Does "inhibition of return" occur in discrimination tasks?

KATHLEEN M. TERRY, LESLIE A. VALDES, and W. TRAMMELL NEILL
Adelphi University, Garden City, New York

When attention is drawn to a location and then withdrawn, responding to a stimulus at that location may be slower than to one at a new location. This "inhibition of return" (IOR) has not been reliably demonstrated in tasks that require discrimination of targets from nontargets. The present experiments replicated IOR in detection and localization tasks only when target/nontarget discrimination was not also required. When discrimination was required, a consistent same-location advantage occurred for repeated targets. Changed targets may, however, induce a bias toward opposite responses. The results cast doubt on IOR as a general attentional phenomenon.

Cuing the location of a stimulus in advance of its presentation usually facilitates responding to that stimulus (see, e.g., Eriksen & Hoffman, 1973; Posner, 1980; Posner, Davidson, & Snyder, 1980). However, if attention is drawn to a location by a cue and then withdrawn, it may be more difficult to respond to a stimulus in that location than to a stimulus in a new location (Posner & Cohen, 1980, 1984; Maylor, 1985; Maylor & Hockey, 1985). This phenomenon is called "inhibition of return" (IOR).

In the initial demonstration of IOR by Posner and Cohen (1980), subjects responded to the onset of a bright probe dot appearing either in a centrally fixated box or in one of two boxes to the right and left of fixation. At the beginning of a trial, either the left or the right box was briefly increased in brightness. The target appeared 0, 50, 100, 200, 300, or 500 msec after the peripheral box was brightened. On most trials, the target appeared in the central box; on 20% of trials, however, the target appeared in either the cued or the uncued peripheral box. At the shortest delays, reaction time (RT) was faster at the cued location than at the opposite location. By 300 msec, however, this effect reversed: RT was slower at the cued location.

Posner and Cohen (1980) interpreted these results as indicating that subjects initially oriented attention toward the cued location. At short delays, detection of a target was thereby enhanced at that location. However, subjects were motivated to return attention to the central box, where the probe was most probable. As a consequence,

orienting to the cued location was inhibited. Hence, detection of a target at that location was hampered, relative to a new location.

Posner and Cohen (1980, 1984) argued that IOR reflects an evolutionary adaptation of the visual system to favor sampling of new locations. Resampling of already sampled locations would be unproductive (or so it was argued); inhibition of return to recently attended locations would therefore maximize the acquisition of information from the visual environment.

Harvey (1980) suggested that subjects must resist responding to an uninformative cue, and that this response inhibition consequently interferes with responding to a target stimulus in the same location. However, IOR can also occur for a target stimulus appearing in the same location as another target stimulus to which the subject has just responded (Maylor, 1985; Maylor & Hockey, 1985; Posner, Cohen, Choate, Hockey, & Maylor, 1984). Hence, IOR does not seem to simply reflect the withholding of a response to an uninformative cue.

IOR has been demonstrated in two-alternative choice RT, as well as simple detection RT. Maylor (1985) required subjects to press one of two keys corresponding to the location, left or right, of the target. In this experiment, a location was cued by flickering a peripheral box, as in Posner and Cohen (1980, 1984). Maylor and Hockey (1985) also demonstrated IOR in a localization task, for targets appearing in the same location as that for the immediately preceding target.

Experiments reporting IOR have required subjects to respond either to the onset of a target at one of several possible locations or to the location of such an onset. (See also Rafal, Calabresi, Brennan, & Sciolto, 1989; Tipper, Driver, & Weaver, 1991.) Thus it has not been necessary for subjects to discriminate between target and nontarget stimuli. Given that attentional orienting is presumed to facilitate discrimination as well as detection (Eriksen & Hoffman, 1973; Posner, 1980; Posner, Davidson, &

These experiments were reported at the April 1993 meeting of the Eastern Psychological Association, in Arlington, VA. We are grateful to Anthony Cirillo, Roseann Genovese, Carolyn Handley, Matthew Loftus, Art Square, and Teresa Tokarska, for assistance with data collection; and to Nancy Kanwisher, Lester Krueger, Kim Shapiro, and Steve Tipper, for helpful comments on the initial draft of this paper. Please direct correspondence to: W. T. Neill, Department of Psychology, Adelphi University, Garden City, NY 11530.

Snyder, 1980), inhibition of orienting to a location should similarly hamper discrimination performance.

The present experiments were motivated by our failure to obtain IOR in eight experiments in which we had expected it to occur (Neill, Valdes & Terry, 1992; see also Neill, Terry, & Valdes, in press). In those experiments, subjects were instructed to respond to the location of a target "O" appearing in one of four locations, ignoring a distractor "X" appearing in another location. A "negative priming" effect reliably occurred for probe targets that appeared in the same location as the recently ignored distractor (cf. Neill, Valdes, Terry, & Gorfein, 1992; Tipper, Brehaut, & Driver, 1990). In all eight reported experiments, we found significant facilitation, rather than inhibition, for probe targets that appeared in the same location as that for the previously attended target.

The experiments by Neill, Valdes, and Terry (1992) differed from past studies demonstrating IOR primarily in that subjects were required to discriminate the target stimulus from a nontarget. Experiments reported by Egly, Rafal, and Henik (1992) also raised the possibility that IOR does not generalize to discrimination tasks: Within each experiment, subjects received central (endogenous) or peripheral (exogenous) cues, varying in cue validity (i.e., the probability that a target would appear in the cued location). IOR was obtained in two experiments that required detection judgments, but not in two other experiments that required discrimination judgments.

In the present experiments, a target letter "A" or "B" appeared to the left or right of fixation, 500 msec after the onset of a fixation cross. After a subject's response, the screen was blanked for 500 msec before onset of the next fixation cross. The fixation cross onset was intended to attract subjects' attention back to the central location, and away from the location of the preceding target (cf. Maylor, 1985; Posner & Cohen, 1980, 1984). In a pilot experiment, using a continuously visible fixation cross, we found facilitation, rather than inhibition, when a target appeared at the same location as did the preceding target. As evidenced by the present experiments, onset of the fixation cross was necessary to produce IOR.

EXPERIMENT 1

In Experiment 1, subjects pressed a single key for the appearance of either target letter. No stimulus was presented on nontarget trials in the no-discrimination condition; hence, the task required only simple onset detection. In the discrimination condition, a letter "C" or "D" appeared on nontarget trials; here, a disjunctive "go/no-go" discrimination was required. (Donders, 1868/1969, referred to these as "a" and "c" tasks, respectively.) We hypothesized that IOR would occur in the simple detection task, but not in the task requiring discrimination.

Method

Subjects. Twenty Adelphi University undergraduates were recruited from introductory psychology courses. Each subject par-

ticipated in an individual session of approximately 30 min to satisfy an experiment participation requirement.

Stimuli and Apparatus. Stimuli were presented on an AMDEK Color-I Plus video monitor controlled by an Apple IIe micro-computer. Subjects responded by pressing the spacebar on the computer keyboard. Response latencies were measured to the nearest millisecond with a Mountain Hardware Apple Clock.

A plus sign (+) served as a fixation point and warning signal, centered on the 10th print line of the video monitor. The stimuli were the uppercase letters "A," "B," "C," and "D" from the standard character set, presented two print spaces to the left or right of the fixation cross. At an average viewing distance of 57 cm, letter height and width subsumed approximately .8° and .5° of visual angle, respectively, centered at approximately 1.1° to the left or right of fixation. The experiment room was moderately well lit, and the monitor was set at the preset "normal" brightness level.

Procedure. Each trial began with the presentation of a fixation cross. On target-present trials, a letter "A" or "B" appeared approximately 500 msec later, randomly to the left or right of fixation. On nontarget trials in the no-discrimination condition, the fixation cross remained in view, but no other stimulus was presented. On nontarget trials in the discrimination condition, a letter "C" or "D" appeared randomly to the left or right of fixation.

The subjects were instructed to press the spacebar with the preferred hand whenever they saw a letter "A" or "B." The stimuli remained in view until the subject responded, or when 3 sec had elapsed without a response. The screen was blanked for approximately 500 msec before the next trial began. Instructions emphasized that responses should be fast, but that errors should be avoided. Error feedback was provided by the word ERROR displayed for approximately 500 msec, accompanied by a computer-generated tone.

The subjects received 5 blocks of 50 trials each in the no-discrimination condition, and another 5 blocks of 50 trials each in the discrimination condition. Half the subjects first participated in the no-discrimination condition, followed by the discrimination condition; the order was reversed for the remaining subjects.

Results

The primary analysis concerned RT to targets appearing in a location that was either the same as or opposite to that of a target to which the subject had correctly responded on the immediately preceding trial. Geometric means in each condition were computed for each subject and entered into a $2 \times 2 \times 2$ analysis of variance (ANOVA) with within-subject variables of location change (same or opposite location), target change (repeated or changed letter), and task (discrimination or no discrimination).

Overall means for each condition are displayed in Table 1. Average RT was faster in the no-discrimination task ($M = 355$ msec) than in the discrimination task (434 msec)

Table 1
Simple and Disjunctive Reaction Time (in Milliseconds)
as a Function of Discrimination Requirement, Location,
and Target Identity (Experiment 1)

Identity	Task Requirement and Location			
	No Discrimination		Discrimination	
	Same	Opposite	Same	Opposite
Repeated	357	352	426	441
Changed	363	350	439	430

$[F(1,19) = 103.83, MS_e = 2,390, p < .0001]$. Target change interacted with location change, in such a way that repeated targets produced slightly faster responses at the same location than at the opposite location (391 vs. 396 msec), whereas changed targets produced the reverse pattern (401 vs. 390 msec) $[F(1,19) = 5.71, MS_e = 439, p < .05]$. Most important was that the interaction of location change with task approached significance $[F(1,19) = 4.15, MS_e = 304, p = .0558]$.

Because the principal hypotheses concern different patterns within each task, separate analyses were performed for the discrimination and no-discrimination conditions. For the no-discrimination task, the main effect of location change approached significance $[F(1,19) = 4.34, MS_e = 348, p = .0509]$. This effect reflected slower responses to same-location targets (360 msec) than to opposite-location targets (351 msec). Notably, there was no main effect of target change, or interaction (both $F_s < 1$).

A very different pattern occurred in the discrimination task. Neither main effect was significant (both $F_s < 1$), but the interaction of target change and location change was significant $[F(1,19) = 5.55, MS_e = 517, p < .05]$. A Fisher LSD of 15 msec ($p < .05$) indicates faster RT for repeated targets in the same (426 msec) as opposed to the opposite (441 msec) location, whereas changed targets were nonsignificantly slower in the same location (439 msec) than in the opposite location (430 msec).

A separate analysis was conducted for trials following nontarget trials. Responses were again faster in the no-discrimination condition (401 msec) than in the discrimination condition (469 msec) $[F(1,19) = 23.85, MS_e = 3,901, p < .0001]$. However, responses in the discrimination condition were unaffected by whether the target appeared in the same or the opposite location with respect to that of a preceding nontarget (both, 469 msec).

Because a stimulus remained in view until either the subject responded or 3 sec had elapsed, errors on target trials were infrequent. In the whole experiment, two misses (failures to respond) occurred in the detection task, and none occurred in the discrimination task. False alarms (anticipation errors) were also infrequent in the detection task: Seven responses were made on nontarget trials that followed a nontarget trial, and only one following a target trial. In the discrimination task, there were more false alarms following a target trial (2.14%) than following a nontarget trial (0.66%) $[F(1,19) = 10.19, MS_e = 4.33, p < .01]$. However, there was no effect of location change, nor was there any interaction (both $F_s < 1$).

Discussion

The results provide at least tentative support for the principal hypothesis: That is, an overall IOR appeared in the detection task without discrimination, yet when discrimination was required, no such effect was obtained. In the latter task, the most clear-cut result was a significant facilitation for repeated targets appearing in the same location, as opposed to repeated targets appearing in opposite locations. The failure to obtain a similar result for

changed targets raises the possibility that IOR may be offset by a "repetition priming" effect specific to repetition at the same location. This possibility will be addressed further.

Meanwhile, it may be noted that the introduction of non-target letters in the discrimination task creates other differences with the no-discrimination task. In particular, the overall rate of stimulus events (target or nontarget) is necessarily higher in the discrimination task. Although there is no obvious reason why differential rates of stimulus presentation should affect IOR, it would be desirable to demonstrate IOR in a condition with the same physical display parameters as those for the present discrimination task. In addition, IOR did not quite reach conventional levels of statistical significance in the no-discrimination condition (although it came very close). Hence, a replication is warranted, to ensure that the present procedures are in fact adequate to produce IOR.

EXPERIMENT 2

In Experiment 2, both of these concerns were addressed in a two-alternative choice RT task (i.e., Donders's, 1868/1969, "b" task). Subjects were here instructed to press a key corresponding to the location of the target (cf. Maylor & Hockey, 1985). A target letter appeared on each trial, to the left or right of fixation. In the discrimination condition, a nontarget letter appeared in the opposite location; in the no-discrimination condition, the opposite location was blank.¹ Again, it was hypothesized that IOR would occur only in the latter condition.

Method

Subjects. Twenty Adelphi University undergraduates were recruited from introductory psychology courses. None had participated in Experiment 1. Each subject participated in an individual session of approximately 30 min to satisfy an experiment participation requirement.

Stimuli and Apparatus. The stimuli and apparatus were identical to those in Experiment 1, except that responses were made on the "open apple" and "filled apple" keys located to the immediate left and right of the spacebar on the computer keyboard.

Procedure. A target letter "A" or "B" was presented on each trial, randomly to the left or right of fixation. The subjects were instructed to press the "open apple" and "filled apple" keys with their left and right index fingers, respectively, according to the location of the target. In the discrimination condition, a nontarget "C" or "D" appeared in the location opposite to that of the target letter. In the no-discrimination condition, the opposite location remained blank. The stimulus arrays remained in view until terminated by the subject's response. All other aspects of procedure were identical to those of Experiment 1.

Results

Error responses and responses immediately following error responses were excluded from the analysis of RTs. As in Experiment 1, the subjects' geometric means for each condition were entered into a $2 \times 2 \times 2$ ANOVA, with within-subject variables of location change (same or opposite location), target change (repeated or changed letter), and task (discrimination or no discrimination).

Table 2
Choice Reaction Time (in Milliseconds) and Error Percentages for Localization, as a Function of Discrimination Requirement, Location, and Target Identity (Experiment 2)

Identity	Task Requirement and Location							
	No Discrimination				Discrimination			
	Same		Opposite		Same		Opposite	
	RT	PE	RT	PE	RT	PE	RT	PE
Repeated	334	1.05	323	0.95	429	1.25	449	2.25
Changed	337	1.20	329	0.80	470	3.10	455	1.10

Note—Discrimination task data are collapsed over repeated and unrepeated nontargets.

Overall means for each condition are displayed in Table 2. Average RT was faster in the no-discrimination task (331 msec) than in the discrimination task (451 msec) [$F(1,19) = 83.97$, $MS_e = 6,844$, $p < .0001$]. In addition, responses were faster to repeated targets (384 msec) than to changed targets (397 msec) [$F(1,19) = 33.86$, $MS_e = 220$, $p < .0001$]. Target change also interacted with task [$F(1,19) = 19.23$, $MS_e = 200$, $p < .0005$] and with location change [$F(1,19) = 20.43$, $MS_e = 132$, $p < .0005$]. These two interactions were further qualified by a significant triple interaction [$F(1,19) = 33.76$, $MS_e = 106$, $p < .0001$].

An analysis of the no-discrimination task alone indicated significant IOR: responses were slower to same-location targets (335 msec) than to opposite-location targets (326 msec) [$F(1,19) = 5.15$, $MS_e = 342$, $p < .05$]. In addition, the main effect of target change approached significance [$F(1,19) = 4.26$, $MS_e = 69$, $p = .0529$]: repeated targets (329 msec) were localized slightly faster than changed targets (333 msec). The interaction, however, did not approach significance ($F < 1$).

The pattern in the discrimination task was very different. There was no main effect of location change ($F < 1$), but repeated targets (439 msec) were localized faster than changed targets (462 msec) [$F(1,19) = 31.30$, $MS_e = 351$, $p < .0001$]. In addition, target change interacted with location change [$F(1,19) = 31.76$, $MS_e = 196$, $p < .0001$]: A Fisher's LSD of 14 msec ($p < .05$) indicates a significant same-location advantage for repeated targets (429 msec, same location, vs. 449 msec, opposite location), but a significant opposite-location advantage for changed targets (470 msec, same location, vs. 455 msec, opposite location).

An additional analysis was performed for the discrimination task to examine effects of repeated or changed nontargets ("C" or "D"). This variable interacted with target change [$F(1,19) = 10.13$, $MS_e = 179$, $p < .005$] in such a way that the advantage of repeated targets over changed targets was greater when the same nontarget was repeated (433 vs. 464 msec) than when it was not (444 vs. 461 msec). No other effects involving this variable approached significance.

Analysis of error rates yielded a significant main effect of task [$F(1,19) = 7.10$, $MS_e = 4.82$, $p < .02$]: fewer errors were made in the no-discrimination task

(1.00%) than in the discrimination task (1.93%). Target change interacted with location change [$F(1,19) = 13.60$, $MS_e = 2.00$, $p < .002$], and this interaction was qualified by a triple interaction with task [$F(1,19) = 14.12$, $MS_e = 1.29$, $p < .002$].

No effects approached significance in the no-discrimination task (all F s < 1). The discrimination task yielded an interaction of target change and location change [$F(1,19) = 22.50$, $MS_e = 2.00$, $p < .0001$], similar to that obtained in RT: Fewer errors were made in response to repeated targets in the same location (1.25%) as opposed to the opposite location (2.25%), but more errors were made in response to changed targets in the same location (3.10%) as opposed to the opposite location (1.10%).

Discussion

The no-discrimination condition yielded a clear IOR effect in target localization, analogous to the results of Maylor and Hockey (1985). It may be noted that the overall stimulus event rate in this condition was identical to that in the discrimination task in Experiment 1. Therefore, the presence or absence of IOR between the two tasks in Experiment 1 cannot be attributed simply to differences in stimulus event rate. Furthermore, the significant IOR in this experiment supports the interpretation of Experiment 1, that IOR did occur in the no-discrimination task.

As in Experiment 1, no overall IOR occurred in the discrimination task. However, this null result is complicated by the significant interaction of location change with target change: A same-location advantage occurred for repeated targets, but an opposite-location advantage occurred for changed targets.

It is possible that IOR really did occur in the discrimination task but was offset by some other location- and identity-specific process that facilitated the detection of a repeated target in the same location. Kahneman, Treisman, and Gibbs (1992), for example, found facilitation for repeated targets only if they were embedded in the same perceptual object. Treisman (1992) argues that object location serves as a retrieval cue for the "object file" containing the name of the previously exposed letter. Such a process might facilitate identification of a repeated target, despite the withdrawal of attention from that location.

Alternatively, IOR may not have occurred at all in the discrimination task. Rather, the difference between repeated and unrepeated targets may reflect a response bias caused by a match or mismatch to the previous target (cf. Fletcher & Rabbitt, 1978). Thus, detecting a repeated target may have induced a bias to make the same localization response, whereas detecting a changed target may have induced the opposite bias.

EXPERIMENT 3

Experiment 3 directly tested the effect of location on identification; either a target ("A" or "B") or a nontarget ("C" or "D") was presented on each trial. The displays were thus identical to those in the discrimina-

tion condition in Experiment 1. However, subjects were here instructed to press one key for targets, and another for nontargets. If IOR in fact occurs, but is compensated by location-specific repetition priming, then a same-location advantage should again occur only for repeated targets, whereas changed targets should show an opposite-location advantage.

Method

Subjects. Twelve Adelphi University undergraduates were recruited from introductory psychology courses. None had participated in Experiment 1 or 2. As in the previous experiments, each subject participated in an individual session of approximately 30 min to satisfy an experiment participation requirement.

Stimuli and Apparatus. The stimuli and apparatus were identical to those in Experiment 2.

Procedure. On each trial, a single letter appeared to the left or right of fixation. Subjects were instructed to press one key if a target "A" or "B" appeared, and to press another key if any other letter appeared. The subjects used the left and right index fingers to press the "open apple" and "filled apple" keys, respectively. Hand assignment to targets and nontargets was counterbalanced over subjects. The instructions did not explicitly mention the nontarget letter identities ("C" or "D"). Each subject received six blocks of 50 trials each. (Because the task explicitly required discrimination, a comparable no-discrimination condition was not possible here.) All other aspects of procedure were identical to those of Experiments 1 and 2.

Results

Overall means for conditions are displayed in Table 3. The subjects responded to nontargets as well as targets, and nontarget trials could be classified according to the same criteria as target trials. Consequently, nontarget trials were included in the analyses. Error responses and responses following error responses were excluded from the RT analyses.

In order to assess the effects of stimulus change independent of response change, repeated targets and nontargets were contrasted with changed targets and nontargets in target-target sequences and nontarget-nontarget sequences. The subjects' geometric means for each condition were entered into a $2 \times 2 \times 2$ ANOVA, with within-subject variables of trial type (target or nontarget), location change (same or opposite location), and target/nontarget change (repeated or changed letter).

Average RT was faster for targets (482 msec) than for nontargets (507 msec) [$F(1,11) = 10.04$, $MS_e = 890$, $p < .01$]; faster for repeated targets and nontargets (471 msec)

than for changed targets and nontargets (517 msec) [$F(1,11) = 19.61$, $MS_e = 1,121$, $p < .001$]; and faster for same-location trials (478 msec) than for opposite-location trials (511 msec) [$F(1,11) = 40.76$, $MS_e = 331$, $p < .0001$]. No interactions approached significance (all F s < 1). It is particularly notable that unrepeated letters yielded a 34-msec same-location advantage (500 vs. 534 msec), statistically equivalent to the 33-msec same-location advantage for repeated letters (455 vs. 487 msec).

A similar analysis of error rates indicated more errors on target trials (3.10%) than on nontarget trials (1.85%) [$F(1,11) = 9.83$, $MS_e = 6.99$, $p < .05$]. Fewer errors occurred for repeated targets and nontargets (1.13%) than for changed targets and nontargets (3.83%) [$F(1,11) = 13.32$, $MS_e = 8.23$, $p < .01$]. No other effects approached significance.

In order to assess the effects of response change independently of stimulus change, in further analyses changed targets and nontargets in target-target and nontarget-nontarget sequences were contrasted with changed targets and nontargets in target-nontarget and nontarget-target sequences. The subjects' geometric means for each condition were entered into a $2 \times 2 \times 2$ ANOVA, with within-subject variables of trial type (target or nontarget), location change (same or opposite location), and response change (same or opposite response).

In the RT analysis, only the interaction between response change and location change was significant [$F(1,11) = 69.59$, $MS_e = 203$, $p < .0001$]. Whereas same-response trials yielded a same-location advantage (500 vs. 534 msec), opposite-response trials yielded an opposite-location advantage (513 vs. 499 msec). A Fisher's LSD of 13 msec indicates that both of these effects were significant at $p < .05$.

More errors again occurred on target trials (3.48%) than on nontarget trials (2.27%) [$F(1,11) = 5.32$, $MS_e = 7.88$, $p < .05$]. Fewer errors occurred on opposite-response trials (1.92%) than on same-response trials (3.83%) [$F(1,11) = 7.97$, $MS_e = 6.87$, $p < .05$]. No other effects approached significance in the error rate analysis.

Discussion

There was no evidence of IOR in this experiment, despite display parameters similar to the conditions that did produce IOR in Experiments 1 and 2. The first two experiments raised the possibility that IOR in discrimi-

Table 3
Choice Reaction Time (in Milliseconds) and Error Percentages for Identification,
as a Function of Trial Type, Location, and Target/Nontarget Identity (Experiment 3)

Identity	Trial Type and Location							
	Target Trials				Nontarget Trials			
	Same		Opposite		Same		Opposite	
	RT	PE	RT	PE	RT	PE	RT	PE
Repeated	442	0.83	479	2.75	468	0.91	495	0.00
Changed, same response	488	4.75	518	4.08	512	3.17	551	3.33
Changed, opposite response	512	3.42	490	1.67	515	1.42	508	1.17

nation tasks might be offset by a location-specific repetition effect, such that a repeated target in the same location might be identified more quickly. However, in this direct test of identification, a changed target showed as much same-location advantage as did a repeated target, as long as it required the same response.

At the same time, it is not clear that presentation of a target in the same location as that of the previous target actually enhanced its identification, since letters requiring the opposite response yielded an opposite-location advantage. Thus, if "A" had appeared to the left of fixation, response to "B" was faster if it also appeared to the left, but response to "C" or "D" was faster if they appeared to the right. This suggests that the nominally irrelevant stimulus attribute, location, affected response bias: if identical, it encouraged the same response; if different, it encouraged the opposite response.

As such, these results complement those of the previous experiment: In Experiment 2, a change in target identity, while irrelevant in principle to localization, biased responding toward the opposite response. In this experiment, a change in target location, irrelevant in principle to identification, nonetheless biased responding toward the opposite response.

Experiment 3 differed from the previous experiments in that subjects responded overtly to the "nontarget" stimuli ("C" and "D"). It is reassuring that these stimuli produced exactly the same interaction with location as did the "target" stimuli. It is interesting, however, that responses to "A" and "B" were faster, but less accurate, than responses to "C" and "D." It may be noted that a response bias per se would not account for such a result, because a bias toward a particular response would produce both faster and more accurate responses on trials requiring that response.

This pattern is reminiscent of the *same/different disparity*, or *fast-same effect*, noted in many studies on perceptual matching (see Krueger, 1978; Proctor, 1981). In such experiments, responses on *same* trials are typically faster, but more error prone, than responses on *different* trials. Krueger (1978) maintains that false mismatches are more likely than false matches; hence, *different* pairs require "rechecking" to ensure that such pairs are really different. The subjects in the present experiment may have used a similar matching process, comparing each stimulus letter to a mental representation of the target letters, which had been emphasized by the instructions.

GENERAL DISCUSSION

The present experiments failed to find any evidence for inhibition of return when target discrimination was required, despite the same display parameters that produced IOR when discrimination was not required. Experiments 1 and 2 raised the possibility that IOR occurred for non-repeated targets in discrimination tasks, but was compensated by a location-specific facilitation for repeated targets.

However, a direct test of identification in Experiment 3 found a same-location advantage for changed targets, as well as for repeated targets, as long as there was no response change.

The most parsimonious account of the present results is that IOR did not occur in the present experiments when discrimination was required. It remains, then, to account for the opposite-location advantage for changed targets in Experiment 2. This discrepancy seems most easily attributable to an "alternation bias" induced by the change in target identity.

A number of studies have found little direct benefit of response repetition, except when it has been accompanied by stimulus repetition (e.g., Ells & Gotts, 1977; Fletcher & Rabbitt, 1978; Krueger & Shapiro, 1981). Subjects may tend to repeat the same response if they recognize the current stimulus as similar to a previous one, bypassing the normal processes for response selection (Bertelson, 1963, 1965). In a two-choice RT task, subjects are similarly biased to make the opposite response if there is a mismatch between successive stimuli (Fletcher & Rabbitt, 1978).

Krueger and Shapiro (1981) observed that subjects use this "bypass rule" even when stimuli match or mismatch on dimensions that should be irrelevant to response selection. This effect of irrelevant dimensions was symmetrical in the present experiments: In Experiment 2, a change in target identity favored the opposite localization response, whereas in Experiment 3, a change in target location favored the opposite identification response.

This interpretation is supported by an experiment in which four possible target locations were mapped into two responses (Neill, Valdes, & Terry, 1992). A target could randomly appear (1) in the same location as that of the previous target, (2) in a new location requiring the same response as did the previous target, or (3) a new location requiring the opposite response. The first condition produced significantly faster responses than the second, indicating a location-specific repetition effect. However, the second condition was significantly slower than the third, indicating an alternation bias for a changed target.

No attempt was made to control eye movements in the present study, other than to instruct subjects to fixate the warning signal at the beginning of the trial. This raises the question of whether subjects continued to fixate the last stimulus location, which would counteract IOR. Even with eye movements controlled, lingering attention to the last stimulus location would, in principle, preclude IOR.

However, uncontrolled eye movements and/or attention do not easily account for the present pattern of data. In order to account for IOR obtained in the no-discrimination conditions of Experiments 1 and 2, it would be necessary to assume that fixation has a greater tendency to linger on the last target location if discrimination is required. Furthermore, lingering fixation and/or attention would be expected to produce a same-location advantage for changed targets in Experiment 2, as well as for opposite-response targets and nontargets in Experiment 3. But, as noted, the

same-location advantage occurred only for repeated targets in Experiment 2, and only for same-response targets and nontargets in Experiment 3.

Neill, Valdes, and Terry (1992) provided further evidence that a same-location advantage cannot be attributed to lingering fixation and/or attention: In one experiment, we still found a same-location benefit when targets were separated by an intervening trial requiring a response to a different location. Thus, the response on trial n was faster if the target appeared in the trial $n-2$ target location, than if it appeared in a neutral location.

In the present experiments, subjects were oriented to particular locations by targets requiring a response (cf. Maylor & Hockey, 1985). As discussed in the introduction, Egly et al. (1992) also failed to find IOR in experiments that required target discrimination. In those experiments, locations were cued by the brightening of a box to the left or right of fixation, which was similar to the procedure used by Posner and Cohen (1980, 1984). Hence, IOR seems to disappear when target discrimination is required, regardless of whether a "target-target" or "cue-target" procedure is used (terminology from Maylor & Hockey, 1985).

It is not possible to prove that IOR *never* occurs in discrimination tasks, and some experiments might produce a counterexample. In this regard, Shapiro and Loughlin (1993) found a tendency toward IOR in a localization task similar to that of Neill, Valdes, and Terry (1992). The effects fell short of statistical significance within each experiment, but did achieve significance when pooled over four experiments. It is unclear what procedural differences account for the discrepancy.

Regardless of whether IOR can sometimes be obtained in discrimination tasks, the present results clearly indicate that IOR is sensitive to changes in what information is critical to task performance. In particular, the effect is at least attenuated when a task is changed to require target discrimination. As such, these results undermine the assertion that IOR reflects an innate bias against returning attention to a recently attended location (Posner & Cohen, 1980, 1984).

We question here the "ecological" argument posed by Posner and Cohen, that it is inefficient to repeatedly sample the same locations (or objects—see Tipper et al., 1991) in the visual environment. This seems especially dubious when a location has just yielded useful information (as when a target for response has just appeared there). There are many occasions in the natural environment in which it is adaptive to return attention to recently attended locations. In the African savannah, for example, antelopes may not immediately flee at sight of a predator; rather, they will intermittently "resample" the lion or leopard for signs of threatening behavior.

Similarly, on the highway, you may notice another car drifting into your lane, presenting a possible danger. Given the many other demands on your attention, you may not be able to continuously monitor that car. Yet it is ob-

viously adaptive to be able to return attention to it quickly and efficiently. In such situations, IOR could be disastrous.

On the other hand, IOR may be more adaptive for certain kinds of information than for others. For example, sudden movements or abrupt onsets are particularly effective at capturing attention (see, e.g., Posner, 1980; Posner & Cohen, 1984). In the absence of any other useful information, resampling of repeated onsets at a particular location probably would not be adaptive. For example, the waving of tree branches in a breeze would cause many uninformative onsets that should probably be ignored. Perhaps this is why IOR is revealed in detection tasks, but not in discrimination tasks.

REFERENCES

- BERTELSON, P. (1963). S-R relationships and reaction times to new versus repeated signals in a serial task. *Journal of Experimental Psychology*, **65**, 478-484.
- BERTELSON, P. (1965). Serial choice reaction-time as a function of response versus signal-and-response repetition. *Nature*, **206**, 217-218.
- DONDERS, F. C. (1969). On the speed of mental processes (W. G. Koster, Trans.). In W. G. Koster (Ed.), *Attention and performance II* (pp. 412-431). Amsterdam: North-Holland. (Original work published 1868)
- EGLY, R., RAFAL, R. D., & HENIK, A. (1992, November). *Reflexive and voluntary orienting in detection and discrimination tasks*. Poster presented at the meeting of the Psychonomic Society, St. Louis.
- ELLS, J. G., & GOTT, G. H. (1977). Serial reaction time as a function of the nature of repeated events. *Journal of Experimental Psychology: Human Perception & Performance*, **3**, 234-242.
- ERIKSEN, C. W., & HOFFMAN, J. E. (1973). The extent of processing of noise elements during selective encoding from visual displays. *Perception & Psychophysics*, **14**, 155-160.
- FLETCHER, B., & RABBITT, P. M. A. (1978). The changing pattern of perceptual analytic strategies and response selection with practice in a two-choice reaction time task. *Quarterly Journal of Experimental Psychology*, **30**, 417-427.
- HARVEY, N. (1980). Non-informative effects of stimuli functioning as cues. *Quarterly Journal of Experimental Psychology*, **32**, 413-425.
- KAHNEMAN, D., TREISMAN, A., & GIBBS, B. J. (1992). The reviewing of object files: Object-specific integration of information. *Cognitive Psychology*, **24**, 175-219.
- KRUEGER, L. E. (1978). A theory of perceptual matching. *Psychological Review*, **85**, 278-304.
- KRUEGER, L. E., & SHAPIRO, R. G. (1981). Intertrial effects of same-different judgements. *Quarterly Journal of Experimental Psychology*, **33A**, 241-265.
- MAYLOR, E. A. (1985). Facilitatory and inhibitory components of orienting in visual space. In M. I. Posner & O. S. M. Marin (Eds.), *Attention and performance XI* (pp. 189-204). Hillsdale, NJ: Erlbaum.
- MAYLOR, E. A., & HOCKEY, R. (1985). Inhibitory components of externally controlled overt orienting in visual space. *Journal of Experimental Psychology: Human Perception & Performance*, **11**, 777-787.
- NEILL, W. T., TERRY, K. M., & VALDES, L. A. (in press). Negative priming without probe selection. *Psychonomic Bulletin & Review*.
- NEILL, W. T., VALDES, L. A., & TERRY, K. M. (1992, November). *Negative priming in target localization*. Paper presented at the meeting of the Psychonomic Society, St. Louis.
- NEILL, W. T., VALDES, L. A., TERRY, K. M., & GORFEIN, D. S. (1992). Persistence of negative priming: II. Evidence for episodic trace retrieval. *Journal of Experimental Psychology: Learning, Memory, & Cognition*, **18**, 993-1000.
- POSNER, M. I. (1980). Orienting of attention: The Seventh Bartlett Memorial Lecture. *Quarterly Journal of Experimental Psychology*, **32**, 3-25.

- POSNER, M. I., & COHEN, Y. (1980, November). *Consequences of visual orienting*. Paper presented at the meeting of the Psychonomic Society, St. Louis.
- POSNER, M. I., & COHEN, Y. (1984). Components of visual orienting. In H. Bouma & D. G. Bouwhuis (Eds.), *Attention and performance X: Control of language processes* (pp. 531-556). Hillsdale, NJ: Erlbaum.
- POSNER, M. I., COHEN, Y., CHOATE, L., HOCKEY, R., & MAYLOR, E. (1984). Sustained concentration: Passive filtering or active orienting? In S. Kornblum & J. Requin (Eds.), *Preparatory states and processes* (pp. 49-65). Hillsdale, NJ: Erlbaum.
- POSNER, M. I., DAVIDSON, B. J., & SNYDER, C. R. R. (1980). Attention and the detection of signals. *Journal of Experimental Psychology: General*, **109**, 160-174.
- PROCTOR, R. W. (1981). A unified theory for matching-task phenomena. *Psychological Review*, **88**, 291-326.
- RAFAL, R. D., CALABRESI, P. A., BRENNAN, C. W., & SCIOLTO, T. K. (1989). Saccade preparation inhibits reorienting to recently attended locations. *Journal of Experimental Psychology: Human Perception & Performance*, **15**, 673-685.
- SHAPIRO, K. L., & LOUGHLIN, C. (1993). The locus of inhibition in the priming of static objects: Object token versus location. *Journal of Experimental Psychology: Human Perception & Performance*, **19**, 352-363.
- TIPPER, S. P., BREHAUT, J. C., & DRIVER, J. (1990). Selection of moving and static objects for the control of spatially directed action. *Journal of Experimental Psychology: Human Perception & Performance*, **16**, 492-504.
- TIPPER, S. P., DRIVER, J., & WEAVER, B. (1991). Object-centred inhibition of return of visual attention. *Quarterly Journal of Experimental Psychology*, **43A**, 289-298.
- TREISMAN, A. (1992). Perceiving and re-perceiving objects. *American Psychologist*, **47**, 862-875.

NOTE

1. The term *discrimination* specifically applies here to the decision of whether a stimulus is a target or a nontarget. This decision is presumably based on the identity of the stimulus. However, we do not use the term *identification* here, because identity directly determined response selection only in Experiment 3; and subjects made the same responses to both "A" and "B" targets in all three experiments.

Technically, *localization* is also a form of discrimination, as subjects must decide between different locations. However, there are many reasons to consider localization of onsets to be qualitatively different from discrimination based on stimulus identity. In particular, the location of onsets may be available concurrently with the detection of the onsets. In this regard, it may be noted that pure localization (without target/nontarget discrimination) in Experiment 2 was as fast as pure detection in Experiment 1. The commonality of detection and localization, in contrast to discrimination based on identity, is further supported by the present findings of IOR in both detection and localization when target discrimination is not required.

(Manuscript received April 5, 1993;
revision accepted for publication July 30, 1993.)