Task dependent modulation of exogenous attention: Effects of target duration and intervening events

Elisa Martín-Arévalo · Ana B. Chica · Juan Lupiáñez

Published online: 25 May 2013
© Psychonomic Society, Inc. 2013

Abstract *Inhibition of return* (IOR) consists of slower reaction times in response to stimuli appearing at previously attended or inspected locations. The exact mechanisms underlying the effect have not yet been determined. In the present work, we manipulated two variables, target duration and intervening event (fixation cue between cue and target), through which we modulated the IOR effect as a function of task. When the target was presented until response, the presence of an intervening event made the cueing effect more negative in all tasks, although facilitation in the absence of an intervening event was only observed in discrimination and go–no-go tasks. When the target duration was 50 ms, the effect of the intervening event on cueing was also only observed for the discrimination and go–no-go tasks. Target duration had no effect at all in the discrimination task. Possible mechanisms for these modulations (detection cost and spatial selection benefit, both of which are based on cue–target integration processes) are discussed.

Keywords IOR · Target duration · Intervening event · Fixation cue · Task set · Detection cost · Cue–target integration

Attentional orienting is described in the literature as being driven by two mechanisms: endogenous and exogenous orienting (Jonides, 1981). The cost-and-benefit paradigm has been widely used to study these two forms of spatial orienting (Posner, 1980). In this

paradigm, a fixation point is presented at the center of a computer screen, with one box being positioned to the left and one to the right of the fixation point. To study *endogenous orienting*, a central symbolic, spatially informative cue (e.g., an arrow or number) is presented at fixation, predicting the most likely location of an upcoming target. Usually, reaction times (RTs) to targets appearing at the expected location are faster than those to targets presented at the unexpected location, even at long cue–target stimulus onset asynchronies (SOAs; Posner, 1980). This effect is known as *facilitation*. In contrast, for investigations of *exogenous orienting*, a spatially uninformative peripheral cue (e.g., a brief flash in one of the boxes) is normally used. This spatial cue does not provide reliable information about the target location (Posner & Cohen, 1984). At short SOAs, RTs are usually faster for targets appearing at the same location as the peripheral cue (i.e., the cued location) than for targets presented at the opposite location (i.e., the uncued location); that is, a facilitatory effect is observed. At longer SOAs, however, the opposite pattern of results emerges: RTs are faster for targets appearing at the uncued as compared to the cued location. This effect, first reported by Posner and Cohen, and named *inhibition of return* (IOR) by Posner, Rafal, Choate, and Vaughan (1985), was initially thought to reflect a bias against returning attention to previously explored locations (see Klein, 2000; Lupiáñez, Klein, & Bartolomeo, 2006, for reviews). However, although these effects of peripheral cueing were thought to be highly automatic, research has shown that they are modulated by different variables. In fact, the expected results—facilitatory effects at short SOAs (i.e., before attention is disengaged from the cued location) and IOR effects at long SOAs (i.e., after attention is disengaged from the cued location)—are not at all as usual as one might think, and have been shown to depend on many variables, some of which are reviewed below.

E. Martín-Arévalo · A. B. Chica · J. Lupiáñez
Departamento de Experimental Psychology, University of Granada,
Granada, Spain

E. Martín-Arévalo (✉)
Departamento de Psicología Experimental, Campus de Cartuja,
S/N, C.P.:18071 Granada, Spain
e-mail: emartina@ugr.es

Modulation of peripheral cueing effects by task demands

Many studies have found that the magnitude and time course of cueing effects are sensitive to task factors. Lupiáñez and colleagues have consistently demonstrated that facilitation is larger in magnitude in discrimination than in detection tasks. Moreover, IOR emerges at longer cue–target intervals, and is smaller in size, in discrimination than in detection tasks (Lupiáñez, Milán, Tornay, Madrid, & Tudela, 1997; Lupiáñez & Milliken, 1999; Lupiáñez, Ruz, Funes, & Milliken, 2007). A review of the literature on cueing effects with detection tasks indicates that, contrary to IOR, which is an extremely robust effect when participants detect the appearance of targets, the occurrence of early facilitation is difficult to observe (see, e.g., Collie, Maruff, Yucel, Danckert, & Currie, 2000; Mele, Savazzi, Marzi, & Berlucchi, 2008; Tassinari, Aglioti, Chelazzi, Peru, & Berlucchi, 1994; Tassinari & Berlucchi, 1995). Instead of being a rather general finding, it may indeed require special stimulus conditions. Thus, in most of the classic studies that have shown evidence of early facilitation in a detection task, the effect is observed at very brief cue–target SOAs (i.e., <250 ms; Maylor, 1985; Maylor & Hockey, 1987; Posner & Cohen, 1984) or with relatively long cues (i.e., displayed until target offset) that overlap in time with the target (Collie et al., 2000). Concretely, Collie et al. showed that with temporal overlap between the cue and target, significant facilitatory effects were observed at the short, 150-ms SOA. In contrast, other studies have shown facilitation in detection tasks no matter whether or not the cue and target overlapped (Berger, Dori, & Henik, 1999). In particular, although target duration seemed not to have a determinant role in the observation of facilitatory effects in Berger et al.'s (1999) study, a long cue duration (200 ms) might have been crucial for observing facilitation in their detection task. Additionally, Tassinari and Berlucchi repeatedly failed to observe facilitation using SOAs as short as 65 ms. It is therefore unknown whether the occurrence of early facilitation in detection tasks crucially requires a very short cue–target SOA, or a temporal (as well as spatial) overlap between the cue and target, or both factors conjointly. In fact, IOR has been observed in many studies without any hint of facilitation at shorter SOAs (see, e.g., Mele et al., 2008; Tassinari et al., 1994).

Given all of the evidence above, cueing effects seem to be more negative (less facilitation and/or larger IOR) in detection than in discrimination tasks. Therefore, any explanation of cueing effects should elucidate why they are rather flexible effects with a variable time course and different signs (facilitation or IOR) depending on different factors, such as the task at hand.

Modulation by target characteristics

Other studies have revealed differences in the magnitudes, time courses, and even signs of cueing effects, depending on

the target characteristics. When target contrast was manipulated in a discrimination task (Snowden, Willey, & Muir, 2001), facilitatory effects were observed for both levels of target contrast (high and low), although the effects were much larger for low-contrast than for high-contrast target trials. Moreover, Taylor and Donnelly (2002) found that IOR in a target–target discrimination task depended on the interaction between the features of the cue and target. They showed that IOR was completely absent when the cues and targets were identical in identity and orientation (i.e., the physical similarity between the cue and target led to the modulations of cueing effects). Reuter-Lorenz, Jha, and Rosenquist (1996) also studied the effects of target intensity, target modality, and response modality on the magnitude of IOR in a detection task. They reported that IOR was larger when target luminance was low than when it was high, and when the target modality was visual rather than auditory. Moreover, Lupiáñez et al. (2007) carried out a study in which target frequency was manipulated; they introduced a frequent target (the letter X) on 75 % of the trials, and two different infrequent targets (the letters O and U) on 25 % of trials. Participants were instructed to detect the frequent target and to discriminate the identities of the other two, infrequent letters. Qualitatively different cueing effects were observed as a function of target type: IOR was observed when the most frequent target was to be detected, whereas a facilitatory effect was revealed for those trials in which one of the infrequent targets occurred and its identity had to be discriminated. Importantly, the sequences of events occurring in a given trial were identical for all conditions with the exception of target type, making it impossible for the participant to know in advance that the target would be presented until its onset, therefore equating attentional orienting in both conditions. Thus, these cueing effects depended completely on the target characteristics, with task set being identical in all conditions prior to target appearance.

In addition, some studies have highlighted the relevance of the temporal relationship between cues and targets in determining the magnitude and time course of cueing effects. Maruff and colleagues observed a facilitatory effect in a detection task only with short SOAs, temporal overlap between the cue and target, and the target remaining visible until the participant's response (Maruff, Yucel, Danckert, Stuart, & Currie, 1999). Concretely, they manipulated the temporal overlap between cues and targets, varying cue and target duration. The results showed facilitatory effects when a temporal overlap was present between the cue and target at the short SOA (i.e., 150 ms), and no effect at longer SOAs (i.e., 350 and 850 ms); when no overlap was present, no facilitation was found at the shortest SOA, and an IOR effect was observed at the longest SOAs. Importantly, the target duration manipulation also modulated cueing effects; in the overlapping condition, no facilitatory effect was observed at the short SOA when the target

duration was brief (i.e., 50 ms). Additionally, in the nonoverlapping condition, IOR was observed for all SOAs when the target duration was brief (i.e., 50 ms).

In sum, given the aforementioned evidence, we can establish that the relationship between the visual and temporal properties of cues and targets can impact the overall cueing effects that are measured.

Modulation by intervening event (fixation cue)

The presentation of a cue at fixation between the peripheral cue and the target (referred to here as the “intervening event”; see Spadaro, He, & Milliken, 2012, for a definition of an intervening event) is known to favor the appearance of IOR (Faust & Balota, 1997; MacPherson, Klein, & Moore, 2003; Pratt & Fischer, 2002; Prime, Visser, & Ward, 2006; Sapir, Henik, Dobrusin, & Hochman, 2001). Prime et al. (2006) investigated the effectiveness of an intervening event in revealing IOR in situations in which it would not be observed otherwise. The presence of an intervening event produced IOR in identity-based discrimination tasks, at cue–target SOAs at which no IOR effect was observed in the absence of an intervening event. However, in detection and localization tasks, they found that the magnitude of IOR was not affected by the presence of an intervening event (see also Pratt & Fischer, 2002). Indeed, many examples have shown the effectiveness of intervening events in revealing IOR in discrimination tasks (see, e.g., Kingstone & Pratt, 1999; Pratt & Abrams, 1999; Pratt, Kingstone, & Khoe, 1997; Prime & Ward, 2004), but we are not aware of many examples revealing IOR in the presence of intervening events in detection tasks. In fact, to our knowledge, the intervening event has been shown to be effective in producing IOR in visual detection tasks only in special populations among whom orienting is altered or is not fully developed, such as in Alzheimer patients (Faust & Balota, 1997), young children (MacPherson et al., 2003), or brain-damaged patients suffering from neglect (Bourgeois, Chica, Migliaccio, Thiebaut de Schotten, & Bartolomeo, 2012). Also, in gaze-cueing paradigms, it has been shown that an intervening event is necessary for IOR to be observed (Frischen & Tipper, 2004; Marotta, Pasini, Ruggiero, Maccari, Rosa, Lupiáñez, & Casagrande, 2013). It is important to note that in all of these studies, the target was displayed until a response was detected, which might be responsible for the intervening event’s modulation of cueing effects in detection tasks.

Similar modulations of IOR have been observed in discrimination tasks for the so-called “nonspatial IOR” (Spadaro et al., 2012). In this paradigm, participants are to identify the color of a centrally presented target. Spadaro et al. (2012) manipulated the presence of an intervening event between the presentation of the two consecutive targets and whether participants had to respond to the intervening event.

When the intervening event was presented and participants had to respond to it, an IOR effect was observed, with slower responses for repeated-color targets than for nonrepeated-color targets. However, when no intervening event was presented, and therefore no response was required, a facilitatory effect was observed instead, with responses being faster for repeated-color than for nonrepeated-color targets. In a follow-up study, Spadaro, Lupiáñez, and Milliken (*in press*) observed that responding to the intervening event was not necessary for IOR to be observed in this paradigm, to the extent that the intervening event was treated as a distinct event, different from the cue and target.

Importantly, although the presentation of an intervening event can be effective in generating IOR, many studies have revealed IOR in the absence of an intervening event (see, e.g., Chica, Lupiáñez, & Bartolomeo, 2006; Danziger & Kingstone, 1999; Ivanoff & Klein, 2001; Lupiáñez et al., 1997; Tassinari et al., 1994). This has been true for long and short SOAs (see, e.g., Maruff et al., 1999; McAuliffe & Pratt, 2005), detection and discrimination tasks (see, e.g., Chica et al., 2006; Lupiáñez et al., 1997; Lupiáñez et al., 2007; Pratt & Fischer, 2002), long and short target durations (see, e.g., Berger et al., 1999; see also Maruff et al., 1999), and so forth. Therefore, these results seem to suggest that intervening events may be unnecessary for obtaining IOR under certain conditions, but that they might be necessary for observing IOR in other conditions.

What is clear from the above-reviewed literature is that, far from being strictly automatic, peripheral cueing effects are modulated by variables such as the task demands, target characteristics, and presence/absence of an intervening event. Moreover, despite the numerous studies on cueing effects in which researchers have manipulated task demands (e.g., Lupiáñez et al., 1997; Lupiáñez & Milliken, 1999; Lupiáñez et al., 2007), target characteristics (e.g., Maruff et al., 1999; Snowden et al., 2001), and the presence/absence of an intervening event (e.g., Prime et al., 2006), a systematic study of the effects of all of these variables on cueing, as well as their interactions, is still to be performed.

Aims of the present work

We assume that part of the current theoretical uncertainty about cueing effects, and more concretely about IOR, is that many of the cue and target characteristics that modulate peripheral cueing effects (e.g., timing between cue and target, task demands, target modality, target intensity, cue type, intervening event, etc.) have not been jointly studied in a systematic way. Although there are some studies in this vein (for an illustrative example, see Taylor & Klein, 2000; for the effects of intervening events, see Prime et al., 2006; Spadaro et al., 2012; for the effects of target duration, see

Berger, Henik, & Rafal, 2005; Maruff et al., 1999; and for the effect of task, see Lupiáñez et al., 2007), further research will be essential for integrating results from experiments that have differed in a variety of experimental conditions, and for manipulating some of these relevant factors together, in order to better understand their possible interactions. With this aim in mind, the main purpose of the present study was to systematically investigate the effect of two of these variables (target duration and the presence/absence of an intervening event) across different tasks (detection, discrimination, and go–no-go¹ tasks), emphasizing the importance of the effects of task set on the presence (or absence) of IOR and facilitatory effects.

According to our general framework to explain spatial cueing effects (Lupiáñez, 2010; see also the [General discussion](#)), we assume that peripheral cues, apart from orienting attention automatically to the cued location, produce other effects: a *detection cost*—that is, a cost for detecting the presence of a target—and a *spatial selection benefit*—that is, discrimination benefits due to the spatial selection of the target when it is integrated within the object file representation opened by the cue. Therefore, we postulated that the larger the contribution of detection processes to target processing, the larger the detection cost would be, and therefore the larger the IOR that would be measured; likewise, the larger the contribution of integration/discrimination processes to target processing, the larger would be the spatial selection benefit, and therefore the larger the facilitation effect. In general, even in a simple detection task, it is necessary both to detect the target and to discriminate its presence from noise. However, different variables (perhaps the most important being the task at hand) will decrease or increase the contributions of detection and integration/discrimination processes, leading to different modulations over cueing effects. Thus, we established two main hypotheses:

1. Regarding *target duration*, we assumed that a very short target duration (i.e., 50 ms) would emphasize the need for the target to be detected, which could lead to larger IOR effects, due to a larger contribution to performance of the detection process (i.e., reflecting the *detection cost* effect), whereas a target duration until response would instead emphasize the integration/discrimination process (i.e., reflecting the *spatial selection benefit* effect), thus leading to larger facilitatory effects. Importantly, interacting with the task, this variable would be important in the detection task and in go–no-go tasks; that is, long target durations could reduce the contribution of the detection process inherent to these tasks. In discrimination tasks, target duration might produce no effects, as spatial selection of the target

would be necessary no matter for how long the target was presented.

2. Regarding the *intervening event*, we assumed that the presence of the intervening event would disrupt cue–target integration processes, making target detection more necessary, and therefore leading to IOR. We hypothesized that, in interaction with the task at hand, the presence of the intervening event would have a greater effect in those tasks in which more integration usually happens (discrimination and go–no-go tasks), revealing IOR when the intervening event was present. In detection tasks, task demands to detect the target already tune the system to be mainly driven by target detection processes.

Experiment 1: Detection task

A simple target detection task was used to investigate whether cueing effects (facilitation and IOR) would be modulated by manipulation of the target duration (i.e., 50 ms vs. until response) and/or by the presentation of an intervening event (i.e., intervening event absent vs. present) between the cue and target.

Method

Participants A total of 48 participants volunteered for this experiment, 12 in each group, from the crossing of two between-participants variables: target duration (50 ms vs. until response) and intervening event (absent vs. present). All of them were naive students from the University of Granada, who participated in the experiment for course credit. All participants in this and the following experiment reported having normal or corrected-to-normal vision. This and the following experiments were conducted in accordance with the ethical guidelines laid down by the Department of Experimental Psychology, University of Granada, in accordance with the ethical standards of the 1964 Declaration of Helsinki.

Apparatus and stimuli The experiment was run on a computer with a 1-GHz Pentium III processor, connected to a 15-in. color VGA monitor. E-Prime 2 software (Schneider, Eschman, & Zuccolotto, 2002) controlled the presentation of the stimuli and the acquisition of data. All of the stimuli were white line drawings on a black background. Two placeholder boxes were presented, one on each side of the fixation point. Each box was 20 mm in width by 20 mm in height (subtending 2.0×2.0 deg of visual angle at a viewing distance of 57 cm, at which 1 cm corresponded to 1 deg of visual angle). The boxes were positioned 25 mm away from the central fixation along the horizontal plane, as measured

¹ Note that the go–no-go task not only demands a detection process (i.e., responding to the presence/absence of the target), but also a discrimination process (i.e., discriminating go from no-go stimuli).

from the center of the bottom edges of each placeholder to the center of the screen (fixation point), and positioned 10 mm above the central fixation along the vertical plane, as measured from the center of the inner lateral edges of each placeholder to the center of the screen. Peripheral cues were created by thickening the outline of one of two placeholder boxes. The intervening event was created by presenting a smaller box around the fixation cue (10 mm in width $\times$ 10 mm in height). The target was either the letter X or O (2 mm).

Procedure The stimuli used and the sequence of events on each trial are illustrated in Fig. 1. Each trial began with the presentation of the fixation display (containing the fixation point and the two boxes), with a duration varying randomly between 1,000 and 1,500 ms. Participants were required to keep their eyes on the fixation point throughout the experiment. The peripheral cue was presented in one of the two possible locations, with equal probabilities, for 50 ms. After the peripheral cue, the fixation display was presented again for a duration varying randomly between 100 and 300 ms. Next, the intervening event was presented for 50 ms. In the group for whom the intervening event was absent, the fixation display was maintained on the screen during these 50 ms, keeping a constant SOA for both groups. After this intervening event (or an additional 50 ms with the fixation display), another fixation display of random variable duration (100–300 ms) was presented. The target was displayed either for 50 ms or until response (depending on the target duration condition) in one of the two peripheral boxes with equal probabilities. Participants were instructed to detect the appearance of any of the two letters by pressing the appropriate response key on the keyboard as quickly as possible (half of the participants pressed the “Z” key, whereas the other half pressed the “M” key). On 33 % of the trials (catch trials),² no target was presented and no response was required. The intertrial interval, during which the screen remained black, was 2,000 ms in duration. Auditory feedback was presented for wrong, missing, or premature responses (faster than 200 ms).

Design The experiment consisted of a three-factor design.³ Peripheral cueing was manipulated within participants,

whereas target duration and the intervening event were manipulated between participants. Peripheral cueing had two levels: cued or uncued location trials. Target duration had two levels, 50 ms or until response, and intervening event had also two levels, absent or present after the peripheral cue.

The experiment consisted of 15 practice trials, which were not analyzed, followed by 576 experimental trials (12 blocks of 48 trials each: 16 cued location, 16 uncued location, and 16 catch trials).

Results and discussion

False alarms (i.e., responses to catch trials) accounted for 0.66 % of the trials in this experiment. Participants missed the target (i.e., no response was made) on 0.38 % of the trials, which were not analyzed further. Responses faster than 200 ms (0.42 %) were considered anticipations and were excluded from the RT analysis.

The mean correct RT data were submitted to a mixed 2 (target duration: 50 ms vs. until response) $\times$ 2 (intervening event: absent vs. present) $\times$ 2 (peripheral cueing: cued vs. uncued) analysis of variance (ANOVA). Table 1 shows the mean RTs and percentages of errors for each experimental condition. The analysis revealed a highly significant main effect of peripheral cueing, $F(1, 44) = 69.69$, $MSE = 9,715$, $p < .0001$, $\eta^2 = .61$, showing that RTs were slower overall when the target appeared in a position previously occupied by the cue, as compared to the uncued location (i.e., IOR was observed). Importantly, as can be observed in Fig. 2, the peripheral cueing effect was significantly modulated by target duration, $F(1, 44) = 4.88$, $MSE = 680$, $p = .0324$, $\eta^2 = .09$: Although IOR was significant both for the 50-ms target duration, $F(1, 44) = 55.55$, $MSE = 7,741$, $p < .0001$, and when the target duration was until response, $F(1, 44) = 18.91$, $MSE = 2,635$, $p < .0001$, IOR was larger in the former (–25 ms) than in the latter (–15 ms) condition. The main effect of target duration was not significant, $F < 1$. The effect of the intervening event was marginally significant, $F(1, 44) = 3.98$, $MSE = 36,406$, $p = .0502$, $\eta^2 = .08$, with faster overall responses when an intervening event was present than when it was absent. Importantly, the intervening event did not interact with peripheral cueing, $F(1, 44) = 1.56$, $MSE = 218$, $p = .2181$, $\eta^2 = .03$, or target duration, $F(1, 44) = 2.00$, $MSE = 18,272$, $p = .1642$, $\eta^2 = .04$, and the interaction between all three factors (Peripheral Cueing $\times$ Target Duration $\times$ Intervening Event) was not significant, either, $F(1, 44) = 1.31$, $MSE = 183$, $p = .2583$, $\eta^2 = .02$.

The results of the present experiment indicate that in detection tasks, the automatic effect generated by peripheral cues (i.e., the IOR effect) was observed in all conditions. When participants were required to detect the target, an IOR effect was always observed. This result is usually found in

² Although some studies have shown that the proportion of catch trials can modulate the IOR effect (see, e.g., Gabay & Henik, 2008; Tipper & Kingstone, 2005), others have not shown such modulations in discrimination tasks (Lupianez & Milliken, 1999). Note that catch trials were used in order to avoid anticipatory responses.

³ We carried out a mixed analysis of variance (ANOVA) including SOA as factor. In none of the three experiments reported in this article did the SOA factor become statistically significant or interact significantly with any of the other variables (all $ps > .21$). Thus, we do not include SOA as a factor in the main analyses.

Fig. 1 Illustration of the trial sequence. In each experiment (detection, discrimination, or go–no-go task), the intervening event was present or absent (depending on the group of participants) and the target duration was either 50 ms or until response. The picture shows an example of a peripherally cued target in an intervening event trial

detection tasks, in which IOR appears at short SOAs, and it is unusual to observe facilitatory effects (see above; Tassinari et al., 1994; Tassinari & Campara, 1996). Importantly, the IOR effect, although always observed, was only modulated by the manipulation of target duration, with reduced IOR when the target duration was until response rather than the 50-ms target duration. IOR was not modulated by the intervening event in this experiment.

These results support the view that the intervening event and target duration might affect peripheral cueing in different ways; intervening events do not always modulate IOR, as has been assumed in the literature. However, note that although the interaction between the three factors (Peripheral Cueing $\times$ Target Duration $\times$ Intervening Event) was not significant, as can be observed in Fig. 2, IOR tended to be larger when the intervening event was present than when it was absent, but only when the target duration was until response. In order to explore this issue, we compared the present data with data from an additional experiment,⁴ in which we used a detection task, target duration until response, and intervening event present versus absent. We pooled together the data from the

two experiments (only data from the condition with a target duration until response in Exp. 1) and submitted the mean RTs to a mixed 2 (intervening event: absent vs. present) $\times$ 2 (peripheral cueing: cued vs. uncued) $\times$ 2 (experiment) ANOVA. Importantly, peripheral cueing significantly interacted with the intervening event, $F(1, 36) = 5.54$, $MSE = 171$, $p = .0241$, $\eta^2 = .13$, showing nonsignificant IOR (-7 ms, $p = .1330$) when the intervening event was absent and significant IOR (-20 ms, $p < .0001$) when the intervening event was present. The three-way interaction between peripheral cueing, intervening event, and experiment was not significant, $F < 1$, indicating that the modulation of IOR when the intervening event was present was observed similarly in both experiments.

In sum, our results suggest that although the automatic effect generated by peripheral cues (i.e., IOR effect) was observed in all conditions in the detection task, its magnitude was reduced when target duration was until response, as compared to the 50-ms target duration. No modulations of the intervening event were found when the target duration was 50 ms, but IOR was increased when the intervening event was present and target duration was until response. The implications of these data are discussed in the [General discussion](#).

Experiment 2: Discrimination task

A target discrimination task was used to further investigate whether cueing effects (i.e., facilitation and IOR) would be affected by the manipulation of target duration (i.e., 50 ms vs. until response) and the presentation of an intervening

⁴ This new experiment was a pilot carried out in order to use event-related potentials (ERPs) to investigate the electrophysiological basis of behavioral exogenous cueing effects. A total of 16 participants from the same pool and conditions as in Experiment 1 took part in this experiment. The procedure and design were identical to those of Experiment 1, except in the following respects: The experiment consisted of 20 practice trials, which were not analyzed further, followed by 392 experimental trials (seven blocks of 56 trials each: 24 cued location, 24 uncued location trials, and eight catch trials). Target duration was always until response, and SOA was jittered between 500 and 700 ms. As in Experiment 1, the presence/absence of the intervening event was manipulated between participants.

Fig. 2 Mean cueing effects (i.e., mean RT for cued – mean RT for uncued condition) as a function of intervening event (absent vs. present) and target duration (50 ms vs. until response) in detection (Exp. 1),

discrimination (Exp. 2), and go-no-go (Exp. 3) tasks. Error bars represent the standard errors of the means

event (i.e., absent vs. present) when target detection was not sufficient to perform the task, which required discriminating the target's features.

Method

Participants A total of 48 new participants from the same pool and conditions as in Experiment 1 took part in this experiment, 12 in each of four groups. The data from one participant were excluded due to low accuracy (below 50 %).

Apparatus, stimuli, and procedure The procedure and design were identical to those of Experiment 1, except for the following: Participants had to discriminate the identity of the letter by pressing one key ("Z" or "M") for each letter; the letter-key assignment was counterbalanced across participants.

Results and discussion

Trials with incorrect responses (2.71 %), those in which no response was made (0.29 %), and those with RTs shorter than 200 ms (0.001 %) were excluded from the RT analysis.

The mean correct RT data were submitted to the same ANOVA as in Experiment 1. Target duration and intervening event were manipulated between participants, and peripheral cueing was manipulated within participants. The mean RTs and percentages of errors for each experimental condition are presented in Table 1. Importantly, the analysis of mean RTs revealed a nonsignificant main effect of peripheral cueing, $F < 1$. However, peripheral cueing interacted with intervening event, $F(1, 43) = 19.18$, $MSE = 3,601$, $p < .0001$, $\eta^2 = .30$, showing a significant facilitatory effect (15 ms) when the intervening event was absent, $F(1, 43) = 13.81$, $p = .0005$, and significant IOR (–10 ms), $F(1, 43) = 6.07$, $p = .0177$, when

the intervening event was present (see Fig. 2). Crucially, none of the others main effects, $F_s < 1$, nor the Target Duration $\times$ Intervening Event interaction, $F(1, 43) = 1.87$, $MSE = 27,280$, $p = .1786$, $\eta^2 = .04$, was significant. The three-way interaction was not significant, either, $F < 1$.

The analysis of mean percentages of errors showed a main effect of target duration as the only significant effect, $F(1, 43) = 5.32$, $MSE = 10.7265$, $p = .0258$, $\eta^2 = .11$: More errors were observed when the target duration was 50 ms (3.9 %) than when the target was presented until response (1.8 %).

Importantly, in contrast to Experiment 1, in Experiment 2 the automatic effect generated by peripheral cues was highly modulated by the Intervening Event factor, leading to different cueing effects (i.e., facilitation or IOR) depending on the presence or absence of this event. In the discrimination task, a significant facilitatory effect was observed when the intervening event was absent, whereas significant IOR was observed when the intervening event was present. Moreover, no effect of target duration was found. Again, as previously described, these results support the view that intervening events and target duration affect peripheral cueing in different ways, with the effects depending on the task at hand (detection vs. discrimination).

Experiment 3: Go-no-go task

Finally, in this third experiment, a go-no-go task was used to investigate the effects of target duration and intervening event when the task at hand demanded not only a detection component (i.e., responding to the presence/absence of the target) but also an important discrimination process (i.e., discriminating the go from the no-go stimuli). Concretely, in this task the go stimuli were perceptually similar to the no-go

stimulus in order to increase the contribution of discrimination processes.

Method

Participants A total of 56 participants from the same pool and conditions as in Experiments 1 and 2 took part in this experiment, with 14 in each of four groups.

Apparatus, stimuli, and procedure The procedure and design were identical to those of the previous experiments, except in the following respects. On a third of all trials, on which no target had been presented in the previous experiments (i.e., catch trials), the number 8 was presented, serving as a no-go stimulus. Participants were instructed to press a response key on the keyboard as quickly as possible when one of the two letters (X or O) was presented (go condition), but to withhold the response when the number 8 was presented (no-go condition). On go trials, half of the participants were to press the “Z” key, whereas the other half were to press the “M” key.

Results and discussion

False alarms (i.e., responses to the no-go condition) accounted for 7.80 % of the trials. Participants missed the target (i.e., no response was made) on 0.54 % of the trials. Responses faster than 200 ms (0.04 %) were excluded from the RT analysis as outliers (see Table 1).

The mean RT data were submitted to a mixed 2 (target duration: 50 ms vs. until response) $\times$ 2 (intervening event: absent vs. present) $\times$ 2 (peripheral cueing: cued vs. uncued) ANOVA. None of the main effects were significant (all F s < 1). We did find a significant interaction between peripheral cueing and target duration, $F(1, 52) = 11.47$, $MSE = 1,815$, $p < .001$, $\eta^2 = .18$, showing a significant IOR effect (−7 ms, $p = .0468$) when the target duration was 50 ms, and a

significant facilitatory effect (9 ms, $p = .0080$) when the target duration was until response. The interaction between peripheral cueing and intervening event was also significant, $F(1, 52) = 13.14$, $MSE = 2,081$, $p < .0001$, $\eta^2 = .20$, showing a significant facilitatory effect (10 ms, $p = .0051$) when the intervening event was absent, and a significant IOR effect (−8 ms, $p = .0319$) when the intervening event was present (see Fig. 2). The three-way interaction was not significant, $F(1, 52) = 1.94$, $MSE = 308$, $p = .1688$, $\eta^2 = .03$.

The analysis of percentages of false alarms revealed a main effect of peripheral cueing as the only significant effect, $F(1, 52) = 5.44$, $MSE = 55.95$, $p = .0235$, $\eta^2 = .09$: Fewer false alarms were observed when the target appeared in a position previously occupied by the cue (7.1 %) as compared to the uncued location (8.6 %).

In this experiment, peripheral cueing effects were modulated by both target duration and intervening event, leading to opposite effects with the two manipulations. Importantly, the three-way interaction was not significant. As can be observed in Fig. 2, the cueing effect was more negative (i.e., an IOR effect) when the target duration was 50 ms and/or when the intervening event was present; in contrast, the cueing effect was more positive (i.e., a facilitatory effect) when the target duration was until response and/or the intervening event was absent. Both factors (Target Duration and Intervening Event) produced additive modulations over the cueing effect; IOR was only significant when the target duration was 50 ms and the intervening event was present (−12 ms, $p = .0135$), whereas the facilitatory effect was only significant with the target duration until response and no intervening event (21 ms, $p < .001$). Therefore, the manipulations of target duration and intervening event in this go–no-go task seem to have generated similar effects: That is, both a target duration of 50 ms and the intervening event present led to a more negative cueing effect (i.e., IOR), whereas a target duration until response

Table 1 Mean reaction times (RTs, in milliseconds) for each condition (Intervening Event $\times$ Target Duration) across all experiments

	Intervening Event Absent				Intervening Event Present			
	50 ms		Until Response		50 ms		Until Response	
	Cued	Uncued	Cued	Uncued	Cued	Uncued	Cued	Uncued
Exp. 1: Detection task	394 (0.0 %)	369 (0.01 %)	426 (0.0 %)	417 (0.01 %)	383 (0.01 %)	357 (0.0 %)	366 (0.0 %)	345 (0.0 %)
Exp. 2: Discrimination task	581 (0.07 %) [3.07 %]	597 (0.09 %) [4.11 %]	528 (0.0 %) [1.51 %]	542 (0.01 %) [1.95 %]	557 (0.05 %) [3.21 %]	547 (0.04 %) [3.64 %]	570 (0.01 %) [2.47 %]	561 (0.03 %) [1.86 %]
Exp. 3: Go–no-go task	470 (0.02 %)	468 (0.02 %)	481 (0.0 %)	501 (0.0 %)	482 (0.0 %)	470 (0.0 %)	486 (0.0 %)	483 (0.0 %)

Percentages of target misses (no response) are presented in parentheses, and erroneous responses in the discrimination task are presented in square brackets.

and the intervening event absent led to a more positive effect (i.e., facilitation), but without significantly interacting with each other.

Nevertheless, as we observed in the detection task (see Fig. 2), it seems that the intervening event tended to modulate cueing effects especially when the target duration was until response. In order to explore this effect in the three tasks, the mean RT data when the target duration was until response were submitted to a mixed 2 (intervening event: absent vs. present) $\times$ 2 (peripheral cueing: cued vs. uncued) $\times$ 3 (experiment: detection, discrimination, and go–no-go tasks) ANOVA. Importantly, the intervening event interacted with peripheral cueing, $F(1, 70) = 28.55$, $MSE = 3,613$, $p < .0001$, $\eta^2 = .28$, showing an overall significant facilitatory effect when the intervening event was absent (9 ms, $p < .0001$) and a significant IOR effect (–11 ms, $p < .0001$) when the intervening event was present. The interaction between all three factors was clearly not significant ($p > .35$). This result demonstrates that the intervening event increased IOR as compared to the condition in which the intervening event was not present, and this was similarly observed in the detection task (–9 vs. –21 ms, respectively, for the intervening event absent vs. present, $p = .0793$), the discrimination task (14 vs. –9 ms, $p = .0006$), and the go–no-go task (21 vs. –3 ms, $p = .0001$). However, although cueing effects were more positive (or less negative) in all tasks when the intervening event was absent, significant facilitation was only observed in the discrimination task (14 ms, $p = .0044$) and the go–no-go task (21 ms, $p < .0001$), whereas a marginally significant IOR effect was observed in the detection task (–9 ms, $p = .0529$).

The same analysis was carried out for the 50-ms target duration. This time, the interaction between peripheral cueing and intervening event was significant, $F(1, 69) = 7.34$, $MSE = 1,445$, $p < .0001$, $\eta^2 = .26$, showing an overall nonsignificant IOR effect when the intervening event was absent (–4 ms, $p = .2955$) and a significant IOR effect (–16 ms, $p < .0001$) when the intervening event was present. Importantly, however, this interaction was marginally modulated by task, $F(1, 69) = 2.51$, $MSE = 495$, $p = .0883$, $\eta^2 = .09$. The Peripheral Cueing $\times$ Intervening Event interaction was significant when the detection and discrimination tasks were compared, $F(1, 43) = 5.26$, $MSE = 185$, $p = .0267$, $\eta^2 = .10$. As can be observed in Fig. 2, the presence of the intervening event made the cueing effect more negative (or less positive), as compared to the conditions in which the intervening event was absent, especially in the discrimination task (–10 and 16 ms, respectively). The same (although reduced) tendency was observed in the go–no-go task (–2 and –12 ms), but was completely absent in the detection task, in which IOR had the same magnitude independently of the intervening event (–25 and –26 ms).

In sum, we can conclude that when the target was displayed until response, an intervening event modulated cueing effects in the three experiments (i.e., detection, discrimination, and go–no-go tasks). In the detection task, this modulation consisted of an increase on the magnitude of IOR observed when the intervening event was absent, whereas in the go–no-go and discrimination tasks, the intervening event produced IOR in conditions in which facilitation was observed in the absence of such an intervening event. However, when the target was displayed for 50 ms, the intervening event modulated the cueing effects only in the discrimination and go–no-go tasks. In both of the latter tasks, larger IOR was observed when the intervening event was present, whereas no modulations were observed in the detection task. The implications of these data are discussed below.

General discussion

Attentional orienting produced by spatially noninformative peripheral cueing is considered involuntary, because there is no incentive to maintain attention at the cued location. However, this type of orienting is far from being automatic (Ruz & Lupiáñez, 2002), as it is modulated by many variables, such as the timing between cue and target, the task demands, target modality, target intensity, cue type, the presence of intervening events, and so forth (see, e.g., Kingstone & Pratt, 1999; Maruff et al., 1999; Pratt & Fischer, 2002; Prime et al., 2006; Reuter-Lorenz et al., 1996; Snowden et al., 2001; Taylor & Donnelly, 2002; see Lupiáñez, 2010, for a review). A review of the literature (see the introduction) revealed that we have acquired some knowledge about the modulation of cueing effects by some of these variables, although they have not yet been jointly studied in a systematic way. In the present series of experiments, we manipulated two of these variables, target duration (i.e., 50 ms or target until response) and the presence/absence of an intervening event, in order to understand how they modulate cueing effects as a function of the task demands: detection, discrimination, or go–no-go tasks.

The results showed that the presence of IOR and/or facilitatory effects was sensitive to target duration or to the presence of an intervening event, depending on the task. Three main results were observed: First, in the detection task, IOR was always observed, and it was mainly modulated by target duration: When the target was presented until response, IOR was reduced as compared to the 50-ms target duration. The presence/absence of the intervening event only modulated IOR when the target was presented until response. Second, in the discrimination task, cueing effects were only modulated by the presence of the intervening event, whereas target duration did not produce any

modulations over the cueing effects; when the intervening event was absent, a significant facilitatory effect was observed, whereas significant IOR appeared when the intervening event was presented. Importantly, in the discrimination task, the intervening event modulated even the sign of the peripheral cueing effect (facilitatory effect vs. IOR when the intervening event was absent vs. present). Finally, in the go–no-go task, the two variables additively modulated peripheral cueing effects: IOR was observed only with the 50-ms target duration and the intervening event present, whereas facilitation occurred only when the target was presented until response and the intervening event was absent. As can be observed in Fig. 2, the intervening event modulated the cueing effect similarly for the two target durations: The cueing effect was more negative (with less facilitation or more IOR) both when the target duration was 50 ms (changing from a null effect to an IOR effect) and when the target was presented until response (changing from facilitation to a null effect). If a three-way interaction had been observed in this go–no-go task, it would have shown differences in the magnitude rather than the nature of the effects. As we pointed out, facilitation was only significantly observed when the target duration was until response and the intervening event was absent; we therefore believe that finding this significant three-way interaction would not have affected the interpretation of the results.

Taking all of the results above together, we conclude that manipulations of target duration and intervening event generate generally similar effects; that is, both a target duration of 50 ms and the presence of an intervening event lead to more negative cueing effects (i.e., IOR and/or less of a facilitation effect), whereas target duration until response and an intervening event absent lead to more positive effects (i.e., facilitation and/or less of an IOR effect), depending on the cueing effects that are observed with the task at hand.

According to the traditional *reorienting hypothesis* (Klein, 2000; Posner & Cohen, 1984), both facilitation and IOR are explained by the same mechanism, the orienting of attention, which is engaged and subsequently disengaged from the cued location. For example, the disengagement of attention has been used to explain the different time courses of IOR observed in detection and discrimination tasks (Klein, 2000). In most studies using an intervening event (called a “fixation cue” or “cue back”), it has been assumed that this fixation cue captures attention and reorients it back to fixation, leading to an earlier appearance of IOR because the disengagement of attention is anticipated (MacPherson et al., 2003; Pratt & Fischer, 2002). However, accumulating evidence has shown that this hypothesis might not be correct (Berger et al., 2005; Berlucchi, 2006; Berlucchi, Chelazzi, & Tassinari, 2000; Chica & Lupiáñez, 2004; Chica et al., 2006; Martín-Arévalo, Kingstone, & Lupiáñez, 2013). In short, IOR has been observed in conditions in which attention is *not* disengaged from the cued location. Furthermore,

it has been shown that facilitation instead of IOR can be observed even after attention has been disengaged from the cued location (Chica & Lupiáñez, 2004; Danziger & Kingstone, 1999, Exp. 2; Lupiáñez, Martín-Arévalo, & Chica, 2013; see also Gabay, Chica, Charras, Funes, & Henik, 2012). Importantly, the aforementioned pieces of evidence allow us to conclude that cueing effects (facilitation and IOR) cannot be explained by the engagement or disengagement of spatial attention, as attentional disengagement seems to be neither necessary nor sufficient for IOR to be observed.

A rather more parsimonious hypothesis regarding the mechanisms that produce the facilitation and IOR effects might be possible according to the *object file segregation/integration hypothesis* (Lupiáñez, 2010), framed in the object file theory proposed by Kahneman, Treisman, and Gibbs (1992). It has been suggested that the appearance of a cue shortly before target appearance, apart from orienting attention automatically to the cued location (a *spatial orienting* process), produces other effects, which seem to be independent of attentional orienting, but nevertheless also affect the processing of the subsequent target. We reckon that the peripheral cue is an event—an object that occupies a specific location and therefore produces different effects on the processing of subsequent stimuli appearing at the same location. Concretely, the subsequent target could be integrated within the same object file when it appears spatiotemporally around the cue (i.e., the cue representation could be updated to incorporate the target’s features), and thus becomes more easily selected for further discriminative processing. In this case, cue–target integration processes (Hommel, 2004; Kahneman et al., 1992) would be beneficial to determining what the target is, as they would help to select the target location in advance (*spatial selection benefit*). In fact, whenever the target appears at the same location as the cue, it would be treated by this system, which integrates information across time, not as a new object, but as an update of the object file representation just opened by the cue. This process can lead to benefits in determining what the target is, due to the accumulation of information over time.

However, discrimination is not all that is needed to respond to the target; detecting the target is also important for fast responding. In fact, other tasks might tap into these detection processes to a greater extent. Importantly, in order to detect the appearance of a new object, it is necessary that the perceptual system treat any piece of information as being different from previous information. Therefore, the tendency to integrate the target within the cue representation as part of the same event would, in fact, constitute a cost in detecting the onset of the target (*detection cost*), producing the standard IOR effect. According to this view, IOR constitutes a cost in detecting new information, with attention

being less captured (by the target) at a location where it has been captured before (by the cue). Therefore, we propose that cueing a location hinders detection of a subsequent object at the very same location (i.e., leading to IOR), whereas at the same time it facilitates selecting this object for subsequent perceptual discriminative processing, leading to its recognition (i.e., leading to facilitatory effect, mostly found in discrimination tasks).

In conclusion, the final effect that will be measured in responding to a target presented at the cued location, apart from spatial orienting, will be sum of all spatial selection benefits and detection costs. Therefore, depending on the nature of the task (Lupiáñez et al., 2007), its timing, and the characteristics of the targets and cues, some process will contribute to performance more than others do, therefore producing a positive (facilitatory effect) or negative (IOR effect) net cueing effect.

This new framework can hold two different assumptions: First, whereas the benefits of spatial selection are more pronounced in discrimination tasks (i.e., leading to more facilitation or less IOR), detection costs are more pronounced in detection tasks (i.e., leading to more IOR or less facilitation). Moreover, in go–no-go tasks, both effects (a detection cost and a spatial selection benefit) are important, and therefore both facilitation and IOR can be measured; this task demands not only a detection process (i.e., responding to the presence/absence of the target), but also a discrimination process (i.e., discriminating go from no-go stimuli). This assumption fits well with the results observed in the third experiment (i.e., go–no-go task): A nonsignificant main effect of peripheral cueing was present, which, however, was modulated by both target duration and intervening event, leading to opposite effects from the two manipulations. This result reflects the peculiarity of the go–no-go task, in which, depending on the presence/absence of an intervening event and/or on the target duration, a detection cost or spatial selection benefit would mainly be measured. In contrast, an overall IOR effect was only observed in the detection task, and cueing effects were nonsignificant overall in the discrimination task. In the detection task, our target duration and intervening event manipulations led to a reduction of IOR, but never to facilitatory effects, since the spatial selection benefit was almost absent in this task.

Second, our main hypothesis postulated that the larger the contribution of detection processes to the target processing generated by any variable (e.g., in the present study, a short target duration of 50 ms, a detection task, and/or the presence of an intervening event), the larger the detection cost will be, and therefore the larger the IOR that will be measured. Likewise, the larger the contribution of integration/discrimination processes to the target processing generated by any variable (e.g., a long target duration, a discrimination task, and/or the absence of an intervening

event), the larger the spatial selection benefit will be, and therefore the larger the facilitatory effect that will be measured. In fact, in relation to the variables investigated in the present article, the event integration/segregation hypothesis predicts that when targets are presented until response, discrimination processes will be emphasized, thus leading to larger facilitatory effects; on the other hand, short target durations (i.e., 50 ms) could emphasize target detection, which could lead to larger IOR effects (i.e., reflecting a detection cost). Both assumptions are based on spatiotemporal resolution: A longer time duration allows the accumulation of information over time that it is necessary to bind together different object-constituting features into an integrated representation; on the other hand, a short target duration increases the need to rapidly detect the target, because it disappears quickly and would be unnoticed otherwise.

Moreover, the role of an intervening event could be to interfere with or disrupt integration processes, eliminating spatial selection benefits and enhancing detection costs (i.e., increasing the IOR effect). Again, this results fits with what we found in the detection task: No effect of the intervening event was found overall, and the spatial selection benefit was almost absent in the detection task. However, when the target was presented until response, thus enhancing integration processes, IOR was increased with the presentation of the intervening event, even in the detection task.

Importantly, the findings of the present article are in good agreement with this new framework. Our results support the view that, as we previously described, the presence of an intervening event and a target duration until response could affect peripheral cueing in different ways, the first probably eliminating spatial selection benefits, and the latter probably decreasing the contribution of detection processes. Thus, in the detection task, in which the detection process is emphasized by the task demands and spatial selection benefits barely contribute to performance, IOR mainly depends on target duration, as the contribution of detection processes decreases when the target duration is long. However, even in the detection task, when the target duration is until response, the intervening event could disrupt integration processes, leading to an increased IOR effect. In the discrimination task, the results also fit with our hypothesis about peripheral cueing effects: In this task, target detection is not sufficient to perform the task, which requires discriminating the target's features. In this case, other processes that are beneficial for target discrimination also contribute to performance (i.e., spatial selection benefits), leading to facilitatory effects. However, when an intervening event is presented, the cueing effect reverses into IOR, probably due to the disruption of the spatial selection benefits. Because in this task the detection cost is less relevant, target duration has no effect (integration processes are already emphasized by the

discrimination task), whereas the intervening event produces a large effect by eliminating the spatial selection benefits usually observed in the discrimination task. Finally, we assume that in the go–no-go task, both the detection cost and the spatial selection benefit play a role. The go–no-go task not only demands a detection process but also has an important discrimination component. Our results showed that IOR was only significant with a 50-ms target duration and an intervening event (i.e., when detection processes were emphasized by the two manipulated factors), and the facilitation effect was only significant with a target duration until response and no intervening event (i.e., when discrimination processes were emphasized by the two manipulated factors).

Conclusion

The main result reported in this article is that the magnitudes, and even the signs (facilitation or IOR), of cueing effects are modulated by both target duration and the presence/absence of an intervening event, depending on the task at hand. We assume that IOR mainly reflects the fact that attention is poorly captured by targets at the cued location, since the target appears at a previously attended location (detection cost), whereas facilitation mainly reflects the benefits of the integration of cue and target within the same object file for discrimination processes. Thus, the larger the contribution of detection processes to target processing (e.g., a 50-ms target duration, presence of an intervening event, and/or detection tasks), the larger the detection cost will be, and therefore the larger the IOR that will be measured. In contrast, the larger the contribution of integration/discrimination processes to the target processing generated by any variable (e.g., a target duration until response, absence of an intervening event, and/or discrimination tasks), the larger the spatial selection benefit will be, and therefore the larger the facilitatory effect that will be measured.

Acknowledgments Elisa Martín-Arévalo was supported by a predoctoral grant (AP2008-02806) from the FPU program from the Spanish ministry of Science and Education. ABC was supported with a Ramón y Cajal fellowship from the Spanish Ministry of Education and Science. Research was funded by research projects PSI2008-03595PSIC, PSI2011-22416, and eraNET- NEURON BEYONDVIS, EUI2009-04082, to Juan Lupiáñez. We would like to thank Avishai Henik, Adriane Seiffert, Jeremy Wolfe, and one anonymous reviewer for comments on previous draft of the manuscript.

References

- Berger, A., Dori, H., & Henik, A. (1999). Peripheral non-informative cues do induce early facilitation of target detection. *European Journal of Cognitive Psychology*, 11(1), 119–137. doi:10.1080/713752304
- Berger, A., Henik, A., & Rafal, R. (2005). Competition between endogenous and exogenous orienting of visual attention. *Journal of Experimental Psychology: General*, 134, 207–221. doi:10.1037/0096-3445.134.2.207
- Berlucchi, G. (2006). Inhibition of return: A phenomenon in search of a mechanism and a better name. *Cognitive Neuropsychology*, 23, 1065–1074. doi:10.1080/02643290600588426
- Berlucchi, G., Chelazzi, L., & Tassinari, G. (2000). Volitional covert orienting to a peripheral cue does not suppress cue-induced inhibition of return. *Journal of Cognitive Neuroscience*, 12, 648–663. doi:10.1162/089892900562408
- Bourgeois, A., Chica, A. B., Migliaccio, R., Thiebaut de Schotten, M., & Bartolomeo, P. (2012). Cortical control of inhibition of return: Evidence from patients with inferior parietal damage and visual neglect. *Neuropsychologia*, 50, 800–809. doi:10.1016/j.neuropsychologia.2012.01.014
- Chica, A. B., & Lupiáñez, J. (2004). Inhibition of return without return of attention. *Psicothema*, 16, 248–254.
- Chica, A. B., Lupiáñez, J., & Bartolomeo, P. (2006). Dissociating inhibition of return from endogenous orienting of spatial attention: Evidence from detection and discrimination tasks. *Cognitive Neuropsychology*, 23, 1015–1034. doi:10.1080/02643290600588277
- Collie, A., Maruff, P., Yucel, M., Danckert, J., & Currie, J. (2000). Spatiotemporal distribution of facilitation and inhibition of return arising from the reflexive orienting of cover attention. *Journal of Experimental Psychology: Human Perception and Performance*, 26, 1733–1745.
- Danziger, S., & Kingstone, A. (1999). Unmasking the inhibition of return phenomenon. *Perception & Psychophysics*, 61, 1024–1037. doi:10.3758/BF03207610
- Faust, M. E., & Balota, D. A. (1997). Inhibition of return and visuo-spatial attention in healthy older adults and individuals with dementia of the Alzheimer type. *Neuropsychology*, 11, 13–29.
- Frischen, A., & Tipper, S. P. (2004). Orienting attention via observed gaze shift evokes longer-term inhibitory effects: Implications for social interactions, attention, and memory. *Journal of Experimental Psychology: General*, 133, 516–533.
- Gabay, S., Chica, A. B., Charras, P., Funes, M. J., & Henik, A. (2012). Cue and target processing modulate the onset of inhibition of return. *Journal of Experimental Psychology: Human Perception and Performance*, 38, 42–52.
- Gabay, S., & Henik, A. (2008). The effects of expectancy on inhibition of return. *Cognition*, 106, 1478–1486.
- Hommel, B. (2004). Event files: Feature binding in and across perception and action. *Trends in Cognitive Sciences*, 8, 494–500. doi:10.1016/j.tics.2004.08.007
- Ivanoff, J., & Klein, R. M. (2001). The presence of a nonresponding effector increases inhibition of return. *Psychonomic Bulletin & Review*, 8, 307–314. doi:10.3758/BF03196166
- Jonides, J. (1981). Voluntary versus automatic control over the mind's eye's movement. In A. Baddeley (Ed.), *Attention and performance IX* (pp. 187–203). Hillsdale, NJ: Erlbaum.
- Kahneman, D., Treisman, A., & Gibbs, B. J. (1992). The reviewing of object files: Object-specific integration of information. *Cognitive Psychology*, 24, 175–219. doi:10.1016/0010-0285(92)90007-O
- Kingstone, A., & Pratt, J. (1999). Inhibition of return is composed of attentional and oculomotor processes. *Perception & Psychophysics*, 61(6), 1046–1054. doi:10.3758/BF03207612
- Klein, R. M. (2000). Inhibition of return. *Trends in Cognitive Sciences*, 4, 138–147. doi:10.1016/S1364-6613(00)01452-2
- Lupiáñez, J. (2010). Inhibition of return. In A. C. Nobre & J. T. Coull (Eds.), *Attention and time* (pp. 17–34). Oxford, UK: Oxford University Press.
- Lupiáñez, J., Klein, R. M., & Bartolomeo, P. (2006). Inhibition of return: Twenty years after. *Cognitive Neuropsychology*, 23, 1003–1014.

- Lupiañez, J., Martín-Arévalo, E., & Chica, A. B. (2013). Inhibition of return: Attentional disengagement or detection cost? *Psicológica*, 34, 221–252.
- Lupiañez, J., Milán, E. G., Tornay, F. J., Madrid, E., & Tudela, P. (1997). Does IOR occur in discrimination tasks? Yes, it does, but later. *Perception & Psychophysics*, 59, 1241–1254. doi:10.3758/BF03214211
- Lupiañez, J., & Milliken, B. (1999). Inhibition of return and the attentional set for integrating versus differentiating information. *The Journal of General Psychology*, 126, 392–418.
- Lupiañez, J., Ruz, M., Funes, M. J., & Milliken, B. (2007). The manifestation of attentional capture: Facilitation or IOR depending on task demands. *Psychological Research*, 71, 77–91. doi:10.1007/s00426-005-0037-z
- MacPherson, A. C., Klein, R. M., & Moore, C. (2003). Inhibition of return in children and adolescents. *Journal of Experimental Child Psychology*, 85, 337–351.
- Marotta, A., Pasini, A., Ruggiero, S., Maccari, L., Rosa, C., Lupiañez, J., & Casagrande, M. (2013). Inhibition of return in response to eye gaze and peripheral cues in young people with Asperger's syndrome. *Journal of Autism Development Disorder*, 43, 917–923.
- Martín-Arévalo, E., Kingstone, A., & Lupiañez, J. (2013). Is “inhibition of return” due to the inhibition of the return of attention? *Quarterly Journal of Experimental Psychology*, 66, 347–359. doi:10.1080/17470218.2012.711844
- Maruff, P., Yucel, M., Danckert, J., Stuart, G. W., & Currie, J. (1999). Facilitation and inhibition arising from the exogenous orienting of covert attention depends on the temporal properties of spatial cues and targets. *Neuropsychologia*, 37(6), 731–744. doi:10.1016/S0028-3932(98)00067-0
- 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*. Hillsdale, NJ: Erlbaum, 11, 189–204.
- Maylor, E. A., & Hockey, R. (1987). Effects of repetition on the facilitatory and inhibitory components of orienting in visual space. *Neuropsychologia*, 25, 41–54. doi:10.1016/0028-3932(87)90042-X
- McAuliffe, J., & Pratt, J. (2005). The role of temporal and spatial factors in the covert orienting of visual attention tasks. *Psychological Research*, 69, 285–291.
- Mele, S., Savazzi, S., Marzi, C. A., & Berlucchi, G. (2008). Reaction time inhibition from subliminal cues: Is it related to inhibition of return? *Neuropsychologia*, 46, 810–819.
- Posner, M. I. (1980). Orienting of attention. *Quarterly Journal of Experimental Psychology*, 32, 3–25. doi:10.1080/00335558008248231
- 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., Rafal, R. D., Choate, L. S., & Vaughan, J. (1985). Inhibition of return: Neural basis and function. *Cognitive Neuropsychology*, 2, 211–228. doi:10.1080/02643298508252866
- Pratt, J., & Abrams, R. A. (1999). Inhibition of return in discrimination task. *Journal of Experimental Psychology: Human, Perception, and Performance*, 25(1), 229–242.
- Pratt, J., & Fischer, M. H. (2002). Examining the role of the fixation cue in inhibition of return. *Canadian Journal of Experimental Psychology*, 56, 294–301.
- Pratt, J., Kingstone, A., & Khoe, W. (1997). Inhibition of return in location- and identity- based choice decision tasks. *Perception & Psychophysics*, 59(6), 964–971.
- Prime, D. J., Visser, T. A. W., & Ward, L. M. (2006). Reorienting attention and inhibition of return. *Perception & Psychophysics*, 68, 1310–1323. doi:10.3758/BF03193730
- Prime, D. J., & Ward, L. M. (2004). Inhibition of return from stimulus to response. *Psychological Science*, 15, 272–276. doi:10.1111/j.0956-7976.2004.00665.x
- Reuter-Lorenz, P. A., Jha, A. P., & Rosenquist, J. N. (1996). What is inhibited in inhibition of return? *Journal of Experimental Psychology: Human Perception and Performance*, 22(2), 367–378. doi:10.1037/0096-1523.22.2.367
- Ruz, M., & Lupiañez, J. (2002). A review of attentional capture: On its automaticity and sensitivity to endogenous control. *Psicológica*, 23, 283–309.
- Sapir, A., Henik, A., Dobrusin, M., & Hochman, E. Y. (2001). Attentional asymmetry in schizophrenia: Disengagement and inhibition of return deficits. *Neuropsychology*, 15, 361–370.
- Schneider, W., Eschman, A., & Zuccolotto, A. (2002). *E-Prime user's guide*. Pittsburgh, PA: Psychology Software Tools.
- Snowden, R. J., Willey, J., & Muir, J. L. (2001). Visuospatial attention: The role of target contrast and task difficulty when assessing the effects of cues. *Perception*, 30(8), 983–991.
- Spadaro, A., He, C., & Milliken, B. (2012). Response to an intervening event reverses nonspatial repetition effects in 2AFC tasks: Nonspatial IOR? *Attention, Perception, & Psychophysics*, 74, 331–349. doi:10.3758/s13414-011-0248-x
- Spadaro, A., Lupiañez, J., & Milliken, B. (in press). *On the role of attending and responding to an intervening event for revealing non-spatial IOR*. Manuscript under review.
- Tassinari, G., Aglioti, S., Chelazzi, L., Peru, A., & Berlucchi, G. (1994). Do peripheral non-informative cues induce early facilitation of target detection. *Vision Research*, 34, 179–189. doi:10.1016/0042-6989(94)90330-1
- Tassinari, G., & Berlucchi, G. (1995). Cover orienting to non-informative cues: Reaction time studies. *Behavioural Brain Research*, 71, 101–112.
- Tassinari, G., & Campara, D. (1996). Consequences of covert orienting to non-informative stimuli of different modalities: A unitary mechanism? *Neuropsychologia*, 34, 235–245. doi:10.1016/0028-3932(95)00085-2
- Taylor, T. L., & Donnelly, M. P. W. (2002). Inhibition of return for target discriminations: The effect of repeating discriminated and irrelevant stimulus dimensions. *Perception & Psychophysics*, 64(2) 292–317. doi:10.3758/BF03195793
- Taylor, T. L., & Klein, R. M. (2000). Visual and motor effects in inhibition of return. *Journal of Experimental Psychology: Human Perception and Performance*, 26, 1639–1656. doi:10.1037/0096-1523.26.5.1639
- Tipper, C., & Kingstone, A. (2005). Is inhibition of return a reflexive effect? *Cognition*, 97, B55–B62. doi:10.1016/j.cognition.2005.02.003