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Evidence for Episodic Retrieval of Inadequate Prime Responses in Auditory Negative Priming

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Four experiments are reported in which the mechanisms underlying auditory negative priming were investigated. In Experiments 1A and 1B, preprime-prime intervals and prime-probe intervals were manipulated. The ratio between the 2 intervals determined the size of the negative priming effect. Results are compatible with the episodic retrieval account, according to which the retrieval of inappropriate response information associated with the previous distractor slows down responding when that stimulus becomes the target. Experiment 2 tested a variant of this account, according to which the retrieval of the prime response rather than the retrieval of nonresponse information interferes with responding. Consistent with this variant, participants erroneously responded with the prime response more frequently in the ignored repetition condition than in the control condition. Experiment 3 replicated this finding and generalized it to the visual modality. The authors conclude that the retrieval of the inappropriate prime response is a determinant of the negative priming phenomenon.

Keywords: negative priming, episodic retrieval, preprime-prime interval, prime-response retrieval

Reactions to recently ignored stimuli are slowed down or more error prone when compared with reactions to control stimuli. This so-called *negative priming phenomenon* is very well established in the field of visual selective attention (for reviews, see Fox, 1995; May, Kane, & Hasher, 1995; Neill, Valdes, & Terry, 1995; Tipper, 2001). Within the last decade, this phenomenon has also been demonstrated repeatedly in the auditory domain. For instance, participants in the study of Buchner and Steffens (2001) heard pairs of tones displayed dichotically via headphones. A click indicated the ear that had to be attended. Participants were asked to classify, by an appropriate keypress, the attended tone as originating from a "wind instrument" or a "string instrument." Each trial consisted of a prime pair and a probe pair of stimuli. The primary contrast was between trials in which the ignored prime was repeated as the attended probe (henceforth, ignored repetition trials) and between parallel trials with four different stimuli (the control trials). Manual responding to the attended probe was slower on ignored repetition than on control trials. Similarly, Banks, Roberts, and Ciranni (1995) reported negative priming for spoken words in a shadowing task, and Mondor, Leboe, and Leboe (2005) found a negative priming effect for artificial sounds in a four-alternative identification task (see also Buchner & Mayr, 2004; Buchner, Zabal, & Mayr, 2003; Mayr, Niedeggen, Buchner, & Pietrowsky, 2003).

The various theories of the negative priming effect have been tested mainly in the visual domain, but they may also explain auditory negative priming. According to the distractor inhibition account (Tipper, 1985; see also Dalrymple-Alford & Budayr, 1966; Houghton & Tipper, 1994; Neill, 1977), negative priming reflects the operation of an attentional selection mechanism that prevents access of ignored objects to overt responses by suppressing competing distractor input. This mechanism enables more efficient responding to the current target, but causes a delay in responding when the previously ignored (and, hence, inhibited) distractor becomes the new target.[1] Neill and colleagues (Neill & Valdes, 1992; Neill, Valdes, Terry, & Gorfein, 1992) later argued that a probe target that is identical to the prime distractor—which is the case on ignored repetition but not on control trials—may serve as a retrieval cue to the prime episode. Part of the retrieved prime episode may be some sort of "do-not-respond" information associated with the prime distractor. This nonresponse information may lead to time-consuming conflicts with the need to respond to the probe target, which would also explain the performance decreases in the ignored repetition relative to the control condition. Note that distractor inhibition and episodic retrieval theories are not mutually exclusive. Both inhibitory and retrieval processes

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[1] Note that all of our comments and arguments with respect to an inhibitory theory refer to a conceptualization of inhibition as proposed by Tipper (1985) or Houghton and Tipper (1994). We do not refer to an inhibition model as proposed by Tipper (2001) in which appropriate retrieval cues are thought to reactivate the inhibitory attentional network state from the time of prime processing. This latter account can be regarded as a reconciliation between inhibitory and episodic retrieval theories including aspects of both theories. Therefore, experimental differentiation between this account and an episodic retrieval theory becomes almost impossible.

could be involved in the emergence of negative priming (Chao & Yeh, 2004; Kane, May, Hasher, & Rahhal, 1997; Tipper, 2001).

For the auditory modality considered here, there is direct evidence of an inhibitory component. Buchner and Steffens (2001) required a manual response to the prime, as in a typical negative priming experiment. For the probe, however, participants simply judged which of two tones had occurred earlier. Ignoring a tone during the prime presentation resulted in a reduced probability of accepting that tone as antecedent on the subsequent probe presentation relative to the control condition in which the same tone had not occurred as the ignored prime. This finding is consistent with the distractor inhibition account according to which inhibitory processes suppress the competing distractor inputs, which, in turn, lead to less efficient signal processing when a previously ignored stimulus is presented again (Houghton & Tipper, 1994; Tipper, 1985). In contrast, the retrieval of the nonresponse information encoded with the ignored prime can only conflict with the requirement to respond when the same stimulus is subsequently presented as the attended probe. It therefore cannot affect perceptual judgments such as those of the temporal order of auditory signals.

Nevertheless, this finding does not exclude the retrieval of inappropriate response information from prior processing episodes (Neill & Valdes, 1992; Neill et al., 1995, 1992) as a factor for the classical, response-time variety of the auditory negative priming phenomenon. In fact, none of the auditory negative priming findings mentioned before excludes the possibility that episodic retrieval is involved in auditory negative priming. However, there is also no direct evidence in favor of this mechanism in the auditory domain. One purpose of this article is to provide just this evidence. Another purpose is to show that episodic retrieval can operate in more than one way.[2]

Strong empirical evidence favoring episodic retrieval in the visual modality comes from studies in which the interval between a participant's response and the presentation of the next stimulus (response-to-stimulus interval; RSI) was manipulated. These studies were originally designed to explore the persistence of the negative priming effect over time. The results appeared inconsistent at first as some experiments showed decreasing negative priming with increasing RSI within as little as 2,020-ms RSI (Neill & Valdes, 1992; Neill & Westberry, 1987), whereas others revealed no effects of RSIs up to 6,600 ms (Hasher, Stoltzfus, Zacks, & Rypma, 1991; Tipper, Weaver, Cameron, Brehaut, & Bastedo, 1991). Neill and Valdes (1992) suggested that these empirical inconsistencies could be resolved by focusing on the relation of the prime-probe RSI to the same interval but for the preceding trial (henceforth, preprime-prime interval). In continuous priming tasks in which each probe trial serves as the prime for the next probe trial, a long preprime-prime RSI is sometimes followed by a short prime-probe RSI, and a short preprime-prime RSI is sometimes followed by a long prime-probe RSI. In the former case, retrieval of the prime distractor in ignored repetition trials should be likely because it is temporally close to the probe, whereas the preprime is distant. In the latter case, in contrast, the prime is close to the preprime so that the chances of confusing prime and preprime episodes increase, and thus the chances of retrieving the prime episode decrease. A negative priming effect results from retrieving the nonresponse information associated with the prime distractor in ignored repetition trials. Therefore, the overall size of the negative priming effect should be a function of the probability of successful retrieval of the prime episode, which is why a long preprime-prime RSI in combination with a short prime-probe RSI should lead to more overall negative priming than the reverse arrangement. This is what Neill et al. (1992) found. Note that a distractor inhibition account cannot explain such a pattern of results, because there is no reason why the preprime-prime RSI should be relevant for the strength of prime distractor inhibition.

In contrast, when RSIs are manipulated between subjects or in a blocked within-subjects design, the retrieval probability of the prime stays basically constant, which is why the size of the negative priming effect should be independent of the size of the RSI, provided there is no trace decay within the levels of RSIs used (Hasher et al., 1991; Tipper et al., 1991).

The aim of the present set of experiments is to investigate whether a retrieval-based mechanism is a factor underlying the negative priming phenomenon in the auditory domain. This is done in two steps. First, we demonstrate that the relative sizes of the preprime-prime and the prime-probe RSIs have exactly the effects on the size of the auditory negative priming effect as predicted by the episodic retrieval account (Experiments 1a and 1b). Second, we analyze more closely the variant of the episodic retrieval theory as formulated by Neill and colleagues (Neill & Valdes, 1992; Neill et al., 1992), and we suggest another variant of this theory, which we then test in Experiments 2 and 3.

Experiment 1A

In Experiments 1A and 1B, the task developed by Buchner and Steffens (2001) was used. Participants received prime-probe pairs of auditory stimuli. They classified the prime and probe targets as either wind or string instruments. However, Buchner and Steffens's prime-probe procedure was extended by adding a preprime pair of stimuli. The preprime-prime RSIs and the prime-probe RSIs were manipulated as follows: In Experiment 1a, the preprime-prime RSI and the prime-probe RSI could be either 500 ms and 5,000 ms, respectively, or they could be 5,000 ms and 500 ms. The episodic retrieval theory predicts smaller negative priming for the former than for the latter RSI combination. Experiment 1b was identical to Experiment 1a with the exception that the preprime-prime RSI and the prime-probe RSI were both either 5,000 ms or 500 ms. For this situation, the episodic retrieval theory predicts no difference in the size of the negative priming effect.

Method

Participants. Participants were 86 adults, 53 of whom were women. They ranged in age from 19 to 48 years ($M = 24$). All of the participants were tested individually and were paid for their participation.

Materials. The stimuli were again six digitized tones, which could be identified and categorized easily and unambiguously as "musical instruments" (piano, guitar, and clarinet) or "animal sounds" (duck, lamb, and frog). Each tone was 200 ms long, complete with attack and decay.

[2] "Feature mismatch" (Park & Kanwisher, 1994) and "temporal discrimination" (Milliken, Joordens, Merikle, & Seiffert, 1998) are alternative explanations of the negative priming phenomenon, but we will not consider these because they cannot explain auditory negative priming in the paradigm that we use here (for details, see Buchner & Mayr, 2004; Buchner & Steffens, 2001; Buchner et al., 2003).

Participants heard the tones over earphones that were fitted with noise-insulation covers and plugged directly into an Apple iMac computer.

A 20-ms metronome click indicated the ear (left or right) at which the to-be-attended tone would be presented. Participants reacted to the tones by pressing the "wind instrument" (arrow up) or "string instrument" (arrow down) key on the computer keyboard. These keys were aligned sagittally so as to avoid spatial compatibility effects between the tones' location and the required response.

Each experimental trial consisted of a preprime, a prime, and a probe display. Each display consisted of a target presented to one ear and a simultaneously presented distractor at the other ear. Attended and ignored primes were always from different response categories, because earlier experiments with a similar paradigm had shown negative priming only for this target-distractor configuration (Buchner et al., 2003). In the same manner, targets and distractors in the preprime as well as in the probe were from different categories. The ignored repetition and control trials were constructed to be parallel, as is illustrated in Table 1. First, an ignored repetition trial was constructed by randomly combining prime and probe targets and distractors with the restriction on the response categories just described and the additional restriction that the ignored prime had to be identical to the attended probe. Next, a control trial was constructed by replacing the ignored prime with a different stimulus but from the same category. In other words, the response category of the ignored prime was always the same on an ignored repetition and its corresponding control trial. This implies that any performance differences between control and ignored repetition trials must be due to the stimulus identity and cannot be due to the response category associated with it. Furthermore, the probe stimulus pair was identical for an ignored repetition and its matching control trial, thus enabling an unequivocal comparison of the probe reactions.

Subsequently, a preprime pair of stimuli was added to each prime-probe pair such that there was no relation between the preprime stimuli on the one side and the prime and probe stimuli on the other. The left half of Table 1 illustrates that two types of preprimes were possible, depending on whether the preprime and prime target required the same response (upper left quadrant of Table 1) or different responses (lower left quadrant of Table 1).

With only ignored repetition and control trials, the required probe response always would have been different from the prime response and thus would have been perfectly predictable. Therefore, filler trials were added in which the required prime and probe responses were the same. The structure of the filler trials is illustrated in the right half of Table 1. Filler trials of Type I were created by exchanging, in the control trials, the to-be-attended and the to-be-ignored primes. Filler trials of Type II were created by exchanging, in the filler trials of Type I, the to-be-attended primes and the to-be-ignored preprimes (upper right quadrant of Table 1) or the to-be-attended primes and the to-be-attended preprimes (lower right quadrant of Table 1).

The resulting trial set had a number of desirable properties. Across ignored repetition, control, and filler trials it was not possible to predict the prime response from the preprime response or the probe response from the prime response, the preprime response, or a combination of both. Also, all of the sounds were presented equally often, both within and across all trial types, as to-be-attended targets and as distractors. Finally, within the restriction that the to-be-attended and the to-be-ignored tones always were from different categories, all pairs of tones were presented equally often both within and across all trial types.

Using all possible combinations of stimuli results in 144 different types of trials within each trial type (ignored repetition, control, filler Type I, filler Type II). In an attempt to keep the experiment within a reasonable duration of approximately one hour, 240 of these trials were selected in the following way. First, separately for each participant, one particular ignored repetition trial was selected randomly from the entire set of ignored repetition trials, with the restriction that in the end there had to be an equal number of ignored repetition trials of the two types illustrated in the upper and lower left quadrants of Table 1. Next, it was randomly determined whether the preprime-prime and the prime-probe RSIs were 500 ms and 5,000 ms or whether they were 5,000 ms and 500 ms, respectively, with the restriction that each of these two RSI combinations had to be used for an equal number of ignored repetition trials for each participant. Subsequently, the control, filler Type I, and filler Type II trials that matched the selected ignored repetition trial were selected, and the same RSI combination was assigned to these trials. In that way, a set of 240 trials, 60 of each trial type, was selected for the entire experiment. The sequence of trials within the experiment was random.

On each trial, the presentation side of the preprime target (left, right) was determined randomly with the restriction that, at the end of the experiment, each location had to be used an equal number of times for a to-be-attended preprime. The prime target was presented to the other ear, and the probe target was again presented to the same ear as the preprime target. In this way, the ignored primes and the attended probes were always presented in

Table 1
Examples of Stimulus Configurations and Required Responses (in quotes) Used in Experiments 1A and 1B

	Ignored repetition		Control		Filler Type 1		Filler Type 2	
Condition	Attended ear	Ignored ear	Attended ear	Ignored ear	Attended ear	Ignored ear	Attended ear	Ignored ear
				Experiment 1A				
Preprime	Duck "animal"	Clarinet	Duck "animal"	Clarinet	Duck "animal"	Clarinet	Duck "animal"	Piano
Prime	Frog "animal"	Guitar	Frog "animal"	Piano	Piano "instrument"	Frog	Clarinet "instrument"	Frog
Probe	Guitar "instrument"	Lamb	Guitar "instrument"	Lamb	Guitar "instrument"	Lamb	Guitar "instrument"	Lamb
				Experiment 1B				
Preprime	Clarinet "instrument"	Duck	Clarinet "instrument"	Duck	Clarinet "instrument"	Duck	Piano "instrument"	Duck
Prime	Frog "animal"	Guitar	Frog "animal"	Piano	Piano "instrument"	Frog	Clarinet "instrument"	Frog
Probe	Guitar "instrument"	Lamb	Guitar "instrument"	Lamb	Guitar "instrument"	Lamb	Guitar "instrument"	Lamb

the same sound-identity–spatial-location combination. For consistency of the experimental procedure, parallel locations were used for the matching ignored repetition, control, and filler trials.

Procedure. During training, participants first heard and reacted to 12 single tones (two presentations of each target stimulus), the presentation side of which was indicated by the 20-ms metronome click. The click–target interval was 250 ms throughout the experiment. The targets had to be classified as “animal” or “instrument” as quickly as possible without making errors by pressing the appropriate keys on the keyboard. Next, participants reacted to 16 preprime-prime-probe training trials that were similar to those of the experiment proper, with the exception that the preprime-prime and the prime-probe RSIs (500 ms or 5,000 ms) as well as the to-be-attended targets and the to-be-ignored distractors were selected randomly. The experiment began if 80% or more of the responses were correct. Otherwise, participants were given a choice to quit the experiment or to start again with the training phase.

Each of the 240 experimental trials began with the 20-ms metronome click, followed by a 250-ms click–target interval and the preprime pair of tones. Depending on the RSI condition, the preprime-prime RSI was 500 or 5,000 ms, after which the prime trial began. The succession of events on the prime trial was identical to that of the preprime trial. Again, depending on the experimental condition, the prime-probe RSI was 5,000 ms or 500 ms, after which the probe trial began. The succession of events on the probe trial was identical to that of the prime trial.

Prime or probe reactions faster than 100 ms and slower than 4,000 ms were counted as invalid, and the entire trial was repeated after a brief warning.[3] After each preprime-prime-probe trial, participants received feedback about the correctness of their preprime, prime, and probe reactions. They initiated the next trial at their own discretion. After every 10th trial, participants received a summary feedback about both their error percentage and their average reaction time, but correctness was emphasized. After the final trial, all of the participants were informed about the purpose of the experiment.

Design. The experiment comprised a 2 × 2 design with trial type (ignored repetition vs. control) and preprime-prime-probe RSI (500 ms and 5,000 ms vs. 5,000 ms and 500 ms as the preprime-prime and the prime-probe intervals, respectively) as within-subject variables. The primary dependent variable was participants’ average reaction time, but error rates were also analyzed.

An a priori power analysis showed that in order to detect effects of size $f = 0.175$ (between “small” and “medium” effects as defined by Cohen, 1988), given a population correlation of $\rho = .7$ between the ignored repetition and control reaction-time variables or between the two levels of the RSI condition variable (conservatively estimated from pilot data; this corresponds to assuming $\eta^2 = .17$ as the population effect size) and desired levels of $\alpha = \beta = .05$, data had to be collected from a sample of at least $N = 66$ participants.[4] We were able to collect data from $N = 86$ participants so that the power was actually even larger than what we had planned for $(1 - \beta = .99)$. The level of alpha was maintained at .05 for all statistical decisions, and partial η^2 is reported as an effect size measure. This applies to all of the experiments reported in this article.

Results

Probe reaction times were evaluated only for trials in which both the prime and the probe reactions were correct.[5] Pure guessing would therefore result in an error rate of .75, which is well above the observed error rates (although these were relatively high). The means of participants’ average reaction times and the corresponding error rates are presented in the upper and lower panels of Figure 1, respectively.

A 2 × 2 multivariate analysis of variance (MANOVA) of the reaction-time data with trial type (ignored repetition vs. control) and preprime-prime-probe RSI (500 ms and 5,000 ms vs. 5,000 ms and 500 ms, respectively) as within-subject variables showed significant main effects of trial type, $F(1, 85) = 61.46$, $p < .001$, $\eta^2 = .42$, and of preprime-prime-probe RSI, $F(1, 85) = 37.13$, $p < .001$, $\eta^2 = .30$. It is important that the interaction between these variables was also significant, $F(1, 85) = 12.26$, $p < .001$, $\eta^2 = .13$, confirming that the negative priming effect was indeed larger after the short than after the long prime-probe RSI. Negative priming was significant at all levels of the preprime-prime-probe RSI variable, as is shown by follow-up tests using the Bonferroni–Holm method of protecting against α-error accumulation, F(1,

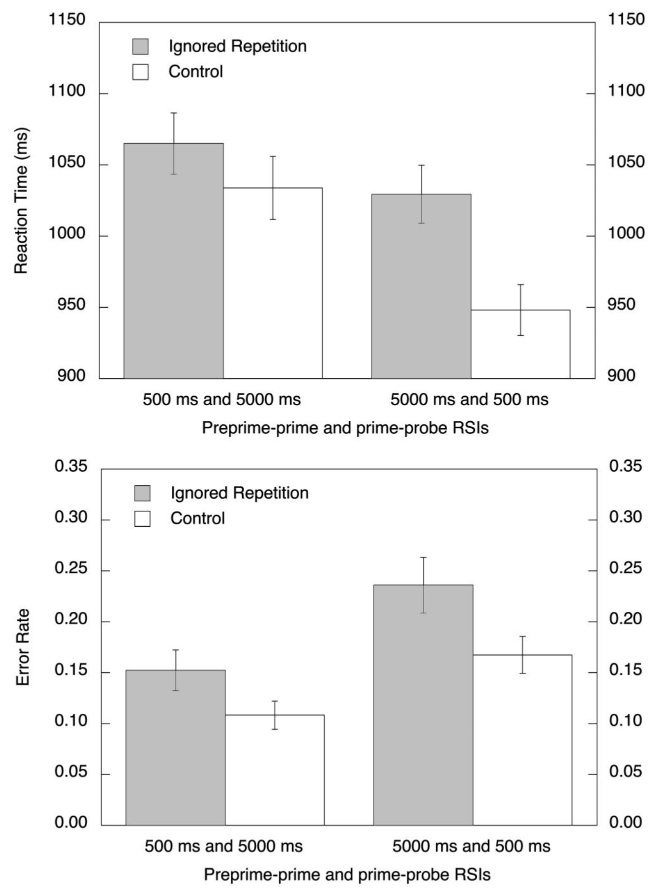

Figure 1. Reaction times (upper panel) and error rates (lower panel) as a function of preprime-prime and prime-probe response-to-stimulus intervals (RSIs) and trial type (Experiment 1A). The error bars depict the standard errors of the means.

[3] Such errors were extremely infrequent (rates less than .01) and the inclusion of repeated trials did not change any of the statistical conclusions in any of the experiments reported in this article.

[4] The power calculations were conducted using the G · Power program (Buchner, Faul, & Erdfelder, 1996; Erdfelder, Faul, & Buchner, 1996).

[5] Note that the analysis included a small number of trials in which preprime errors were made. This was uncritical because preprime error rates were distributed evenly across ignored repetition and control trials. This has to be so because ignored repetition and control trials did not differ with respect to preprime configuration. Excluding the few trials with preprime errors would not change any of our statistical conclusions.

85) = 10.17, p = .002, η^2 = .11, for the 500-ms and 5,000-ms preprime-prime-probe RSIs and $F(1, 85) = 59.53$, $p < .001$, η^2 = .41 for the 5,000 ms and 500 ms preprime-prime-probe RSIs. An analogous analysis but for the error data showed a similar pattern in that there were significant main effects of trial type, $F(1, 85)$ = 11.21, p = .001, η^2 = .12, and of preprime-prime-probe RSI, F(1, 85) = 19.30, $p < .001$, η^2 = .19, but no interaction between these variables, $F(1, 85) = 0.86$, p = .36, η^2 = .01.

Experiment 1B

Method

Participants. Participants were 98 adults, 73 of whom were women. They ranged in age from 18 to 40 years (M = 22). All of the participants were tested individually and were paid for their participation.

Materials. The stimuli were the same as those of Experiment 1A. However, preprime-prime and the prime-probe RSIs could either both be 5,000 ms or they could both be 500 ms. Each of these two RSI combinations had to be used for an equal number of trials of each type for each participant.

Procedure. The procedure was the same as that of Experiment 1A, with the exception that the preprime-prime RSI was 500 or 5,000 ms, and the prime-probe RSI was 500 ms or 5,000 ms.

Design. The experiment comprised a 2 × 2 design with trial type (ignored repetition vs. control) and preprime-prime-probe RSI (5,000 ms and 5,000 ms vs. 500 ms and 500 ms as the preprime-prime and the prime-probe intervals, respectively) as within-subject variables. The primary dependent variable was participants' average reaction time, but error rates were also analyzed.

Given the effect size of the critical interaction in Experiment 1A, we decided that we wanted to be able to detect effects of at least η^2 = .13 (equivalent to f = 0.15 and ρ = .7). An a priori power analysis showed that given this effect size and desired levels of $\alpha = \beta = .05$, data had to be collected from a sample of at least N = 89 participants. We were able to collect data from N = 98 participants so that the power was actually even larger than what we had planned for ($1 - \beta = .97$).

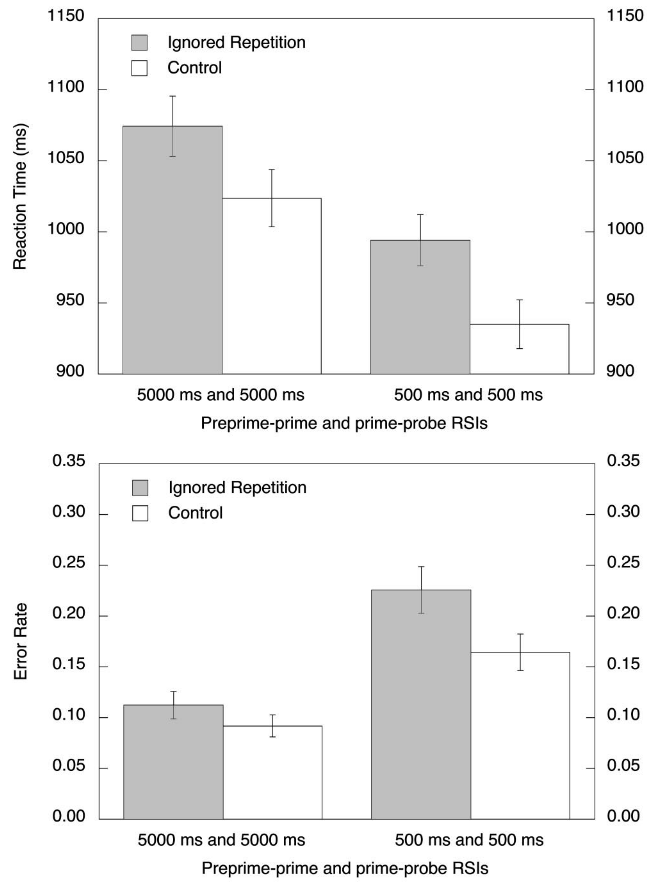

Figure 2. Reaction times (upper panel) and error rates (lower panel) as a function of preprime-prime and prime-probe response-to-stimulus intervals (RSIs) and trial type (Experiment 1B). The error bars depict the standard errors of the means.

Results

Probe reaction times were evaluated only for trials in which both the prime and the probe reactions were correct. The means of participants' average reaction times and the corresponding error rates are presented in the upper and lower panels of Figure 2, respectively.

A 2 × 2 MANOVA of the reaction time data with trial type (ignored repetition vs. control) and preprime-prime-probe RSI (5,000 ms and 5,000 ms vs. 500 ms and 500 ms) as within-subject variables showed significant main effects of trial type, $F(1, 97)$ = 113.49, $p < .001$, η^2 = .54, and of preprime-prime-probe RSI, $F(1, 97) = 62.47$, $p < .001$, η^2 = .39. It is important that the interaction between these variables was not significant, $F(1, 97)$ = 0.46, p = .50, $\eta^2 < .01$, showing that the negative priming effect did not depend on the length of the RSI. Negative priming was significant at all levels of the preprime-prime-probe RSI variable, as is shown by follow-up tests using the Bonferroni–Holm method of protecting against α-error accumulation, $F(1, 97) = 39.16$, $p <$ .001, η^2 = .29, for the 5,000-ms and 5,000-ms preprime-prime-probe RSIs and $F(1, 97) = 53.49$, $p < .001$, η^2 = .36 for the 500-ms and 500-ms preprime-prime-probe RSIs. An analogous analysis but for the error data showed essentially the same in that there were significant main effects of trial type, $F(1, 97) = 11.02$, p = .001, η^2 = .10, and of preprime-prime-probe RSI, $F(1, 97)$ = 29.33, $p < .001$, η^2 = .23, and again no interaction between these variables, $F(1, 97) = 2.85$, p = .10, η^2 = .03.

Discussion

The results of Experiments 1A and 1B show that the absolute duration of the prime-probe interval is irrelevant for the size of the negative priming effect, whereas the relative size of this interval in comparison to the preprime-prime interval is crucial. The distractor inhibition account cannot explain the results of Experiments 1A and 1B because there is no plausible reason why the duration of the interval before the prime should be of any importance for the strength of the prime distractor inhibition.[6] In contrast, it follows

[6] A reviewer suggested that a potential inhibitory mechanism activated during the time of the prime display might depend on the preprime-prime interval length. Following his idea, inhibition after a short preprime-prime interval should be less efficient than after a long preprime-prime interval possibly due to a refractory delay of inhibitory processes that had already been required in the preceding preprime display. A less efficient inhibitory mechanism at the time of the prime display should be observable in the

from the episodic retrieval account that the probability with which the prime episode can be retrieved determines the probability with which information from that prime episode can interfere with responding to the probe target. Successful retrieval of the prime episode, in turn, depends on the trace discriminability of this episode relative to the preceding episode. The results of Experiments 1A and 1B replicate those found in the visual modality (Neill et al., 1992), and they extend these findings to the auditory modality.

Episodic Retrieval of Prime Responses

Given this state of affairs, the next logical step concerns the question of exactly what the "inappropriate" information is that interferes with responding to the probe. The original episodic retrieval theory (Neill & Valdes, 1992) assumes that the retrieved prime distractor is associated with some form of nonresponse information. When retrieved, this nonresponse information may conflict with the requirement to respond to the same stimulus when it appears as the probe target. The conflict takes time to resolve.

Although this is a reasonable explanation of the negative priming phenomenon, it is not the only one that is possible within the episodic retrieval account. Alternatively, the response associated with the prime target could be retrieved in ignored repetition trials. When retrieved, this response would be inappropriate and lead to a conflict when responding to the probe target. For instance, in Experiments 1A and 1B, the correct prime and probe responses always differed in category (or else negative priming cannot be observed; see Buchner et al., 2003). Similarly, in standard negative priming tasks in which participants need to name or otherwise identity (features of) the targets, the probe response is different from the prime response (cf. Fox, 1995; May et al., 1995; Neill et al., 1995; Tipper, 2001). If, on ignored repetition trials, the probe target cued the prime response together with the prime episode, then this response would conflict with the probe response. Negative priming should result. Experiments 2 and 3 were designed to test this variant of the episodic retrieval account.

Obviously, both the original nonresponse and the prime-response variant of the episodic retrieval theory can explain the reaction time pattern of the present Experiments 1A and 1B. However, the prime-response variant allows deriving a unique prediction about the relative frequencies of the different probe error types. Simply put, if the prime-response variant has any validity, then incorrect repetitions of the prime response as a reaction to the probe target should be overrepresented in the error rates of ignored repetition trials. In order to test this prediction we transformed the two-alternative categorization task used in Experiments 1A and 1B into a four-alternative identification task in which every stimulus required a unique response.

The left side of Table 2 depicts an example of an ignored repetition and a corresponding control trial configuration and their respective responses. The probe display is identical for both trial types, as is the required probe response ("piano") and the preceding prime response ("frog"). The only difference is that the prime distractor is the piano in the ignored repetition condition and the bell in the control condition. The prime-response retrieval variant of the episodic retrieval account predicts that the repetition of piano in the ignored repetition condition triggers the retrieval of the prime display and the prime response ("frog"), which conflicts with the correct probe response ("piano"). Nothing is repeated in the relevant control condition, hence there is nothing to cue the retrieval of the prime response. If these assumptions were appropriate, erroneous probe responses should occur more often among the errors in the ignored repetition than in the control condition. In contrast, the nonresponse retrieval variant of the episodic retrieval account predicts that the probe target cues the retrieval of a "do-not-respond" tag associated with the previous distractor in ignored repetition trials. The resolution of the conflict of nonresponse information with the requirement to respond to the probe target should slow down responding and perhaps increase the overall error rate, but there is no reason why one should expect an increase specifically in the probability of incorrectly retrieved prime responses.

Figure 3 depicts a multinomial processing tree model (cf. Hu & Batchelder, 1994) that we used to evaluate the prime response against the nonresponse retrieval variants of the episodic retrieval account. The model represents the processing stages that we assumed to be involved in generating a probe response for both the ignored repetition (upper part of Figure 3) and the control condition (lower part of Figure 3). With probability *ci* (i.e., correct identification), participants correctly identify the probe target and respond to it without making an error. Selecting the probe target against the probe distractor is difficult. We therefore assume that if an error occurs (with probability $1 - ci$), it will predominantly be the confusion of the probe target with the probe distractor. Probe stimulus confusion occurs with the conditional probability *psc* (i.e., probe stimulus confusion) and leads to incorrect probe distractor responses.

If probe stimulus confusion does not dominate responding (with probability $1 - psc$), then, with probability *prr* (i.e., prime-response retrieval), prime-response retrieval may occur and lead to incorrect prime target responses. This is the critical stage for which prime-response retrieval and nonresponse retrieval variants of the episodic retrieval account make different predictions with respect to the processes that generate overt behavior. The probability of retrieving a prime response in the ignored repetition condition, prr_{IR}, is expected to be larger than prr_C, the probability of retrieving a prime response in the control condition if the prime-response retrieval variant, but not if only the nonresponse retrieval variant of the episodic retrieval account is correct. Thus, if the goodness-of-fit test of the restricted model assuming $prr_{IR} = prr_C$ leads to a

prime data in that reaction times after short preprime-prime intervals should be slower and more error prone than after long preprime-prime intervals. Reanalysis of the prime data in Experiments 1A and 1B showed, however, that this was not true: In both experiments, participants responded faster to the primes after short preprime-prime intervals than after long preprime-prime intervals, but participants also made more errors in primes after short preprime-prime intervals than after long preprime-prime intervals. (There were no effects of trial type or of the interaction between trial type and preprime-prime-probe RSI in the reaction times or error rates for any of the two experiments.) Note that this differential weighting of speed versus accuracy in prime responding depending on preprime-prime length cannot be responsible for the negative priming variations found in Experiments 1A and 1B: Whereas in Experiment 1A the negative priming effect was smaller after small preprime-prime intervals than after long preprime-prime intervals, the negative priming effect in Experiment 1B did not differ between the two preprime-prime interval lengths.

Table 2
Examples of Stimulus Configurations and Required Responses (in quotes) Used in Experiment 2

	Ignored repetition		Control		Attended repetition filler		Control filler	
Condition	Attended ear	Ignored ear	Attended ear	Ignored ear	Attended ear	Ignored ear	Attended ear	Ignored ear
Prime	Frog "frog"	Piano	Frog "frog"	Bell	Piano "piano"	Bell	Frog "frog"	Bell
Probe	Piano "piano"	Drum	Piano "piano"	Drum	Piano "piano"	Drum	Piano "piano"	Drum

significant misfit, then this is evidence in favor of the prime-response retrieval variant of the episodic retrieval theory. Note that in this way, this multinomial model allows us to perform statistical tests of our hypothesis directly at the level of the assumed processes rather than indirectly at the level of raw performance scores.

For completeness, if none of the processes mentioned so far dominates responding, the person inevitably reacts (with probability $1 - prr$) with the only remaining incorrect response.

Experiment 2

Method

Participants. Participants were 74 adults, 57 of whom were women. They ranged in age from 20 to 43 years ($M = 26$). All of the participants were tested individually and were paid for their participation.

Materials. The stimuli were four digitized tones (frog, piano, drum, and bell). Each tone was 300 ms long, complete with attack and decay.

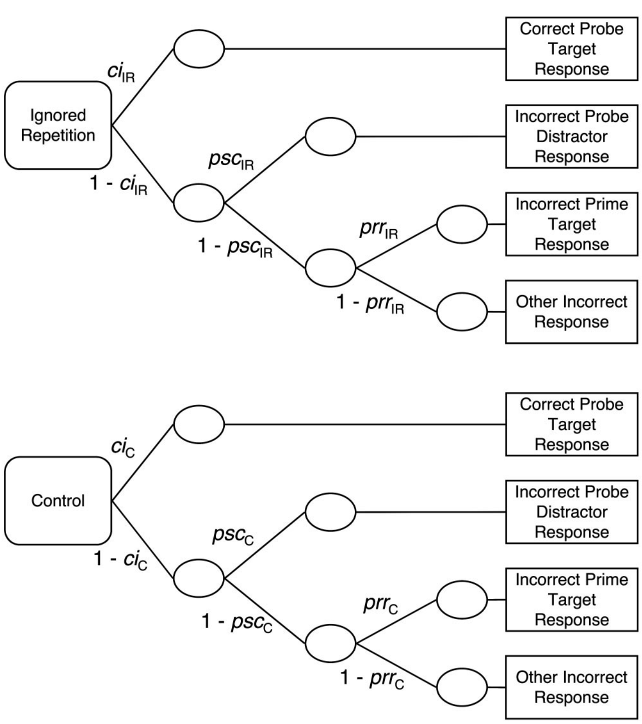

Figure 3. Multinomial processing tree model (prime-response-retrieval model) for analyzing the probe reactions in the trial type conditions Ignored Repetition (IR) and Control (C). ci = correct identification; psc = probe stimulus confusion; prr = prime-response retrieval.

Participants heard the tones over earphones that were fitted with noise-insulation covers and plugged directly into an Apple iMac computer.

A 20-ms metronome click indicated the ear (left or right) at which the to-be-attended tone would be presented. Participants reacted to the attended tone by pressing the response key assigned to the tone. Response keys were the four sagittally aligned keys, "9" (frog), "6" (piano), "3" (drum), and "." (bell), on the numeric keypad of the computer keyboard. Participants were instructed to press the two upper keys ("9" and "6") with the middle and index fingers of their right hands and the two lower keys with the middle and index fingers of their left hands. Keys were labeled with the color of the associated object (green for frog, white for piano, blue for drum, and red for bell).

Each experimental trial consisted of a prime and a probe display. Each display consisted of a target presented to one ear and a simultaneously presented distractor at the other ear. Ignored repetition trials were constructed by randomly selecting three of the four different stimuli as prime and probe targets and distractors with the restriction that the ignored prime had to be identical to the attended probe (left-most column of Table 2). Next, parallel control trials were constructed by replacing the ignored prime with the remaining stimulus (piano replaced by bell in the example displayed in Table 2). Within these two types of trials the ignored prime would have been the correct probe response on 50% of the trials, and the prime response would never have been equal to the probe response. Filler trials were constructed to compensate by randomly selecting three of the four different types of stimuli as prime and probe targets and distractors with the restriction that the attended prime had to be identical to the attended probe (labeled *attended repetition filler* in Table 2). Additional filler trials (labeled *control filler* in Table 2) were constructed by replacing, in the attended repetition filler trials, the attended prime with the remaining stimulus. For the entire set of stimuli, the correct probe reaction cannot be inferred from the prime response.

Note that an ignored repetition trial always shared its control trial with an attended repetition filler trial (see Table 2 for an example). Had we used the entire set of trials that can be generated by the algorithm just described, then every control trial would have occurred twice. In order to avoid this confound for control trials, ignored and attended repetition trials were systematically assigned to Set 1 or Set 2 with three restrictions: First, identical control trials had to belong to different sets. Second, within each trial type, the frequencies of the different tones had to be identical. Third, the frequencies of the combinations of attended and ignored tones, both within the prime and within the probe pairs, had to be equal for the different trial types. Sets 1 and 2 were completely parallel with respect to the second and the third restriction. For each set, the required prime response did not predict the required probe response. Participants were randomly assigned to Set 1 or 2.

Each set included 12 different trials of each of the four trials types (ignored repetition, control, attended repetition filler, and control filler). Each of the trials in Set 1 and 2 was duplicated, once to be presented with the attended prime on the left side and the attended probe on the right side, and once to be presented with the opposite arrangement. Consequently, each set comprised 96 unique trials. A set was presented four times, resulting in 384 experimental trials that were presented in a random sequence.

Procedure. In order to familiarize participants with the sound stimuli, drawings of a frog, a piano, a drum, and a bell were shown in the initial instructions and participants could hear the corresponding sound when clicking on the drawing with the computer mouse. Next, participants heard and reacted to pairs of tones. Preceding the sound pair, the metronome click indicated the randomly selected ear at which the to-be-attended tone would be presented. Following a 500-ms click–target interval, a randomly selected target tone was presented at that ear and a to-be-ignored distractor was presented simultaneously to the other ear. Participants reacted to the target sound by quickly pressing the corresponding key. They were given feedback about the correctness of each reaction, after which they initiated the next trial. The tone–response association was shown in the upper left corner of the display during the first 25 training trials. Participants entered the experiment proper when 60% of the preceding 50 responses had been correct. Participants who did not reach this criterion within 150 trials were given a choice to quit the experiment or to start again with the training.

Each of the 384 experimental trials began with the metronome click, followed by a 500-ms click–target interval and the prime pair of tones. After the prime reaction, a RSI of 500 ms preceded the click that cued the to-be-attended probe. The probe click (presented to the opposite of the prime target presentation side) was followed by a 500-ms click–target interval, after which the probe pair of tones was presented. After each prime-probe pair of trials, participants were given feedback about the correctness of their prime and probe reactions for 1,100 ms, followed by a 1,800-ms intertrial interval. Prime or probe reactions faster than 100 ms and slower than 3,000 ms were counted as invalid, and the entire trial was repeated after the last experimental trial. After every 10th trial, participants received a summary feedback about both their average reaction time and their error percentage. After the final trial, all of the participants were informed about the purpose of the experiment.

Design. The experiment comprised a one-factorial design with trial type (ignored repetition vs. control)[7] as the independent variable. The dependent variable of greatest interest was the probe error frequency, accumulated across participants, but participants' average reaction times and overall probe error rates were also analyzed in order to validate that the task used here generated a typical negative priming effect. Given an expected size for this effect of $f = 0.175$ and a population correlation of $\rho = .7$ between the ignored repetition and control reaction-time variables and desired levels of $\alpha = \beta = .05$, an a priori power analysis suggested a necessary sample size of $N = 66$. We were able to collect data from $N = 74$ participants, so that the power was $1 - \beta = .97$ and thus even larger than what we had planned for.

Results

Probe reaction times were evaluated only for trials in which both the prime and the probe reactions were correct. Probe errors were evaluated only if they followed a correct prime response. The means of participants' average reaction times and the overall probe error rates are presented in the upper and lower panels of Figure 4, respectively.

Reactions were significantly slower in ignored repetition trials than in control trials, $t(73) = 6.37$, $p < .001$, $\eta^2 = .36$, and participants made more errors in the ignored repetition condition than in the control condition, $t(73) = 6.38$, $p < .001$, $\eta^2 = .36$. Given this typical negative priming effect, we may now take a closer look at the types of probe errors. In the ignored repetition condition, 19.69% ($SE = 2.49\%$) of all probe errors were incorrect prime target responses, whereas only 1.3% ($SE = 0.57\%$) of all probe errors in the control condition were of this type. The absolute frequencies of the correct probe responses and of the different probe error types are displayed in Table 3.

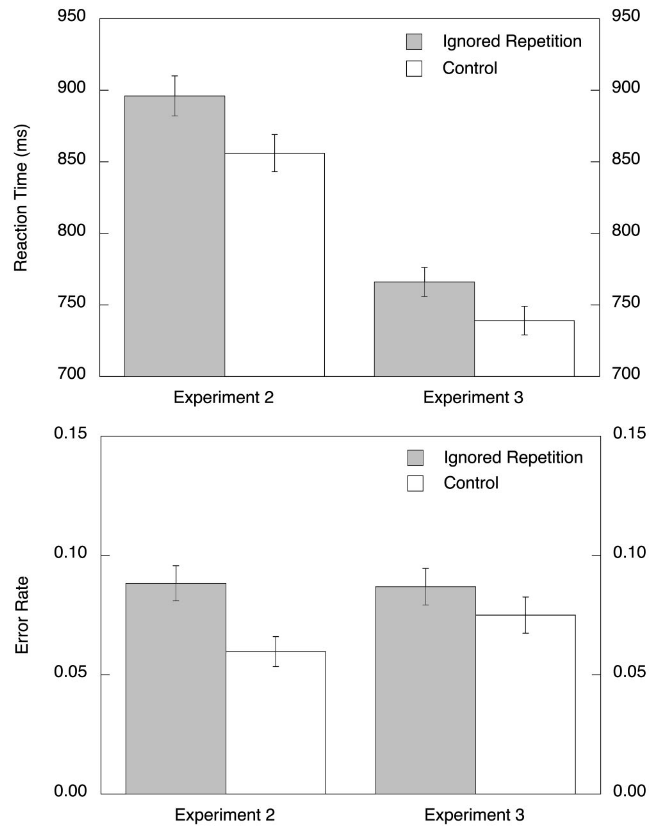

Figure 4. Reaction times (upper panel) and error rates (lower panel) as a function of trial type and material (auditory in Experiment 2 and visual in Experiment 3). The error bars depict the standard errors of the means.

The multinomial model displayed in Figure 3 has as many identifiable parameters as there are independent category probabilities to fit. Thus, the goodness-of-fit test of this model has zero degrees of freedom, and it fitted the frequency data of Experiment 2 perfectly. The parameter estimates of the critical error type (prr_{IR} and prr_C) are illustrated in Figure 5. In order to test the prime-response retrieval variant of the episodic retrieval account against the nonresponse variant, we tested the goodness-of-fit of the model with the restriction that $prr_{IR} = prr_C$, which is implied by the nonresponse variant. The restricted model did not fit the data, $G^2(1) = 57.24$, $p < .001$,[8] and had to be rejected.

[7] Attended repetition filler and control filler trials were treated as filler trials because they were irrelevant to the substantive hypotheses tested in Experiment 2. For completeness, however, note that responses were significantly faster on attended repetition filler than on control filler trials.

[8] The log-likelihood goodness-of-fit statistic G^2 is asymptotically χ^2-distributed with degrees of freedom indicated in parentheses (see Hu & Batchelder, 1994, for details). The goodness-of-fit tests were conducted using the *AppleTree* program (for details see Rothkegel, 1999).

Table 3
Accumulated Absolute Frequencies of Correct Probe Responses and of the Different Types of Probe Errors for the Ignored Repetition Condition and the Control Condition in Experiments 2 and 3

	Experiment 2		Experiment 3	
Measure	Ignored repetition	Control	Ignored repetition	Control
Correct probe target responses	6119	6311	6425	6514
Incorrect probe distractor responses	412	326	389	357
Incorrect prime target responses	111	7	53	26
Other incorrect responses[a]	52	50	149	127

[a] Ignored repetition trials: Incorrect responses using the key that was assigned to the nonpresented stimulus. Control trials: Incorrect prime distractor responses.

Discussion

Experiment 2 demonstrated a standard negative priming effect in both the reaction times and the overall probe errors. A detailed analysis of the probe errors using a multinomial modeling approach showed that the probability of prime-response retrieval given that neither a probe target identification nor a simple probe stimulus confusion had occurred was significantly larger in the ignored repetition than in the control condition. This data pattern is unexpected given the nonresponse variant of the episodic retrieval account, but it is compatible with the prime-response retrieval variant.

To this end, we have shown that prime-response retrieval is a viable explanation of auditory negative priming. In a next step we thought it important to test whether such a mechanism could also be assumed for the visual modality. Therefore, Experiment 3 was designed to extend and replicate the results of Experiment 2 using visual stimuli.

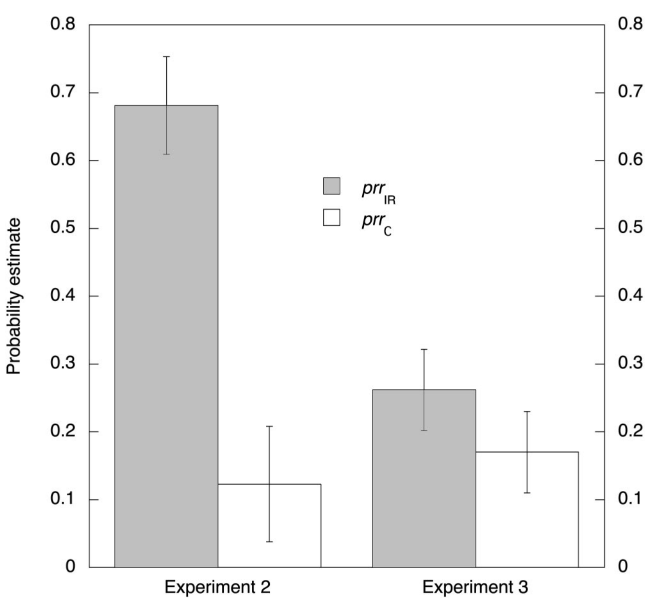

Figure 5. Probability estimates for the model parameters representing the probability of prime-response retrieval as a function of trial type (Ignored Repetition (IR) and Control (C)) and material (auditory in Experiment 2 and visual in Experiment 3). The error bars depict the .95 confidence intervals. prr_{IR} = prime response retrieval, Ignored Repetition; prr_C = prime response retrieval, Control.

Experiment 3

Method

Participants. Participants were 77 adults, 50 of whom were women. They ranged in age from 19 to 44 years (M = 26). All of the participants were tested individually. Most of them were paid for their participation.

Materials. The stimuli were four line drawings (pentacle, crescent, heart, and arrow), each of which existed both as a blue outline and as a red outline before a white background. Drawings varied in size between 52–57 mm width and 51–55 mm height (viewing angles of 4.3°–4.7° horizontally and 4.2°–4.5° vertically). Participants heard auditory feedback over earphones that were fitted with noise-insulation covers and plugged directly into an Apple iMac computer.

A centrally located blue or red square (side length = 17 mm or 1.4°) indicated the color in which the to-be-attended object would be presented. Participants reacted to the attended drawing by pressing the response key assigned to the drawing. (The experimental technique was similar to Tipper (1985) in that the target was selected on the basis of a cued color, but different from Tipper's experiments, participants did not name the attended object, but instead responded via keypress.) Response keys were the four sagitally aligned keys, "9" (pentacle), "6" (crescent), "3" (heart), and "." (arrow), on the numeric keypad. The key-to-finger assignment was identical to that of Experiment 2. Keys were labeled with the outline of the associated object in black.

Each experimental trial consisted of a prime and a probe display. Each display consisted of a target presented in one color and a simultaneously presented distractor drawing in the other color. The two line drawings were centrally aligned and overlapped each other (see Figure 6 for an example). Stimulus Sets 1 and 2 were created as in Experiment 2. Participants were assigned to Set 1 or 2. Each set included 12 different trials of each of the four trials types (ignored repetition, control, attended repetition filler, and control filler). Participants attended to the red prime and the blue probe stimuli or vice versa. In that way, the color of the ignored prime was always identical to the color of the attended probe. Each of the trials was duplicated, once to be presented with the attended prime in blue and the attended probe in red, and once to be presented with the opposite arrangement. Consequently, the two sets comprised 96 unique trials each. A set was presented four times, resulting in 384 experimental trials that were presented in a random sequence.

Procedure. The procedure was parallel to Experiment 2 with the following exceptions. A red or blue square cued the color of the target. The

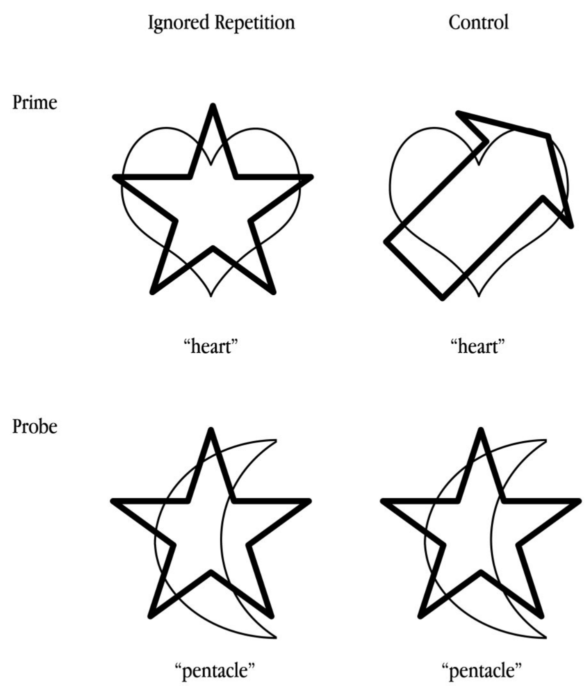

Figure 6. Examples of stimulus configurations and required responses (in quotes) used in Experiment 3. Regular print signifies red color. Bold print signifies blue color. Selection criterion was red color in the prime and blue color in the probe.

cue was presented for 150 ms. After an interval of 300 ms, a pair of line drawings was presented for 200 ms, after which 2,000 ms were allowed for the probe response. Probe presentation started 400 ms after the prime response. The time-out for the probe response was 1,300 ms. Tighter timing was used in an attempt to increase error rates. Speed emphasis in the instructions served the same purpose.

Prime and probe responses faster than 200 ms, prime responses slower than 2,000 ms, and probe responses slower than 1,300 ms were counted as invalid and the entire trial was repeated after the last experimental trial. After each trial, participants received feedback about the correctness of their prime and probe reactions for 1,100 ms. After an interval of 2,200 ms the prime cue of the next trial was presented.

After every 10th trial, participants received a summary feedback about both their average reaction time and their error percentage. After the final trial, all of the participants were informed about the purpose of the experiment.

Design. The design was identical to that of Experiment 2. The same was true for the a priori power considerations.

Results

Probe reaction times were evaluated only for trials in which both the prime and the probe reactions were correct. For the overall probe error analysis, probe errors were evaluated only if they followed a correct prime response. The means of participants' average reaction times and the probe error rates are presented in the upper and lower panels of Figure 4, respectively.

Reactions were significantly slower in ignored repetition trials than in control trials, $t(76) = 8.84$, $p < .001$, $\eta^2 = .50$, and participants made more errors in the ignored repetition condition than in the control condition, $t(76) = 2.71$, $p = .008$, $\eta^2 = .09$. Given this typical negative priming effect, we may now take a closer look at the types of probe errors. In the ignored repetition condition, 9.02% ($SE = 1.68\%$) of all probe errors were incorrect prime target responses, whereas only 6.56% ($SE = 2.05\%$) of all probe errors in the control condition were of this type. The absolute frequencies of the correct probe responses and of the different probe error types are displayed in Table 3.

As with Experiment 2, the multinomial model displayed in Figure 3 fitted the frequency data of Experiment 3 perfectly. The parameter estimates of the critical retrieval process (prr_{IR} and prr_{C}) are illustrated in Figure 5. In order to test the prime-response retrieval variant of the episodic retrieval account against the nonresponse variant, we tested the goodness-of-fit test of the model with the restriction that $prr_{\mathrm{IR}} = prr_{\mathrm{C}}$, which is implied by the nonresponse variant. The restricted model did not fit the data, $G^2(1) = 4.39$, $p = .036$, and had to be rejected.

Discussion

Experiment 3 replicated, for the visual domain, the results obtained with auditory stimuli in Experiment 2. Again, the probability of retrieving the prime response, given that neither a correct identification of the probe nor a simple probe stimulus confusion had occurred, was larger in the ignored repetition than in the control condition. Taken together with the findings from Experiment 2, this result supports the prime-response retrieval variant of the episodic retrieval account and is not expected given the nonresponse retrieval variant.

General Discussion

Experiments 1A and 1B established direct evidence for the operation of an episodic retrieval mechanism in the current auditory negative priming paradigm. They demonstrated that the relative length of the preprime-prime interval to the prime-probe interval clearly affected the size of the negative priming effect. Specifically, when preprime and prime episodes were temporally close, and both were temporally distant from the probe, then the negative priming effect was much smaller than when the preprime and prime episodes were temporally distant and the prime was close to the probe. This is consistent with predictions that can be derived from the episodic retrieval account, according to which the probability of retrieving elements of the prime episode should be larger in the latter than in the former case, in which the preprime episode is relatively likely to be retrieved instead of the prime episode. A negative priming effect, however, can be caused only by retrieving the ignored prime. An increasing number of preprime retrievals instead of prime retrievals should therefore dilute the overall negative priming effect. This is exactly what we observed. Within the distractor inhibition account there is no plausible reason why the relative duration of the interval before the prime should be of any importance for the strength of the prime distractor inhibition. Together, the results of Experiments 1A and 1B replicate those found in the visual modality (Neill et al., 1992), and they extend these findings to the auditory modality.

The original version of the episodic retrieval account of the negative priming phenomenon postulates that, during prime processing, the prime distractor becomes associated with the information that it must not be responded to. On ignored repetition trials, the probe target may cue the retrieval of the prime episode, in which case this nonresponse information may interfere with the required target response. An alternative possibility is that the prime response is retrieved as part of the prime episode in ignored repetition trials. The retrieved prime response would also conflict with the required probe response. Experiments 2 and 3 were designed to test the specific prediction of the prime-response variant of the episodic retrieval account. In essence, if the prime-response retrieval variant is valid, then the probability of prime-response retrieval—given that neither a probe target identification nor a simple probe target and distractor confusion determine the response—should be larger for ignored repetition than for control trials. This is exactly what was found. Given that this pattern of results would not be expected from the perspective of the original nonresponse variant of the episodic retrieval account, we concluded that the data reported here support the prime-response retrieval variant. Note that Neill and Mathis (1998) considered the possibility of a modified (and more general) episodic retrieval theory of negative priming, which assumes that retrieval of any task-inappropriate processing operation from the prime episode can lead to a negative priming effect. In a sense, prime-response retrieval can be conceived of as one possible task-inappropriate process in terms of this very general framework.

The nonresponse retrieval and the prime-response retrieval variants of the episodic retrieval account are not mutually exclusive. It may well be that prime-response information and nonresponse information are retrieved when the probe target serves as a cue to the prime episode. For instance, it could be argued that the conflict induced by prime-response retrieval would show up primarily in the error rates, whereas conflicts due to nonresponse retrieval may be reflected in the slowing of responding in ignored repetition as opposed to control trials. The same argument of course holds for an inhibitory attentional mechanism, for the operation of which some direct evidence exists (Buchner & Steffens, 2001). Also, when looking at the error frequencies in Table 3, it is obvious that whereas incorrect prime target responses increase dramatically when comparing the control to the ignored repetition condition (16-fold and 2-fold in Experiments 2 and 3, respectively), the frequencies of other errors increase as well, albeit on a much smaller scale. It could be argued that the increase of the frequencies of other error types reflected the operation of mechanisms other than the prime-response retrieval mechanism, and that may also include distractor inhibition (Chao & Yeh, 2004; Kane et al., 1997; Tipper, 2001). Although this may be so, the overall increase in errors could also reflect a spillover of the general uncertainty about the correct response created by the conflict between the retrieved prime response and the response determined appropriate on the basis of the probe target analysis.

It is interesting that Rothermund, Wentura, and De Houwer (2005, p. 482) have recently presented independent evidence of what they refer to as a "stimulus–response retrieval account" of negative priming, which is very similar to the prime-response retrieval variant of the episodic retrieval account discussed here. They reported a clever series of experiments that make use of a task-switch paradigm to get around the problem that in standard negative priming tasks, the response must necessarily change between prime and probe. For instance, in their Experiment 1 the color of a word had to be categorized (yellow vs. green) in the prime but the word's grammatical category (adjective vs. noun) had to be categorized in the probe. Response repetition could occur when the correct color response (a left or right keypress) was the same as the correct grammatical-category response (also a left or right keypress). A response switch could occur when the correct response keys differed between prime and probe. An ignored repetition trial was given when the prime word was repeated as the probe word, whereas prime and probe words differed on control trials. Negative priming was observed in the response-switch condition in which the retrieved prime response would interfere with the required probe response. In contrast, positive priming was observed in the response-repetition condition in which the retrieved prime response would be identical to the required probe response.

However, there are other negative priming effects that cannot be attributed to retrieval of the prime response, necessitating the assumption of at least one further mechanism. For example, some experiments revealed negative priming effects, although participants were instructed to refrain from responding in the prime (see, e.g., Milliken et al., 1998; Milliken, Lupianez, Debner, & Abello, 1999; Mondor et al., 2005). It is still ambiguous which mechanism leads to a negative priming effect in these situations. It is clear, however, that this result cannot be attributed to retrieval of the prime response. Furthermore, experiments using a same/different matching procedure revealed negative priming, irrespective of whether the response changed between the prime and probe (same–different, different–same) or did not change (same–same, different–different; see, e.g., DeSchepper & Treisman, 1996). If prime-response retrieval was the only mechanism behind the phenomenon, no negative priming should have been expected for trials without a response change. Consequently, some other mechanism(s) must have been involved.

This notwithstanding, the data reported by Rothermund et al. (2005) and those reported here nicely complement each other in showing that probe-cued retrieval of prime responses is indeed a mechanism underlying the negative priming phenomenon. What we cannot currently say is whether prime-response retrieval and nonresponse retrieval contribute jointly to the slowing of responses on ignored repetition trials or whether they are alternative memory-based mechanisms behind this phenomenon.

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