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Participants' reaction time (RT) data in a prime-probe flanker task (e.g., ABA–CAC) were analyzed in terms of the characteristics of RT distribution to examine possible mechanisms that produce negative priming. When the prime and probe were presented in the same context and the proportion of repetition-target trials (TRP) was 0.33, negative priming increased as a function of RT bins, supporting the episodic retrieval account (Neill, 1997). Manipulations that discourage the use of episodic retrieval (i.e., switching context between prime and probe or 0.00 TRP) eliminated the increase in negative priming across RT bins, even though the overall effect remained significant. These data support a dual-mechanism account in which, depending on task demands, both selective inhibition and episodic retrieval can be involved in producing negative priming.

Keywords: distributional analyses, episodic retrieval, inhibition, negative priming, reaction time

In a typical flanker task, participants are shown three letters simultaneously and told to identify the middle letter (target) while ignoring the left and right distractor letters (flankers). In this task, participants often identify a target such as *A* in the display *CAC* more slowly and/or less accurately following a prime display in which *A* served as the flanker such as *ABA* (ignored repetition trial) than following an unrelated display such as *DBD* (unrelated trial). This negative priming effect occurs when ignored information in a previous stimulus (prime) interferes with participants' responses to a subsequent stimulus (probe) that is related to the prime, relative to a subsequent unrelated stimulus (e.g., Neill, 1977; Tipper, 1985). In contrast, participants would typically identify *B* in the probe *CBC* more quickly and/or accurately when it is preceded by a prime containing the same target such as *ABA* (target-repetition trial) than when it is preceded by an unrelated prime such as *ADA*. This repetition priming effect reflects how an attended target in the prime can later enhance responding when it is repeated as the probe target.

Selective Review of Theoretical Accounts of Negative Priming

In the current study, we focus on three theoretical accounts of negative priming: selective inhibition, episodic retrieval, and a dual mechanism. According to selective inhibition accounts, successful identification of a prime target depends in part on successfully inhibiting one's internal representation of the prime flanker (e.g., Houghton & Tipper, 1994; Neill, 1977, 1979; Tipper, 1985; Tipper & Cranston, 1985). Subsequent identification of a previously ignored flanker, which is then the probe target, would be impaired because this requires overcoming the persisting inhibition (e.g., Houghton, Tipper, Weaver, & Shore, 1996). Some researchers (e.g., Neill, 1989; Neill & Westberry, 1987; Tipper & Cranston, 1985) instead have proposed that the ignored flanker's internal representation remains activated, but is inhibited from accessing response mechanisms, when the response required on the probe target is perceived as a conflict. However, we do not intend to test whether the ignored flanker's internal representation per se or its associated response is inhibited in the current study. Rather, we want to test whether the account that we introduce next, episodic retrieval, is sufficient to account for negative priming, without positing selective inhibition, be it representation based or response based.

According to the episodic retrieval account (e.g., Neill, 1997; Neill & Valdes, 1992), negative priming occurs due to memory retrieval of prime-flanker episodes during probe-target processing. Following Logan's (1988) instance account of automaticity, the episodic retrieval account begins with an assumption that performance on a task (e.g., selecting *A* in the display *CAC*) initially depends on an algorithmic process necessary to solve the task (e.g., identifying all stimuli in a display, selecting the appropriate target letter, and executing the appropriate response). However, when

previously encountered stimuli are repeated, people can solve the task by either repeating the above slow algorithmic process or automatically retrieving a past episode from memory involving the same stimuli and in turn the correct response A. Thus, in this model, participants' responses are influenced by the process that finishes first, either the algorithmic process or the retrieval process. Although Logan emphasized the beneficial role of memory retrieval in practice effects via repeated exposure, Neill and colleagues (Neill, 1997; Neill & Valdes, 1992) focused on how such retrieval can sometimes impair performance. Specifically, if the retrieved episode includes information that the stimulus (e.g., the target A in the display CAC) was to-be-ignored (as would be the case when that stimulus was previously a distractor as in ADA), this retrieved information interferes with participants' response execution to the current stimulus. In a more recent episodic retrieval account (S. Mayr & Buchner, 2006; Rothermund, Wentura, & De Houwer, 2005), repetition of a flanker as the probe target leads to retrieval of the response given during the prime episode (e.g., the response C), which is incompatible with the required response (e.g., A) to the probe target. In either case, negative priming may occur under conditions that encourage the retrieval of the incompatible information (either the prime response or a "to-be-ignored" tag).

Some dual-mechanism models have been proposed to explain how both episodic retrieval and selective inhibition processes could contribute to negative priming (e.g., Kane, May, Hasher, Rahhal, & Stoltzfus, 1997; May, Kane, & Hasher, 1995; Tipper, 2001). According to Kane et al.'s (1997) account, selective inhibition and episodic retrieval are separate sources of negative priming, such that the impact of one mechanism is minimal during the operation of the other mechanism. Episodic retrieval contributes to negative priming when target-repetition trials are included, the contexts of prime and probe are similar, and/or stimuli are degraded because these situations increase the likelihood of retrieving previous episodes. When none of these elements occurred in the task, any negative priming is attributed to selective inhibition during the prime processing that persists into the probe display. Contrary to the mutual exclusivity of selective inhibition and episodic retrieval in Kane et al.'s account, Tipper (2001) proposed a revised inhibition account in which the retrieval process was incorporated into his selective inhibition account. When a flanker is inhibited in a selective attention process, the inhibition effect is encoded as part of the memory representation and the retrieval of this representation can lead to a reinstatement of the inhibition effect. Thus, Tipper's account emphasized that the negative priming effect is simultaneously triggered by both forward-acting (encoding) and backward-acting (retrieval) processes.

Factors That Affect Episodic Retrieval in the Negative Priming Paradigm

According to Tulving's (1983) encoding specificity principle, episodic retrieval is influenced by contextual similarity between "study" and "test" conditions. When the contextual similarity is manipulated in negative priming experiments, the contexts within the prime and probe can be used as cues for memory retrieval. When the context for a probe is similar or identical to that for the prime, the probe display can serve as a cue to retrieve the prime episode. This has been shown in negative priming studies using various context manipulations, including target-flanker stimulus-onset asynchrony (SOA; e.g., Neill, 1997; Neill & Valdes, 1996, but see Hasher, Zacks, Stoltzfus, Kane, & Connelly 1996; Moore, 1996), stimulus intensity (e.g., Fox & de Fockert, 1998; Lowe, 1998; Stolz & Neely, 2001; but see Luna, Villarino, Elosua, Merino, & Moreno, 2006; Paquet, 2001, Experiment 2), and the symbols accompanying the target/flanker in the prime and probe (e.g., Chao, 2009; but see Wong, 2000; Yang, Yeh, Chao, & Chang, 2004). It is noteworthy that the few cases in which the contextual similarity effect was not replicated could be attributed to their weak manipulations (e.g., a narrower range of target-flanker SOA, smaller contrast in stimulus intensity and the lack of context variability).

Apart from contextual similarity, Kane and colleagues (Kane, Hasher, Stoltzfus, Zacks, & Connelly, 1994; Kane, May, Hasher, Rahhal, & Stoltzfus, 1997, see also Kane, Conway, Hambrick, & Engle, 2007) argued that episodic retrieval is also sensitive to the proportion of target-repetition trials (TRP). Including TRPs encourages the use of episodic retrieval because the retrieved prime episodes often contain the appropriate response for the current trial. In support of this account, Kane et al. (1997, Experiment 3, see also Sullivan & Faust, 1993; Sullivan, Faust, & Balota, 1995) reported a significant negative priming effect in older adults (a group with presumed inhibitory deficits, see Hasher, Lustig, & Zacks, 2007, for a review) when there was a high TRP (.40) in the task, but not when there were no TRPs in the task (Kane et al., 1994; Kane et al., 1997, Experiments 1 and 2). Although Kane and colleagues provided a compelling argument that increasing the TRP should bolster episodic retrieval, this has not been shown in any negative priming experiments in which the participants were randomly assigned to the two TRP conditions within the same experiment.

RT Distribution and Priming

To our knowledge, all negative priming studies to date have focused on mean-level reaction time (RT) performance. However, effects observed in mean RT may reflect distinct patterns at the level of underlying RT distributions. For instance, even though mean RT is slower for ignored-repetition trials than for unrelated trials, such a difference can be constant or gradually increasing across the bins of a RT distribution. In the present study, we carried out the distributional analyses by averaging RT distributions across a number of participants. We plotted the mean of individual RTs across bins to determine if there are differential influences of contextual similarity and/or TRP on different portions of the RT distribution. These vincentile analyses provide mean estimates of ascending bins of RTs for each condition. For example, to obtain eight vincentiles, individual RT data within each condition is first sorted from fastest to slowest responses. The first 12.5% of the data is then averaged, followed by the second 12.5%, and so on. Individual vincentiles are then averaged across participants. The vincentizing reflects the average shape of the RT distributions without any assumptions on the shape of empirical RT distribution, and thus allows a more direct examination of the raw data, relative to other analytic procedures, such as fitting an ex-Gaussian distribution (e.g., Yap, Balota, Cortese, & Watson, 2006).

Despite the fact that the RT distributional analysis has not been employed in any negative priming studies, it has recently been used to examine semantic priming (faster responding to a target when it is preceded by a related prime, relative to an unrelated prime, see Hutchison, 2003; McNamara, 2005; Neely, 1991, for reviews). Balota, Yap, Cortese, and Watson (2008) found that the semantic priming effect remains approximately the same magnitude across RT bins and argued that this reflects a head-start mechanism akin to spreading activation. The related prime produces a certain amount of activation for the target prior to the target's presentation. Assuming that inhibition analogously operates like spreading activation, if negative priming can be solely attributed to inhibition, one would expect that the effect should be constant across RT bins, similar to the pattern of semantic priming reported in Balota et al. (see also Yap, Tse & Balota, 2009). Hence, the selective inhibition account would postulate a "delayed-start" in responding to the probe target due to persisting inhibition carried over from the prime distractor.

When targets are difficult to process (e.g., degraded or low-frequency words), the semantic priming effect increases across bins, which Balota et al. (2008) argued reflects the retrieval of prime episodes. Following the explanation for the contextual similarity effect and TRP effect on negative priming, this retrieval benefits target recognition when the prime is related, but delays target recognition when the prime is unrelated. The overall pattern of results are consistent with a dual-mechanism account consisting of both spreading activation plus an additional episodic retrieval mechanism that contributes to priming when targets are difficult to process, as long as the prime can provide useful information for the target response (e.g., Bodner & Masson, 2001; Whittlesea & Jacoby, 1990). Given that Neill's (1997) account pinpointed the role of episodic retrieval in modulating negative priming, it is important to investigate the change of RT distribution as a function of manipulations that encourage or discourage episodic retrieval, such as prime-probe contextual similarity and TRP. Based on the semantic priming findings, we expect that manipulations that encourage episodic retrieval should boost the negative priming effect and this boost should increase across RT bins. It should be emphasized that although we assume that the effects of (a) spreading activation and inhibition and (b) episodic retrieval at the level of RT bins should be analogous in semantic priming and negative priming, this does not necessarily mean that the mechanisms underlying these two effects have to be identical.

The Present Study

The goal of the present study is to test the episodic retrieval account of negative priming using RT distributional analyses. Rather than evaluating various episodic retrieval accounts (e.g., Rothermund et al., 2005), we focus on the account proposed by Neill (1997). In Experiment 1, a flanker paradigm with a "standard" TRP (i.e., 0.33) was used to examine the RT distributional characteristics in this most basic negative priming paradigm. Given that the prime and probe were presented in the same context and the proportion of repetition-target trials was 0.33, we expected that episodic retrieval would have an effect on negative priming and thus, there should be an increasing trend of negative priming over the RT bins.

Experiment 1

Method

Participants. Undergraduates with normal or corrected-to-normal vision and normal color vision participated in exchange for partial course credit for research participation. There were 24 undergraduates from the University at Albany, State University of New York, who were recruited to participate.

Materials and design. The prime-probe pairs were created by combining two of the following triplets: ABA, ACA, ADA, BAB, BCB, BDB, CAC, CBC, CDC, DAD, DBD, and DCD, with the constraints that the prime and probe never shared the same flanker letters (e.g., BAB–BCB) and no prime target could be used as a probe flanker (e.g., ABA–BCB). All triplets were used equally often as primes and probes. Thus, the prime was never predictive of the subsequent probe. There were three types of prime-probe relations: target repetition, in which the same target (i.e., middle letter) appeared in the prime and the probe, each time with a different flanker (e.g., ABA–CBC), ignored repetition, in which the same letter was presented as the prime flanker and as the probe target (e.g., BAB–CBC), and unrelated, in which both target and flankers were different in prime and probe (e.g., DAD–CBC). All stimuli were presented against a black background at the center of the screen. Both prime and probe were presented in Times New Roman Bold with font size 18 in white color.

Procedure. The stimulus display and data collection were controlled by E-Prime and run on an IBM Pentium-compatible computer equipped with a VGA monitor. All participants were tested individually in a dimly lit cubicle. They were seated 60 cm away from the screen. At the beginning of the experiment, participants were instructed to ignore the left and right letters and identify the middle letter (target) by pressing a key on the computer keyboard. The middle and index fingers of each hand were used to press the *A, C, N,* and *L* keys, to the targets, *A, B, C,* and *D*, respectively. Both speed and accuracy were emphasized in the instruction.

On each trial, a plus sign "+" first appeared for 250 ms as a fixation. Following a 300-ms blank-screen interstimulus interval, a prime appeared and remained on the screen for 500 ms. Immediately after participants made a response, a 1,000-ms "Correct" or "Incorrect" response feedback was presented. The probe then appeared and remained on the screen for 500 ms. On probe response, an immediate 1,000-ms feedback screen again appeared that was blank if the probe response was correct, displayed "Incorrect" following an error, or "Too Slow" if participants' probe RT was longer than 1,500 ms. After another 300-ms blank-screen intertrial interval, the next trial began.

There were two practice blocks at the beginning of all three experiments. The first practice block was to get participants familiar with the key assignment. On each of the 20 trials, they were asked to identify the single letter, A, B, C, or D, presented at the center of the screen by pressing A, C, N, or L key, respectively. Feedback was given on each trial. In the second practice block, participants received 27 practice trials, which the sequence of the events was the same as on the experimental trials. After the second practice block, experimental trials were presented. There were 126 target-repetition trials, 126 ignored-repetition trials, and 126 unrelated trials. These 378 trials were divided into six blocks, with a

self-paced break inserted every 63 trials. The trials in all conditions in each experiment were randomly intermixed and the proportions of target-repetition, ignored-repetition, and unrelated trials were roughly the same within each block. The whole experiment lasted about 45 min.

Results

Unless otherwise specified, the significance level is set at .05, two-tailed. For the sake of brevity, only the analyses relevant to our hypotheses are reported. The effect sizes of F and t are represented by partial eta-squared, and Cohen's d, respectively. Participants' mean RT and error were submitted to separate within-sample t tests with negative priming (ignored repetition vs. unrelated) or repetition priming (target repetition vs. unrelated) as a factor. Vincentizing averages RT distributions across participants to produce the RT distribution of a typical participant (Ratcliff, 1979). The factors in the vincentile analyses were exactly the same as above, except that now the vincentile factor was also included. The Greenhouse–Geisser correction was used in all these analyses to avoid the potential violation of sphericity assumption.

RT and error analyses.[1]   Only trials with correct responses on the prime were included. For the RT analyses, error trials and correct trials with RTs faster than 200 ms were first excluded. Of the remaining responses, any RT 3 standard deviations above or below each participant's overall mean was removed, resulting in the elimination of 3.3% of correct-response trials. Table 1 presents the cell means of all dependent measures. Figure 1 shows the negative priming and repetition priming effects for all dependent measures. Both negative priming, RT: $t(23) = 5.98$, $d = 1.73$; error: $t(23) = 3.27$, $d = .94$, and repetition priming effects were significant, RT: $t(23) = 9.88$, $d = 2.85$; error: $t(23) = 7.96$, $d = 2.30$.

Table 1

Mean RTs and Percentage Errors for Probe Targets in Experiments 1 to 3 as a Function of Target Repetition Proportion (TRP), Context (Same vs. Different), and Condition (IR, UN, TR)

| Experiment | Same context, 0.33 TRP | | | Different context, 0.33 TRP | | |
	IR	UN	TR	IR	UN	TR
1						
RT	643	628	540			
Error	11.15	8.77	3.11			
2						
RT	685	670	570	686	679	584
Error	12.08	9.31	3.78	12.09	9.12	4.15
				Same context, 0.00 TRP		
				IR	UN	
3						
RT	666	647		627	617	
Error	7.88	5.93		5.38	5.05	

Note. RTs for correct responses are given in milliseconds. The data reported in this table are based on trimmed data—see text for the rationale. RT = reaction time; IR = ignored repetition; UN = unrelated; TR = target repetition.

Vincentile analyses.   Only trials with correct responses on the prime were included. To closely examine the negative priming effect across RT bins, we included the RT data of all correct trials in the analyses. (Note that the analyses for mean RTs in all three experiments, which was based on the trimmed data, as what was always done in previous negative priming studies, yield the qualitatively identical pattern of results as those reported here.) Figure 2 shows the vincentile plots. As shown in Table 2, the standard deviation of participants' mean RT averaged across three conditions was larger for the slowest-bin data (100) than the remaining bins ($M = 58.4$, range: 45–80). To avoid the masking of genuine bin-associated interaction effects by the noisy data of the slowest bin, in the following analyses we included only the data from the first to seventh bins. (As depicted in Figure 2, the overall pattern remained the same after including the data of the slowest bin in the analyses, although some of the interactions became marginally significant.) The significant Vincentile × Negative Priming interaction, $F(3.00, 68.93) = 5.04$, $MSE = 156.85$, $\eta_p^2 = .18$, and Vincentile × Repetition Priming interaction, $F(2.02, 46.45) = 25.13$, $MSE = 325.88$, $\eta_p^2 = .52$, indicated that negative priming and repetition priming increased as a function of bin, respectively.

Experiment 2

In Experiment 1, we found that negative priming increased across RT bins, suggesting that under this circumstance (i.e., prime and probe in the same context and 0.33 TRP), episodic retrieval contributes to the negative priming effect. However, the increasing negative priming over bins per se is not sufficiently diagnostic in testing between the selective inhibition, episodic retrieval, and dual-mechanism accounts. To tease these accounts apart, one needs to manipulate a condition that may or may not encourage the use of episodic retrieval and examine how this manipulation yields differential patterns of negative priming across RT bins. To achieve this, in Experiment 2 we manipulated the contextual similarity between prime and probe, while keeping the TRP constant (i.e., 0.33). Because previous studies have provided mixed evidence for this effect, we strengthened our manipulation by using two different sets of typeface, size, and color to increase the salience of contextual changes.

Relative to the same-context condition, results indicating that presenting the prime and probe in different contexts reduces negative priming in mean RT or errors should provide support for Neill's (1997) episodic retrieval account over accounts based purely on selective inhibition during prime processing. We also examined if the contextual similarity manipulation had distinct effects on the characteristics of the RT distribution. According to the episodic retrieval account, the negative priming effect should increase across bins in the RT distribution because the longer participants take to perform the algorithmic process of identifying the appropriate target and executing the appropriate response, the more likely the retrieval of the prime episode and its conflicting "not-to-respond" tag, which produces interference on response selection (Neill & Joordens, 2002). In contrast, selective inhibition

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[1] Similar analyses were performed on mean RTs/errors of the primes. None of the main effects or interactions approached significance in all experiments (all Fs < 1.75, ps > .17, η_p^2s < .02).
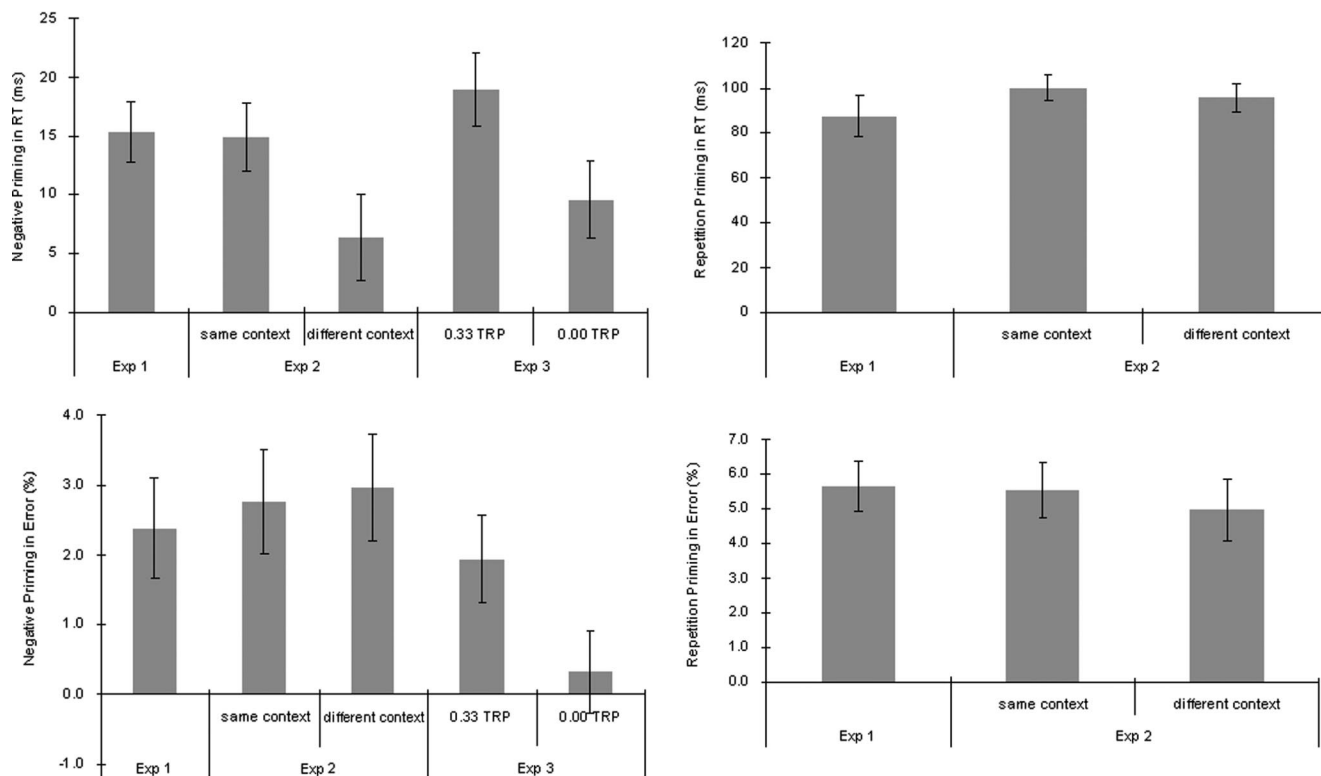
Figure 1. Negative priming and repetition priming effects in reaction times (RTs) and percentage errors for Experiments (Exp) 1 to 3. Error bar indicates standard error of mean for negative priming and repetition priming effects.

accounts posit that inhibition occurs during the prime processing and persists into the probe processing. As a result, negative priming should be significant and relatively constant across the RT distribution, producing a delayed-start effect similar in nature to the head-start effect predicted by spreading activation. This would be the case regardless of whether the context encouraged episodic retrieval. Finally, the dual-mechanism account of negative priming suggests that negative priming should be affected by episodic retrieval when the context of prime and probe is similar. This does not preclude the possibility that inhibition induced by the suppression of a prime flanker could persist and in turn delay the subsequent response to the probe. Hence, when the context encourages the use of episodic retrieval, negative priming would increase across RT bins. However, given that negative priming is likely induced by selective inhibition when episodic retrieval does not play a role, negative priming should remain significant and constant across RT bins (due to the delayed-start effect of selective inhibition) under conditions that do not encourage episodic retrieval.

Method

Participants. There were 60 participants from the University at Albany, State University of New York, who were recruited to participate. None participated in previous experiments.

Materials and design. The materials and design were identical to those in Experiment 1, except that the typeface/size/color of the letters was varied to manipulate the prime-probe contextual similarity within participants. There were two sets of typeface/size/color (Context A: Arial Bold with font size 24 in white color or Context B: Courier News Regular with font size 12 in maroon color). In the same-context condition, the prime and probe were presented in the same set of context (both in A or both in B), whereas in the different-context condition, they were presented in two different sets of context (prime in A and probe in B or prime in B and probe in A). The prime-probe pairs with the same context and those with different contexts were randomly intermixed within each block of trials.

Procedure. The procedures were identical to those in Experiment 1, except that the total number of experimental trials was increased to 432, with half of the trials in the same-context condition and half in the different-context condition. In each context condition, there were 72 target-repetition trials, 72 ignored-repetition trials, and 72 unrelated trials. These 432 trials were divided into eight blocks, with a self-paced break inserted in between every 54 trials. The whole experiment lasted about 60 min.

Results

The preliminary data treatment was the same as in Experiment 1, resulting in a removal of 3.1% of correct-response trials. Participant's mean RT and error were submitted to separate repeated-measures analyses of variance (ANOVAs) with context (same vs. different) and negative priming (ignored-repetition vs. unrelated)
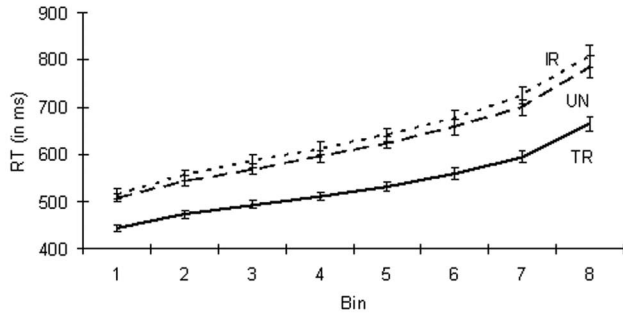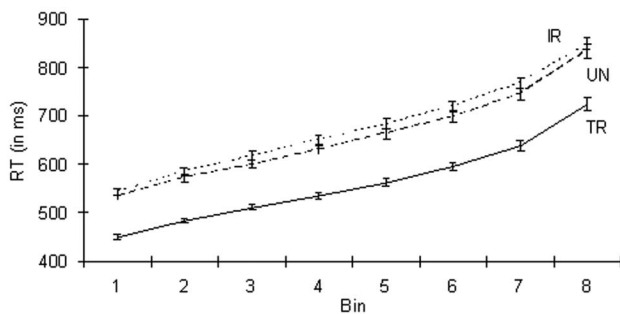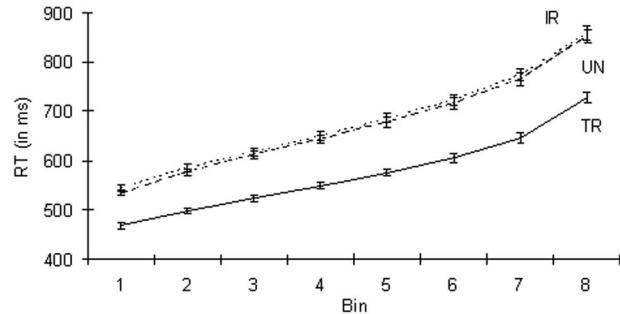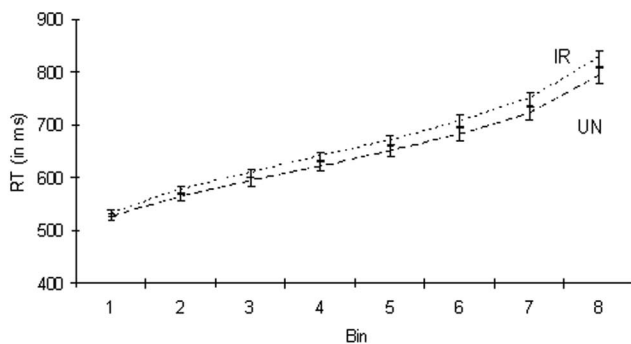
Figure 2. Vincentile plots for Experiments 1 to 3. Error bar indicates standard error of mean. The data reported in this figure are based on untrimmed data—see text for the rationale. RT = reaction time; UN = unrelated; TR = target repetition; TRP = target repetition proportion; IR = ignored repetition.

or repetition priming (target-repetition vs. unrelated) as factors. Table 1 presents the cell means of all dependent measures. Figure 1 shows the negative priming and repetition priming effects for all dependent measures.

RT and error analyses. The Context $\times$ Negative Priming interaction was marginally significant in RT, $F(1, 59) = 3.72$, $MSE = 296.25$, $p = .06$, $\eta_p^2 = .06$, but not in error, $F(1, 59) = 0.04$, $MSE = 17.54$, $\eta_p^2 = .001$. The negative priming effect in RT was stronger in the same-context condition, $t(59) = 5.17$, $d = 0.94$, than in the different-context condition, $t(59) = 1.73$, $d = 0.32$, but the effect in errors did not differ across the two context conditions, $t(59) = 3.70$, $d = 0.68$, and $t(59) = 3.87$, $d = 0.71$, respectively. The Context $\times$ Repetition Priming interaction was

not significant, RT: $F(1, 59) = 0.54$, $MSE = 502.00$, $\eta_p^2 = .01$; error: $F(1, 59) = 0.64$, $MSE = 7.18$, $\eta_p^2 = .01$, indicating that repetition priming did not differ in the same- versus different-context conditions in RT, $t(59) = 17.91$, $d = 3.27$, and $t(59) = 15.20$, $d = 2.78$, respectively or in error, $t(59) = 7.13$, $d = 1.31$, and $t(59) = 5.67$, $d = 1.04$, respectively.

Vincentile analyses. Figure 2 shows the vincentile plots. Following the procedure in Experiment 1, we included the full set of RT data (i.e., untrimmed) but excluded the noisy data in the slowest bins to avoid the genuine pattern being masked (see Table 2). Though the Context $\times$ Vincentile $\times$ Negative Priming interaction was only marginally significant, $F(2.63, 155.36) = 2.33$, $MSE = 455.04$, $p = .09$, $\eta_p^2 = .04$, planned analyses showed that

Table 2

Standard Deviation of Participants' Mean RTs for Probe Targets in Experiments 1 to 3 as a Function of Bins, Target Repetition Proportion (TRP), Context (Same vs. Different), and Condition (IR, UN, TR)

Bin no.	Same context, 0.33 TRP (Experiment 1)			Same context, 0.33 TRP (Experiment 2)			Different context, 0.33 TRP (Experiment 2)			Same context, 0.33 TRP (Experiment 3)		Same context, 0.00 TRP (Experiment 3)	
	IR	UN	TR	IR	UN	TR	IR	UN	TR	IR	UN	IR	UN
1	50	47	37	47	47	38	54	50	37	46	44	47	43
2	55	50	40	58	56	40	61	58	43	52	51	49	46
3	61	54	41	65	61	45	66	67	47	56	56	49	52
4	64	58	41	73	70	51	71	69	52	62	62	53	57
5	69	65	46	79	76	57	77	75	59	68	67	57	61
6	79	76	54	84	82	66	84	90	68	80	75	65	68
7	94	83	63	89	93	81	96	101	78	91	87	75	85
8	115	114	72	99	113	103	104	105	93	100	103	98	106

Note. The data reported in this table are based on untrimmed data—see text for the rationale. IR = ignored repetition; UN = unrelated; TR = target repetition.

it was in the predicted direction: negative priming increased across bins in the same-context condition, $F(2.43, 143.11) = 3.94$, $MSE = 427.90$, $\eta_p^2 = .06$, but not in the different-context condition, $F(2.07, 122.11) = 0.37$, $MSE = 679.34$, $\eta_p^2 = .01$. It is noteworthy that the overall negative priming effect, collapsed across bins, was significant in the different-context condition, $F(1, 59) = 4.99$, $MSE = 2,719.26$, $\eta_p^2 = .08$. The Vincentile $\times$ Context $\times$ Repetition Priming interaction was significant, $F(1.63, 95.98) = 5.67$, $MSE = 987.33$, $\eta_p^2 = .09$. The degree to which repetition priming increased as a function of bin was greater in the different-context condition, $F(1.73, 101.95) = 30.38$, $MSE = 1,172.63$, $\eta_p^2 = .34$, than in the same-context condition, $F(1.80, 105.99) = 9.78$, $MSE = 760.27$, $\eta_p^2 = .14$. Follow-up analyses on each bin revealed that the repetition priming effect was stronger in the same-context condition than in the different-context condition in the first two bins (both $ts > 2.54$, $ds > 0.46$). The contextual similarity effect on repetition priming decreased from the second to fourth bin and switched to negative in the fifth to seventh bins (indicating less repetition priming in the same-context condition). However, none of the negative contextual similarity effects were significant (all $ts < 1.11$, $ds < 0.20$).

Experiment 3

In Experiment 2, we found that negative priming was marginally greater in the same-context condition than in the different-context condition. More important, across the RT bins we found that the negative priming effect significantly increased in the same-context condition, but remained constant in the different-context condition, although the Vincentile $\times$ Context $\times$ Negative Priming interaction was marginally significant. This is consistent with the dual-mechanism account that predicted that negative priming can be attributed to the influence of selective inhibition or episodic retrieval, if conditions favor such retrieval (i.e., same context from prime to probe).

However, there are three potential limitations in Experiment 2. First, despite the clear contrast between the significant Vincentile $\times$ Negative Priming effect in the same-context condition versus the nonsignificant Vincentile $\times$ Negative Priming effect in

the different-context condition, the marginally significant Vincentile $\times$ Context $\times$ Negative Priming interaction may weaken support for a dual-mechanism account. Second, (a) the absence of a Vincentile $\times$ Negative Priming interaction in the different-context condition and (b) the significant negative priming in that condition after collapsing across bins, could argue against episodic retrieval being the sole cause for negative priming. This, however, is based on a null vincentile interaction in the different-context condition. Finally, one could argue that the prime/probe context manipulation was confounded with exact stimulus repetition. Given that negative priming can be specific to perceptual details, if, for example, processing of a white Arial font/size 24 flanker letter *B* is inhibited, one would expect the negative priming to be greater when the stimulus in that specific color, size, and font reappears as the target, than when it reappears, as the target, in a different color, size, and font (i.e., red maroon Courier size 12, letter *B*). Hence, it could be the strength of inhibition, rather than context per se, that led to the pattern found in Experiment 2. Of course, the manipulation of stimulus perceptual characteristics has been used in prior negative priming studies that yielded evidence supporting the episodic retrieval account (e.g., Fox & de Fockert, 1998; Stolz & Neely, 2001). Still, it would be beneficial to use another manipulation that encourages episodic retrieval and is not confounded with exact stimulus repetition to examine whether the marginal Vincentile $\times$ Episodic Retrieval Likelihood $\times$ Negative Priming interaction found in Experiment 2, in which negative priming increases across bins only when episodic retrieval likelihood is high, can be replicated.

As mentioned in the Introduction, Kane et al. (1994, 1997, 2007) found that another manipulation, TRP, encourages the use of episodic retrieval. In Experiment 3, we used the same-context condition in Experiment 2 and manipulated the TRP between-subjects by treating the target-repetition trials as filler trials that either remained as target-repetition trials for the 0.33 TRP group or were replaced by unrelated filler trials for the 0.00 TRP group. The proportions of ignored-repetition and unrelated trials were kept constant (i.e., 0.33). If exclusion of target repetition trials for the .00 TRP group greatly reduces negative priming, relative to the .33

TRP group, this would support Neill's (1997) episodic retrieval account over selective inhibition accounts. The predictions for the characteristics of the RT distribution are identical to those in Experiment 2. The episodic retrieval account would predict that the increase in negative priming across RT bins should occur for the 0.33 TRP group and the overall negative priming averaged across RT bins should be nonsignificant for the 0.00 TRP group. Alternatively, the selective inhibition account would predict that the negative priming effect should remain constant across RT bins for both the 0.00 and 0.33 TRP groups. Finally, the dual-mechanism account would predict that negative priming should increase across RT bins for the 0.33 TRP group (due to episodic retrieval), but remain significant and constant across RT bins for the 0.00 TRP group (due to persisting inhibition from the prime trial).

Method

Participants. There were 100 participants from Montana State University who were recruited as participants. None participated in previous experiments. Half of the participants were randomly assigned to the 0.33 TRP group and half to the 0.00 TRP group.

Materials and design. The materials and design were identical to those in Experiment 2, except that the prime-probe pairs were always presented in the same context. The participants in either TRP group received trials with both prime and probe presented either in Context A or in Context B, thereby controlling for the potential effect of context (Set A vs. Set B) across Experiments 2 and 3.

Procedure. The procedures were identical to those in Experiment 1, except that there were 72 unrelated trials, 72 ignored-repetition trials, and 72 target-repetition filler trials for the 0.33 TRP group, and 72 unrelated trials, 72 ignored-repetition trials, and 72 unrelated filler trials for the 0.00 TRP group. These 216 trials were divided into eight blocks, with a self-paced break inserted between every 27 trials. The whole experiment lasted about 30 min.

Results

We first excluded the filler unrelated trials in the 0.00 TRP group and filler target-repetition trials in the 0.33 TRP group in our analyses.[2] The preliminary data treatment was the same as in Experiment 1, resulting in a removal of 2.9% of correct-response trials. The participants' mean RT and error were submitted to mixed-factor ANOVAs with TRP (0.33 vs. 0.00) as a between-subject factor and negative priming (ignored-repetition vs. unrelated) as a within-subject factor. Table 1 presents the cell means of all dependent measures. Figure 1 shows the negative priming and repetition priming effects for all dependent measures.

RT and error analyses. The TRP $\times$ Negative Priming interaction was significant in RT and marginally so in errors, RT: $F(1, 98) = 4.24$, $MSE = 258.07$, $\eta_p^2 = .04$; error: $F(1, 98) = 3.56$, $MSE = 9.18$, $p = .06$, $\eta_p^2 = .04$. The negative priming effect was stronger for the 0.33 TRP group than for the 0.00 TRP group, RT: $t(49) = 5.99$, $d = 1.20$, and $t(49) = 2.93$, $d = 0.59$, respectively; error: $t(49) = 3.08$, $d = 0.62$, and $t(49) = 0.57$, $d = 0.12$, respectively.

Vincentile analyses. Figure 2 shows the vincentile plots. Following the procedure in previous experiments, we included the full set of RT data (i.e., untrimmed) but excluded the noisy data in the slowest bin to avoid the genuine pattern being masked (see Table 2). The TRP $\times$ Vincentile $\times$ Negative Priming interaction was significant, $F(2.60, 254.45) = 3.92$, $MSE = 347.65$, $\eta_p^2 = .04$. Planned analyses showed that negative priming increased as a function of bin for the 0.33 TRP group, $F(2.76, 135.14) = 8.54$, $MSE = 313.26$, $\eta_p^2 = .15$, but not for the 0.00 TRP group, $F(2.35, 115.22) = 0.14$, $MSE = 400.32$, $\eta_p^2 = .00$. The overall effect collapsed across bins remained significant for the 0.00 TRP group, $F(1, 49) = 4.83$, $MSE = 1,844.36$, $\eta_p^2 = .09$. Hence, Experiment 2's findings that the presence versus absence of a Negative Priming $\times$ Vincentile interaction when the episodic retrieval likelihood was high versus low, respectively, were replicated when a TRP manipulation was used instead of a contextual similarity manipulation.

Issues concerning the dropping of the slowest bin data in the vincentile analyses. As stated above, in all of our above vincentile analyses we dropped the slowest bin data because the standard deviation of the RTs in that bin tended to be larger than the others, potentially masking any interaction pattern (see Table 2). However, one could argue that because standard deviations typically increase in a linear fashion as RT bins increase, it is not surprising that they were largest in the slowest bin. It is therefore necessary to show that the increase in standard deviation in the slowest bin was larger than expected based on this linear progression. To verify this, for each condition we created a linear equation based on overall participants' data in the first seven bins and used it to predict the RTs one would expect to find in the eighth (i.e., slowest) bin had the trend been linear. If RTs were indeed atypically noisy in the slowest bin, then standard deviations in this bin should be larger than expected based on the linear progression. The actual versus predicted standard deviations in ignored, unrelated and attended conditions were 115 versus 94, 114 versus 86 and 72 versus 62 in Experiment 1, 99 versus 98, 113 versus 99, and 103 versus 82 in Experiment 2's same-context condition, and 104 versus 99, 105 versus 105, and 93 versus 81 in Experiment 2's different-context condition. Because there was no attended condition in Experiment 3, the actual versus predicted values in ignored and unrelated conditions were 100 versus 94 and 103 versus 90 in the high-TRP condition and 98 versus 74 and 106 versus 84 in the zero-TRP condition. Because the actual standard deviations were not always substantially larger than predicted standard deviations in all conditions, we performed additional analyses to examine if this would complicate the interpretation of the current findings.

Despite the justification above for removing the noisy eighth bin from analyses, we performed an analysis to examine whether our results from the two experiments that manipulated episodic retrieval likelihood (Experiments 2 and 3) would replicate when data from the last bin is included. More specifically, we combined the

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[2] When these filler trials were regarded as target-repetition trials for the 0.33 TRP group and unrelated trials for the 0.00 TRP group, the pattern of negative priming was qualitatively the same as the one reported in Experiment 3 and the pattern of repetition priming was qualitatively the same as the one reported in Experiment 2, in which the TRP was the same (i.e., 0.33).

data in Experiments 2 and 3 and tested if negative priming still increased over RT bins when episodic retrieval likelihood was high (same-context/ 0.33 TRP), but did not when the likelihood was low (different-context/0.00 TRP), after the data in the last bin were included in the analyses. To test this possibility more stringently, we used a conservative way to combine Experiments 2 and 3's data. We treated the within-subject variable, context in Experiment 2, as a between-subject variable, such that episodic retrieval likelihood became a between-subject variable in both Experiments 2 and 3. The negative priming effect as a function of bins is depicted in Figure 3. Including all eight bins in the analyses, we found a significant Episodic Retrieval Likelihood × Negative Priming interaction in RTs, $F(1, 218) = 9.82$, $MSE = 2,461.36$, $\eta_p^2 = .04$. More important, the Negative Priming × Vincentile × Episodic Retrieval Likelihood interaction was also significant, $F(2.47, 537.86) = 3.05$, $MSE = 807.01$, $\eta_p^2 = .014$, with the Vincentile × Negative Priming interaction being significant when episodic retrieval was likely (i.e., 0.33 TRP or same context), $F(2.08, 226.51) = 5.96$, $MSE = 1,001.62$, $\eta_p^2 = .05$, but not when it was unlikely (i.e., 0.00 TRP or different context), $F(2.73, 297.09) = 0.55$, $MSE = 697.37$, $\eta_p^2 = .005$. The overall effect collapsed across bins remained significant when episodic retrieval was unlikely, $F(1, 109) = 10.11$, $MSE = 2,808.40$, $\eta_p^2 = .09$. The results from this analysis with all eight bins included converged with our earlier findings in demonstrating that increases in the negative priming effect across bins was modulated by whether the experimental manipulation encouraged the use of episodic retrieval.

A final analysis examined whether there was a possible confound between the increases in standard deviation across RT bins and the Negative Priming × Vincentile × Episodic Retrieval Likelihood interaction. That is, could an absence of the Negative Priming × Vincentile interaction when the episodic retrieval is unlikely be due to a larger increase in the standard deviation across RT bins in that condition? To test this, we submitted participants' standard deviations to repeated-measures ANOVAs with context, vincentile and negative priming in Experiment 2 and mixed-factor ANOVAs with TRP, vincentile and negative priming in Experiment 3. Critically, we should find no higher order interaction in
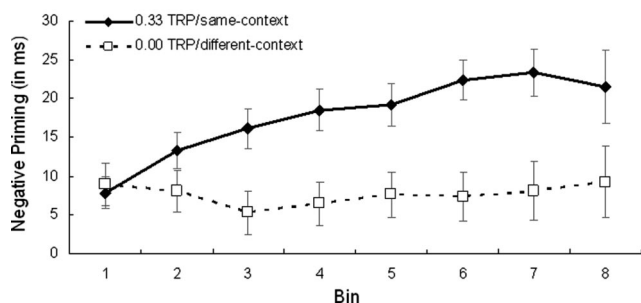

Figure 3. Negative priming as a function of bin and episodic retrieval likelihood (0.33 TRP/same context vs. 0.00 TRP/different context) in Experiments 2 to 3. The data reported in this figure are based on untrimmed data—see text for the rationale. The within-subject variable, context, in Experiment 2 was treated as a between-subject variable to combine the data of Experiment 3, where the TRP was also a between-subject variable. Each data point on the figure was based on the mean and standard errors of 110 participants. TRP = target repetition proportion.

these analyses if there is no differential effect of episodic retrieval likelihood on negative priming in standard deviation across RT bins. This was indeed the case. In Experiment 2, neither the Negative Priming × Vincentile × Context interaction nor the Negative Priming × Vincentile interaction was significant, $F(3.48, 205.57) = 1.47$, $MSE = 108.71$, $\eta_p^2 = .02$, and $F(3.25, 191.50) = 0.33$, $MSE = 119.73$, $\eta_p^2 = .01$, respectively. In Experiment 3, neither the Negative Priming × Vincentile × TRP interaction nor the Negative Priming × Vincentile interaction was significant, $F(3.55, 348.25) = 0.15$, $MSE = 87.15$, $\eta_p^2 = .00$, and $F(3.55, 348.25) = 1.42$, $MSE = 87.15$, $\eta_p^2 = .01$, respectively. Hence, the pattern of a Negative Priming × Vincentile × Episodic Retrieval Likelihood interaction we observed in RTs could not be attributed to a differential pattern of standard deviations that varied across RT bins.

General Discussion

The findings of the present study can be summarized as follows. In Experiment 1, we found negative priming in both RT and errors in a standard flanker paradigm in which the contexts of the prime and probe were the same and the TRP was 0.33 and this effect increased as a function of RT bin. In Experiments 2 and 3, we showed that the negative priming effect was modulated by variables sensitive to episodic retrieval (TRP and contextual similarity). The enhancing effect of episodic retrieval on negative priming started at the second bin and increased steadily thereafter, as depicted in Figure 3 in which the data of Experiments 2 and 3 were combined. Apart from negative priming, we explored the effect of contextual similarity on repetition priming in Experiment 2 and the characteristics of the RT distribution for repetition priming in Experiments 1 and 2. The robust repetition priming effect occurred at the mean-RT level and was not modulated by whether the prime and probe were in the same or different context. However, a complex pattern was revealed in the characteristics of the RT distribution. The repetition priming effect was only stronger in the same-context condition than in the different-context condition in the first two bins and there was no contextual similarity effect in the subsequent bins. In the following section, we first discuss the implications of the current findings on negative priming theories and then elaborate how our findings, despite not being consistent with Neill's (1997) results, nevertheless support his claim that repetition priming and negative priming are likely modulated by two distinct mechanisms. Note that the current study focused on the selective inhibition versus episodic retrieval accounts and it remains to be determined whether other negative priming theories, such as Milliken, Joordens, Merikle, and Seiffert (1998) and Park and Kanwisher (1994), could account for the present findings of the RT distributional analyses.

Selective Inhibition, Episodic Retrieval, or Both?

We replicated the effects of contextual similarity and TRP on negative priming reported from prior research (e.g., Fox & de Fockert, 1998; Kane et al., 1997). A study of the underlying RT distribution shed further light on the mechanism that drives the negative priming effect. Under conditions that encourage the use of episodic retrieval (0.33 TRP or same context), negative priming increased as a function of bin (see Figure 3). This supports the

episodic retrieval account (e.g., Neill, 1997; Neill & Joordens, 2002) because longer processing of the targets allows more time for retrieval of the prime episode and its conflicting not-to-respond tags, producing interference in response selection, and thus a greater negative priming effect. Contrary to the episodic retrieval account, when manipulations discouraged episodic retrieval (0.00 TRP or different context), even though the overall residual negative priming effect remained significant, it did not increase across RT bins. Although one should be cautious when interpreting a null result, the absence of a Negative Priming × Vincentile interaction was found in both Experiments 2 and 3, each using different manipulations to decrease the episodic retrieval likelihood. The residual negative priming obtained when conditions discouraged episodic retrieval is in line with the prediction of a selective inhibition account that would postulate a delayed start in responding to the probe target due to persisting inhibition carried over from the prime distractor. This is analogous to the head-start mechanism of the semantic priming effect, which also remains constant across RT bins (e.g., Balota et al., 2008, see also Yap et al., 2009). Given that both selective inhibition and episodic retrieval can be involved in producing negative priming, the current findings support dual-mechanism accounts of negative priming (e.g., Kane et al., 1997; Neill, 2007; Tipper, 2001).

Explanations From Dual-Mechanism Accounts of Negative Priming

According to Kane et al.'s (1997) account, the contributions of selective inhibition and episodic retrieval are mutually exclusive. When the task demand makes it more likely that episodic retrieval could facilitate performance (e.g., when target-repetition trials are included and when the contexts of prime and probe are similar), the negative priming effect should be solely attributed to episodic retrieval. However, when these conditions are not met, participants should unlikely trigger episodic retrieval and negative priming should be solely attributed to selective inhibition. The current findings suggest that the selective inhibition and episodic retrieval mechanisms for producing negative priming may actually be additive and independent, rather than mutually exclusive. As depicted in Figure 3, whereas the influence of selective inhibition was generally constant regardless of participants' overall RTs, episodic retrieval played a role when participants' overall RTs became longer and the appropriate retrieval condition was present (e.g., similar context between prime and probe). Hence, the finding that both selective inhibition and episodic retrieval could operate simultaneously is inconsistent with Kane et al.'s (1997) mutual exclusivity proposal for the effects of selective inhibition and episodic retrieval on negative priming. One way to reconcile the current findings with Kane et al.'s (1997) account is to assume that under an optimal condition, the influence of episodic retrieval is stronger than those of selective inhibition—as soon as episodic retrieval is triggered, it could induce negative priming to a greater extent than the selective inhibition could. Thus, the negative priming effect in the later bins in the same-context/0.33 TRP condition in Figure 3 could be solely due to the episodic retrieval. However, this assumption requires further verification.

In contrast to Kane et al.'s (1997) account, Tipper's (2001) revised selective inhibition account may provide a better explana-

tion for the current findings. Given that the inhibition effect associated with prime flankers can be encoded as part of the memory representation, under an optimal condition (e.g., high TRP), the probe target in ignored-repetition trials can cue retrieval of the encoded representation, "reinstating" the inhibitory state of the representation and causing negative priming. This account does not preclude the effect of forward-acting inhibition; it just postulates that negative priming could be enhanced by the episodic retrieval of the "inhibitory state" under some circumstances. Hence, it allows the simultaneous operation of both selective inhibition and episodic retrieval (but see Neill, 2007, for a single-mechanism view on Tipper's revised account) and is thus able to account for the present findings.

Similar to this Tipper's (2001) account, Neill and Mathis (1998, see also MacDonald & Joordens, 2000) proposed a transfer inappropriate processing model, which assumes that the retrieval of prime-processing episodes involving similar stimuli (i.e., prime flanker) reinstates similar processing of the items during probe processing. However, Neill and Mathis argued that the reinstatement during probe processing depends on the nature of the processing operated during the earlier episode. It is the retrieval of prime processing being incompatible with probe processing, rather than the prime episode (or its inhibitory state) per se that induces the negative priming effect. More recently, Neill (2007) modified his transfer inappropriate processing account to include both episodic retrieval and persisting inhibition mechanisms. As with his earlier account, Neill (2007) argued that negative priming for perceptual and conceptual representations is due specifically to episodic retrieval of previous incompatible processing episodes involving those (or similar) representations. However, in his new theory, Neill (2007) argued that specific responses may be inhibited during the prime trial and this persisting inhibition (of a specific response) can also cause negative priming. Thus, the revised transfer inappropriate processing theory of negative priming can also be regarded as a dual-mechanism account. This theory could easily explain the current results by suggesting that the persisting negative priming effect we observed in the 0.00 TRP/different-context condition (as well as in the fastest RT bins of the 0.33 TRP/same-context condition) reflected persisting inhibition at the response level. An increase in negative priming in the later bins of the 0.33 TRP/same context condition reflects episodic retrieval of incompatible processing for the perceptual/conceptual representation of the previous distractor.

It is noteworthy that due to the design of the present experiments, the current findings could not distinguish between Tipper's (2001) revised selective inhibition account and Neill's (2007) transfer inappropriate processing account, but they at least point to a possible dissociation between Tipper's revised account and Neill's (1997) episodic retrieval account. When considering the mean RT data, Hutchison (2002) argued that episodic retrieval and Tipper's contextually retrieved inhibition could not easily be distinguished as they derived similar predictions for the effect of contextual similarity on negative priming. However, by observing the change of negative priming across RT bins, the current study showed that episodic retrieval per se may not account for the constant effect across RT bins under conditions that do not encourage episodic retrieval strategies (i.e., 0.00 TRP/different con-

text condition). Instead, these data support dual-mechanism accounts (Kane et al., 1997; Neill, 2007; Tipper, 2001).

Distinct Mechanisms of Repetition Priming and Negative Priming

Our effect of contextual similarity on repetition priming was not in line with those reported in Neill (1997). Neill (1997) found stronger repetition priming in the same-context condition than in the different-context condition, whereas we obtained statistically equivalent repetition priming effects in the same- and different-context conditions. Neill (1997) argued that negative priming and repetition priming are operated via distinct mechanisms because (a) negative priming only occurred in the same-context condition, and (b) repetition priming occurred in both same- and different-context conditions. Neill (1997) therefore suggested that repetition priming could be attributed to episodic retrieval and persistent spreading activation, the latter of which was not sensitive to contextual change (cf. Tenpenny, 1995), whereas negative priming could be attributed only to episodic retrieval. As elaborated below, our current results support Neill's (1997) claim that negative priming and repetition priming are triggered by different mechanisms, despite discrepancies between Neill's (1997) and our results, which could be due to the following methodological differences.

First, unlike our Experiment 2 in which target-repetition, ignored-repetition, and unrelated trials were all included, in Neill (1997) negative priming and repetition priming were separately investigated in two experiments. That is, the target-repetition and ignored-repetition trials were never included in the same experiment. The presence of ignored-repetition trials in the current study may therefore have influenced the effect of contextual similarity on repetition priming.

Second, we manipulated the prime-probe similarity of font/color/size. In contrast, Neill (1997) manipulated the contextual similarity by using four types of prime-probe flanker onsets (early–early, early–late, late–early, and late–late). The early–early and late–late conditions were contextually similar (because the target-flanker SOA was the same for prime and probe), and the early–late and late–early conditions were contextually dissimilar (because the target-flanker SOA was not the same for prime and probe). The temporal separation of target and flanker may allow an early selection of targets in Neill's (1997) paradigm. In fact, we replicated the contextual similarity effect on repetition priming in the two earliest bins of the RT distribution, in which the effect of an early selection of target should be best captured.

However, our finding that contextual similarity has an effect on repetition priming only in the earlier bins contradicts the idea that repetition priming is modulated by episodic retrieval, which would predict that the contextual similarity effect be stronger in the later bins than in the earlier bins. That is, when the algorithmic process is sped up (i.e., what happened in the fastest RT bins), episodic retrieval should play less role in participants' responses and hence the effect of contextual similarity should be minimal. To explain the substantial contextual similarity effect in early bins without attributing it to episodic retrieval, one could argue that persisting activation might be stronger at the early stage of target-repetition probe processing due to an 100% overlap of the feature (font/color/size) and identity (the target letter) between prime and probe in the same-context condition, but not in different-context condition. On

the other hand, previous repetition priming studies (e.g., Bodner & Masson, 2001) reported that repetition priming effect could be boosted by TRP. Bodner and Masson (2001) argued that the encoded episode of the prime event is a resource that can be recruited to aid in subsequent word identification and a high TRP encourages this kind of recruitment. Because our Experiment 3 was not designed to examine the effect of TRP on repetition priming, the extent to which contextual similarity and TRP modulated the repetition priming differentially at the level of RT distributions awaits further investigation.

In sum, given the methodological differences between the present study and Neill (1997), further investigation should be done to determine (a) which difference is critical in contributing to the discrepancy in the findings between the two studies and (b) the underlying mechanisms that contribute to the contextual similarity effect on repetition priming. Yet at least, the present findings that contextual similarity exerts an early influence on repetition priming, but a late influence on negative priming support Neill's (1997) claim that repetition priming and negative priming are operated by two different mechanisms.[3]

The Discrepancy Between the Current Findings and the Gratton Effect

Before concluding, it is worth noting the apparent discrepancy between the effect of contextual similarity on negative priming and the literature regarding the Gratton effect. In a flanker task, the flanker effect refers to the slowdown of RTs (or the increase of error rates) when the target and flanker are incongruent (e.g., ABA) relative to when they are congruent (e.g., AAA). Gratton, Coles, and Donchin (1992) found the flanker effect to be smaller in the Nth trial after an incongruent Nth − 1 trial than after a congruent Nth − 1 trial—that is, the Gratton effect. According to Botvinick, Braver, Barch, Carter, and Cohen's (2001) conflict monitoring theory, an incongruent Nth − 1 trial produces more response conflict than a congruent Nth − 1 trial does. This monitored conflict is used to sharpen the attentional focus on the Nth trial, which leads to a better exclusion of the flankers and thus to a smaller flanker effect. On the other hand, other researchers

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[3] Given that (a) there is a relation between repetition priming and semantic priming and (b) activation arising from repetition priming versus from semantic priming may behave similarly, one could argue that the patterns of repetition priming and negative priming would be very similar at the level of RT bins. The current results clearly showed otherwise. However, the assumptions of this argument are worth discussing. First, even though we assume the effects of spreading activation and inhibition and episodic retrieval at the level of RT bins to be similar for semantic priming and negative priming, this does not necessarily entail that the mechanisms underlying these two priming effects must be identical. Second, to our knowledge, it is not clear if there is indeed a relation between semantic priming and repetition priming. Third, we used letters that had minimal semantic content as our stimuli and repeated prime and probe, thus being highly different from those used in the semantic priming and repetition priming studies, where the prime and target are often words and they are not repeated throughout the experiment. Hence, before speculating the relationships among semantic priming, repetition priming, and negative priming based on the current study, which was not designed for that purpose, we consider that future studies should replicate our current findings using word stimuli and directly compare the semantic priming and repetition priming effects for these stimuli within the same experiment.

(e.g., U. Mayr, Awh, & Laurey, 2003) argued that the Gratton effect could be due to the priming of repeated features/responses. The response was faster in the incongruent Nth trial followed by incongruent Nth − 1 trial than by congruent Nth − 1 trial because the stimulus–stimulus and stimulus–response representations (which are bound in the event file, cf. Hommel, 2004) in the Nth − 1 trial was repeated in the Nth trial (see Verguts & Notebaert, 2009, for a review). Given that the repetition of the congruent–incongruent features across the Nth − 1 and Nth trials could reduce the flanker effect (i.e., Gartton effect), one may be puzzled by the boost in negative priming when the prime and probe are contextually similar versus dissimilar, as demonstrated in Experiment 2 (and previous studies in negative priming; e.g., Fox & de Fockert, 1998). However, it should be noted that the feature similarity in the Gratton-effect studies may not be functionally the same as the contextual similarity in negative-priming studies. Although the repeated features on the Nth trials are relevant to the participants' response in the task that produces the Gratton effect, the prime-probe contextual similarity does not hint the response that participant should make in the negative priming paradigm. Finally, the paradigms used to examine these two effects are highly different: Whereas the paradigm yielding the Gratton effect includes both congruent and incongruent target-flanker trials, those yielding negative priming include only incongruent trials, with "congruency" being manipulated across prime and probe, rather than within prime/probe. Future research should examine the effects of feature repetition and contextual similarity in the flanker task to shed light on the relationship between the negative priming and Gratton effect.

Conclusions

To our knowledge, this is the first study that examined the characteristics of the RT distribution for negative priming and repetition priming effects in a flanker paradigm. We obtained evidence that suggests the contribution of both selective inhibition and episodic retrieval on negative priming, supporting general dual-mechanism accounts (e.g., Kane et al., 1997; Neill, 2007; Tipper, 2001). Whereas the effect of selective inhibition was quite constant across RT bins (i.e., regardless of participants' overall RTs), the effect of episodic retrieval, which operates when conditions encourage the use of this strategy, increased across bins of the RT distribution. This pattern suggests that episodic retrieval and selective inhibition work independently, rather than exclusively, to produce negative priming. As noted by Tipper (2001), selective inhibition accounts focus on variables such as processing load or behavioral goals that influence the response selection process, whereas episodic retrieval theories focus on variables such as contextual similarity or temporal discriminability that influence the retrieval process. In the current study, variables that modulate episodic retrieval, such as contextual similarity, were manipulated, so it would be interesting in future research to examine how variables that modulate selective inhibition (e.g., number of distractors or distractor proximity) could affect the characteristics of the RT distribution.

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