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Is Inhibition of Return due to attentional disengagement or to a detection cost? The Detection Cost Theory of IOR

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When the time interval between two peripheral stimuli is long enough, reaction times (RTs) to targets presented at previously stimulated locations are longer than RTs to targets presented at new locations. This effect is widely known as *Inhibition of Return* (IOR). The effect is usually explained as an inhibitory bias against returning attention to previously attended locations. Thus, attentional disengagement is considered to be a necessary condition to observe IOR (Klein, 2000). We report data from three experiments with 2 different paradigms in which we show that IOR can be dissociated from the endogenous disengagement of spatial attention. Two main results are reported: 1) IOR is observed at an endogenously attended location in some situations, and 2) even after the endogenous disengagement of attention, facilitation instead of IOR is observed in other situations. We conclude that the endogenous disengagement of attention is neither sufficient nor necessary for IOR to be observed. However, by presenting an intervening event between the cue and the target, an IOR effect occurred in all conditions, indicating the importance of attentional segregation processes (exogenous disengagement) for generating IOR. These results are interpreted on the basis of cue-target event integration and segregation processes (Lupiáñez, 2010), which constitute our dynamical perceptual experience. IOR is explained as a cost in detecting the appearance of new attention-capturing information (i.e., the target) at locations where attention has been already captured by previous events (the cue).

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Attentional processes play an important role in rapid and efficient scanning of visual environments. Behavioural, neuropsychological, and imaging studies suggest that two separate attentional systems support the exogenous and endogenous orienting of spatial attention (e.g., Bartolomeo & Chokron, 2001; Chica, Bartolomeo, & Lupiáñez, 2013; Chica, Bartolomeo, & Valero-Cabre, 2011; Corbetta & Shulman, 2002; Funes, Lupiáñez, & Milliken, 2005, 2007; Kincade, Abrams, Astafiev, Shulman, & Corbetta, 2005; Klein, 2004). The cost and benefit paradigm has been widely used to study these two mechanisms for the orienting of spatial attention (Posner, 1980). In *endogenous orienting* studies, a spatially informative central or symbolic cue predicts the most likely location of target appearance. Participants are encouraged to endogenously orient attention towards the location predicted by the cue (i.e., the expected location). Usually, reaction times (RTs) to targets appearing at the expected location (i.e., valid location) are shorter than those to targets presented at the unexpected location (i.e., invalid location), even at long cue-target stimulus onset asynchronies (SOAs, Posner, 1980). In *exogenous orienting* studies, a spatially noninformative peripheral cue (i.e., not predictive of the location of the upcoming target), that is supposed to involuntarily capture spatial attention, is normally used. At short SOAs, RTs are usually shorter for targets appearing at the same location as the peripheral cue (i.e., cued location) as compared to RTs for targets presented at the opposite location (i.e., uncued location). This effect is thought to reflect the facilitation of target's perceptual processing due to the capture of attention by the cue (e.g., Cameron, Tai, & Carrasco, 2002). At longer SOAs, however, the opposite pattern of results is observed: RTs are shorter for targets appearing at the uncued location as compared to the cued location[1]. This effect, first reported by Posner and Cohen (1984), and named *Inhibition of Return* (IOR) by Posner, Rafal, Choate, and Vaughan (1985), is thought to reflect a bias against attention returning to previously explored locations. The IOR effect has been observed using a great variety of dependent variables and tasks (see Klein, 2000; Lupiáñez, Klein, & Bartolomeo, 2006, for reviews). The effect was first reported in detection tasks (Posner & Cohen, 1984), but it has also been observed in discrimination tasks (e.g., Lupiáñez, Milan, Tornay, Madrid, & Tudela, 1997; Pratt, Kingstone, & Khoe, 1997). However, the time-course of the effect is different depending on the task at

[1] Note that, although with both cue types (central and peripheral) there are valid and invalid trials (Ruz & Lupiáñez, 2002), we refer to “valid vs. invalid trials” for endogenous orienting studies, since the cue is informative about the target location, and to “cued vs. uncued trials” for exogenous orienting studies, since the cue appears either at the same or opposite location of the upcoming target.

hand, with IOR being observed at longer SOAs in discrimination tasks than in detection tasks (Lupiáñez et al., 1997).

Following the general metaphor of attention as a spotlight (Cave & Bichot, 1999), the delayed appearance of IOR in discrimination tasks, as compared with detection tasks, has been generally explained on the basis of a larger attentional capture and/or a later disengagement of attention from the cued location in discrimination tasks than in detection tasks. Concretely, Klein (2000) postulated that more attentional resources are necessary for processing the target in discrimination tasks than in detection tasks. Given the difficulty in quickly changing the task set between the cue and the target, more attentional resources are also assigned to processing the cue in discrimination than in detection tasks. Thus, at short SOAs, the attentional capture by the cue might be larger in discrimination tasks, producing a greater facilitatory cuing effect in discrimination than in detection tasks. At longer SOAs, this facilitatory effect turns into IOR but it does so at longer SOAs (although see Gabay, Chica, Charras, Funes & Henik, 2012).

Alternatively, Lupiáñez and colleagues (Lupiáñez, Milliken, Solano, Weaver, & Tipper, 2001) have argued that, independently on the effectiveness of the initial attentional capture, attention might be disengaged later in discrimination than in detection tasks, as it produces larger benefits on location-cued trials in the former. Importantly, however, some manipulations can lead to a larger positive cuing effect at short SOAs (supposedly bigger capture), which is followed nevertheless by a larger IOR effect at longer SOAs (Milliken, Lupiáñez, Roberts, & Stevanovski, 2003), indicating that a greater attentional capture is not necessarily followed by a later appearance of IOR. Thus, attentional capture and attentional disengagement might be different processes rather than the two sides of the same coin (Klein, 2000), as conceived by the reorienting hypothesis of IOR.

Posner and Cohen (1984) proposed the *reorienting hypothesis* of IOR, in which IOR is conceived as the inhibition of the return of attention to a previously attended location. According to this hypothesis, both the early facilitatory and later IOR effects are explained by the same mechanism: the orienting of attention. When a peripheral cue appears, attention is involuntarily drawn to its position, giving rise to the facilitatory effect; after a few hundred ms, attention is disengaged from that spatial position, after which an inhibitory mechanism starts to operate, inhibiting the return of attention to that previously attended location, producing the IOR effect.

Importantly, in spite of recent accumulative evidence showing that this hypothesis might not be correct (Berlucchi, 2006), this way of thinking about IOR is maintained by most researchers in the field. According to the reorienting hypothesis, attentional disengagement would be a necessary condition to observe IOR. Consequently, if IOR is a bias against attention returning to a previously attended location, no IOR should be observed until attention leaves the cued location (Klein, 2000; Posner & Cohen, 1984).

Overview of the present experiments

The main aim of this study is to investigate the relationship between IOR and attentional disengagement. In the first two experiments, we aimed at investigating whether presenting a second cue at fixation (after the peripheral cue) would lead to IOR in a situation in which facilitation is otherwise observed. In Experiment 1, a standard exogenous cuing procedure with a spatially non-informative cue was used. The SOA was fixed at 500 ms and the participants' task was to discriminate a target letter (either X or O). According to our previous research (Lupiáñez, Milliken et al., 2001), facilitation was expected to occur at this specific SOA. However, when a cue was presented at fixation after the peripheral cue, IOR was expected, since the presentation of a central fixation cue is known to favour the appearance of IOR (Faust & Balota, 1997; MacPherson, Klein, & Moore, 2003; Martín-Arévalo, Chica & Lupiáñez, under review; Pratt & Fischer, 2002; Prime, Visser & Ward, 2006; Sapir, Henik, Dobrusin, & Hochman, 2000). In the context of the reorienting hypothesis, the central fixation cue is usually named "cue-back" because it is supposed to attract attention back to the centre, thus inhibiting the return of attention to the cued location. Therefore, according to this hypothesis, IOR should be observed provided that attention is moved back to the centre (i.e., disengaged from the cued location) by any means (either exogenous or endogenous). However, from a different perspective, the same fixation cue is named "intervening event" as it is supposed to disrupt cue-target integration processes (Spadaro, He, & Milliken, in press; Spadaro, Lupiáñez, & Milliken, under review; Spadaro, & Milliken, 2013; Martín-Arévalo, et al., under review; Wang, Yue, & Chen, 2012).

Experiment 2 aimed at contrasting these two views by testing whether IOR would be observed when attention is disengaged from the cued location endogenously. This experiment was very similar to Experiment 1, but the target was highly likely to be presented at the central location, thus encouraging participants to endogenously disengage attention from the peripherally cued location and move it back to the centre. As in Experiment 1, the presence/absence of a fixation cue was manipulated in different groups of participants, so that the role of exogenous vs. endogenous attentional disengagement on IOR could be investigated. If attentional disengagement were the crucial factor for observing IOR, then the effect should be observed no matter whether attention is disengaged endogenously (due to the likely appearance of the target at the central location) or exogenously (by presenting the fixation cue). However, if only exogenous disengagement were related to the appearance of IOR, only the group receiving the fixation cue should show the IOR effect. Thus, these two experiments will be able to dissociate the role of exogenous and endogenous disengagement of attention on IOR.

Experiment 3 used a different procedure to further explore the relation between IOR and endogenous attentional disengagement. We used a paradigm initially introduced by Warner, Juola, and Koshino (1990), in which endogenous and exogenous orienting of attention are manipulated orthogonally using the same set of experimental stimuli (Chica & Lupiáñez, 2004, 2009; Chica, Lupiáñez, & Bartolomeo, 2006; Chica, Sanabria, Lupiáñez, & Spence, 2007; Lupiáñez et al., 2004). If IOR consists of a mechanism that inhibits the reorienting of attention to a previously attended location, no IOR should be observed at a location where participants expect the target to appear, since attention is supposed to be maintained at that position. The IOR effect should only be observed at cued locations where participants do not expect the target to appear (from where they would have disengaged attention).

To anticipate some results, the three experiments showed that endogenous disengagement of attention can be fully dissociated from IOR. These results might invite the conclusion that while endogenous disengagement is not necessary to observe IOR, exogenous disengagement might be. However, in the third experiment, a detection task was also included in the design, to demonstrate that under certain situations, IOR can be observed without exogenous disengagement, thus indicating that both exogenous and endogenous disengagement seems unnecessary for IOR to be observed.

EXPERIMENT 1

In Experiment 1, a standard exogenous cuing procedure was used in order to investigate the role of a central fixation cue on IOR. In this experiment, participants were asked to discriminate between two target letters (X and O). The cue-target SOA was fixed at 500 ms, a SOA at which facilitation is usually observed in discrimination tasks (Lupiáñez et al., 1997; Lupiáñez, Milliken et al., 2001). Two groups of participants took part in the experiment. In one group, nothing was presented during the cue-target inter-stimulus interval (ISI). We predicted a facilitatory effect to be observed in this condition. In the other group, a second cue was presented at fixation during the cue-target interval. We predicted an IOR effect to be observed in this condition. In order to see whether these effects decrease with practice as previously reported (Lupiáñez, Weaver, Tipper, & Madrid, 2001), participants performed several blocks of trials.

METHOD

Participants. Sixteen psychology students from the University of Granada participated in the experiment, eight in each group. All of them were naïve as to the purpose of the experiment and participated voluntarily for course credits.

Apparatus and stimuli. Stimuli were presented on a 14-inch colour VGA monitor. An IBM compatible PC running MEL software (Schneider, 1988) controlled the presentation of stimuli, timing operations, and data collection. Three boxes (displayed in grey on a black background) were presented on the screen. Each box was 17 mm in height by 14 mm in width (subtending 1.62 and 1.33 degrees of visual angle at a viewing distance of 60 cm). The inner edge of each box was 77 mm (7.31 degrees) from the centre of the central box. The target was either the letter “X” or “O”.

Procedure. The sequence of events on each trial is depicted in Figure 1. The three boxes appeared at the beginning of the trial, and remained on the screen until the disappearance of the target. After 1000 ms, the exogenous peripheral cue was presented (one of the two peripheral boxes was displayed in white for 50 ms). In the group without fixation cue, the three boxes remained on the screen for 450 ms after the cue disappeared (i.e. 500 ms SOA). In the group with fixation cue, the central box flickered after 100 ms (it was displayed in white for 50 ms), and the three boxes remained on the screen for 300 ms after the fixation cue, in order to maintain a constant 500 ms SOA. The target was displayed for 100 ms in one of the two peripheral boxes with equal probability. Auditory feedback (a 400 Hz computer-generated tone, 100 ms duration) was provided when a mistake was made. The inter-trial interval, in which the screen remained black, was 1000 ms in duration. Participants were instructed not to move the eyes from the fixation point and to press the appropriate response key on the keyboard as fast as possible, according to the target letter (either the “Z” or “B” key; the letter-key assignment was counterbalanced across participants). All possible combinations of cue and target location, and target letter variables were randomly presented within a block of trials. Thus, the target location was cued on half of the trials and uncued in the other half. Participants were allowed to take a rest after every 32 trials, and were instructed to press the space bar to continue the experimental session.

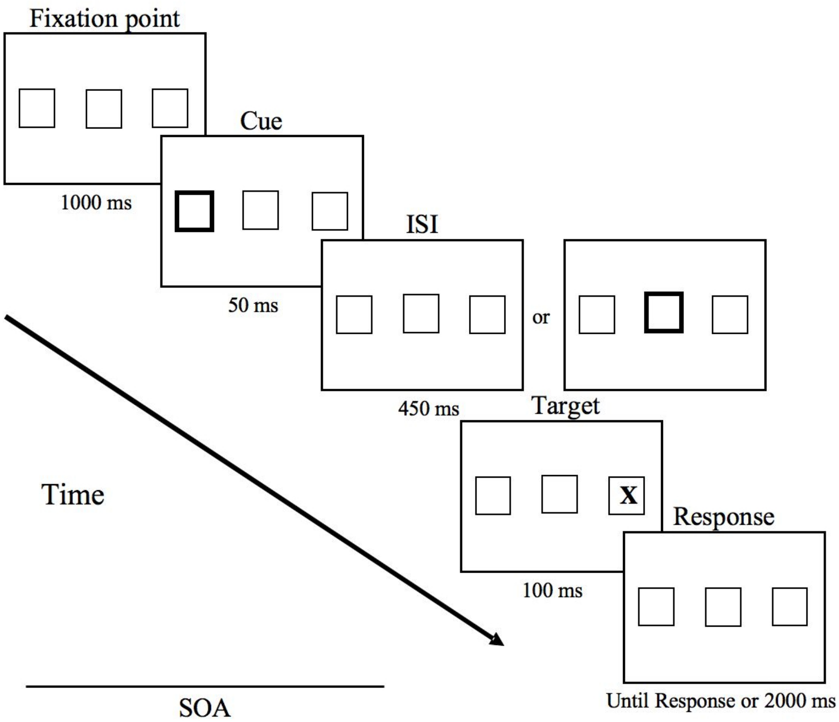

Figure 1. Example of one of the trials in Experiments 1 and 2. In the group without fixation cue, three boxes were presented for 50 ms during the ISI, while in the group with fixation cue, the central box was displayed in white for 50 ms during the ISI.

Design. The experiment consisted of a three-factor mixed design. Cuing and Block of trials were manipulated within participants, while Fixation Cue was manipulated between participants. Fixation Cue had two levels: With and without fixation cue after the peripheral cue. Cuing had two levels (cued vs. uncued location trials) and Block had 4 levels.

Each of the 4 blocks of experimental trials consisted of 128 trials, 64 cued and 64 uncued. Before the experimental trials started, participants completed 16 practice trials (2 trials for each combination of target-letter, target-location, and cuing).

RESULTS

Trials with incorrect responses (19%), those in which no response was made (3%), and those with RTs shorter than 200 ms (0.00%), or longer than 1800 ms (0.32%), were excluded from the RT analyses.

The mean RT data were submitted to a mixed analysis of variance (ANOVA) with the following factors: 4(Block) x 2(Cuing) x 2(Group: With vs. Without fixation cue). Table 1 shows the mean RTs and percentage of errors for each experimental condition. As it can be observed in Figure 2, the cuing effect was modulated by the presentation of the fixation cue, $F(1, 14)=17.86$, $MSE=6026$, $p<.001$. Whereas the group without a fixation cue showed a significant facilitatory effect (RT was 58 ms shorter for cued than for uncued trials, $F(1, 14)=9.08$, $MSE=6026$, $p<.01$), the group with a fixation cue showed an IOR effect (RT was 58 ms longer for cued than for uncued trials, $F(1, 14)=8.79$, $MSE=6026$, $p<.02$).

There was also a main effect of Block, $F(3, 42)=16.66$, MSE=4844, p<.0001, indicating a gradual decrease in RT with practice in the task, and a Block x Cuing interaction, $F(3, 42)=7.11$, $MSE=1218$, $p<.001$, revealing a linear shift of the cuing effect toward facilitation with practice, $F(1, 14)=10.97$, $p<.01$ ($F< 1$, for both the quadratic and cubic tendencies): As it can be observed in Figure 2, in the group without fixation cue, the facilitatory cuing effect increased with practice, whereas in the group with fixation cue, the IOR effect decreased with practice, $F(1, 14)=4.37$, $p=.05$, and $F(1, 14)=6.73$, $p<.05$, respectively for the linear components.

A similar ANOVA was performed on the mean percentage of errors (i.e., incorrect responses). This analysis showed a main effect of Block, $F(3, 42)=8.28$, $MSE=35.40$, $p<.001$. The Block x Cuing, and the Fixation Cue x Cuing interactions were also significant, $F(3, 42)=3.75$, $MSE=29.35$, $p<.05$, and $F(1, 14)=5.12$, $MSE=307.27$, $p<.05$, respectively. These interactions showed the same pattern as the RT data (see Table 1). Thus, facilitation was observed (6.13% fewer errors for cued than uncued trials) when no fixation cue was presented, while IOR emerged (8.75% more errors for cued than uncued trials) in the group with fixation cue.

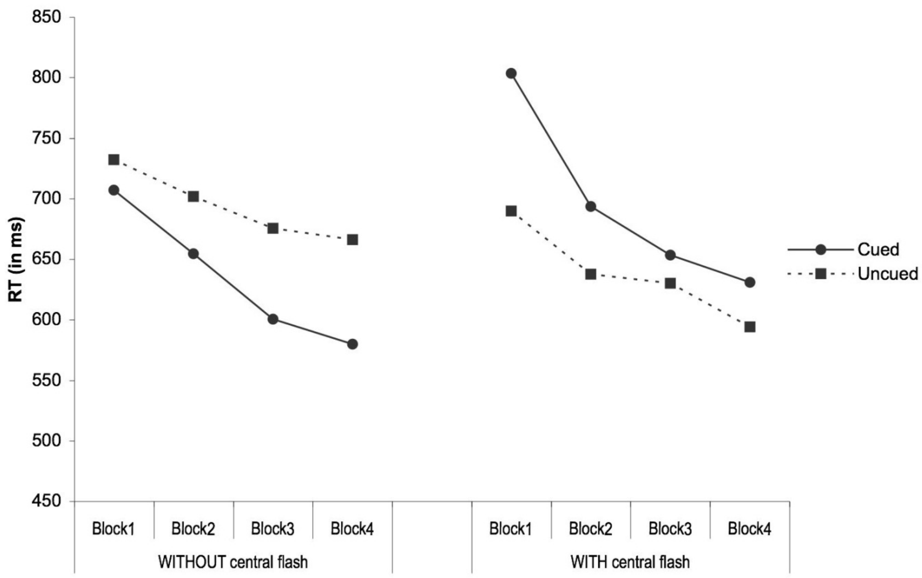

Figure 2. Mean RTs for cued and uncued trials across blocks of trials, as a function of the presence/absence of the Fixation Cue, in Experiment 1 (in which all targets were presented at one of the two peripheral locations).

Table 1. Mean RT (in ms), percentage of errors, and cuing effect for each experimental condition of Fixation Cue, Block, and Cuing.

Fixation Cue	Block 1		Block 2		Block 3		Block 4	
	Cued	Uncued	Cued	Uncued	Cued	Uncued	Cued	Uncued
NO	707	732	655	702	600	676	580	666
	(20.6%)	(22.0%)	(17.6%)	(21.8%)	(9.6%)	(19.9%)	(12.4%)	(21.1%)
	25		**47**		**75**		**86**	
	(1.4%)		**(4.1%)**		**(10.3%)**		**(8.8%)**	
YES	804	690	693	638	654	630	631	594
	(34.1%)	(19.8%)	(24.5%)	(16.2%)	(24.3%)	(17.2%)	(19.5%)	(14.1%)
	-114		**-56**		**-24**		**-37**	
	(-14.4%)		**(8.3%)**		**(-7.0%)**		**(-5.4%)**	

Note: Cuing effect (Uncued - Cued), in bold

DISCUSSION

The results of the present experiment revealed that the cuing effect was significantly modulated by the presentation of a fixation cue during the interval between the peripheral cue and target. Participants showed a significant facilitatory effect when no fixation cue was presented, while IOR was observed in the fixation cue group. The effect of the fixation cue seems to be a robust result, as it has been observed in different studies (Faust & Balota, 1997; MacPherson et al., 2003; Pratt & Fischer, 2002; Sapir et al., 2001). Prime et al. (2006) directly investigated this issue; they observed that whereas the fixation cue had no effect on detection and localization tasks, it had an important role in discrimination tasks. In their experiments, IOR was only observed in a discrimination task when a fixation cue was presented. According to the authors, the role of the fixation cue "is consistent with its putative role in reorienting attention away from the cued location".

Thus, considering the IOR effect as the result of a bias against returning attention to a previously attended location, the facilitatory effect observed in our group without fixation cue can be easily explained by assuming that, due to the perceptual difficulty of our discrimination task (Lupiáñez, Milliken et al., 2001), participants maintained attention at the cued location, even though the cue was not spatially informative about the location of the target. The observed pattern of cuing effects across blocks of trials seems to support this explanation. Previous research has shown that the facilitatory effect observed at short SOAs with spatially non-informative cues does not increase but decreases with practice in both detection and discrimination tasks (Lupiáñez, Weaver et al., 2001). Contrary to this finding, in the present experiment we have observed that the facilitatory effect observed in the group without fixation cue increased across blocks of trials. This clearly seems to support the hypothesis that attention was maintained at the cued location due to the difficulty of the task. Therefore, in the following experiment, participants were encouraged to endogenously disengage attention and move it back to fixation.

EXPERIMENT 2

By presenting a central cue at fixation after the peripheral cue, the facilitatory effect observed in Experiment 1 reversed into IOR. In order to test whether this was due to the disengagement of attention (Prime et al., 2006), a second experiment was carried out, in which the target was presented at fixation on 50% of the trials. Participants were informed that these central targets were the most important, and therefore attention should be kept at fixation all the time. On the remaining 50% of trials, the target appeared at one of the peripheral locations (25% of trials at the cued location, and 25% at the uncued location)[2]. If the lack of IOR observed in Experiment 1 when no fixation cue was presented was due to the maintenance of attention at the cued location, IOR should be observed in this experiment. In other words, if the role of the fixation cue is to reorient attention back to the centre, it should have no effect in this experiment, as attention will be in any case endogenously reoriented at the central location, where the target is more likely to appear. Alternatively, if endogenous and exogenous disengagement of attention were different processes, and only exogenous disengagement were necessary for IOR to be observed, we will again find facilitation in the group without fixation cue and IOR in the one with fixation cue.

METHOD

Participants. Two different groups of sixteen students each participated in the experiment. Participants were naïve as to the purpose of the experiment, and participated voluntarily for course credits.

Procedure and Design. The procedure was the same as in Experiment 1, except for the following: Although the peripheral cue was always presented at one of the peripheral locations, the target was presented at fixation on 50% of the trials, and participants were informed that those trials were the most important, so they should always keep their attention at fixation. On the remaining 50% of the trials, the target appeared at one of the two peripheral locations (25% cued and 25% uncued). There were 4 blocks of experimental trials (128 trials each). In each block, there were 32 cued and 32 uncued location trials, which were the only ones considered in the analysis, so the design was the same as in Experiment 1.

RESULTS

Trials with incorrect responses (17.7%), those in which no response was made (0.28%), and those with RTs shorter than 200 ms (0.41%), or longer than 1800 ms (0.19%) were excluded from the RT analysis. The remaining RTs were averaged per experimental condition and participant,

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[2] Note that Posner and Cohen (1984) implemented a similar strategy to ensure that attention was disengaged from the cued location.

and introduced into a 4(Block) x 2(Cuing) x 2(Group: With vs. Without fixation cue) mixed ANOVA. The mean RT and percentage of errors for each experimental condition are presented in Table 2.

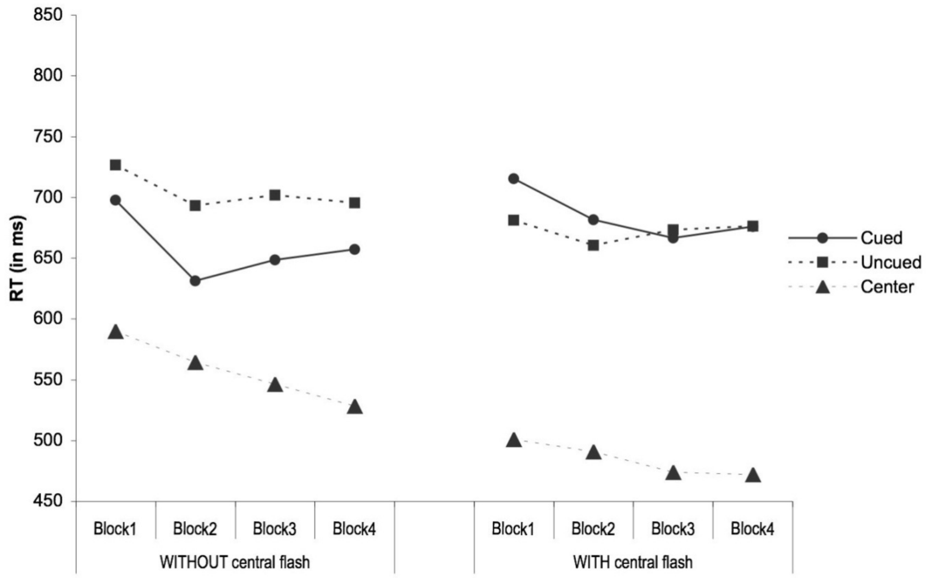

Figure 3. Mean RTs for peripheral target trials, cued and uncued, and for central location targets, across blocks of trials, as a function of the presence/absence of the Fixation Cue, in Experiment 2 (where 50% of the targets were presented at the central location).

As in Experiment 1, the RT analysis showed a main effect of Block, $F(3, 87)=3.87$, $MSE=4710$, $p<.05$. More importantly, as it can be observed in Figure 3, the cuing effect was again significantly modulated by the Fixation Cue, $F(1, 29)=8.13$, $MSE=6298$, $p<.01$. In the group without fixation cue, there was a significant facilitatory effect, comparable to that obtained in Experiment 1 (47 ms shorter RTs for cued than for uncued trials), $F(1, 14)=6.18$, $MSE=6297$, $p<.05$. This facilitatory effect was independent of the block of trials, $F<1$. In sharp contrast, in the group with fixation cue, IOR was observed, and it was marginally modulated by block, $F(3, 45)=2.48$, $p=.073$. The IOR effect (mean RT was 23 ms shorter for cued than for uncued trials) was only present in the first two blocks of trials, $F(1, 15)=6.31$, $p<.05$.

Table 2. Mean RT (in ms), percentage of errors, and cuing effect for each experimental condition of Fixation Cue, Block, and Cuing.

	Block 1			Block 2			Block 3			Block 4		
Fixation Cue	Central Target	Cued	Uncued	Central Target	Cued	Uncued	Central Target	Cued	Uncued	Central Target	Cued	Uncued
NO	590	697	726	564	631	692	545	648	702	529	657	695
	(5.6%)	(21.6%)	(28.8%)	(3.6%)	(21.9%)	(24.7%)	(3.1%)	(23.0%)	(25.8%)	(5.2%)	(20.3%)	(23.0%)
		29			**61**			**54**			**38**	
		(7.2%)			**(2.8%)**			**(2.8%)**			**(2.7%)**	
YES	501	715	681	491	682	661	474	666	673	472	676	676
	(5.6%)	(28.4%)	(23.7%)	(3.4%)	(26.6%)	(24.1%)	(3.1%)	(26.3%)	(20.7%)	(2.3%)	(26.3%)	(22.7%)
		-34			**-21**			**7**			**0**	
		(-4.7%)			**(-2.6%)**			**(-5.6%)**			**(-3.6%)**	

Note: Cuing effect (Uncued - Cued), in bold

The percentage of error analysis showed that the only significant effect was the Cuing x Fixation Cue interaction, $F(1, 29)=8.50$, $MSE=121.12$, $p<.01$. The cuing effect was positive in the group without fixation cue (3.87% fewer errors for cued trials than for uncued trials), although the effect was only marginally significant, $F(1, 29)=3.26$, MSE=121.19, $p<.081$. However, when a fixation cue was presented, IOR was observed (4.11% more errors for cued trials than uncued trials), $F(1, 29)=5.41$, $MSE=121.19$, $p<.05$.

DISCUSSION

In this experiment, the effect of the fixation cue on IOR was replicated: Facilitation was observed when no fixation cue was presented, and IOR appeared after the presentation of the fixation cue. The IOR effect observed with a fixation cue, however, was nominally smaller in this experiment than the one observed in Experiment 1 (with a fixation cue). This is consistent with Wright and Richard (2000) who found no IOR when the cue was very unlikely to appear at peripheral locations (10% at cue, 10% at uncued, 80% at the centre). The most important result was, however, that the presentation of 50% of the targets at fixation, together with the instructions to keep attention at that central position, did not affect the overall cuing effect observed when no fixation cue was presented. In Experiment 1, the fact that the cuing effect produced IOR in the group with a fixation cue could be interpreted, according to the reorienting hypothesis of IOR, by assuming that the fixation cue led to the disengagement of attention from the peripherally cued location. However, if this were the case, we should have observed IOR in the group without a fixation cue in Experiment 2, given that in this experiment participants were encouraged to endogenously disengage attention from the cued location, and the 500 ms SOA is long enough to move attention endogenously (Müller & Rabbitt, 1989; Theeuwes, Godijn, & Pratt, 2004). In contrast, in the group without fixation cue, the same facilitatory effect as in Experiment 1 was observed. Therefore, this experiment served to dissociate between endogenous and exogenous disengagement of attention as regards to their role in producing the IOR effect. Whereas endogenous disengaging of attention seems unnecessary for IOR to be observed, fixation cues seem effective in producing IOR, which could be taken as evidence that exogenous disengagement is necessary to observe IOR, which will be discussed in more detail in the General Discussion.

However, it could be argued that attention was not fully disengaged endogenously from the cued location, in spite of the target being presented with a high probability at the central location, while participants were encouraged to maintain attention there. Importantly, the facilitatory effect was independent of practice in this experiment, whereas it increased with practice in Experiment 1. This might be taken as indirect evidence that attention was maintained at the cued location in Experiment 1, but not in Experiment 2. Apart from this, we do not have any direct evidence that attention was in fact disengaged from the cued location in the group without a fixation cue in Experiment 2. In order to ensure the disengagement of attention, and to be able to measure it, in the following experiment we used a different procedure in which the effects of peripheral cuing (correspondence between the location of the cue and the target) is measured orthogonally to the endogenous orienting of attention (Chica & Lupiáñez, 2004, 2009; Chica et al., 2006; Chica et al., 2007; Lupiáñez et al., 2004).

EXPERIMENT 3

Experiments 1 and 2 demonstrated that attentional disengagement is not a sufficient condition to observe IOR. The effect is observed when attention is disengaged by means of a fixation cue, but no IOR effect is observed when participants endogenously disengage attention from the cued location. Thus, an interim conclusion might be that whereas endogenous disengagement seems not to be sufficient for IOR to be observed, exogenous disengagement (i.e., fixation cues) might be necessary.

The purpose of Experiment 3 was to further study the relationship between IOR and attentional disengagement. To this aim, we used a paradigm in which endogenous and exogenous orienting are manipulated orthogonally, using the same set of stimuli. A peripheral cue was presented, predicting, in different blocks of trials, either the same or opposite location of target appearance. With this manipulation, endogenously attended and unattended locations can either be peripherally cued or uncued. Importantly, using this design, we can measure where attention is oriented to, by computing the expectancy effect (i.e., RTs to targets presented at expected versus unexpected locations).

Consequently, we can directly test the *reorienting hypothesis* of IOR. If IOR consists of the inhibition of the return of attention to previously attended locations, no IOR should be observed when attention is maintained at the expected location. Similarly, IOR should always be observed when attention has been disengaged from the cued location (unexpected location trials). Detection and discrimination tasks were used in order to test these two predictions: based on our previous findings, we expect to find significant IOR at the endogenously attended locations (Chica et al., 2006) mostly in detection tasks, in which IOR is usually larger than in discrimination tasks (Lupiáñez et al., 1997; Lupiáñez, Milliken et al., 2001). In the discrimination task (in which larger facilitatory effects are usually observed, Lupiáñez et al., 1997; Lupiáñez, Milliken et al., 2001) we expect to find facilitation instead of IOR, even when attention has probably been disengaged from the cued location (at unexpected locations). Thus, we expect to replicate the finding from Experiment 2 that facilitation instead of IOR can be observed in a discrimination task even after attention has been fully disengaged from the cued location.

As it could be argued that exogenous rather than endogenous disengagement is necessary for IOR to be observed, we included the detection task. In this case we expect to observe an IOR effect even when no fixation cue is presented. Importantly, observing IOR at the expected location (from where attention has not been disengaged), and without a fixation cue (thus, without exogenous attentional disengagement), will be a demonstration that neither endogenous (Berger, Henik & Rafal, 2005; Chica et al., 2006; Chica & Lupiáñez, 2009) nor exogenous disengagement are really necessary for the occurrence of IOR.

METHOD

Participants. Thirty-two psychology students, from the University of Granada, participated in this experiment (16 for the detection task and 16 for the discrimination task). As in the previous experiments, all participants were unaware of the purpose of the experiment, and participated voluntarily for course credits.

Apparatus, stimuli, procedure, and design. In contrast to Experiment 1, E-Prime software (Schneider, Eschman, & Zuccolotto, 2002) was used to control the presentation of stimuli and data collection. No fixation cue was presented in any block of trials. Task (detection versus discrimination) was manipulated between participants. In the detection task, participants were asked to detect the appearance of a target letter by pressing one key on the keyboard (half of the participants pressed the "Z" key, and the other half pressed the "B" key). In the discrimination task, participants had to discriminate the identity of the letter by pressing the appropriated key for each letter (also "Z" or "B"). The response-key mapping was counterbalanced across participants, who were encouraged not to move the eyes from the fixation point.

Catch trials were included (20% of trials) in both tasks. Each task consisted of two blocks of trials. In one of them, the peripheral cue predicted that the target would appear at the same spatial location as the cue on 75% of the target-present trials. Thus, when the target was presented at the same position as the cue, these trials were "expected location" trials (because the participants were expecting the target to appear at that location), and "cued location" trials (because the cue and target were presented at the same spatial position). However, on the remaining 25% of the target-present trials, the target was presented at the opposite location to the cue. These were "unexpected location" trials (because the target was not expected to appear at this location), and also "uncued location" trials (because the cue and target appear at different spatial locations). In the other block, the cue predicted that the target would appear at the opposite location on 75% of trials. Thus, when the target was presented at the opposite location as the cue, these were "expected location" trials but "uncued location" trials. On the remaining 25% of the trials, the cue appeared at the same location as the cue, thereby comprising "unexpected location" trials but "cued location" trials. By using this manipulation, both expected and unexpected location trials can be either cued or uncued, making it possible to dissociate endogenous orienting from exogenous cuing of spatial attention. Participants were asked to attend to the position predicted by the cue, although they were not informed about the exact predictive value of the cue.

Each block consisted of 160 trials, preceded by 20 practice trials. Participants were allowed to take a break after every 80 trials. For each experimental condition of cuing (cued vs. uncued location trials), there were 32 observations for unexpected location trials, and 96 observations for expected location trials.

The factors in the design were: 2 (Task; Detection vs. Discrimination) x 2 (Expectancy; Expected vs. Unexpected location trials) x 2 (Cuing; Cued vs. Uncued location trials). Task was manipulated between participants, while Expectancy and Cuing were manipulated within participants.

RESULTS

False alarms accounted for 0.96% and 1.30% of trials in the detection and the discrimination task, respectively. Participants missed the target on 1.31% and 0.71% of the target-present trials in the detection task and the discrimination task, respectively. Responses shorter than 200 ms (2.69% and 0.00% of trials in the detection task and the discrimination task, respectively), or longer than 1200 ms (0.0% and 1.17% of trials in the detection task and the discrimination task, respectively) were eliminated from the RT analysis. Incorrect responses in the discrimination task (5.71% of trials) were also removed from the analysis.

The mean RT data were submitted to a 2 (Task) x 2 (Expectancy) x 2 (Cuing) mixed ANOVA. The analysis revealed a significant main effect of Task, $F(1, 30)=145.71$, $MSE=14244$, $p<.0001$, with participants being faster in the detection task than in the discrimination task (M=333 ms and M=587 ms, respectively). Importantly, the main effect of Expectancy was also highly significant, $F(1, 30)=39.24$, $MSE=1226$, $p<.0001$, showing that RT was faster when the target was presented at the expected than the unexpected location (M=441 ms and M=479 ms, respectively). Importantly, the expectancy effect did not interact with task, $F(1, 30)=2.44$, $MSE=1226$, $p=.129$, being statistically significant in both the detection and the discrimination task ($F(1, 30)=11.06$, $MSE=1225$, $p=.002$ and $F(1, 30)=30.63$, $MSE=1225$, $p<.001$, respectively). In agreement with previous research on tasks effects, Cuing interacted with Task, $F(1, 30)=19.65$, $MSE=1403$, $p<.001$. IOR was observed in the detection task (mean cuing effect of -35 ms), $F(1, 30)=13.96$, $MSE=1403$, $p<.001$, while facilitation was observed in the discrimination task (mean cuing effect of 23 ms), $F(1, 30)=6.41$, $MSE=1403$, $p<.05$.

The interaction between Task, Expectancy, and Cuing was significant, $F(1, 30)=5.24$, $MSE=802$, $p<.05$. As shown in Figure 4, this interaction revealed that, in the detection task, although a significant IOR effect was observed at both expected and unexpected location trials, $F(1, 30)=4.66$, $MSE=755$, $p<.05$, and $F(1, 30)=13.25$, $MSE=1449$, $p<.01$, respectively, the effect was larger at the unexpected location, $F(1, 15)=4.74$, $MSE=663$, $p<.05$. In the discrimination task, the cuing effect (facilitation instead of IOR) was larger, and only significant, at the unexpected location, $F(1, 30)=5.87$, $MSE=1449$, $p<.05$. Although also positive, the effect of cuing was not significant at the expected location, $F(1, 30)=2.32$, $MSE=755$, $p=.13$.

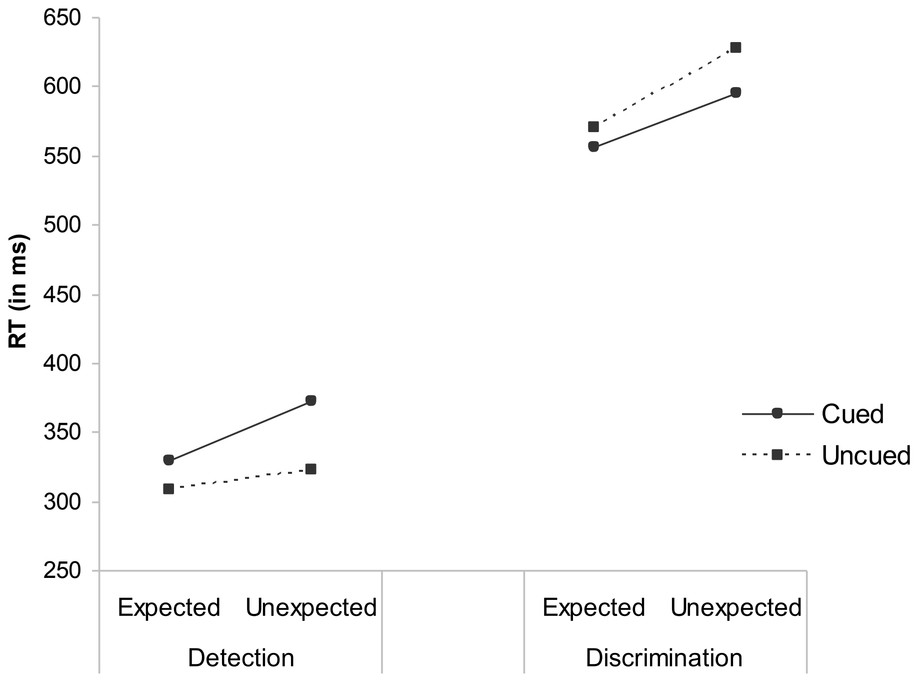

Figure 4. Mean RTs for cued and uncued trials, as a function of Expectancy and Task, in Experiment 3 (in which endogenous and exogenous orienting of attention were manipulated orthogonally using a spatially informative peripheral cue).

Table 3. Mean RT (in ms), percentage of errors in the discrimination task, and cuing effect for each experimental condition of Task, Expectancy, and Cuing.

	Detection		Discrimination	
	Expected	Unexpected	Expected	Unexpected
Cued	329	372	556 (3.8%)	596 (4.8%)
Uncued	308	323	571 (5.9%)	628 (11.4%)
Mean Cuing effect	**-21**	**-49**	**15 (2.1%)**	**33 (6.6%)**

The mean percentage of errors in the discrimination task were also submitted to a 2 (Expectancy) x 2 (Cuing) repeated-measures ANOVA[3]. Similarly to the RT analysis, the main effects of Expectancy, $F(1, 15)=12.59$, $MSE=13.16$, $p<.01$, and Cuing, $F(1, 15)=10.98$, $MSE=27.49$, $p<.01$, were significant. Importantly, the interaction between Expectancy and Cuing was marginally significant, $F(1, 15)=3.59$, $MSE=23.13$, $p=.07$, revealing that although the facilitatory effect was significant at both expected and unexpected locations, $F(1, 15)=5.46$, $MSE=6.23$, $p<.05$, and $F(1, 15)=7.90$, $MSE=44.39$, $p<.05$, respectively, the effect was larger at the unexpected than at the expected location (cuing effect of 2.1 and 6.6, respectively).

DISCUSSION

In the present experiment, the effect of expectancy was highly significant, both in the detection task and the discrimination task, thus showing that the 500 ms SOA was long enough for participants to orient attention according to the information provided by the cue. Previous research with our paradigm, in which we used several levels of cue-target SOA, has shown that the effect of expectancy does not increase with SOAs longer than 300-400 ms (Chica & Lupiáñez, 2004; Chica et al., 2006). Therefore, we can be confident that the orienting of attention was completed by 500 ms, which increases the importance of the two relevant

[3] Note that the mean percentage of errors was much reduced in this experiment as compared to the previous experiments (with stimuli presented in a much older computer screen). Importantly, however, the results in all experiments converge with the general message of the paper.

results observed in relation to spatial orienting. On the one hand, IOR was observed at the expected location when participants detected the appearance of the target. That is, IOR can be observed at a position from where attention has not been disengaged, revealing that the endogenous disengagement of attention is not a necessary condition in order to observe IOR. Importantly, considering that no fixation cue was presented in this experiment, we can also conclude that exogenous disengagement is not necessary either to observe IOR.

On the other hand, even after the disengagement of attention (when the target is presented at the unexpected location), facilitation instead of IOR was observed in the discrimination task. Therefore, in agreement with the data from Experiment 2, attentional disengagement is not sufficient to observe IOR: Facilitation, instead of IOR, can be observed at locations from where attention has been disengaged (e.g., unexpected locations).

GENERAL DISCUSSION

The present study aimed at investigating the relationship between IOR and attentional disengagement. It has been proposed that IOR consists of a mechanism that inhibits the reorienting of attention to a previously attended location (Posner & Cohen, 1984). Thus, no IOR should be observed until attention leaves the cued location (Klein, 2000). This hypothesis considers the disengagement of attention is a necessary condition to observe IOR, an idea shared by most researchers in the field. Accordingly, using the cost and benefit paradigm, Posner & Cohen (1984) presented a cue at fixation after the peripheral cue, in order to ensure that attention was disengaged from the cued location when the target was presented (which is called cue-back procedure, in reference to its supposed function of bringing attention back to centre). However, later on, other researchers have used a different procedure in which no fixation cue was used, and the usual IOR effect was also observed (e.g., Lupiáñez et al., 1997). In this case it is assumed that, given the lack of spatial predictability of the peripheral cue, after several hundreds of milliseconds, participants disengage attention spontaneously from the cued location. Nevertheless, it is believed that the fixation cue could anticipate the disengagement of attention, and therefore leads to an earlier appearance of the IOR effect (MacPherson et al., 2003; Pratt & Fischer, 2002; Sapir et al., 2001). This is especially true in discrimination tasks, in which IOR appears much later when no cue is presented at fixation (Prime et al., 2006). Exogenous and endogenous attentional disengagement have been considered as two ways of producing the same result: the disengaging of attention from the cued location, which leads to IOR. Thus, an important goal of the present research was to investigate the mechanisms involved in these two ways of attentional disengagement.

In the first two experiments, we manipulated the presentation of a fixation cue (exogenous disengaging) after the spatially non-informative peripheral cue in a discrimination task. Facilitation was observed in the group without fixation cue, while IOR was observed when a fixation cue was presented. However, when participants were encouraged to (endogenously) disengage attention from the cued location by making the target highly likely to appear at the central location, no IOR effect was observed (Experiment 2). These results clearly show that the endogenous disengagement of spatial attention is not a sufficient condition to observe IOR.

Furthermore, in Experiment 3, we used a paradigm that allowed us to isolate the effects of peripheral cuing from the endogenous orienting of spatial attention. The reorienting hypothesis of IOR predicts that IOR should always be observed when the target appears at a cued but unexpected location, from where attention has been already disengaged. However, in line with the results of the previous experiments, when participants performed a discrimination task, facilitation instead of IOR was observed at the unexpected location, even after the disengagement of spatial attention. This result reveals that endogenous attentional disengagement is not sufficient to observe IOR. A similar dissociation between target explicit expectancy and target repetition effects has been observed in a non-spatial IOR procedure (Spadaro & Milliken, 2013).

Additionally, the reorienting hypothesis predicts that no IOR effect should be observed at the expected location, where attention is supposedly maintained, and therefore not disengaged from it. However, in the detection task, a significant IOR effect was measured at the expected location. Note that no fixation cue was presented in this experiment, so that neither was attention exogenously disengaged. Therefore, IOR can be observed at a position where attention is being maintained and from where it has not been exogenously disengaged, revealing that neither exogenous nor endogenous disengagement of attention are necessary conditions to observe IOR. These results are consistent with other studies that have reported, with a variety of paradigms, IOR at endogenously attended locations (Berger & Henik, 2000; Berger et al., 2005; Berlucchi, Chelazzi, & Tassinari, 2000; Berlucchi, Tassinari, Marzi, & di-Stefano, 1989; Chica et al., 2006; Chica & Lupiáñez, 2009; Lupiáñez et al., 2004).

Previous evidence with different paradigms has also shown that IOR is not always related to the disengagement of attention from the cued location. For example, IOR has been consistently reported with no evidence of previous facilitation (Danziger & Kingstone, 1999; Pratt, Hillis, & Gold, 2001; Tassinari, Aglioti, Chelazzi, Peru, & Berlucchi, 1994; Tassinari & Campara, 1996). This IOR effect is difficult to interpret as the inhibition of the return of attention to a previously attended location, if no orienting of attention (facilitation) has been previously measured at the cued location (see also Mele, Savazzi, Marzi, & Berlucchi, 2008).

Our finding that the endogenous disengagement of attention is not sufficient to observe IOR is similar to the one reported by Danziger and Kingstone (1999). They observed that at a 50 ms SOA, when facilitation was observed in a detection task, IOR was instead observed when participants were asked to disengage attention from the cued location. This result led them to conclude that by disengaging attention from the cued location, the IOR effect was unmasked. However, in their less known second experiment, in which a discrimination task was used, facilitation instead of IOR was observed (even at longer SOAs), when participants were asked to disengage attention from the cued location. Taken together Danziger and Kingstone's results and the results of the three experiments reported here, we can conclude that after endogenously disengaging attention from the cued location, facilitation or IOR can be observed depending on tasks demands (detection vs. discrimination). That is, cuing effects can be dissociated from the endogenous orienting of spatial attention, and they manifest differently (either as facilitation or IOR) depending on factors such as task demands.

The counterargument might be, however, that when the task is manipulated between participants, or between blocks of trials or sessions, participants will adopt a particular task set that is applied not only to the processing of the target but also to the processing of the cue (Klein, 2000; Lupiáñez, Milliken et al., 2001). Therefore, it is difficult to know whether the tasks differences observed in the measured cuing effect are due either to the fact that the cue captures attention differently depending on the task (Klein, 2000), that attention is disengaged earlier or later depending on the task (Lupiáñez, Milliken et al., 2001), or to different manifestations of the cuing effect. This problem was directly tested in a study by Lupiáñez, Ruz, Funes, and Milliken (2007) who demonstrated that the same attentional capture produced by a peripheral cue can lead to either facilitation or IOR depending on the task at hand. In their experiments, a spatially non-informative peripheral cue was presented, followed by one of several possible target letters. Participants were asked to detect the appearance of one of the letters (e.g., “X”), which was presented in most of the trials (i.e., 80% of the trials) and differed from the other letters in a single feature. In the remaining 20% of the trials, however, one of two alternative letters was presented (either “O” or “U”), and participants were asked to discriminate them, by pressing one of two keys on the computer keyboard. Note that, by the time the cue appears, no information is provided about the future identity of the target, so the same attentional capture must have taken place for both the frequent and the infrequent target. In spite of attentional capture (and subsequent reorienting processes) being controlled, the results revealed that the measured cuing effects depended on the frequency of the target, with a significant IOR effect observed for the frequent (to be detected) target, and a significant facilitatory effect for the infrequent (to be discriminated) target. That is, the same attentional capture can manifest differently in performance depending on factors such as the task at hand.

Crucially, it is important to make explicit that we do not argue that peripheral cues do in fact attract attention automatically, as most researchers in the field would consider. What we argue is that peripheral cues, apart from orienting attention automatically to the cued location, produce other effects, which seem to be independent of the orienting of the attentional spotlight. The important pieces of evidence for this argument are that a) the two opposite cuing effects, facilitation and IOR, can be dissociated from the orienting of attention (see Experiments 1 to 3 reported in this paper; see also, Berger & Henik, 2000; Berger et al., 2005; Chica & Lupiáñez, 2004; Chica et al., 2006; Chica & Lupiáñez, 2009; Danziger & Kingstone, 1999; Riggio & Kirsner, 1997; Martín-Arévalo, Kingstone & Lupiáñez, in press), and b) when the attentional capture and subsequent orienting processes are controlled, opposite cuing effects (facilitation vs. IOR) can be observed depending on the task at hand (Lupiáñez et al., 2007).

In the first two experiments of this paper an extra factor was considered: the presence of an intervening event at fixation between the cue and target events reversed the facilitatory cueing effect into IOR. One might argue that the same way as IOR is only observed with exogenous cues, attention should be disengaged exogenously in order to observe the effect, thus explaining why the presentation of a central fixation cue leads to IOR in discrimination tasks, whereas the endogenous disengagement of attention does not. However, one should then explain the meaning of disengaging attention exogenously as something different from disengaging attention endogenously. Furthermore, it should be explained why in detection tasks neither endogenous nor exogenous disengaging seems to be necessary for observing IOR. Thus, it should also be explained why whatever exogenous disengaging is, as different to endogenous disengaging, it has a further more important role in discrimination than in detection tasks (Martín-Arévalo, et al., under review). The following account of IOR is an attempt in this direction.

The Detection Cost Theory of IOR

Following a previous exposition of our theory (Lupiáñez, 2010), we propose that the IOR effect constitutes a cost in rapidly detecting or encoding the appearance of new objects or events when they are similar to previous attention-capturing events. Therefore, the more similar the target is to the cue, the more difficult it will be to detect it as something different from the cue. However, in peripheral cueing paradigms, in which IOR is observed, the peripheral cue not only affects target detection, but it also affects its selection and discrimination. We propose that cueing a location hinders detection of a subsequent event at the very same location, whereas it facilitates selecting this object for subsequent perceptual discriminative processing leading to its recognition. Therefore, the larger the contribution of detection processes to target processing, the larger the detection cost will be, and therefore the larger the IOR effect that is measured.

Underlying these opposite effects of cueing might be the perceptual processing in the dorsal vs. the ventral stream (Milner & Goodale, 1995). For object detection /encoding and fast and automatic reactions to them (i.e., in the dorsal stream and other subcortical structures like superior colliculus) it is necessary to have very precise spatio-temporal resolution. In order to detect the appearance of a new object it is necessary that this perceptual system treats any piece of information as different from previous information, and the system works on the basis of salience; the more different the new information is, the more likely it is to be considered as a new object, and therefore the easier it will be detected. Therefore, in the cueing paradigms, in which IOR is observed mainly in detection tasks, the more similar the target is to the cue (or to the previous target in target-target paradigms; Spadaro et al., 2012), the larger the detection cost will be, with location being the most important feature for this principle. IOR will be largest when the target is presented at the very same location as the cue.

In contrast, for object recognition in the ventral stream, it is necessary to bind together the different object-constituting features into an integrated representation. This representation (which has been called object-file representation by Khaneman et al., 1992) needs to accumulate information over time until a match with stored representations is produced, the object being then interpreted according to previous experience. The spatial overlap between features has been shown to be critical for the integration within the bounded object-file representation (van Dam & Hommel, 2010). Therefore, 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. In standard cue-target paradigms, the cue does not carry any features apart from location. Therefore, the cue would merely open the object-file representation to which the following target features are added when appropriate cue-target spatio-temporal overlap occurs, i.e., mainly at short SOAs at the cued location, thus leading to the observed cueing benefits (i.e., facilitation).

A much more complicated scenario emerges when more complex designs are used, as with the target-target paradigm in IOR procedures, or other procedures in which stimulus features and/or response can repeat or not on consecutive displays, like in the preview paradigm (Kahneman, Treisman & Gibbs, 1992), or other more general priming procedures. In this case, we propose that the detection cost would still come into play leading to a linear increase in target detection difficulty as similarity increases (Hu, Samuel & Chan, 2010). However the contribution of detection to performance will be negligible in comparison to the contribution of perceptual discrimination and categorization and response-selection processes. Due to the prominent role of response in this context it might be more appropriate to describe binding as occurring within event-files (Hommel, 2004) rather than object-files.

Furthermore, in contrast to the linear relation between similarity and detection cost, the effects of binding (within these episodic representations) that is needed for perceptual discrimination is also much more complex, and leads to interactions between features and response repetition. These effects would rather be governed by the principle of appropriate vs. inappropriate processing (Morris, Bransford, & Franks, 1977; Wood & Milliken, 1998). When a target object is encountered, the previous event-file is retrieved to the extent that it shares some features with the previous object, and location might be also very relevant for this correspondence (van Dam & Hommel, 2010). When this new object is the same or very similar to the information available in the retrieved event-file, and requires the same response, a large benefit would be observed; this situation is known in the literature as a *complete match*. However, when the new object is only partially similar and/or requires a different response, a situation that is known in the literature as a *partial match* occurs, producing an important cost in comparison to a *complete alternation* situation, where no feature or response is repeated. This cost can be considered as a transfer of inappropriate processing: when the retrieved information is not sufficient for solving the target task and a new event-file has to be created for the target, the retrieved event-file will interfere with target processing. Also note that better performance in the complete alternation situation would also be due to the benefits of novelty in target detection and therefore the ease with which the new event-file is created.

In summary, we propose that episodic memory has an important role in perception and action even at short intervals. This makes the repetition of features (and responses) produce a cost in the detection of new object targets. This cost might be linearly related to the amount of repetition, with location having a special role in object continuity, and therefore larger location-repetition IOR effects should be observed in static displays. In other words, the more different and unexpected a target is, the more likely it is that it will capture attention and be quickly detected. However, detection is not sufficient to appropriately respond to events. Usually further perceptual processing is needed, which is also importantly affected by repetition. In this case, repetition leads to complex interactions between the content of the retrieved event-file and the current target-event, producing benefits in target discrimination and response selection but only when the retrieved event-file does not contain conflicting information (as in partial match situations; Terry, Valdes, & Neill, 1992).

Therefore, any variable increasing the contribution to target performance of detection processes will increase the observed IOR effect. The most natural way to increase the contribution of target detection is to have a relatively long SOA (e.g., 1000 ms) between cue and target. At long SOAs cue-target integration is disrupted by breaking the spatio-temporal correspondence that is suitable for integration. This necessitates the detection of the target (as a new event) and therefore IOR is also observed in discrimination tasks at longer intervals (Lupiáñez et al., 1997; 2001). Other variables could encourage target detection even at shorter intervals, so that IOR is observed at shorter cue-target SOAs. Data from our first two experiments show that presenting a cue at fixation abruptly interrupts cue-target integration processes, thus making target detection necessary along with the creation of a new event-file representation. Presenting a distractor at the same time as the target (in opposite locations) seems to be another way of increasing the need of target detection, and therefore observing IOR at shorter intervals (Funes, Lupiáñez & Milliken, 2008; Lupiáñez & Milliken, 1999). We predict that very short target durations and other manipulations that emphasize the need of target detection (like when it is not expected to appear; Milliken et al., 2003) will lead to larger IOR effects, especially in discrimination tasks. In detection tasks, there is usually not much modulation of the IOR effect because task demands to detect the target already tune the system to be mainly driven by target detection processes.

At this point one might ask, why is any detection cost necessary? What is the functional relevance of the detection cost, and therefore of the IOR effect? From an attentional point of view, it is important that the attentional system helps us selecting the relevant information in a cluttered environment. The better this attentional system works, the better we will be at selecting relevant among irrelevant information, and therefore the better will be our adaptation to the environment. However, a perfect goal-directed selective attentional system (voluntary attention) can be sometimes dangerous if it leads us not to take into account unforeseen potentially relevant (perhaps threatening?) new information. Therefore, across evolution we have developed a counteracting attentional system driven by novelty and saliency: exogenous attentional capture. New salient enough events will capture our attention (Ruz & Lupiáñez, 2002) no matter whether we are focused on something else, interrupting our ongoing processing and instantly prioritizing processing of the new information (Corbetta, Patel & Shulman, 2008). To the extent that this new information is interesting and/or shares properties with the present relevant information, we will continue to pay attention to this new event that captured attention (Folk, Remington, & Johnston, 1992; Theeuwes, Atchley & Kramer, 2000). In any case, this event will not be as new the next time it occurs and therefore will not be quickly detected as to capture attention again. This equilibrium between the voluntary attentional system and the attentional capture by new events is necessary for an appropriate interaction with our environment. New attention-capturing events are quickly detected, but attention capture by them should also habituate, thus leading to effects like the IOR effect (Dukewich, 2009); otherwise we would be constantly interrupted by irrelevant information.

To recapitulate, we have tested the reorienting hypothesis about IOR, which proposes that IOR consists of the inhibition of the return of attention to previously attended locations. This hypothesis predicts no IOR effect until attention is disengaged from the cued location. In contrast to this hypothesis, we have reported evidence that IOR can be observed at a location to which endogenous attention is oriented to, and therefore with reorienting being unnecessary. Furthermore, we have shown that if endogenous attention is removed from the cued location (in discrimination tasks) no IOR is observed. Thus, we have shown that the endogenous disengagement of attention from the cued location is neither sufficient nor necessary in order to observe IOR. Importantly, significant IOR is observed in the detection task in the absence of any attentional disengagement, either endogenous (i.e., at the expected location) or exogenous (i.e., when no fixation cue is presented). Consequently, even if we argue that exogenous and endogenous disengaging of attention are different processes, we can conclude that neither of them is necessary for IOR to be observed. Therefore, perceptual consequences of peripheral cuing should be dissociated from its role in orienting attention exogenously. One of these consequences is a cost in detecting/encoding the appearance of new information (the target) when it is very similar to a previous event (the cue), especially when it appears at the same location, which would be the more direct cause of IOR.

RESUMEN

Inhibición de Retorno: ¿desenganche atencional o coste en la detección?. La teoría del coste en la detección. Cuando el intervalo temporal entre dos estímulos periféricos es lo suficientemente largo, el tiempo de reacción (TR) en responder a los estímulos que aparecen en lugares previamente atendidos es mayor que el empleado en responder a nuevas localizaciones. Este efecto es extensamente conocido como Inhibición de Retorno (IR), y suele ser explicado como un sesgo que impide que la atención se reoriente hacia lugares previamente atendidos. Así, el desenganche atencional es considerado una condición necesaria para observar IR (Klein, 2000). En este trabajo mostramos resultados de tres experimentos, con dos paradigmas diferentes, en los que la IR se puede disociar del desenganche atencional voluntario. Los dos resultados principales demuestran que: 1) en algunas situaciones la IR se observa en localizaciones voluntariamente atendidas y 2) en otras situaciones, se observa facilitación en lugar de IR, incluso después de darse el desenganche atencional. Concluimos que el desenganche atencional voluntario no es ni necesario ni suficiente para observar IR. Sin embargo, si presentamos una "señal de interrupción" entre los dos estímulos periféricos (la señal de orientación y el estímulo objetivo), se observa IR en todas las condiciones, lo que demuestra una disociación entre el desenganche atencional voluntario y desenganche involuntario, por la interrupción de los procesos atencionales. Estos resultados son interpretados basándonos en procesos de integración y segregación entre los dos estímulos (Lupiáñez, 2010), que dan continuidad a nuestra experiencia perceptiva. La IR se explica como un coste en detectar la aparición de un nuevo objeto (el estímulo objetivo) en lugares donde la atención fue capturada previamente (por la señal de orientación).

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