1]

We believe our findings to suggest a mechanism not presently accounted for in a traditional selective rehearsal interpretation of item-method-directed forgetting. According to this view, following an R instruction participants rehearse the study item, whereas following an F instruction they allow the study item to decay passively while potentially rehearsing preceding TBR items. A proponent of this account may interpret the present findings as a reduction in interference for repeated compared with novel words due to repetition priming following F instructions and an increase in interference due to rehearsal processes or additional attention to repeated probes following R instructions. It is true that repetition priming has been found to reduce interference for repeated compared with novel words in certain color-naming tasks (e.g., Burt, 1994), although this reduction is relatively small (except for low-frequency words; see Burt, 1994, 2002) and not always present (see Chao, 2011, Experiment 2). More importantly the magnitude of color-naming interference observed in a repetition priming task has been found to be unaffected by a level of processing manipulation even in the face of a concurrent memory task (Burt, 2002).

According to the post hoc interpretation that participants are affording greater processing resources to the TBR items resulting in greater interference, it would be expected that a similar pattern would emerge in comparisons of deep and shallow encoding (e.g., Burt, 2002) or recall-present and recall-absent tasks (cf. Burt, 1994, 2002). This does not appear to be the case insofar as the present literature is concerned. Even so, it is curious that the present findings reveal no repeated-novel reduction in interference following R instructions, but rather a slight tendency toward greater interference. We do not view this as particularly problematic given the description provided above. The important point is that there is significantly less interference for repeated TBF words compared with repeated TBR words. Nonetheless, we recognize that the present data are unable to rule out the possibility that processes occurring during TBR trials are unexpectedly increasing interference and are therefore partly or wholly responsible for the observed differences.

However, the data were predicted by an active account of item-method-directed forgetting. Assuming participants were biased against the reallocation of processing resources to words they had been instructed to intentionally forget (e.g., Fawcett & Taylor, 2010; Taylor & Fawcett, 2011), relatively less interference would be expected for repeated TBF words compared with repeated TBR words. This prediction was supported albeit with the caveat that alternate post hoc interpretations are conceivable. The effect of repetition on the interference measure was specific to items the participant intended to forget and was specific to the study item—it did not produce a more general reduction in interference overall.

Given the importance of our findings to understanding the mechanisms believed to occur following an item-method F instruction, we next replicate this effect using stimuli even more likely to

[1] An astute reader will recognize that repeated TBF items still produce some degree of interference in relation to the control condition, suggesting that they are not completely inaccessible. We are not arguing that participants are incapable of reactivating repeated TBF items but rather that they are relatively biased against this reactivation. As described earlier, color-naming interference is thought to arise from the automatic activation of the probe item. Therefore, we interpret the $R_{Repeated} > F_{Repeated}$ pattern as demonstrating relatively greater activation for or a relatively greater propensity toward activating the repeated TBR item compared with the repeated TBF item.

interfere with the secondary color-naming task. We further increase our sample size to get a more precise estimate of our effects.

Experiment 2

In Experiment 2, we aimed to replicate the results of Experiment 1 in a task closer to a standard Stroop color-naming task (Stroop, 1935). A new list of words was used in this task, with strongly associated colors likely to interfere with the production of the appropriate color-naming response within the study phase.

Method

Participants. The participants were 96 university students enrolled in an introductory psychology course; they participated in partial fulfillment of their course requirements. Participants had not participated in any of our other experiments.

Design. The design was the same as Experiment 1.

Materials. A new list of two-character Chinese words was generated such that each was strongly associated with a specific color. Words were selected from 10 taxonomic categories and associated with colors in one of two ways. First, some words were strongly associated with specific colors without the need for any explicit modifier, such as apple or blood. Second, other words contained a character that indicated color, such as *red* bean or *green* tea. Incongruent colors (e.g., "blood" printed in blue ink or "green tea" printed in red ink) were assigned to each of the probe words to maximize the interference observed within the color-naming task. As in Experiment 1, each list was counterbalanced across each condition.

Procedure. The procedure was identical to Experiment 1.

Results

Table 1 provides the color-naming interference (RT for colored words – RT for colored symbols) calculated following a log-transformation to correct for nonnormality; Table 2 and Figure 2 provide the same data back-transformed into milliseconds. Table 3 contains the mean proportion of study items recalled as a function of memory instruction and probe type.

Naming latency. Prior to performing any analyses, we conducted a log-transformation on color-naming RTs to correct for nonnormality; any values greater or less than three standard deviations from the mean were then rejected as outliers. Interference generated by the probe item was once again analyzed as a function of memory instruction (R, F) and repetition condition (repeated, novel). The main effect of both memory instruction, $F(1, 95) = 4.13$, $MSE = 0.009$, $p = .045$, $\eta_g^2 = .011$, and repetition, $F(1, 95) = 18.94$, $MSE = 0.007$, $p < .001$, $\eta_g^2 = .035$, were significant. However, these effects were also qualified by a significant Memory Instruction × Repetition interaction, $F(1, 95) = 5.02$, $MSE = 0.004$, $p = .027$, $\eta_g^2 = .004$. Planned contrasts revealed reduced interference within the repeated condition following F instructions ($M = 0.11$, $SE = 0.01$) relative to R instructions ($M = 0.14$, $SE = 0.01$), $F(1, 95) = 8.62$, $MSE = 0.006$, $p = .004$, $\eta_g^2 = .031$, whereas no difference was found for the novel condition, $F(1, 95) < 1$. In addition, the amount of interference was smaller for TBF trials in which the study word was repeated ($M = 0.11$, $SE = 0.01$) relative to when a novel word was presented ($M = 0.16$, $SE = 0.01$), $F(1, 95) = 20.79$, $MSE = 0.006$, $p < .001$, $\eta_g^2 = .067$. Whereas less interference was also observed for repeated ($M = 0.14$, $SE = 0.01$) as compared with novel ($M = 0.16$, $SE = 0.01$) TBR words, $F(1, 95) = 5.40$, $MSE = 0.004$, $p = .022$, $\eta_g^2 = .014$, the magnitude of this effect was much larger for TBF trials compared with TBR trials ($\eta_{gForget}^2 = .067 > \eta_{gRemember}^2 = .014$).

Cued recall. We performed a 2 (memory instruction: R vs. F) × 2 (probe condition: symbol vs. repeated vs. novel) ANOVA on proportion of correctly recalled words. The main effect of the memory instruction was significant, $F(1, 95) = 239.25$, $MSE = 0.025$, $p < .001$, $\eta_g^2 = .322$. Participants recalled more TBR words ($M = 0.37$, $SE = 0.01$) than TBF words ($M = 0.17$, $SE = 0.01$). No other effects or interactions were significant (both Fs < 1).

Discussion

Experiment 2 replicated the methods of Experiment 1 using words with strongly associated colors. This change was intended to maximize the interference elicited by the probe words during the study-phase color-naming task and therefore mirrors a standard Stroop paradigm more closely. Unlike in Experiment 1, repetition resulted in a relatively small but significant repeated novel reduction in color-naming interference, as has been observed in some past studies (e.g., Burt, 2002). However, this did not change the basic findings: Experiment 2 demonstrated not only a directed forgetting effect in cued recall but also a relative reduction in the interference caused by repeated TBR and TBF probe words. This outcome is consistent with the hypothesis that participants are biased against the reallocation of processing resources to repeated F instructed words (e.g., Taylor & Fawcett, 2011).

Because the probe items within the repeated condition were identical to the study items within those trials, the reduction observed regarding color-naming interference is equally attributable to the semantic or perceptual properties of those words. We addressed this distinction in the remaining studies by manipulating both the perceptual and semantic relatedness of the probe item relative to the study item. There are three possible outcomes: First, if the reduction in color-naming interference were observed for perceptually distinct but semantically related probe items (Experiment 3), we would conclude that it was the semantic representation of the study item that was affected. If, instead, the reduction in color-naming interference were observed for semantically distinct but perceptually identical probe items (Experiment 4), we would conclude that it was the perceptual representation of the study item that was affected. Finally, if the reduction in color-naming interference were observed in both of the preceding cases, we would conclude that both the semantic and the perceptual representation of the study item were affected by our manipulation.

Experiment 3

Experiment 3 was designed to further examine the nature of the effects observed in Experiments 1 and 2. Across both of those experiments, the study item and the probe item were identical in the repeated condition. Therefore, these items overlapped not only in meaning but also in their perceptual qualities. As a result, any processes acting upon the study item following the memory instruction may have occurred at either the perceptual or the semantic level. To address this possibility, Experiment 3 presented the study item in the format of *zhuyin*, a phonetic system for transcribing Mandarin Chinese. This ensured that whereas repeated probe items were *semantically* identical to the preceding study item, they were *perceptually* distinct. Therefore, if the TBR-TBF differences in color-naming interference identified in Experiments 1 and 2 were dependent on the semantic (as opposed to the perceptual) representation of the study item, we should observe a pattern of color-naming interference similar to the preceding experiments.

Method

Participants. The participants were 24 university students enrolled in an introductory psychology course; they participated in partial fulfillment of their course requirements. Participants had not participated in any of our other experiments.

Design. The design was the same as in Experiments 1 and 2.

Materials. The materials were identical to those used in Experiment 2, except that all study items were presented in *zhuyin*, instead of Chinese characters. For example, "木瓜" (papaya) was presented as "ㄇㄨˋ ㄍㄨㄚ". Probe items in *zhuyin* were not presented because the concern was that reading *zhuyin* would be more effortful (i.e., less automatic) than conventional Chinese characters. Although participants would be motivated to read the study items, the concern was that they might instead more readily ignore a probe item presented in *zhuyin*, potentially reducing any color-naming interference.

Procedure. The procedure was identical to Experiment 2.

Results

Table 1 provides the color-naming interference (RT for colored words – RT for colored symbols) calculated following a log-transformation to correct for nonnormality; Table 2 and Figure 2 provide the same data back-transformed into milliseconds. Table 3 contains the mean proportion of study items recalled as a function of memory instruction and probe type.

Naming latency. Prior to performing any analyses, we conducted a log-transformation on color-naming RTs to correct for nonnormality; any values greater or less than three standard deviations from the mean were then rejected as outliers. The color-naming interference generated by the probe item was once again analyzed as a function of memory instruction (R, F) and repetition condition (repeated, novel). This time, only the main effect of repetition condition was significant, $F(1, 23) = 10.18$, $MSE = 0.006$, $p = .004$, $\eta_g^2 = .089$. The color-naming interference generated in the repeated condition ($M = 0.24$, $SE = 0.01$) was larger than that in the novel condition ($M = 0.18$, $SE = 0.01$). There was a marginal effect of instruction, $F(1, 23) = 3.86$, $MSE = 0.007$, $p = .062$, $\eta_g^2 = .089$, such that greater interference was observed during TBR trials ($M = 0.23$, $SE = 0.01$) than TBF trials ($M = 0.19$, $SE = 0.01$). However, the interaction was not significant, $F(1, 23) = 0.56$, $MSE = 0.005$, $p = .462$, $\eta_g^2 = .004$, indicating that this pattern did not differ according to repetition condition.

Cued recall. We performed a 2 (memory instruction: R vs. F) × 2 (probe condition: symbol vs. repeated vs. novel) ANOVA on the proportion of correctly recalled words. The main effect of memory instruction was significant, $F(1, 23) = 219.90$, $MSE = 0.008$, $p < .001$, $\eta_g^2 = .389$. Participants recalled more TBR items ($M = 0.41$, $SE = 0.02$) than TBF items ($M = 0.19$, $SE = 0.02$). The main effect of repetition was also significant, $F(1, 23) = 7.01$, $MSE = 0.013$, $p = .002$, $\eta_g^2 = .066$. Participants recalled more study items from the repeated ($M = 0.35$, $SE = 0.03$) trials than either the novel ($M = 0.27$, $SE = 0.02$) or the symbol ($M = 0.29$, $SE = 0.02$) trials. The interaction was not significant, $F(1, 23) = 0.51$, $MSE = 0.010$, $p = .605$, $\eta_g^2 = .004$.

Discussion

Experiment 3 replicated the methods of Experiments 1 and 2 with the exception that the study items were presented in *zhuyin*, a phonetic system for transcribing Mandarin Chinese, instead of Chinese characters. A directed forgetting effect was again found in cued recall. The color-naming interference generated by the probe items in the repeated condition was larger overall than that in the novel condition, with a marginal tendency toward greater interference following R instructions compared with F instructions. Repeated study items were also remembered better than study items followed by novel probe items. For a regular reader of the Chinese language, recognizing the phonetic symbols was more effortful than recognizing a conventional word. Participants would need to covertly pronounce the phonetic symbols in order to recognize the character. In contrast, semantic information for the characters used as study items in the preceding experiments could be activated without activating phonological information (e.g., Zhou & Marslen-Wilson, 2000). The effort required to process the phonetic symbols could account for the relative increase in color-naming interference observed in Experiment 3 compared with the preceding experiments. By allocating additional processing resources to the study item, the representation of that item would ultimately become more active in working memory—making it more accessible (and therefore readily reactivated) when it was repeated as a probe item (see Burt, 2002). Furthermore, by presenting the same word in multiple forms, the overall representation of that item would be strengthened resulting in a general improvement in memory performance. This effect failed to interact with memory instruction, suggesting that it was unrelated to the mechanisms acting upon the study item.

For our present purpose, the most important finding was that the interaction between repetition and memory instruction on color-naming interference observed in Experiments 1 and 2 disappeared when the study items and probe items had a different visual form. As noted above, there was a tendency for greater interference to occur following R instructions, but this effect failed to reach significance and did not discriminate between novel and repeated words. Overall, this result suggests that it is not the semantic but rather the perceptual properties of the study item that had driven the Repetition × Memory Instruction interaction in the preceding experiments. Experiment 4 was designed as a direct test of this possibility.

Experiment 4

Experiment 3 failed to replicate the color-naming interference effects observed in Experiments 1 and 2. The only difference between Experiments 2 and 3 was that repeated probe items were identical to the preceding study items in Experiment 2, but they were presented in a different visual form in Experiment 3. Thus, it seems reasonable that the effects observed in Experiments 1 and 2 resulted from a process working on the visuoperceptual representation of the study item. To test this possibility, we used in Experiment 4 probe items that were visually similar to the study items in the repeated condition, instead of identical words as those used in Experiment 2. If the effects observed in our initial experiments were specific to the perceptual features of the study item, then we should once again observe reduced color-naming interference following F (relative to R) instructions in the repeated condition.

Method

Participants. The participants were 24 university students enrolled in an introductory psychology course; they participated in partial fulfillment of their course requirements. Participants had not participated in any of our other experiments.

Design. The design was the same as the preceding experiments.

Materials. The materials were identical to those used in Experiment 2, except that probe items within the repeated condition were visually similar (as opposed to identical) to the associated study item. The visually similar characters had the same character structure and shared at least half of the radicals. For example, for the study item "木瓜" (papaya), the corresponding probe item was "未 (yet) 爪 (claw)". Therefore, each probe item contained two characters, each corresponding to the characters used in the associated study item. These characters were meaningful individually but were meaningless pseudowords when combined.

Procedure. The procedure was identical to Experiment 2.

Results

Table 1 provides the color-naming interference (RT for colored words – RT for colored symbols) calculated following a log-transformation to correct for nonnormality; Table 2 and Figure 2 provide the same data back-transformed into milliseconds. Table 3 contains the mean proportion of study items recalled as a function of memory instruction and probe type.

Naming latency. Prior to performing any analyses, we conducted a log-transformation on color-naming RTs to correct for nonnormality; any values greater or less than three standard deviations from the mean were then rejected as outliers. The color-naming interference generated by the probe item was once again analyzed as a function of memory instruction (R, F) and repetition condition (repeated, novel). Only the interaction between memory instruction and repetition condition was significant, $F(1, 23) = 5.01$, $MSE = 0.005$, $p = .035$, $\eta_g^2 = .032$. Planned contrasts revealed marginally less color-naming interference for TBF trials ($M = 0.10$, $SE = 0.02$) than TBR trials ($M = 0.16$, $SE = 0.01$) within the repeated condition, $F(1, 23) = 4.00$, $MSE = 0.012$, $p = .0573$, $\eta_g^2 = .096$, but no difference was found for the novel condition, $F(1, 23) < 0.01$, $MSE = 0.006$, $p = .926$, $\eta_g^2 < .001$. The difference between repeated and novel conditions failed to reach significance for either TBF trials, $F(1, 23) = 2.11$, $MSE = 0.006$, $p = .159$, $\eta_g^2 = .034$, or TBR trials, $F(1, 23) = 1.74$, $MSE = 0.007$, $p = .201$, $\eta_g^2 = .031$, although as depicted in Figure 2, repetition tended to decrease interference for TBF trials and increase interference for TBR trials. Neither the main effect of instruction, $F(1, 23) = 1.78$, $MSE = 0.012$, $p = .195$, $\eta_g^2 = .028$, nor the main effect of repetition was significant, $F(1, 23) < 1$, $MSE = 0.008$, $p = .999$, $\eta_g^2 < .001$.

Cued recall. We performed a 2 (memory instruction: R vs. F) × 2 (probe condition: symbol vs. repeated vs. novel) ANOVA on the proportion of correctly recalled study items. Only the main effect of memory instruction was significant, $F(1, 23) = 166.65$, $MSE = 0.017$, $p < .001$, $\eta_g^2 = .479$. Participants recalled more TBR items ($M = 0.41$, $SE = 0.03$) than TBF items ($M = 0.13$, $SE = 0.01$). No other effects or interactions reached significance (both ps $> .28$).

Discussion

Experiment 4 replicated the methods of our preceding studies with the exception that the repeated probe items were visually similar (as opposed to identical) to the study items. The purpose of this experiment was to determine whether the influence of memory instruction on color-naming interference observed in Experiments 1 and 2 operated at the level of the perceptual representation of the study item. If so, probe items with similar perceptual properties to the preceding study item should be less likely to draw on subsequent processing resources and should therefore produce less color-naming interference. This prediction was supported by the present results: In addition to the directed forgetting effect observed for cued recall, the present experiment demonstrated less color-naming interference for repeated TBF words compared with repeated TBR words.

General Discussion

The present study combined an item-method-directed forgetting task with a secondary color-naming task to examine the fate of study items that participants had been instructed to intentionally forget. Past research has argued that the representation of a colored word can become active even when tasked with naming the ink color of that word (as opposed to reading it). This representation then competes for limited capacity-processing resources, slowing the color-naming response (e.g., Klein 1964; Monsell et al., 2001). In the context of the present experiments, the degree of color-naming interference resulting from a given word was calculated as the difference between the time required to name the color of that word and the time required to name the color of a meaningless symbol. By comparing the color-naming interference elicited by repeated and novel probe items, we investigated how readily processing resources would be reallocated to the study item—or items sharing semantic or perceptual properties—if that word were presented as a probe immediately following R and F instructions. In Experiments 1 and 2, we found less color-naming interference for repeated TBF words as compared with repeated TBR words as well as relatively diminished color-naming interference for repeated TBF words as compared with novel words. Experiments 3 and 4 further characterized the nature of this effect by demonstrating that the reduction in color-naming interference for TBF trials arose for probe items sharing perceptual but not necessarily semantic properties with the study items immediately preceding their presentation. Importantly, the relative reduction in color-naming interference observed during TBF trials was not of a general nature. If it were, then we would have observed reduced color-naming interference for both the repeated and novel conditions: This was not true in any of our experiments, although Experiment 3 demonstrated a tendency in this direction. The fact that this effect was evident only within the repeated condition suggests a mechanism specific to the study item in question.

To further examine whether there was a relationship between naming latencies and recall performance, we also calculated a regression analysis relating the magnitude of the interference elicited by repeated TBF items (independent variable) to the magnitude of the directed forgetting effect (dependent variable). For the purpose of this analysis, we collapsed the data from the experiments, demonstrating a relative reduction in color-naming interference for repeated TBF items compared with repeated TBR items (Experiments 1, 2, and 4). The calculation of the directed forgetting effect used the following formula: (number of TBR words recalled − number of TBF words recalled) / (number of TBR words recalled + number of TBF words recalled). Our model produced an intercept of 0.48 and a slope of −0.43, suggesting that as the magnitude of the interference for repeated TBF items increased, the magnitude of the directed forgetting effect decreased. This model just failed to reach significance, $F(1, 158) = 3.84$, $MSE = 0.008$, $p = .051$, $R^2 = .02$.

Recognizing that the directed forgetting effect emerges from the selective retention of TBR items but not TBF items, we next conducted similar analyses replacing the directed forgetting effect with the proportion of TBR or TBF items recalled as the dependent measure. Interference elicited by repeated TBF items significantly predicted the number of TBF items that were recalled, producing an intercept of 0.14 and a slope of 0.17, $F(1, 158) = 4.26$, $MSE = 0.009$, $p = .041$, $R^2 = .03$. Similar to the preceding analysis, lower interference scores were associated with the recall of fewer TBF items (resulting in a larger directed forgetting effect). Unsurprisingly, the interference elicited by repeated TBF items did not significantly predict recall of TBR items, $F(1, 158) = 1.48$, $MSE = 0.015$, $p = .226$, $R^2 < .01$, but neither did the interference elicited by repeated TBR items, $F(1, 158) = 0.18$, $R^2 < .01$.

Together, our analyses suggest a relation between the interference elicited by the repeated TBF items and the degree to which participants are capable of intentionally forgetting these items: Participants who experienced a great deal of interference when responding to repeated TBF items are likely to remember more of the TBF items resulting in a smaller directed forgetting effect compared with participants who experienced less interference. No such association was observed between TBR or TBF trial interference and the number of TBR items retrieved. This finding hints at the mechanisms at play in the present task. Certainly the association between color-naming interference and subsequent memory performance could be interpreted as suggesting an active mechanism that somehow discouraged further processing of the repeated TBF item. Such a mechanism has been theorized in recent studies and has been shown to be associated with the withdrawal of processing resources from the representation of the study item (e.g., Taylor & Fawcett, 2011). This theory has been supported by the observation of a larger inhibition of return effect following F than R instructions (see Fawcett & Taylor, 2010; Taylor, 2005; Taylor & Fawcett, 2011) as well as recent neuroimaging studies demonstrating the involvement of frontal brain regions (e.g., Nowicka et al., 2009; Paz-Caballero & Menor, 1999; Paz-Caballero et al., 2004; Van Hooff et al., 2009; Wylie et al., 2008) and the suppression of hippocampal activity (Ludowig et al., 2010). Fawcett and Taylor (2012) have argued that such an active mechanism could ensure that TBF study items did not receive any further incidental processing following the memory instruction as might occur if the item were dropped passively from the rehearsal set. This view argues that following the expulsion of the study item from working memory on TBF trials, participants often engage in the rehearsal of prior TBR study items (see Fawcett & Taylor, 2008; Golding, Roper, & Hauselt, 1996; Sahakyan & Foster, 2009). Therefore, it is not inconsistent with the view that selective rehearsal contributes to the directed forgetting effect—rather it is believed that the removal of the TBF study items from working memory maximizes the efficiency of such a rehearsal strategy.

It is worth revisiting the alternate interpretation discussed following Experiment 1 that instead of a reduction in color-naming interference for repeated TBF items we have observed an increase in color-naming interference for TBR items. To recount this view, it assumes that repetition priming decreases color-naming interference overall resulting in the pattern observed for repeated TBF items but that this reduction is masked for repeated TBR items because participants are using the repetition as an opportunity to further process the study item or its associates. As discussed earlier, this post hoc interpretation essentially claims inclusion of a memory task that drives participants to strategically incorporate the prime into their rehearsal strategy, slowing responses and masking the benefits of repetition. Past experiments have included a memory task and have not observed this issue—they instead observe a small (e.g., Burt, 2002) if inconsistent (see Chao, 2011) reduction in color-naming interference for repeated relative to novel items. Although it is curious that Experiments 1 and 4 fail to demonstrate this pattern, it is worth noting that past studies have not processed their data in the same manner we have (e.g., log-transformation, baseline-corrected using symbol trials, etc.).

Another prediction derived from the hypothesis that participants are attending the repeated TBR probe words is that as participants incorporate the probe into their rehearsal strategy, their recall performance for those items should increase commensurate with their interference performance. As demonstrated above, this is not the case—there is no association between the interference caused by the repeated TBR items and subsequent recall performance. The only association is between color-naming interference for repeated TBF items and subsequent recall performance such that better intentional forgetting is associated with lower color-naming interference. We urge caution when interpreting this finding. Although it is consistent with an active account of item-method-directed forgetting, it is correlational in nature and could also be explained more mundanely. For example, it is possible that those participants who are best at selectively rehearsing the TBR items are also somehow better at mitigating color-naming interference for repeated TBF items.[2] If so, the effects observed in Figure 2 may be a consequence of intentional forgetting as opposed to a cause (see also Taylor & Fawcett, 2011). Nonetheless, our regression analyses are inconsistent with the hypothesis that the present findings are due to additional processing of the repeated TBR items.

Yet, in favoring an active interpretation of intentional forgetting, we find ourselves at odds with work conducted by Marks and

[2] We thank an anonymous reviewer for proposing this possibility.

Dulaney (2001) in which they failed to observe an effect of memory instruction on the magnitude of perceptual or semantic priming elicited by the study item. Those researchers integrated a secondary lexical decision task into the study phase of an item-method-directed forgetting paradigm in a manner similar to the present methodology. Across three experiments, they varied the perceptual and semantic similarity of their study and probe items to evaluate whether memory instruction would influence the perceptual or semantic accessibility of the study item. Although performance in all three of their studies tended to toward greater priming following repeated TBR as compared with repeated TBF items (see Marks & Dulaney, 2001, Tables 2 and 4), these differences were very small (3 ms, 5 ms, and 4 ms) and did not reach significance. They concluded that TBR and TBF items were equally accessible and unimpeded by so-called inhibitory processes.

It remains unclear as to why the findings of Marks and Dulaney (2001) and the present study have come to such different conclusions regarding the fate of the TBR and TBF study items. One possibility would be the methodological differences between our paradigms. Marks and Dulaney (2001) required a lexical decision response to both the study and probe items, whereas our participants made no overt response to the study item and instead named the color of the probe item. It could be that by requiring a response to the study item, they encouraged participants to process the TBF items differently than in a task wherein participants were not required to make such a response—and that in doing so, priming was to some degree equalized between their TBR and TBF conditions. If participants applied additional processing to the TBF items preceding instruction onset, then we would expect a relatively small directed forgetting effect as a result of the equated processing. Their directed forgetting effect was smaller on average (the reported TBR-TBF differences were .22, .16, and .15) compared with the present study (we reported TBR-TBF differences of .23, .20, .22, and .28) or past research using recall (e.g., .26; Basden & Basden, 1998). Unfortunately, whether the study item task influenced memory performance is difficult to determine because performance in each of their TBF conditions was consistently at floor (mean TBF recall was .04 for each experiment).

Another manner in which the response task used by Marks and Dulaney (2001) proves problematic is that it conflates response preparation with probe condition. During their study-phase task, participants first received a study item that was either a word or a nonword requiring a lexical decision response. If the study item were a word, then it was followed by an R or F instruction (nonwords were followed by a neutral cue) and then a probe item that was either (a) the same word (Experiments 1 and 2) or a semantic associate (Experiment 3), (b) a novel word, or, (c) a nonword. Participants made a lexical decision to this item, which served as the critical measure. As a result, each probe word response was primed by the response made for the preceding study word (Schmidt, Haberkamp, & Schmidt, 2011). Assuming that participants responded relatively accurately to the study item, this means that repeated and novel trials were primed with the correct response, whereas nonword trials were primed with the incorrect response on the majority of trials. Although this does not necessarily negate the core findings of Marks and Delaney's study, it adds yet another layer of complexity to its interpretation. It could be that any differences between the TBR and TBF conditions were simply "washed out" by other factors involved in their design.

In concluding discussion of Marks and Dulaney (2001), it should be mentioned that although their work conflicts with the present study, there are many other studies that are also inconsistent with their general findings. For example, they observed slower lexical decision responses following R instructions compared with F instructions, whereas Fawcett and Taylor (2008) observed slower detection responses following F instructions compared with R instructions, and this has been replicated several times (e.g., Fawcett & Taylor, 2010; Hansen, 2011). Fawcett and Taylor (2012) observed that the time course of the TBF > TBR RT effect was delayed for a two-alternative forced-choice color discrimination response, and it is possible that something similar is happening in their study, although it remains surprising that the effect inverted: They observed a TBR > TBF RT effect as opposed to TBR = TBF as observed in the novel trials of the present study. Furthermore, there is the finding that enacting an F instruction increases the magnitude of inhibition of return instated by the study item as compared with enacting an R instruction or a baseline task (see Fawcett & Taylor, 2010; Taylor, 2005; Taylor & Fawcett, 2011). Preliminary evidence also suggests that enacting an F instruction impairs incidental memory formation for items presented at certain intervals following the memory instruction (Fawcett & Taylor, 2012). This is not to mention the growing body of neuroimaging literature implicating the involvement of frontal brain regions (e.g., Wylie et al., 2008), which have been interpreted as suppressing the reactivation of the physical trace associated with the study item (Paz-Caballero et al., 2004) or mediotemporal regions associated with encoding the study item (Ludowig et al., 2010). Together these findings and those of Marks and Dulaney (2001) raise serious questions regarding the precise nature of the mechanism(s) involved in intentional forgetting as well as the best manner in which to quantify them. Although these are certainly important questions, their resolution is likely beyond the scope of any single article.

In summary, we have demonstrated that being instructed to forget an item results in relatively less color-naming interference should that item be re-presented than had the item instead received an instruction to remember. This effect was found to be specific to the perceptual as opposed to semantic representation of the study item. The precise elements of the physical representation that are affected remain an open question. The present findings certainly indicate that reconstitution of the visual characteristics of the item is sufficient to reveal the effect; however, we cannot make any strong conclusions along any other dimension. For example, we do not know whether the phonological representation is likewise affected. One hint is that some theorists (e.g., Burt, 2002) have linked color-naming interference to activation of the phonological features of the probe word. If this were true, then the relative difference observed for TBF repeated and TBR repeated probes could to some degree represent the relative accessibility of the phonology associated with those respective words. However, this is purely speculative and a matter for future investigation. We would also like to temper our conclusions regarding the impact of intentional forgetting on the semantic representation of the study item. We failed to observe the critical interaction between instruction and repetition in Experiment 3 that we have thus far taken as evidence that participants are not biased against engaging with the semantic representation of the study word following an F instruction. Although we believe this to be a sound conclusion, we also recognize that in Experiment 3 but not Experiments 1, 2, and 4, participants demonstrated greater interference for repeated than novel words overall. It is possible that this feature of our data adulterated our desired effect. Even so, some theorists have specifically linked the instantiation of an F instruction to the suppression of the physical representation of the study item (Paz-Caballero et al., 2004). Therefore, our findings have at least some precedent and provide preliminary behavioral support for their claim.

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Appendix A

The 10 Categories of 120 Two-Character Chinese Words (and Their English Translation) Used in Experiment 1

飲料 Drink	天氣現象 Weather phenomenon	疾病 Disease	國家 Country	家俱 Furniture	鳥類 Bird	職業 Occupation	樂器 Musical instrument	交通工具 Vehicle	四腳動物 Four-footed animal
麥茶	乾旱	感冒	越南	鞋櫃	鸚鵡	醫生	豎琴	飛機	狐狸
barley drink	drought	flu	Vietnam	shoe cabinet	parrot	doctor	harp	airplane	fox
沙士	颱風	肝炎	蘇俄	椅子	鴿子	商人	長笛	汽車	斑馬
root beer	typhoon	hepatitis	Russia	chair	pigeon	businessman	flute	car	zebra
牛奶	下雪	中風	印度	窗簾	天鵝	農夫	銅管	帆船	熊貓
milk	snow	apoplexy	India	curtain	swan	farmer	brass	sailboat	panda
可樂	寒流	氣喘	瑞典	電視	孔雀	秘書	喇叭	轎子	老虎
coke	cold wave	asthma	Sweden	television	peacock	secretary	trumpet	palanquin	tiger
開水	起霧	瘧疾	緬甸	檯燈	兀鷹	律師	大鼓	遊艇	野狼
boiled water	fog	malaria	Burma	lamp	vulture	lawyer	big drum	yacht	wolf
咖啡	冰雹	潰瘍	挪威	書桌	烏鴉	司機	古箏	木筏	松鼠
coffee	hailstorm	ulceration	Norway	desk	crow	driver	zither	raft	squirrel
啤酒	多雲	霍亂	智利	衣櫥	斑鳩	經理	吉他	雪橇	駱駝
beer	overcast	cholera	Chile	wardrobe	turtledove	manager	guitar	sledge	camel
香檳	陣雨	頭痛	巴西	冰箱	八哥	校長	二胡	客輪	犀牛
champagne	shower	headache	Brazil	refrigerator	myna	school principal	erhu fiddle	passenger steamer	rhinoceros
豆漿	海嘯	天花	埃及	地毯	畫眉	職員	洞簫	軍艦	恐龍
bean milk	tsunami	smallpox	Egypt	carpet	thrush	employee	bamboo flute	warship	dinosaur
舒跑	晴朗	砂眼	波蘭	花瓶	鸕鶿	警察	琵琶	鐵馬	綿羊
sports drink	fine	trachoma	Poland	vase	cormorant	police	pipa	bicycle	sheep
薑湯	氣壓	麻疹	捷克	床鋪	海鷗	木匠	木魚	巴士	獵狗
ginger soup	atmosphere	measles	Czech Republic	bed	shearwater	carpenter	woodblock	bus	hound
果汁	大霧	貧血	南非	壁畫	水鴨	礦工	銅鑼	地鐵	山羊
fruit juice	dense fog	anemia	South Africa	mural painting	teal	miner	gong	subway	goat

(*Appendices continue*)

Appendix B

The 10 Categories of 120 Two-Character Chinese Words (and Their English Translation) Used in Experiment 2

水果 Fruit	動物 Animal	飲料 Drink	礦物寶石 Gem & mineral	自然景觀 Natural formation	調味料 Flavoring	豆類 Legume	顏色 Color	蔬菜 Vegetable	病症 Symptom
柳丁 orange	斑馬 zebra	可樂 coke	珊瑚 coral	丘陵 hill	食鹽 salt	毛豆 young soy bean	乳白 milk white	白菜 pak choi	血栓 thrombus
香蕉 banana	烏鴉 crow	綠茶 green tea	珍珠 pearl	烏雲 dark cloud	味噌 miso	綠豆 mung bean	鮮紅 florid	洋蔥 onion	流血 shed blood
蕃茄 tomato	大象 elephant	開水 boiled water	瑪瑙 agate	沙漠 desert	八角 aniseed	菜豆 frijole	鵝黃 apricot	苦瓜 balsam pear	唇裂 cleft lip
葡萄 grape	天鵝 swan	咖啡 coffee	黃金 gold	雪花 snowflake	咖哩 curry	白豆 navy bean	墨綠 deep green	玉米 maize	蒼白 pallor
芒果 mango	狐狸 fox	沙士 root beer	水晶 crystal	火山 volcano	醬油 soy sauce	蠶豆 broad bean	草綠 olive green	韭菜 leek	燒傷 burns
蘋果 apple	青蛙 frog	牛奶 milk	藍鑽 blue diamond	夕陽 setting sun	辣椒 chili	黃豆 soybean	大紫 oriental purple	蘆筍 asparagus	黑斑 chloasma
枇杷 loquat	野狼 wolf	菊茶 chrysanthemum tea	玻璃 glass	沼澤 marsh	沙茶 satay	大豆 soy	水藍 sea blue	茄子 eggplant	天花 smallpox
草莓 strawberry	黑狗 black dog	啤酒 beer	煤炭 coal	晴天 sun shine	芥末 mustard	黑豆 black soy bean	藏青 dark navy blue	竹筍 bamboo shoot	紅腫 erythema
芭樂 guava	老虎 tiger	果汁 fruit juice	石英 quartz	綠洲 oasis	大蒜 garlic	扁豆 wax bean	粉紅 pink	芹菜 celery	發膿 suppuration
木瓜 papaya	白兔 rabbit	豆漿 bean milk	翡翠 green jade	岩漿 magma	冰糖 crystal sugar	青豆 green bean	米黃 cream-colored	蘿蔔 carrot	黃疸 jaundice
檸檬 lemon	駱駝 camel	汽水 soda	琺瑯 enamel	冰河 glacier	味素 monosodium glutamate	納豆 nattō	淺紫 lilac	絲瓜 loofah	淤青 stasis
楊桃 carambola	熊貓 panda	紅茶 red tea	碧玉 jasper	烈日 burning sun	烏醋 black vinegar	紅豆 adzuki bean	漆黑 inky black	菠菜 spinach	發紫 cyanosis

(*Appendices continue*)

Appendix C

The 10 Categories of 120 Two-Character Chinese Words (in zhuyin) Used in Experiment 3

水果 Fruit	動物 Animal	飲料 Drink	礦物寶石 ineral jewel	自然景觀 Natural formation	調味料 Flavoring	豆類 Legume	顏色 Color	蔬菜 Vegetable	病症 Symptom
ㄌㄧㄡˇ ㄉㄧㄥ	ㄅㄢ ㄇㄚˇ	ㄎㄜˇ ㄌㄜˋ	ㄕㄢ ㄏㄨˊ	ㄑㄧㄡ ㄌㄧㄥˊ	ㄕˊ ㄧㄢˊ	ㄇㄠˊ ㄉㄡˋ	ㄖㄨˇ ㄅㄞˊ	ㄅㄞˊ ㄘㄞˋ	ㄒㄧㄝˇ ㄕㄨㄢ
ㄒㄧㄤ ㄐㄧㄠ	ㄨ ㄧㄚ	ㄌㄩˋ ㄔㄚˊ	ㄓㄣ ㄓㄨ	ㄨ ㄩㄣˊ	ㄨㄟˋ ㄘㄥ	ㄌㄩˋ ㄉㄡˋ	ㄒㄧㄢ ㄏㄨㄥˊ	ㄧㄤˊ ㄘㄨㄥ	ㄌㄧㄡˊ ㄒㄧㄝˇ
ㄈㄢ ㄑㄧㄝˊ	ㄉㄚˋ ㄒㄧㄤˋ	ㄎㄞ ㄕㄨㄟˇ	ㄇㄚˇ ㄋㄠˇ	ㄕㄚ ㄇㄛˋ	ㄅㄚ ㄐㄧㄠˇ	ㄘㄞˋ ㄉㄡˋ	ㄜˊ ㄏㄨㄤˊ	ㄎㄨˇ ㄍㄨㄚ	ㄔㄨㄣˊ ㄌㄧㄝˋ
ㄆㄨˊ ㄊㄠˊ	ㄊㄧㄢ ㄜˊ	ㄎㄚ ㄈㄟ	ㄏㄨㄤˊ ㄐㄧㄣ	ㄒㄩㄝˇ ㄏㄨㄚ	ㄎㄚ ㄌㄧˇ	ㄅㄞˊ ㄉㄡˋ	ㄇㄛˋ ㄌㄩˋ	ㄩˋ ㄇㄧˇ	ㄘㄤ ㄅㄞˊ
ㄇㄤˊ ㄍㄨㄛˇ	ㄏㄨˊ ㄌㄧˊ	ㄕㄚ ㄕˋ	ㄕㄨㄟˇ ㄐㄧㄥ	ㄏㄨㄛˇ ㄕㄢ	ㄐㄧㄤˋ ㄧㄡˊ	ㄘㄢˊ ㄉㄡˋ	ㄘㄠˇ ㄌㄩˋ	ㄐㄧㄡˇ ㄘㄞˋ	ㄕㄠ ㄕㄤ
ㄆㄧㄥˊ ㄍㄨㄛˇ	ㄑㄧㄥ ㄨㄚ	ㄋㄧㄡˊ ㄋㄞˇ	ㄌㄢˊ ㄗㄨㄢˋ	ㄒㄧˋ ㄧㄤˊ	ㄌㄚˋ ㄐㄧㄠ	ㄏㄨㄤˊ ㄉㄡˋ	ㄉㄚˋ ㄗˇ	ㄌㄨˊ ㄙㄨㄣˇ	ㄏㄟ ㄅㄢ
ㄆㄧˊ ㄆㄚˊ	ㄧㄝˇ ㄌㄤˊ	ㄐㄩˊ ㄔㄚˊ	ㄅㄛ ㄌㄧˊ	ㄓㄠˇ ㄗㄜˊ	ㄕㄚ ㄔㄚˊ	ㄉㄚˋ ㄉㄡˋ	ㄕㄨㄟˇ ㄌㄢˊ	ㄑㄧㄝˊ ˙ㄗ	ㄊㄢ ㄏㄨㄚ
ㄘㄠˇ ㄇㄟˊ	ㄏㄟ ㄍㄡˇ	ㄆㄧˊ ㄐㄧㄡˇ	ㄇㄟˊ ㄊㄢˋ	ㄑㄧㄥˊ ㄊㄢ	ㄐㄧㄝˋ ㄇㄛˋ	ㄏㄟ ㄉㄡˋ	ㄗㄤˋ ㄑㄧㄥ	ㄓㄨˊ ㄙㄨㄣˇ	ㄏㄨㄥˊ ㄓㄨㄥˇ
ㄅㄚ ㄌㄜˋ	ㄌㄠˇ ㄏㄨˇ	ㄍㄨㄛˇ ㄓ	ㄕˊ ㄧㄥ	ㄌㄩˋ ㄓㄡ	ㄉㄚˋ ㄙㄨㄢˋ	ㄅㄧㄢˇ ㄉㄡˋ	ㄈㄣˇ ㄏㄨㄥˊ	ㄑㄧㄣˊ ㄘㄞˋ	ㄈㄚ ㄋㄨㄥˊ
ㄇㄨˋ ㄍㄨㄚ	ㄅㄞˊ ㄊㄨˋ	ㄉㄡˋ ㄐㄧㄤ	ㄈㄟˇ ㄘㄨㄟˋ	ㄧㄢˊ ㄐㄧㄤ	ㄅㄧㄥ ㄊㄤˊ	ㄑㄧㄥ ㄉㄡˋ	ㄇㄧˇ ㄏㄨㄤˊ	ㄌㄨㄛˊ ˙ㄅㄛ	ㄏㄨㄤˊ ㄉㄢˇ
ㄋㄧㄥˊ ㄇㄥˇ	ㄌㄨㄛˋ ㄊㄨㄛˊ	ㄑㄧˋ ㄕㄨㄟˇ	ㄈㄚˇ ㄌㄤˊ	ㄅㄧㄥ ㄏㄜˊ	ㄨㄟˋ ㄙㄨˋ	ㄋㄚˋ ㄉㄡˋ	ㄑㄧㄢˇ ㄗˇ	ㄙ ㄍㄨㄚ	ㄩ ㄑㄧㄥ
ㄧㄤˊ ㄊㄠˊ	ㄒㄩㄥˊ ㄇㄠ	ㄏㄨㄥˊ ㄔㄚˊ	ㄅㄧˋ ㄩˋ	ㄌㄧㄝˋ ㄖˋ	ㄨ ㄘㄨˋ	ㄏㄨㄥˊ ㄉㄡˋ	ㄑㄧ ㄏㄟ	ㄅㄛ ㄘㄞˋ	ㄈㄚ ㄗˇ

(*Appendices continue*)

Appendix D

The 10 Categories of 120 Two-Character Chinese Nonwords (Probes) and the Associated Study Items Used in Experiment 4

水果 Fruit		動物 Animal		飲料 Drink		礦物寶石 Mineral jewel		自然景觀 Natural formation		調味料 Flavoring		豆類 Legume		顏色 Color		蔬菜 Vegetable		病症 Symptom	
泖可	柳丁	玨馮	斑馬	何藥	可樂	柵玥	珊瑚	乓陵	丘陵	香沺	香油	尾佢	毛豆	蚿里	玄黑	池爪	地瓜	洫恮	血栓
香憔	香蕉	鳥鴣	烏鴉	祿荼	綠茶	沴玝	珍珠	鳥雪	烏雲	咮礑	味噌	祿佢	綠豆	浮曰	乳白	曰萊	白菜	梳洫	流血
潘加	蕃茄	太豫	大象	珈韭	咖啡	橫全	黃金	陳士	凍土	鳥酣	烏醋	曰佢	白豆	早祿	草綠	若爪	苦瓜	嗆曰	蒼白
譯咖	釋迦	媥湢	蝙蝠	門氷	開水	馮緇	瑪瑙	雷吪	雪花	可香	丁香	萊佢	菜豆	臧倩	藏青	笳了	茄子	辱製	唇裂
早侮	草莓	考彪	老虎	東錯	果醋	冰昌	水晶	災秈	火山	入用	八角	橫佢	黃豆	太紮	大紫	非萊	韭菜	橫担	黃疸
蘋東	蘋果	冰懶	水獺	牟仍	牛奶	監囋	藍鑽	歹湯	夕陽	辡淑	辣椒	紮佢	紫豆	挑紝	桃紅	吪萊	花菜	澆楊	燒傷
秕把	枇杷	町狠	野狼	枯荼	桔茶	坡矖	玻璃	活潭	沼澤	抄荼	沙茶	里佢	黑豆	氷監	水藍	筧萊	莧菜	夭吪	天花
亡東	芒果	里拘	黑狗	碑栖	啤酒	洫右	血石	侮肅	海嘯	妎未	芥末	太佢	大豆	黑祿	墨綠	炵筍	冬筍	紝腄	紅腫
惕挑	楊桃	曰免	白兔	扶荼	抹茶	右英	石英	祿栦	綠洲	昧情	味精	倩佢	青豆	俴紮	淺紫	斤萊	芹菜	傫珍	濕疹
把藥	芭樂	抓悝	狐狸	紝荼	紅茶	橫王	黃玉	吵乒	沙丘	太菻	大蒜	篇佢	扁豆	珞橫	鉻黃	靖淑	青椒	里玨	黑斑
協技	荔枝	倩坨	青蛇	東汀	果汁	右黑	石墨	泳可	冰河	廿早	甘草	紝佢	紅豆	盼紝	粉紅	波萊	菠菜	菸婧	淤青
未爪	木瓜	悰能	棕熊	氘氷	汽水	曰王	白玉	曰飪	日蝕	加悝	咖哩	汭佢	納豆	玥曰	月白	橫爪	黃瓜	潑紮	發紫

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