Revisiting the role of probe distractors in negative priming: Location negative priming is observed when probe distractors are consistently absent

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Negative priming (NP) refers to the delayed response to a probe target that was previously a prime distractor. One peculiar problem in NP literature is the observation that the manifestation of identity NP is contingent on the presence and type of probe distractors. When the probe distractors were completely removed, positive priming, rather than NP, was usually observed. This study investigated whether location NP was affected by the same manipulations. The proportion of ignored repetition trials, attended repetition trials, and control trials was manipulated across Experiments 1–3. These three experiments showed reliable location NP effect when the probe distractor was consistently absent. Experiment 4 showed that the presence of probe distractors did not increase the magnitude of the location NP effect. Experiment 5 showed that the location NP effect observed was not contingent on perceptual mismatching. These findings suggest that the presence of probe distractors is not a necessary component for the manifestation of location NP. Theoretical implications were discussed.

In order to achieve successful target selection, attention should be paid to the object that matches the target template, and the distractor should be ignored. However, the distractor is not simply kept unprocessed. The *effect of negative priming* (NP) refers to the observation that, when a distractor is repeated as the target, the response to the target is slower than that in the control condition (Tipper, 1985; Tipper & Cranston, 1985; for reviews, see Fox, 1995; May, Kane, & Hasher, 1995; Neill, Valdes, & Terry, 1995). The NP paradigm is used widely to investigate the underlying processes and aftereffects of selective attention.

However, one question pertaining to NP has not yet been completely resolved: If this phenomenon merely reflects the aftereffect of attentional selection, why are probe distractors required to observe the NP effect? A typical NP task comprises couplets of prime and probe displays. In the ignored repetition (IR) condition, the prime distractor is repeated as a probe target; in the control condition, the prime stimuli are not repeated in the following probe trial. NP is measured as the difference in reaction times (RTs)—and sometimes in error rates (ERs)—between the control and IR conditions. It has been demonstrated that, when the distractor was absent during all the probe displays, the NP effect was eliminated (Lowe, 1979; Milliken, Joordens, Merikle, & Seiffert, 1998; Tipper, Brehaut, & Driver, 1990; Tipper & Cranston, 1985). With a Stroop color-naming task, Lowe's Experiment 4 demonstrated that identity NP was eliminated when there was no probe distractor word. In fact, an effect of positive priming

was found when the probe distractor word was replaced by the color patch (23 vs. 21 msec). In a letter-naming task, Tipper and Cranston observed significant NP when the probe distractor was present (–17 msec). However, response in the IR condition was faster than that in the control condition (14 msec) when the probe distractor was consistently absent. In a word-naming task, Milliken et al. (1998) also found significant NP when the probe distractor was present (–8 msec), but they observed significant positive priming (5 msec) when the probe distractor was consistently absent. These findings are theoretically important and provide interesting insights into the NP phenomenon.

Distractor Competition Hypothesis

According to a computational model of the inhibition account of NP (Houghton & Tipper, 1994), the effect of distractor inhibition is manifested during a competition between a probe target and a probe distractor. If there is no such competition (i.e., when the probe distractor is absent), it should be easy to respond to the target. As a result, the NP effect should not surface.

The study of probe distractor competition can support this hypothesis. According to the distractor competition hypothesis, NP is manifested only when the probe distractor is competitive. In other words, even when the probe distractor is present, if it is not competitive, NP should not be observed. To test this prediction, we compared repeatedly used, familiar stimuli and novel stimuli (Chao & Yeh, 2008). We used repeatedly used stimuli as the

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prime target, prime distractor, and probe target. The probe distractor could be either a repeatedly used stimulus or a novel stimulus. In keeping with the activation account of Strayer and colleagues (Malley & Strayer, 1995; Strayer & Grison, 1999), our repeatedly used stimuli were in a state of high activation and could compete with probe target processing when they served as probe distractors. On the other hand, our novel stimuli had low activation and had difficulty competing with target processing. We found that the identity NP effect was reduced when novel stimuli were used as probe distractors.

However, when the probe-distractor-absent couplets were mixed with probe-distractor-present couplets, the findings differed considerably. In this context, NP was observed regardless of the presence of a probe distractor (Christie & Klein, 2001; Moore, 1994; Neill, Terry, & Valdes, 1994). The competition hypothesis cannot explain these results without further modification. Instead, the selection state hypothesis (Tipper & Cranston, 1985) was more capable of accounting for these findings.

Selection State Hypothesis

According to the selection state hypothesis, the inhibitory effect was maintained until the presentation of the probe display only when the need for selective attention in the probe display was perceived. Therefore, when participants are able to anticipate the absence of probe distractors, NP should not be observed. On the other hand, if the removal of probe distractors cannot be predicted, the NP effect should be observed even when the probe distractor is absent.

In her study on identity NP, Moore (1994) concluded that NP was eliminated only when it was easy to detect that there was no conflict in the probe display. When the nonconflict probe (i.e., when the probe distractor was absent, or when a nonresponse stimulus was used as the probe distractor) and conflict probe trials were presented in separate blocks, NP was not observed when nonconflict probes were used. However, when the nonconflict probe and conflict probe displays were mixed in a block, NP was observed in the nonconflict condition when the nonresponse probe distractor was similar to the target. In this situation, because it was difficult to identify whether it was a conflict or nonconflict display, NP manifested regardless of the type of probe distractor. According to the selection state hypothesis, such a finding implies that if the selection state was maintained, NP could be observed.

Prime-Probe Contextual Similarity Hypothesis

Another explanation was derived from the memory retrieval account of NP (Neill, 1997; Neill & Mathis, 1998; Neill, Valdes, Terry, & Gorfein, 1992). According to this account, NP is due to the retrieval of inappropriate prime-related information that interferes with probe target processing. For example, if an item that was associated with a "do-not-respond" tag after serving as a prime distractor became the probe target, the retrieval of the "do-not-respond" tag would interfere with the task requirement of responding to it. Recently, Mayr and Buchner (2006) and Rothermund, Wentura, and De Houwer (2005) proposed

an alternative retrieval account of negative priming. They demonstrated that retrieval of the prime response interfered with probe target processing and, hence, delayed the response to the probe target.

According to this view, factors that can increase the likelihood of retrieving the prime episode should increase NP. One of the most critical factors is prime-probe contextual similarity, which alters the probability of memory retrieval. When the probe display is dissimilar to its prime display, a reduction in NP is observed (Chao, 2009; Chao & Yeh, 2008; Fox & de Fockert, 1998; Neill, 1997). With regard to the impact of the removal of the probe distractor, because there usually is a target and distractor in the prime display, a probe display of only one target would be different from its prime display. If such a difference is sufficient to impede memory retrieval, the NP effect should diminish (Neill, 1997).

Contingency-Based Strategy Hypothesis

In recent times, Frings and Wentura (2006) proposed another explanation. They noted that a standard NP experiment usually comprises one-third IR couplets, one-third attended repetition (AR) couplets (the prime target is repeated as probe target), and one-third control couplets. Therefore, the probability of repeating a prime stimulus in the following probe display is high. Such a contingency might lead participants to process prime distractors. As a result, NP is reduced. Frings and Wentura further suggested that such a contingency-based strategy might result in the removal of NP when probe distractors were absent. They used a lexical decision task to maintain the proportion of the IR, AR, and control trials at 1:1:1. They demonstrated that when the repetition of a prime stimulus was associated with one response with a higher probability (i.e., in their Experiment 1, when a prime stimulus was repeated as the probe target, there was a 75% probability that the probe target was a word), positive priming rather than NP was observed when there was no probe distractor. On the other hand, when such a contingency was removed, in the absence of probe distractors, NP was observed.

In sum, the distractor competition hypothesis, selection state hypothesis, prime-probe contextual similarity hypothesis, and contingency-based strategy hypothesis were proposed to account for the dependency of NP on the presence of a probe distractor. However, it should be noted that these four hypotheses were primarily based on studies on identity NP. Considering that both location inhibition (Tipper et al., 1990) and identity inhibition are important parts of selective attention, one tactic for examining these four accounts was to further study the influence of probe distractor removal on location NP.

In fact, the role of probe distractors in location NP may be different from that in identity NP. In 1994, Neill et al. manipulated the presence of the probe distractor. The probe-distractor-absent trials were mixed with probe-distractor-present trials. Location NP was observed, regardless of the status of the probe distractor. This observation is different from Moore's (1994) findings. In both studies, the probe-distractor-present and probe-distractor-absent trials were mixed together. However, identity NP

was not observed when there was no probe distractor (Moore, 1994), and location NP was observed in the absence of a probe distractor (Neill et al., 1994). Therefore, it would be reasonable to speculate whether or not the dependency of identity NP on probe distractors could be generalized to the phenomenon of location NP.

In Neill et al. (1994), because probe-distractor-absent trials and probe-distractor-present trials were mixed, there were two interpretations: The effect was the result of the persistence of the selection state when the probe distractor was absent; or location NP could be observed even when the probe distractor was consistently absent. Buckolz, Boulougouris, and Khan's (2002) study on location NP supported the selection state account. They manipulated the presence and absence of probe distractors and either cued or did not cue the absence of probe distractors in advance. They found reliable location NP when the probe distractor was unexpectedly removed, but they found no evidence of location NP when the absence of the probe distractor was predictable. This implies that when people were expecting the presence of probe distractors, the selection state was maintained, regardless of whether the probe distractor was removed. Therefore, NP surfaced in this context.

Guy, Buckolz, and Pratt (2004) added that the location NP effect can survive in several contexts. They found that when only a target or distractor was presented in the prime display, location NP could be observed, even when the absence of the probe distractor was expected. In addition, they found that when there were two distractors in the prime display, NP was significant, even if the probe distractor was expected to be absent. Fitzgeorge and Buckolz (2008) replicated Guy et al. by demonstrating that the effect of location NP without probe distractors could be observed when a distractor (but not a target) was presented in the primes. They suggested that location-based retrieval was blocked when only a target was presented. These findings indicate the limitation of the selection state account: Location NP was not always abolished when the absence of the probe distractors was expected.

In the present study, I examined the impact of complete probe distractor removal on location NP. At the empirical level, this is important because it is not evident whether location NP, similar to identity NP, disappears completely when the probe distractor is consistently absent. Considering that the presence of location NP could be modulated by global task contexts, such as types and proportions of different types of trials in one experiment (e.g., Christie & Klein, 2001; Fitzgeorge & Buckolz, 2008), a pure task context is required for examining the impact of probe distractor removal on location NP. In other words, what is required is a context in which a probe distractor is never presented throughout the entire experiment. In such a situation, participants do not have to develop a set regarding the proportion of probe-distractor-absent trials or the proportion of prime-target/distractor-absent trials.

In addition, the present study may reveal whether it is necessary to include and manipulate probe distractors when studying location NP. Considering the fact that dif-

ferent trial compositions are commonly employed in NP studies, including IR:control = 1:1 (e.g., Moore, 1994), IR:AR:control = 1:1:1 (e.g., Frings & Wentura, 2006), and IR:AR:control = 1:1:2 (e.g., Neill et al., 1994), these three trial compositions will be tested across Experiments 1, 2, and 3. If location NP is not eliminated by the complete removal of the probe distractor, this would indicate that it is not necessary to present probe distractors in future studies on location NP.

At the theoretical level, the present study could provide a test for the four hypotheses of the importance of probe distractors in the context of location NP. According to the distractor competition account and the selection state account, the effect of location NP is not anticipated when the probe distractors are not presented. In addition, the composition of the trials was manipulated in the present study. In Experiment 1, half of the trials were IR trials; the remaining trials were control trials. Because four locations were used in this experiment, the probability of repetition was much higher than that at the chance level. In Experiment 2, the ratio of IR trials to AR trials to control trials was 1:1:1. The probability of repetition was still higher than that at the chance level. In Experiment 3, the ratio of IR trials to AR trials to control trials was 1:1:2. In this experiment, the probability of target repetition and distractor repetition was at the chance level. According to the contingency-based strategy hypothesis, location NP should be observed only in Experiment 3. Finally, in Experiments 1 and 2, and to a certain extent in Experiment 3, the letters "O" and "X" were used as the prime stimuli; a dot was used as the probe stimuli. In this context, it was more apparent that the probe displays were different from the prime displays. Therefore, the prime-probe contextual similarity hypothesis did not anticipate location NP either.

EXPERIMENT 1

The purpose of Experiment 1 was to investigate whether location NP would be observed when the probability of location repetition was biased and the probe distractor was consistently absent. In this experiment, half of the trials were IR trials; the rest were control trials. The probability of repeating the location of the prime distractor as the location of the following probe target was 50%, which is higher than the chance level of 25%. In addition, the location of the prime target was never repeated. Therefore, participants could anticipate the location of the probe target on the basis of the information conveyed by the prime distractor. According to the contingency-based strategy hypothesis (Frings & Wentura, 2006), this situation lowers the probability of observing location NP without a probe distractor.

In Experiment 1, each prime display consisted of the letter "O" (the target) and the letter "X" (the distractor), followed by a probe display containing a probing dot. Therefore, the prime-probe structure was salient in this experiment. It was apparent to the participants that there never existed a need for selection during the probe trials. According to the distractor competition hypothesis

Figure 1. Sequence of a couplet. The probe trial was presented immediately after the prime trial. Participants were required to selectively respond to the target letter “O” in the prime display and respond to the probing dot in the probe display. The ignored repetition condition is illustrated in this example, in which the probe target is presented at the distractor location of the prime display.

(Houghton & Tipper, 1994) and the selection state hypothesis (Tipper & Cranston, 1985), NP should not manifest itself. Finally, because the similarities between the prime and probe were reduced not only by removing the distractor but also by using a dot to replace the “O” target, the prime–probe contextual similarity hypothesis should also predict the absence of location NP in the present experiment (Neill, 1997).

Method

Participants. Fifteen undergraduate students (8 female; mean age = 21.5 years, $SD = 2.5$) participated in this experiment, which was conducted at the Chung Yuan Christian University, for a bonus credit or a reward of 200 NT dollars. They were unaware of the purpose of the experiment and had normal or corrected-to-normal vision.

Stimuli. Four locations, arranged in a broad V shape at the center of the screen, were used to present the prime target (a white “O”), the prime distractor (a white “X”), and the probe target (a white dot). From a viewing distance of approximately 57 cm, four white lines that subtended a visual angle of 2.0° were presented at the four locations as placeholders. The horizontal distance between the two locations at the top of the broad V shape was 4.7° , and the horizontal distance between the two locations at the bottom of the broad V shape was 3.3° . The vertical distance between the two locations was 3.0° . At this viewing distance, each stimulus letter subtended a visual angle of 0.8° vertically and horizontally. The fixation was a white cross that was identical in size to the letters.

Procedure. A computer with an Intel Pentium 4 processor was used. The refresh rate of the 17-in. CRT monitor was 75 Hz. The experiment was run using DMDX software (Forster & Forster, 2003).

Each couplet comprised a prime and a probe trial (see Figure 1 for an illustration of the sequence of a couplet). Each prime trial began with a display of the four placeholders. After 187 msec, a fixation cross was displayed at the center of the screen for 506 msec. At the same time as the onset of the fixation, a “ding” sound was presented as a warning signal. After a blank interval of 506 msec, during which only the placeholders were presented, the target was presented at one location; the distractor was simultaneously presented at another. The probability of the target or the distractor being presented at each of the locations was equal. Participants were instructed to respond to the location of the target by pressing the F, V, J, and N keys on a computer keyboard, which were mapped spatially onto the four locations. This stimulus display was presented on the screen until the participants pressed one of the keys or until 3,000 msec had elapsed. The procedure of the probe trial was similar to that of the prime trial, but the probe trial involved two constraints: Only the probe target was presented, and the target location of the probe trial

would be the distractor location of the prime trial in the IR condition. Furthermore, the location of the probe target would be different from the locations of the prime target and the prime distractor in the control condition.

There were a total of 6 practice couplets and 48 test couplets. Among the test couplets, 24 were IR couplets and 24 were control couplets. The test couplets were presented in a random order. The participants were instructed to pay attention to the computer screen when the fixation cross appeared and to respond to the prime target and the probe target quickly and accurately; they were allowed to rest after completing 24 test couplets.

Results

The average median correct RTs and average ERs of each condition are presented in Table 1. The effect of trial type on RTs was analyzed by a one-way repeated measures ANOVA, revealing that participants responded slower in the IR condition than in the control condition [$F(1,14) = 6.8$, $MS_e = 143.9$, $p = .02$]. Analysis of the ERs did not reveal a significant effect ($p = .32$).

Discussion

This is the first experiment demonstrating that location NP (-11.4 msec; 12 of the 15 participants' performance was in the direction of NP) could manifest itself when the probe distractor was always absent. The distractor competition hypothesis, selection state hypothesis, prime–probe contextual similarity hypothesis, and contingency-based strategy hypothesis failed to anticipate this. A possible explanation is that only identity NP was contingent on the presence of a probe distractor, whereas location NP was not. For the contingency-based strategy hypothesis, another possible explanation is that participants had not learned the contingency. Before endorsing these conclusions, I will be further examine whether location NP is eliminated by the complete removal of the probe distractor in different contexts in Experiments 2 and 3.

Another explanation of the findings of Experiment 1 is that the inhibitory effect was due to inhibition of return (IOR; Posner & Cohen, 1984; Posner, Rafal, Choate, & Vaughan, 1985; for a review, see Klein, 2000) rather than to location NP. Studies of IOR indicate that an uninformative cue receives inhibition, and, hence, it takes longer to revisit the cued condition. More importantly, a probe

Table 1
Averages of Correct Response Times (RTs, in Milliseconds) and Error Rates (ERs, in Percentages), As a Function of Trial Type in Experiments 1, 2, and 3

	Trial Type							
	IR		AR		Control		NP	
	RT	ER	RT	ER	RT	ER	RT	ER
Experiment 1	376.7	1.1			365.3	1.1	-11.4	0.0
Experiment 2	383.1	1.4	369.1	0.3	368.0	1.7	-15.1	0.3
Experiment 3								
Probe Target								
Dot	399.3	2.2	380.2	1.4	379.5	1.5	-19.8	-0.7
Letter "O"	374.1	0.9	344.2	0.8	355.7	2.0	-18.4	1.1

Note—IR, ignored repetition; AR, attended repetition; NP, effect of negative priming (control minus IR).

distractor is not necessary for observing the IOR effect. Christie and Klein (2001) argued that location NP and IOR may stem from the same mechanism. To support their claim, they demonstrated that the AR trials in a target localization task also produced an inhibitory effect. In other words, an IOR-like effect could be found in a location NP paradigm. In the present Experiments 2 and 3, the AR condition is included. If the inhibitory effect is observed in the AR trials, as well as in the IR trials, the assertion that location NP without a probe distractor reflects IOR would be supported.

EXPERIMENT 2

In comparison with the studies of identity NP (e.g., Lowe, 1979; Milliken et al., 1998; Tipper & Cranston, 1985), the finding that location NP could resist the complete removal of the probe distractor was surprising, and it challenged the hypotheses about why the probe distractor is critical. Therefore, it is necessary to replicate the finding of Experiment 1 in another context in which the AR trials are included.

In addition, the inclusion of the AR trials could demonstrate whether or not IOR operates in the present task context. If IOR contributes to the slowing of the RTs, then the response cost should be observed in the AR condition, as well as in the IR condition.

Method

Participants. Fifteen undergraduate students (9 female; mean age = 20.9 years, $SD = 1.7$) participated in this experiment, which was conducted at the Chung Yuan Christian University, for a bonus credit or a reward of 200 NT dollars. They were unaware of the purpose of the experiment and had normal or corrected-to-normal vision. None had participated in Experiment 1.

Stimuli and Procedure. The stimuli and procedure used in the present experiment were identical to those used in Experiment 1. The only exception was that 24 AR couplets were included and mixed with the IR and control couplets in a random order. In the AR condition, the location of the prime target was repeated as the location of the probe target.

Results

Table 1 shows the average median correct RTs and average ERs of each condition. The effect of trial type on RTs was analyzed by a one-way repeated measures ANOVA. A

significant main effect of trial type was found [$F(2,28) = 11.1$, $MS_e = 96.3$, $p = .0005$]. Follow-up paired t tests revealed that the participants responded more slowly in the IR condition than in the AR and control conditions ($ps < .01$), and there was no significant difference between the latter two conditions ($p > .20$). Analysis of the ERs did not reveal a significant effect ($p = .22$).

Discussion

The finding of Experiment 1 was replicated, and the effect of location NP (-15.1 msec; 14 of the 15 participants' performance was in the direction of NP) was observed, despite the fact that there was consistently no probe distractor. This result further indicated that location NP did not require a probe distractor to manifest itself.

Furthermore, a response cost in the AR condition was not observed in the present experiment. This might exclude the possibility that IOR rather than NP contributed to the delayed RTs observed in the present study. However, it should be noted that Christie and Klein (2001) indicated that the response cost as a result of IOR in the AR condition could be revealed when the probability of location repetition was controlled at the chance level. In Experiment 2, the probability of repeating the location of the prime target as the probe target location was 33.3%, which is slightly higher than the chance level of 25%. Although the difference was weak, it is still possible that participants had detected the utility of attending to the location of the prime target, thus masking the IOR effect. Therefore, the finding of Experiment 2 should be replicated in Experiment 3, in which the probability of repeating the prime target location and prime distractor location was controlled at the chance level.

EXPERIMENT 3

The finding of Experiment 2 should be replicated by setting the probability of location repetition at the chance level. According to Christie and Klein (2001), the effect of IOR should manifest itself in the present context. If IOR does contribute to the response cost, delayed RTs should be expected in both the AR and IR conditions. On the other hand, if location NP results in the delayed response, then the response cost should be expected only in the IR condition.

Another issue to examine is the type of probe target in the present experiment. In Experiments 1 and 2, a dot was used as the probe target. Although it could reveal the effect of location NP, the use of a probing dot was different from previous studies on location NP, in which the probe target was identical to the prime target. Therefore, one potential explanation for the successful, repeated demonstrations of location NP without a probe distractor is that such an effect of location NP manifested itself only when the prime target and probe target differed in form. That is, when the same form (e.g., a white letter "O") was repeatedly presented, positive priming due to form or identity repetition could have masked the inhibitory effect.

In order to examine the effect of the type of probe target, a white dot was used as the probe target in one block of the present experiment; a white letter "O" was used in the other block. If the use of the white dot enables the manifestation of location NP without a probe distractor, location NP should be expected only when the probe target is a dot. On the other hand, if location NP is different from identity NP, it could manifest itself despite the complete removal of the probe distractor; furthermore, location NP should be expected regardless of the type of probe target.

The comparison between the different types of probe targets could also reveal the impact of prime–probe contextual similarity on location NP without probe distractors. The degree of similarity was higher when the probe target was the letter "O" than when it was a dot. If memory retrieval plays an important role in the present task context, location NP should also be higher when the probe target is the letter "O."

Method

Participants. Sixteen undergraduate students (13 female; mean age = 20.6 years, $SD = 1.5$) participated in this experiment, which was conducted at the Chung Yuan Christian University, for a bonus credit or a reward of 200 NT dollars. They were unaware of the purpose of the experiment and had normal or corrected-to-normal vision. None had participated in either Experiment 1 or Experiment 2.

Stimuli and Procedure. The stimuli and procedure used in the present experiment were identical to those used in Experiment 2, but with several exceptions. First, there were 24 IR couplets, 24 AR couplets, and 48 control couplets in each block. The locations of the prime target and prime distractor could not predict the location of the probe target. Second, the white dot (identical to the probe target of Experiments 1 and 2) was used as the probe target in one block; the white "O" (identical to the prime target of all the experiments reported in the present study) was used as the probe target in the other block. The order of these two blocks was counterbalanced across participants.

Results

The average median correct RTs and average ERs of each condition are shown in Table 1. The order of the blocks did not interact with any other variables ($ps > .20$). The effect of trial type on RTs was analyzed by a two-way repeated measures ANOVA: trial type (IR/AR/control) $\times$ target type (dot/letter "O"). The main effect of target type was significant [$F(1,15) = 31.1$, $MS_e = 619.1$, $p = .0001$]. The main effect of trial type was also signifi-

cant [$F(2,30) = 18.9$, $MS_e = 282.3$, $p < .0001$]. Follow-up paired t tests revealed that the participants responded more slowly in the IR condition than in the AR and control conditions ($ps < .01$). There was no significant difference between the AR and control conditions ($p > .20$). The interaction between trial type and target type was not significant [$F(2,30) = 1.6$, $MS_e = 218.5$, $p = .21$]. Analysis of the ERs did not reveal any significant effect ($ps > .20$).

Discussion

Despite the changes in trial composition, the results of Experiments 1 and 2 were replicated in Experiment 3. Location NP was observed in the absence of probe distractors. In addition, location NP was observed regardless of whether the probe target was a probing dot (-19.8 msec; 15 of the 16 participants' performance was in the direction of NP) or the letter "O" (-18.4 msec; 15 of the 16 participants' performance was in the direction of NP), suggesting that the findings of Experiments 1 and 2 were not due to the use of an atypical probe target.

On the other hand, although the locations of the prime target and distractor could not predict the location of the probe target, no inhibitory effect was observed in the AR condition. In fact, there was a repetition benefit when the target was the letter "O" (11.5 msec). A two-tailed t test indicated that this difference was significant [$t(15) = 3.91$, $p = .0014$]. According to Christie and Klein (2001), the manifestation of an inhibitory effect in the AR condition would indicate the involvement of IOR in the location NP paradigm. Because this inhibitory effect was not observed, there was no strong evidence suggesting that the location NP effect without a probe distractor was due to IOR rather than NP. On the other hand, because the facilitatory effect was observed when the target was the letter "O" but not when it was a probing dot, stimulus repetition might be one cause of this facilitatory effect.

EXPERIMENT 4

Experiments 1–3 have reliably demonstrated that location NP can be observed without the presence of probe distractors. Nevertheless, whether or not the probe distractors can modulate the magnitude of the location NP effect was not examined. For instance, it is possible that the presence of probe distractors could have enhanced the location NP effect. Such prediction is compatible with the contingency-based strategy hypothesis. It could also be proposed that the presence of probe distractors could have increased the likelihood of memory retrieval because the probe was more similar to the prime. Hence, the NP effect was larger in the presence of probe distractors.

In Experiment 4, the magnitude of the location NP effect when the probe distractor was absent was compared with that when the probe distractor was present. In the distractor-absent block, the design of Experiment 3 was replicated. The probe distractor was absent, and the prime stimuli did not predict the location of the probe target. In the distractor-present block, the probe distractor was

Discussion

The present experiment replicated the findings of Experiments 1–3. Location NP could be observed regardless of whether the probe distractors were always absent (–9.9 msec; 20 of the 24 participants' performance was in the direction of NP) or present (–14.1 msec; 23 of the 24 participants' performance was in the direction of NP). In addition, the results further revealed that the addition of probe distractors could not reliably increase the magnitude of the location NP effect. Such findings suggest that probe distractors do not play a critical role in location NP when the experimental contexts are simple (i.e., probe distractors are entirely absent, or probe distractors are consistently present).

An intriguing finding of the present experiment was the impact of probe distractors on the effect of target repetition. Christie and Klein (2001) suggested that when the probability of stimulus repetition was controlled at the chance level, an inhibitory effect rather than a facilitatory effect should be observed in the AR condition. In the present experiment, the probability of stimulus repetition met Christie and Klein's (2001) criteria in both the probe-distractor-absent and probe-distractor-present blocks. Nevertheless, a facilitatory effect was observed when the probe distractor was absent (the magnitude of this effect was similar to what was observed in Experiment 3), but not when the probe distractor was present. In fact, a nonsignificant trend of repetition cost was found in the latter condition, indicating that there was no sign of positive priming. Considering that the presence of the probe distractor could not increase the magnitude of NP, one potential function of the probe distractor might be to reduce the facilitatory effect.

EXPERIMENT 5

Park and Kanwisher (1994) indicated that location NP might be due to perceptual mismatching rather than to distractor inhibition. In most studies on location NP, the target is the letter "O" and the distractor is the letter "X." In the IR condition, the letter "X" is presented at the repeated location in the prime display; the letter "O" is presented at that location in the probe display. The perceptual mismatching between these two letters might lead to a response cost. Although Tipper, Weaver, and Milliken (1995) showed that location NP could be observed without perceptual mismatching, it is still possible to attribute the NP effect observed in the present Experiments 1–4 to perceptual mismatching.

Experiment 5 investigated the location NP effect without probe distractors when perceptual mismatching in the IR condition was eliminated. In contrast with the previous experiments, the target was the letter "O" and the distractor was the letter "X" in the prime displays; the target was the letter "X" in the probe displays. In such a design, there was perceptual matching rather than perceptual mismatching in the IR condition. Any observed NP effect cannot be attributed to perceptual mismatching.

In addition, the design of the present experiment allowed for a test of the impact of perceptual mismatching

in the AR condition; there was a perceptual mismatching (prime target = "O," probe target = "X") in this condition. In comparison with Experiments 2–4, in which the AR condition showed a facilitatory effect or a nonsignificant effect in comparison with the control condition, repetition cost due to perceptual mismatching was expected in the AR condition of the present experiment.

Method

Participants. Twenty-four undergraduate students (11 female; mean age = 20.7 years, $SD = 2.0$) participated in this experiment, which was conducted at the Chung Yuan Christian University, for a bonus credit or a reward of 200 NT dollars. They were unaware of the purpose of the experiment and had normal or corrected-to-normal vision. None had participated in Experiments 1–4.

Stimuli and Procedure. The stimuli and procedure were identical to those used in the block of Experiment 3, in which the probe target was the letter "O," with only one exception: The probe target was replaced by the letter "X." Participants were instructed to indicate the location of the letter "O" when both the "O" and the "X" were presented on the screen, but they were to indicate the location of the letter "X" when only this letter was presented.

Results

Table 3 shows the average median correct RTs and average ERs of each condition. The effect of trial type on RTs was analyzed by a one-way repeated measures ANOVA. A significant main effect of trial type was found [$F(2,46) = 8.3$, $MS_e = 375.6$, $p = .0011$]. Follow-up paired t tests revealed that the participants responded more slowly in the IR and AR conditions than in the control condition ($ps < .01$). There was no significant difference between the IR and AR conditions ($p > .15$).

ERs were analyzed in the same manner. A significant main effect of trial type was found [$F(2,46) = 5.4$, $MS_e = 3.1$, $p = .008$]. Follow-up paired t tests indicated that the ERs were higher in the IR and control conditions than in the AR condition ($ps < .01$), and there was no significant difference between the former two conditions ($p > .20$).

Discussion

A significant NP effect was observed in the present experiment (–13.7 msec; 20 of the 24 participants' performances were in the direction of NP), despite the fact that there was no perceptual matching between the prime distractor and the probe target. The present experiment suggests that the location NP effect observed in the present study was not due to perceptual mismatching (cf. Park & Kanwisher, 1994). Consistent with the findings of Tipper et al. (1995), the effect of location NP was observed even

Table 3
Averages of Correct Response Times (RTs, in Milliseconds)
and Error Rates (ERs, in Percentages), As a Function
of Trial Type in Experiments 5

Trial Type							
IR		AR		Control		NP	
RT	ER	RT	ER	RT	ER	RT	ER
392.0	1.6	401.0	0.0	378.3	1.1	–13.7	–0.5

Note—IR, ignored repetition; AR, attended repetition; NP, effect of negative priming (control minus IR).

when there was perceptual matching between the prime distractor and the probe target.

The priming effect in the AR condition showed a contrast of perceptual matching/mismatching. In Experiments 3 and 4, when there was perceptual matching between the prime target and the probe, a significant repetition benefit (11.5 msec in Experiment 3, 6.8 msec in Experiment 4) was observed. In the present experiment, when there was perceptual mismatching between the prime target and the probe, a significant repetition cost (−22.7 msec) was observed. This finding is consistent with that of Park and Kanwisher (1994) and suggests that perceptual matching/mismatching can affect the priming effect observed. In addition, this finding further suggests that a probing dot might be a better probe target for minimizing the impact of perceptual matching/mismatching.

However, it should be noted that the ER in the AR condition was lower than that in the control condition. Therefore, the repetition cost observed might be due to the trade-off between speed and accuracy rather than to perceptual mismatching. Two lines of evidences excluded this possibility. First, there was a positive correlation ($r = .30$) between the priming effect in RT and the priming effect in ER. Such correlation indicated that, whereas the repetition cost in RT was larger, the repetition benefit in ER was less. Second, reanalysis of the RT data after excluding participants who showed positive priming in ER revealed a reliable repetition cost in the AR condition (402.8 msec), as compared with that in the control condition (375.2 msec) [$t(15) = 3.46, p < .01$]. Hence, the response cost in RT was not due to the trade-off between speed and accuracy.

GENERAL DISCUSSION

The dependency of NP on probe distractors was an influential but puzzling finding in the NP literature. Several hypotheses were proposed to account for the role of probe distractors in NP (e.g., Frings & Wentura, 2006; Houghton & Tipper, 1994; Neill, 1997; Tipper & Cranston, 1985). In addition, such probe distractor dependency was used as an index to check whether the observed response cost was due to NP (e.g., Milliken et al., 1998; Tipper et al., 1990). Nevertheless, the impact of the consistent removal of probe distractors was primarily studied with the identity NP effect. Its impact on location NP had not yet been systematically investigated. The present study demonstrated that location NP could be observed in the complete absence of probe distractors. This finding was reliable in three contexts of commonly used trial composition, including IR:control = 1:1 (Experiment 1), IR:AR:control = 1:1:1 (Experiment 2), and IR:AR:control = 1:1:2 (Experiment 3). In addition, the location NP effect could be found regardless of whether there was perceptual mismatching (the target was the letter “O”; Experiments 3 and 4) or perceptual matching (the probe target was the letter “X”; Experiment 5) between the prime distractor and the probe target. At the empirical level, the findings of the present study suggest that it is not necessary to include a probe distractor to observe location NP. Therefore, the experimental design of the location NP

paradigm can be simplified, and manipulations for other variables can be incorporated more easily.

The present study indicated that the requirement of the presence (or the expected presence) of probe distractors for the manifestation of NP is not a universal rule. It has been demonstrated that when probe-distractor-present and probe-distractor-absent trials are mixed, location NP can be observed in the absence of probe distractors (Neill et al., 1994). The present experiment further demonstrated that location NP can occur when the probe distractor is completely removed. These findings challenge the hypotheses that are based on the studies on identity NP, including the distractor competition hypothesis (Houghton & Tipper, 1994), selection state hypothesis (Tipper & Cranston, 1985), prime–probe contextual similarity hypothesis (Neill, 1997), and contingency-based strategy hypothesis (Frings & Wentura, 2006). These hypotheses failed to account for the location NP observed in one or all of the present experiments. Therefore, these hypotheses are either incorrect or limited to the domain of identity NP.

Considering the possibility that the complete removal of probe distractors has different effects on identity NP and location NP, such dissociation might suggest that identity NP and location NP involve different processes (Christie & Klein, 2008). For example, it has been suggested that location NP and IOR may be due to the same mechanism (Buckolz, Boulougouris, O'Donnell, & Pratt, 2002; Christie & Klein, 2001; Milliken, Tipper, Houghton, & Lupiáñez, 2000), whereas identity NP and IOR do not share the same mechanism. However, because the inhibitory effect was not observed in the AR condition of the present study—even when the probability of location repetition was controlled, as Christie and Klein (2001) suggested—there was no direct evidence supporting the presence of the IOR effect in the present task context. In addition, it has been suggested that IOR is a sensory rather than attentional phenomenon (Berlucchi, 2006; Dukewich & Boehnke, 2008). This further demonstrates that IOR and location NP might be different. Hence, it appears that the evidence is not strong enough to support the suggestion that identity NP and location NP involve different mechanisms.

In fact, it is also plausible that the probe distractor is not critical to the manifestation of identity NP, either. It has recently been demonstrated that location NP has a response locus. Buckolz, Goldfarb, and Khan (2004) modified the conventional location NP task (four responses mapped to four locations) by adding a location in the middle of the display, so that participants could respond to it with one of the two responses mapped to the other two nearby locations. Participants were free to choose whichever response they wanted to make once the target was presented at this middle location. With this design, assuming that the effects of location repetition and response repetition were independent of each other, it was possible to separate the impacts of location repetition and response repetition in the modified localization task. Buckolz et al. (2004) found that location repetition resulted in facilitation; response repetition resulted in response cost. A follow-up study by Guy and Buckolz (2007) used many-to-one location–

response mappings, wherein two locations were paired with one response. They also observed a significant cost of response repetition. Therefore, it was suggested that response inhibition was the major source of location NP. Because response inhibition could be observed without the presence of probe distractors (e.g., Eimer & Schlaghecken, 1998), the response locus of location NP might explain why the location NP effect could be observed when the probe distractors were completely removed. However, such speculation raises another intriguing prediction: If identity NP has several loci, including a semantic locus and a response locus, it might not be abolished by the complete removal of probe distractors, either. This is not impossible; studies on response inhibition usually use identities rather than locations to manipulate stimulus–response mappings when no probe distractor is presented.

In fact, there is some evidence indicating that identity NP can be observed when probe distractors are constantly absent. Although positive priming has been observed in the identity NP paradigm when the probe distractor was consistently absent (e.g., Lowe, 1979; Milliken et al., 1998; Tipper & Cranston, 1985), Yee (1991) observed the effect of identity NP when the probe distractor was never presented. In addition, Frings (2008) demonstrated that identity NP could be obtained in the complete absence of any probe distractor. He found that when the task difficulty was increased, identity NP could be obtained when probe distractors were constantly absent. Furthermore, a positive correlation between the magnitude of NP and RT (as an index of task difficulty) was observed. Although the reason for the contingency of identity NP without probe distractors on task difficulty is unknown, it is evident that identity NP does not require any probe distractor to manifest—at least in certain contexts. Hence, it is plausible that the presence of the probe distractor is not a necessary component in all types of NP phenomena. Were this true, probe distractor dependency should not be considered to be the signature of NP, and theories of NP should be modified to account for the less critical role of probe distractors in NP.

Although the present study did not demonstrate the importance of the presence of the probe distractors, it should be noted that the presence and absence of a probe distractor can affect location NP in several contexts. Buckolz, Boulougouris, and Khan (2002) observed the elimination of the location NP effect when the absence of the probe distractor was predictable. In their study, probe-distractor-present and probe-distractor-absent trials were mixed. It is plausible that their participants treated probe-distractor-absent trials differently when they encountered probe-distractor-present trials in the same session, or in other sessions, than did their participants who did not encounter any probe-distractor-present trials. For instance, participants might develop extra strategies to deal with situations in which probe distractors are sometimes present and sometimes absent. Such strategies might mask the location NP effect. In Guy et al. (2004), location NP was absent when the prime displays required selection and the probe displays did not. A peculiar problem in the present findings was that in one of Guy et al.'s sessions, location NP was not observed when all prime displays required selec-

tion and all probe displays did not require selection. The design of that session is similar to that of Experiment 3 of the present study, which revealed a significant location NP effect. One potential explanation is that, because the prime displays in other sessions of their experiment did not require response selection (only a distractor or either a target or a distractor was presented in the prime displays) in their Experiment 1, and because all of the prime displays did not require a T-to-D distinction (either one or two distractors presented in the prime displays) in their Experiments 2A and 2B, prime displays that consisted of both a target and a distractor became unusual events. Therefore, the location NP did not occur. Second, there were several procedural differences between these two studies, including the locations of the target and distractor, the prime-to-probe stimulus onset asynchrony, and the presentation duration of the prime and probe displays. If these were the causes for the inconsistent results, further work is required in order to examine which factor is critical.

In addition, the impact of the probe distractor on the effect of target repetition was revealed in the present study. In Experiment 4, when the probe distractor was absent, repetition of the location of the prime target as the probe target resulted in positive priming. However, the facilitatory effect was reversed to a nonsignificant trend of repetition cost when the probe distractor was present. Such findings suggest that, although the probe distractor cannot facilitate the observation of location NP, it can help reduce the facilitatory effect. It is possible that in studies in which the location NP effect was masked by feature repetition or strategy effects, probe distractors were crucial in removing these facilitatory effects to reveal the location NP effect.

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