

**Subjective expectancy and inhibition of return:
A dissociation in a non-spatial two-alternative forced
choice task**

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Inhibition of Return (IOR) is conventionally defined by slow responses to targets that appear at the same location as a prior attentional cue, relative to a condition in which targets appear at a different location from a prior attentional cue (Posner & Cohen, 1984). A number of recent studies have extended the study of IOR to non-spatial orienting tasks (Law, Pratt, & Abrams, 1995; Hu, Samuel, & Chan, 2011; Spadaro, He, & Milliken, 2012), which is consistent with the view that a fundamental process that favours the perceptual encoding of new events is responsible for IOR. However, an alternative account of IOR is that participants expect uncued targets to appear more often than cued targets even when these two target types are equiprobable. The aim of the current study was to examine directly the relation between performance and subjective expectancy in a task known to produce repetition benefits under one set of conditions, and IOR-like effects under another set of conditions. The performance measure (i.e. RTs) showed either repetition benefits or IOR-like effects depending on whether or not an intervening event was introduced. Interestingly, participants reported that they expected uncued targets more often than cued targets across both conditions, a result that is inconsistent with the view that repetition effects generally, and IOR-like effects specifically, are directly related to subjective expectancy.

Orienting to novelty is a fundamental property of an efficient attention system, as it ensures that attention shifts efficiently to events that violate predictions about the world based on prior experiences (Sokolov, 1963). Such a fundamental property of attention might be expected to contribute to performance in many behavioural tasks. Indeed, evidence of an attentional

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benefit for processing of novel events could be argued to contribute to novel pop-out (Johnston, Hawley & Farnham, 1993), new object benefits in visual search (Yantis & Jonides, 1984), visual marking effects in visual search (Watson & Humphreys, 1997), negative priming effects in identification and spatial localization, (Milliken, Joordens, Merikle & Seiffert, 1998), and inhibition of return (IOR) effects in spatial orienting tasks. The focus of the current study is the IOR effect (Posner & Cohen, 1984), and in particular the role of expectancy in producing IOR effects.

The IOR effect is typically measured using a spatial cueing procedure in which a non-predictive spatial cue is presented in one of two peripheral locations. A target can then appear in either the cued location or the uncued location. When the interval between onsets of the cue and target is greater than about 300 ms, response times to detect the target are slower for targets that appear in the cued location than for targets that appear in the uncued location. This result is often taken as evidence that attention is initially captured by the cue, then withdrawn from the cued location, and consequently inhibited from reorienting to the cued location. A similar result is observed in studies in which participants localize two targets on consecutive trials (i.e., a target-target procedure), rather than respond to a single target following presentation of a passively perceived cue (i.e., a cue-target procedure; Maylor & Hockey, 1985). In both cases, slower orienting to a previously attended location than to an unattended location constitutes an example of attentional preference for novelty.

To the extent that a broad mechanism favouring orienting to novelty underlies the IOR effect, one might expect a similar effect would occur in a task that involves non-spatial orienting. Early studies that addressed this issue failed to demonstrate a non-spatial variant of IOR, and instead found that repetition of non-spatial dimensions led to repetition priming (Kwak & Egeth, 1992; Tanaka & Shimojo, 1996). However, there are now quite a few studies that have demonstrated IOR-like effects with non-spatial stimulus dimensions, such as colour (Law, Pratt & Abrams, 1995; Fox & de Fockert, 2001; Hu, Samuel, & Chan, 2011; Spadaro, He & Milliken, 2012), auditory frequency (Mondor, Breau, & Milliken, 1998), line length (Francis & Milliken, 2003; Spadaro et al., 2012), and semantic relatedness (Fuentes, Vivas, & Humphreys, 1999; Spadaro et al., 2012). In many cases, the key to observing such effects where others had instead observed repetition priming (Kwak & Egeth, 1992; Tanaka & Shimojo, 1996) appears to be the insertion of an intervening event between cue and target in a cue-target procedure (Law et al., 1995), or the insertion of an intervening event that is responded to between consecutive targets in a target-target procedure (Spadaro et al., 2012). Although the precise reason why intervening events

are often necessary to observe non-spatial IOR-like effects remains a matter of debate, a generic explanation is that intervening events interfere with processes that produce facilitation, which in turn allows an underlying IOR effect to be measured. In any event, these recent results suggest that spatial IOR effects and non-spatial IOR-like effects could conceivably reflect the same broad property of attention that favours orienting to novelty.

The attentional momentum hypothesis

An alternative account of spatial IOR effects proposes that it measures a tendency for attention to continue along the path it has followed most recently, rather than for attention to shift preferentially toward novelty (Pratt, Spalek, & Bradshaw, 1999; Spalek & Hammad, 2004). As noted above, in some variants of the IOR procedure a peripheral cue is followed by an intervening event, usually a cue presented centrally. By many accounts, attention is initially pulled to the location of the peripheral cue, but then shifts in the direction of the central cue upon its onset. According to the attentional momentum hypothesis, the IOR effect occurs because attention then moves more efficiently along the same trajectory than along other trajectories, as if the movement of attention is subject to momentum. By this view, orienting attention back to the cued location involves overcoming the momentum carrying attention in the opposing direction. As a result, responses to targets back at the cued location are slow.

The attentional momentum hypothesis is rooted in the idea that shifts of attention might obey learned environmental regularities – objects that move in one direction tend to continue moving in the same direction rather than abruptly shifting and moving in the opposite direction. In support of this general view, Spalek and Hammad (2005) discovered that the size of the IOR effect was sensitive to a left-to-right bias for English readers and a right-to-left bias for Arabic readers. To the extent that effects such as these hinge on targets matching predictions that derive from learned regularities, the conceptual distinction between the attentional momentum and orienting to novelty hypotheses for IOR is clear-cut. The orienting to novelty view assumes that IOR reflects a mechanism intended to overcome a bias that derives from prior experience, whereas the attentional momentum hypothesis assumes that IOR directly reflects the biases from prior experience itself.

The results of Spalek and Hammad (2004, 2005) offer compelling evidence that a form of expectancy can contribute to the size of the IOR effect. That is, if we think of learned environmental regularities as leading to predictions about future environmental states, these predictions, or

expectancies, appear to modulate spatial cueing effects. At the same time, the proposal that expectancies of this sort are the cause of IOR effects is a more contentious issue. In particular, it may be that learned regularities contribute to spatial orienting performance independent of another process that produces IOR effects (see Snyder, Schmidt & Kingstone, 2001). In other words, there is room for expectancy derived from learned regularities to affect performance in spatial orienting tasks without expectancy being the direct cause of IOR effects.

An additional issue raised by the results of Spalek and Hammad (2004, 2005) concerns the distinction between two different uses of the term expectation. Expectation might derive from learned environmental regularities, in which case it would not be surprising for such expectancies to affect behaviour automatically and without accompanying awareness on the part of participants (Lambert, Naikar, McLachlan & Aitken, 1999; Lambert, Norris, Naikar & Aitken, 2000; Lambert, 1996). In contrast, a different use of the term expectation refers to controlled, strategic expectations that can be reported voluntarily by the participant, and that can produce behaviour that is either consistent or inconsistent with learned regularities (McCormick, 1997). Presumably, the results of Spalek and Hammad (2004; 2005) speak to the fact that expectancies that are expressed automatically in performance, but that are not open to conscious subjective report, can contribute to spatial orienting effects.

Yet, a subsequent study reported by Spalek (2007) offers a potentially more compelling link between subjectively reported expectancy and spatial orienting effects. The procedure used in this study was a modified variant of the spatial orienting procedure typically used to measure the IOR effect. Participants were first presented with a cue that could appear in one of eight locations. Following offset of the cue, participants were instructed to indicate in which of the eight locations they expected the following target to appear. In particular, participants were led to believe that a target location had been selected on every trial but not displayed to them, and they were to try to guess which location had been chosen as the target location. Expectation that the target would appear in a location opposite the cue was significantly greater than chance, while expectation that the target would appear in the cued location was significantly less than chance. These results were viewed as supporting the attentional momentum hypothesis for IOR, in the sense that the subjectively reported expectations of participants mirrored the usual pattern of response times observed with similar procedures (see Pratt, Spalek, & Bradshaw, 1999).

Expectancy and the IOR effect

Although the Spalek (2007) study describes an interesting set of results, it might be taken to imply that there is a direct link between IOR effects and consciously reported expectancies, rather than the original claim that IOR effects can be affected by automatically retrieved learned environmental regularities (Spalek & Hammad, 2004; 2005). Our concern with the idea that consciously reportable expectancies are at the root of IOR effects is two-fold. First, although the expectation results reported by Spalek (2007) mapped nicely onto prior behavioural results generated using a similar procedure (Spalek, Pratt & Bradshaw, 1999), there is no way to know whether the subjectively reported expectancies reported by Spalek (2007) constitute the mechanism that produced the response times for cued and uncued trials reported by Spalek et al. (1999). In effect, the two patterns of results co-vary in an interesting way, but the causal connection between them (if indeed there is one) is unclear. Second, the inference that IOR reflects greater expectancy for uncued than cued targets does not fit with results from studies that have manipulated expectancy directly and measured IOR effects. In particular, several studies have now shown that IOR effects are observed both when targets appear at unexpected locations and when targets appear at expected locations (Berger, Henik, & Rafal, 2005; Berlucchi, Chelazzi, & Tassinari, 2000; Lupiáñez, Decaix, Sieroff, Chokron, Milliken, & Bartolomeo, 2004). All told, the claim that IOR reflects greater explicit expectancy for uncued than for cued locations does not stand on particularly strong ground.

Nonetheless, the pattern of expectancy results reported by Spalek (2007) is an interesting one, and the relation between subjective expectancy and performance in tasks that measure repetition/cueing effects certainly merits further study. In particular, to examine the relation between expectancy and performance more closely we aimed to measure subjective reports of expectancy in two contexts; one in which participants respond faster to repeated (i.e., cued) events than to alternated (i.e., uncued) events, and another in which participants respond slower to repeated events than to alternated events. To the extent that expectancy determines performance, subjectively reported expectancies for repeated relative to alternated events ought to mirror behavioural performance; that is, opposite repetition effects in response time across two contexts ought to be accompanied by opposite patterns of subjective expectancies.

The Present Study

To measure the relation between expectation and performance in two different contexts, we adopted a non-spatial orienting procedure introduced by Spadaro et al. (2012). Importantly, this procedure offers the opportunity to measure both repetition benefits and repetition costs (i.e., IOR) in a simple two-alternative forced choice (2-afc) task. In the Spadaro et al. study, participants responded to the colour (blue or yellow) of two sequential targets appearing centrally within a trial. For half of the trials, the screen remained blank between the offset of the first target (T1) and the onset of the second target (T2); those trials belonged to the no-intervening event condition. For the other half of trials, participants had to respond to an intervening event that was presented between the offset of T1 and the onset of T2; those trials belonged to the intervening event condition. In a series of experiments that used this procedure, Spadaro et al. found that when no intervening event was presented, participants responded faster to T2 on repeated trials (trials in which T1 and T2 matched in color) than on alternated trials. However, when an intervening event was presented and responded to, participants responded faster to T2 on alternated trials than on repeated trials.

The dependence of performance on an intervening event between T1 and T2 makes it tempting to conclude that similar mechanisms underlie performance in this task and in spatial orienting tasks. Indeed, the method was designed to create a non-spatial analogue of the “cue-back” procedure in spatial orienting studies, and to examine whether response to an intervening event would produce an effect that is analogous to that produced by a central cue in spatial orienting tasks (Prime, Visser, & Ward, 2006). From this perspective, the repetition cost measured on the intervening event trials by Spadaro et al. might be considered a non-spatial variant of the IOR effect (see also Law et al., 1995; Francis & Milliken, 2003; Dukewich, 2009; Hu et al., 2010; Hu & Samuel, 2011). Nonetheless, we recognize that there are some salient differences between this method and those used in spatial orienting studies, and therefore any conclusions about the relation between performance and expectancy observed here should be applied cautiously to the domain of spatial IOR.

In any case, if response times in this task are determined by expectancy, then a qualitative shift in response times across the two intervening event conditions ought to be accompanied by a qualitative shift in subjective expectancy. In particular, in the intervening event condition, response times should be slower for repetitions than for alternations and expectancy for repetition ought to be lower than dictated by chance. In

contrast, in the no-intervening event condition, response times should be faster for repetitions than for alternations, and expectancy for repetition ought to be greater than chance.

METHOD

Participants. 17 participants were recruited from an introductory psychology course or a second year cognitive psychology course from McMaster University, and participated for course credit. All participants reported to have normal or corrected-to-normal vision.

Apparatus and Stimuli. The experiment was run on a PC using MEL experimental software. Subjects sat directly in front of a 15" SVGA computer monitor, at a distance of approximately 57 cm. A plus sign was presented as the fixation point in the center of the screen, and subtended a visual angle of 0.6 degrees horizontally and 0.7 degrees vertically. The target stimuli (T1 and T2) were presented centrally against a black background.

Both T1 and T2 were a colored rectangle, either blue or yellow, subtending a visual angle of 6.3 degrees horizontally and 1.2 degrees vertically. On trials in which participants were asked to indicate the color in which they expected T2 to appear, T2 was presented as a white outline of a rectangle with the same dimensions as the blue or yellow rectangles. The intervening event was a red dot presented centrally with radius subtending .25 degrees of visual angle.

Procedure and Design. The experiment consisted of two blocked conditions: an intervening event condition and a no-intervening event condition. Each condition had an initial practice block consisting of 16 trials, followed by nine experimental blocks of 16 trials each.

For both conditions, a trial began with the appearance of a fixation cross in the middle of the computer screen for 1000 ms, and then a blank screen for 500 ms. In the no-intervening event condition, T1 appeared and remained on the screen until the participant made a key press response ("z" or "/") to the color of T1. A blank interval of either 1200 ms or 2500 ms followed the key press to T1. T2 was then presented and remained on the screen until the participant made another key press response ("z" or "/") to the color of T2. Participants were instructed to press the "/" key to indicate the presence of a blue rectangle and to press the "z" key to indicate the

presence of a yellow rectangle for both T1 and T2. Participants used the index finger of their right hand to respond to the "/" key and the index finger of their left hand to respond to the "z" key. Response time was measured as the latency between onset of the target stimulus and key press response.

The intervening event condition differed from the no-intervening event condition from the point after the participant responded to T1. A blank interval of either 400 ms or 600 ms followed the response to T1 in the intervening event condition. The length of this interval was chosen at random between these two values with the intention of producing some temporal uncertainty as to the onset of the intervening event. Following this blank interval, the red dot appeared and remained on the screen until the participant pressed both the "z" and the "/" keys in unison. After this response to the intervening event, a blank interval of either 200 or 1500 ms occurred prior to onset of T2. These intervals were chosen so as to roughly equate the response-stimulus interval (RSI) for T1 and T2 across the intervening event and no-intervening event conditions. T2 remained on the screen until participants responded to its identity by pressing the "/" key or the "z" key.

Across both intervening event and no-intervening event conditions, participants were instructed that on some trials T2 would be presented as a white rectangle (the actual proportion of trials was .20). On these expectancy trials, participants were instructed to press the "z" or "/" key to indicate the color in which they expected T2 to appear, either blue or yellow.

Task instructions were displayed on the screen prior to starting the practice block. Prior to each block of trials within each condition, the message "Press B to begin block" appeared, allowing participants to rest between blocks when needed. For all trials in both conditions, there was a 2000 ms inter-trial interval that started once a response was made to T2. The procedure for Color-Response trials is displayed in Figure 1, and the procedure for Expectancy-Response trials is displayed in Figure 2.

The design for the study differed slightly depending on whether T2 appeared as a rectangle filled by a particular color (Color-Response trials) or T2 appeared as a white outline of a rectangle (Expectancy-Response trials). For Color-Response trials, there were three within-subject variables: intervening event (no-intervening event/intervening event), repetition (repeated/alternated), and RSI (1,200 ms/2,500 ms). Intervening event was manipulated blocked within-participants, with the order of the two intervening event conditions counterbalanced across participants.

Repetition was manipulated randomly within blocks. In the repeated condition, T1 and T2 appeared in identical colors, whereas in the alternated condition, T1 and T2 appeared in different colors. RSI was also manipulated within blocks. In the no-intervening event condition, the 1,200 ms and 2,500 ms RSI conditions were measured precisely as the latency between response to T1 and the onset of T2, whereas in the intervening event condition, these RSI values were approximated in accord with the estimated time to respond to the intervening event.

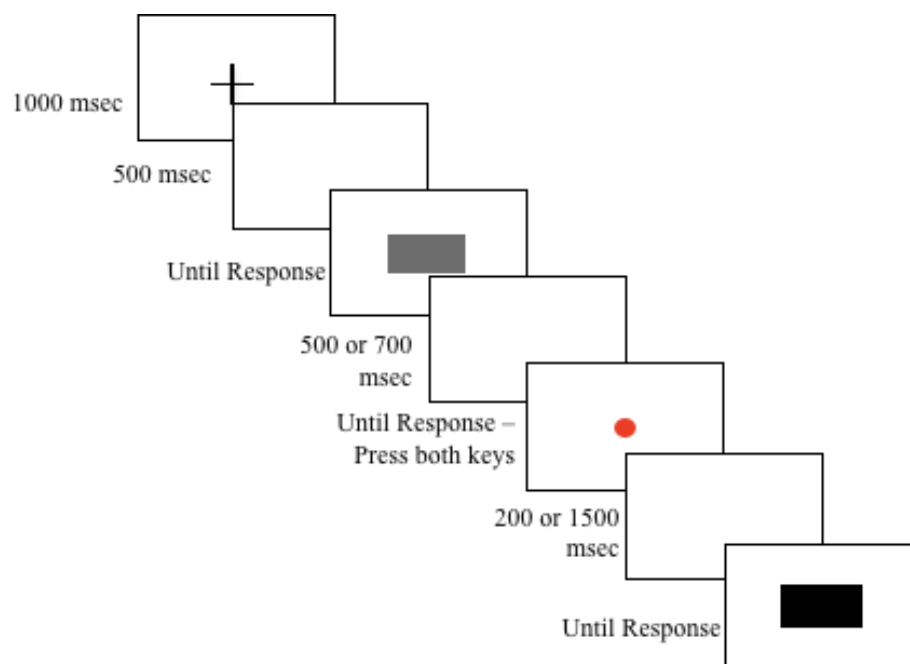


Figure 1. The sequence of events for a Color-Response trial in the intervening event condition is shown. In the experiment, the darker rectangle would have been blue and the lighter rectangle would have been yellow. In the no-intervening event condition (not shown), the intervening event was replaced by a blank screen that remained for approximately the same length of time as the intervening event.

For Expectancy-Response trials, the design was identical to the Color-Response trials with the exception that repetition was no longer a meaningful variable. As T2 was a white outline of a rectangle rather than a colored rectangle, repetition was undefined for the Expectancy-Response

trials. The proportion of trials in which participants expected repetition was the dependent variable for the Expectancy-Response trials.

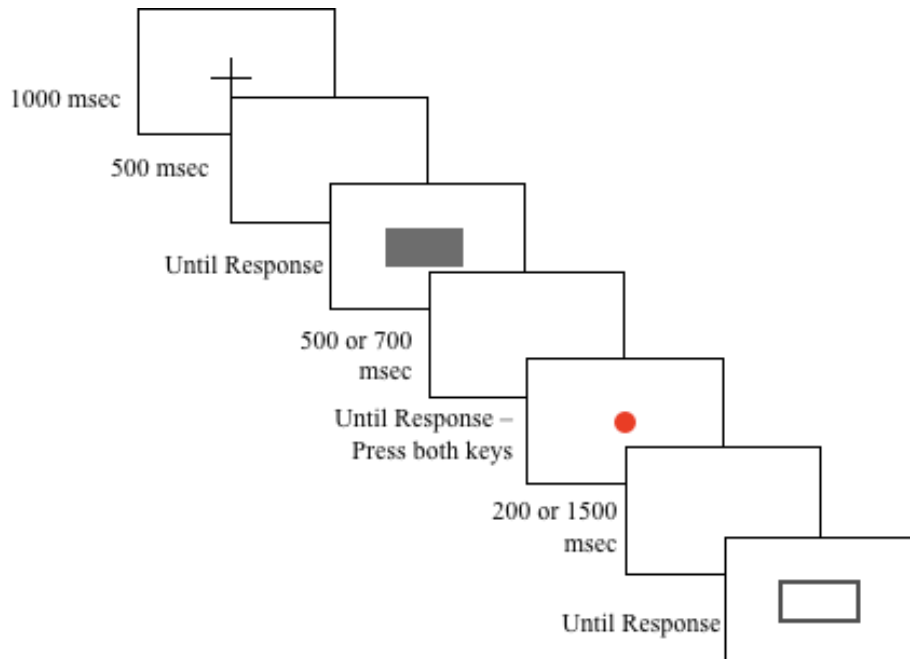


Figure 2. The sequence of events for an Expectancy-Response trial in the intervening event condition is shown. In the experiment, the darker rectangle would have been blue and the lighter rectangle would have been yellow. In the no-intervening event condition (not shown), the intervening event was replaced by a blank screen that remained for approximately the same length of time as the intervening event.

RESULTS

For the Color-Response trials, a trial was coded as correct if responses to both T1 and T2 were correct, and as an error if the response to T2 was incorrect while the response to T1 was correct. Response times (RTs) on correct trials were submitted to an outlier analysis (Van Selst & Jolicoeur, 1994) that eliminated 2.9% of the RTs from further analysis. Mean RTs for each condition were then computed based on the remaining observations. These mean RTs and corresponding error rates were submitted to repeated measures analyses of variance that included Repetition (repeated or

alternated), RSI (short or long), and Intervening Event (intervening event or no-intervening event) as within-subject factors.

For the Expectancy-Response trials, the focus was on participant's expectancy for T2 as a function of the relation between T1 and T2. Only trials in which a correct response was made to T1 were analyzed. The mean proportion of trials in which participants reported expecting a repetition for each condition were then submitted to a repeated measures analysis of variance that included RSI (short or long)¹, and Intervening Event (intervening event or no-intervening event) as within-subject factors.

The alpha criterion was set to .05 for all analyses. Means RTs in each condition for the Color-Response trials, collapsed across participants and RSI, are displayed in Figure 3. Mean proportions of Expectancy-Response trials in which participants expected a repetition/alternation, collapsed across participants and RSI, are displayed in Figure 4².

Color-Response Trials

In the analysis of RTs, there was a significant interaction between Intervening Event and Repetition, $F(1,16) = 13.34$, $p = .002$, $\eta_p^2 = .46$. To examine this interaction in more detail, simple main effects for repetition were analyzed separately for the intervening event and no-intervening event conditions. In the intervening event condition, RTs were slower for repeated trials (543 ms) than for alternated trials (505 ms), $F(1,16) = 8.81$, $p = .009$, $\eta_p^2 = .36$. In contrast, in the no-intervening event condition, RTs were faster for repeated trials (518 ms) than for alternated trials (562 ms), $F(1,16) = 11.88$, $p = .003$, $\eta_p^2 = .43$. The opposite repetition effects for the two intervening event conditions nicely replicates the pattern of results reported by Spadaro et al. (2012).

In the analysis of error rates, there was a significant main effect of Intervening Event, $F(1,16) = 3.50$, $p = .040$, $\eta_p^2 = .28$. Participants made more errors on intervening event trials (.03) than on no-intervening event

¹ The RSI factor was manipulated to determine whether the proportion of subjective expectancies for alternation increases across time between events (Kirby, 1976).

² The aim of Figure 4 was to represent the data in a similar manner to Figure 3, to allow comparison between participant's performance on the Expectancy-Response and Color-Response trials. To that end, Figure 4 presents both proportions of expected repetitions and expected alternations, with the sum of these two measures equal to 1.0 for both intervening event conditions.

trials (.02). The interaction between Intervening Event and Repetition was not significant, $F < 1$.

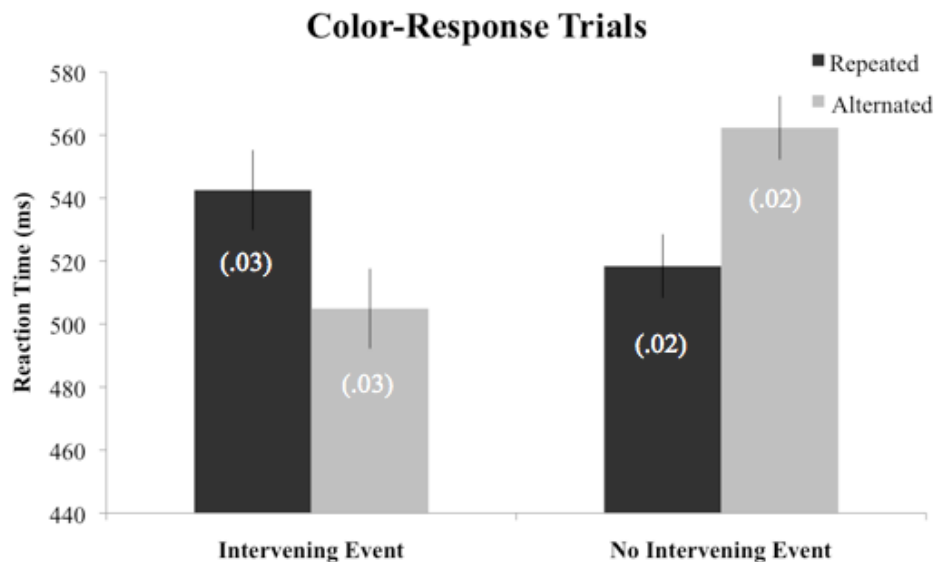


Figure 3. Mean response times for T2 across the two intervening event conditions, collapsed across participants and RSI. Error rates for each condition are presented in parentheses. Error bars represent the standard error of the difference between repeated and not-repeated conditions.

Expectancy-Response Trials

If the RT pattern reported above were perfectly associated with participants' subjective expectancies, then we ought to observe that the proportion of trials in which participants expected a repetition would vary as a function of the intervening event condition. In particular, expectancy for a repetition ought to be higher than .50 in the no-intervening event condition and lower than .50 in the intervening event condition. With this prediction as context, the key result here was a non-significant main effect of Intervening Event, $F < 1$. The proportion of trials in which participants expected a repetition was nearly identical for the intervening event (.41) and no-intervening event (.40) conditions. One-sample t-tests confirmed that the mean proportion of expected repetitions was significantly lower than chance (.50) for both the intervening event condition, $t(16) = -2.40$,

$p = .030$, $d = .58$, and the no-intervening event condition, $t(16) = -3.12$, $p = .007$, $d = .76$.

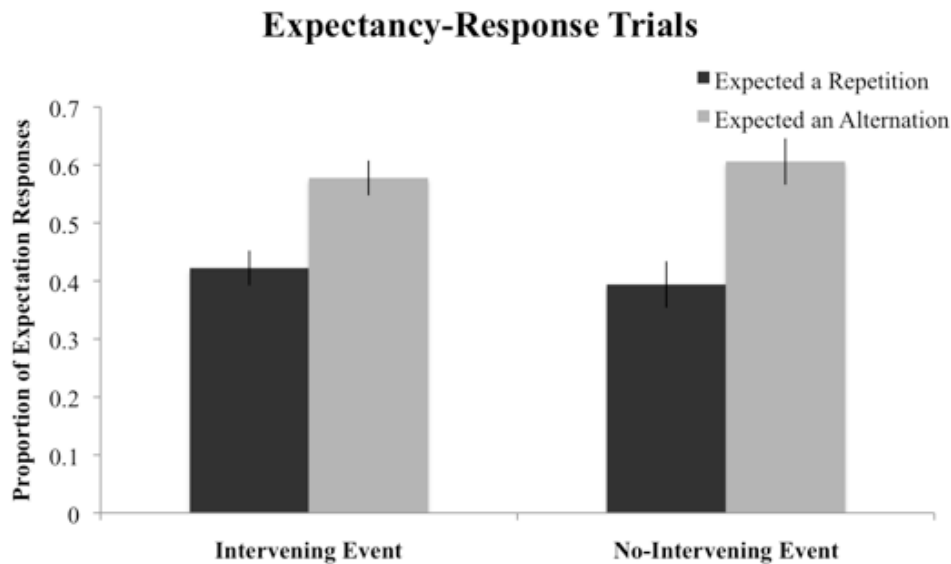


Figure 4. Mean proportion of expectancy responses as a function of whether a repetition or an alternation was expected across the two intervening event conditions, collapsed across participants and RSI. Error bars represent the standard error of the mean proportion of expectancy responses for both intervening event and no-intervening event conditions.

The only other noteworthy results in this analysis were a non-significant main effect of RSI, $F < 1$, and a non-significant interaction between RSI and Intervening Event, $F < 1$. Interestingly, these results suggest that subjective expectancy for repetition/alternation was not modulated by the time interval between T1 and T2 (see Kirby, 1976).

Table 1. Mean response times and error rates for T2 (ms) for each condition.

RSI	Intervening Event Condition		No-Intervening Event Condition	
	Repeated	Alternated	Repeated	Alternated
Short	545 (.03)	521 (.03)	525 (.01)	571 (.02)
Long	540 (.04)	489 (.02)	512 (.03)	554 (.02)

Table 2. Mean proportion of expectations for repetitions and alternations for T2 for each condition.

RSI	Intervening Event Condition		No-Intervening Event Condition	
	Expected a Repetition	Expected an Alternation	Expected a Repetition	Expected an Alternation
Short	0.39	0.61	0.39	0.61
Long	0.46	0.54	0.39	0.61

DISCUSSION

The key result in this study was that subjective expectancies were aligned with performance in just one of the two intervening event conditions. On the Color-Response trials, participants responded faster to repeated events than to alternated events in the no-intervening event condition, and responded faster to alternated events than to repeated events in the intervening event condition, a result that replicates prior work by Spadaro et al. (2012). The new findings are those observed on the Expectancy-Response trials. In particular, participants reported that they expected alternated events to occur more often than repeated events in both no-intervening event and intervening event conditions. These results clearly illustrate the insufficiency of subjective expectancies in explaining the repetition effects across all of the conditions tested here.

Separate influences of automaticity and expectancy?

The repetition effects reported here cannot be explained entirely by reference to subjective expectancy, but it remains possible that expectancy and an additional process could handle the present findings. In particular, in the intervening event condition of our study, participants responded more quickly to alternations than to repetitions and also indicated that they expected alternations more often than repetitions. On their own, these data are consistent with the view that speed of responding to the color-response trials is related directly to subjective expectancies. However, in the no-intervening event condition, the same pattern of expectancy is accompanied by the opposite pattern of RT data. Clearly, these no-intervening event condition data must be attributed to a mechanism other than that which drives subjective reports of expectancy. One way to explain these data is by reference to separate influences on performance of expectancy and automaticity. In particular, an automatic process that produces repetition benefits may predominate in the no-intervening event condition, but this process may co-exist with an expectancy-based process that predominates and produces repetition costs in the intervening event condition (Kirby,

1976; Soetens, Boer, & Hueting, 1985). By this dual process view, our results are not necessarily inconsistent with the link between subjectively reported expectancy and IOR implied by the study of Spalek (2007). Rather, the apparent dissociation between repetition effects and expectancy reported here could be attributed to the fact that expectancy is really only expressed in performance in a pure form in the intervening event condition.

Yet, as noted in the Introduction, the results of several published studies contradict the idea that IOR is related to consciously controlled expectancies. In particular, several previous studies have manipulated endogenous expectancy and exogenous cueing orthogonally, and have found that IOR effects occur for targets appearing both at expected and at unexpected locations (Berger et al., 2005; Berlucchi et al., 2000; Lupiáñez et al., 2004). These results suggest that the processes producing IOR effects are separate from those responsible for implementing consciously controlled spatial expectancies. Given such results, we offer an alternative dual process account that does not hinge on any direct relation between subjective expectancies and performance.

The intervening event effect: A dual process framework

The pattern of RTs reported here closely replicates that reported recently by Spadaro et al. (2012), and supports the idea that IOR-like effects can be observed with non-spatial stimulus dimensions and a target-target method. To explain this pattern of RTs, Spadaro et al. (2012) proposed a dual process account somewhat like that described above. Again, the general idea is that there is the potential for two processes to contribute simultaneously to performance, with one process speeding responses to repeated events relative to alternated events, and another process doing the opposite. The relative contributions of these two processes can change across experimental contexts, and thus explain why opposite repetition effects are observed across the two intervening event conditions.

A candidate process that would speed performance for repeated relative to alternated trials is episodic integration (Logan, 1988; Kahneman, Treisman, & Gibbs, 1992; Hommel, 1998). By this view, T2 can cue the retrieval of episodic representations of similar events, which in the case of a repeated trial would result in retrieval of the T1 episode. As a result, response to T2 would depend on the rapid integration of the T1 episode into current processing of T2, rather than the encoding of a separate event representation for T2. The result of this episodic integration process would be particularly fast responses for repeated relative to alternated trials.

To explain the opposite pattern of results in the intervening event condition, Spadaro et al. (2012) argued that the requirement to respond to an intervening event disrupts the episodic integration process, and reveals a second process that slows responses to repeated relative to alternated events. This second process is assumed to have a broad scope, slowing the encoding of repeated relative to alternated events in both spatial and non-spatial contexts³. In line with this idea, Dukewich (2009) proposed recently that IOR may be caused by habituation of orienting that is not tied specifically to the spatial domain. A similarly broad argument has been forwarded by Lupiáñez and colleagues (Lupiáñez, 2010; Lupiáñez, Martín-Arévalo, & Chica, 2013; see also Hu et al., 2011), in which they argue that IOR effects reflect a cost specifically in the process of detecting old events relative to new events. In any event, the key distinction between this dual process account and the one described earlier is that expectancy is not the process driving the IOR effect. Rather, a process that generally favours the encoding of novel relative to familiar events is responsible for IOR.

As noted in the Introduction, the method used here to measure the intervening event effect was motivated by consideration of “cue-back” procedures in spatial orienting studies. As such, we favour an interpretation in which spatial and non-spatial IOR-like effects are attributed to the same cause. At the same time, there are certain to be different processes involved in our task and in spatial orienting tasks, and so conclusions drawn here about the relation between performance and expectancy should be applied cautiously to the domain of spatial orienting.

What do subjective expectancies measure?

An important implication of the dual process account favored here is that the subjective expectancies reported by participants should not be taken as faithful measures of the preparatory state of participants. Indeed, the processes that determine subjective expectancies may well depend in subtle ways on the task context in which they are measured (Danziger & Rafal, 2009). One response to this concern is to exercise great care so that the processing conditions associated with performance measures (e.g., the colour naming trials in our study) are as comparable as possible to the

³ In follow-up work on this issue, we have discovered that a response to the intervening event is not required to observe the non-spatial IOR-like effect. Instead, it appears that engagement in response selection processes may be critical. In particular, using a procedure similar to the one reported here, we found that non-spatial IOR-like effects were observed when participants withheld a response to a NoGo intervening event that was identical to a previous Go intervening event (Spadaro, Lupiáñez & Milliken, submitted).

processing conditions associated with judgments of expectancy (the expectancy trials in our study). Perhaps if these processing conditions are very similar then the mapping between performance and expectancy measures would be a close one. In line with this view, one might argue that our method for measuring subjective expectancy, and in particular mixing together the color naming and expectancy trials, introduced a disrupting intervening task between presentation of T1 and report of subjective expectancy. In particular, presentation of the empty rectangle required a shift of task on the participants' part from the usual color identification task to that of expectancy judgment. If this unexpected shift in task itself constitutes an "intervening event", then it might well explain why an IOR-like pattern of expectancies was produced for the no-intervening event condition.⁴

Although this interpretation of our results cannot be ruled out, the different patterns of performance and expectancy in our study may instead imply that, in many task contexts, the processes driving performance are fundamentally different than those that drive subjective reports of expectancy. This conclusion fits well with results from a recent study that examined subjective expectancy and the conflict adaptation effect (Jiménez & Méndez, 2012). The conflict adaptation effect refers to the finding that conflict effects (e.g., Stroop, flankers) tend to be smaller following an incompatible (or incongruent) trial than following a compatible (or congruent) trial (Gratton, Coles, & Donchin, 1992). One account of this effect is that participants adjust their expectancy on a trial-to-trial basis in accord with the type of trial that has just been completed; participants expect an incongruent trial following an incongruent trial, and they expect a congruent trial following a congruent trial. By this view, these putative shifts in expectancy have the consequence that participants are particularly well prepared to respond to an incongruent trial following an incongruent trial, resulting in relatively small interference effects on these trials. In contrast to this view, Jiménez and Méndez (2012) found that conflict adaptation effects and subjective expectancies can be dissociated. In particular, when participants performed a run of congruent Stroop trials they were more likely to report an expectancy favoring an incongruent Stroop trial, in line with the gambler's fallacy (Jarvik, 1951). At the same time, interference effects tended to be large rather than small following a run of congruent trials, indicating that preparation for an incongruent trial was actually poor under conditions in which participants reported an expectancy for an incongruent trial. As in the present study, subjective expectancy

⁴ We thank Tom Spalek for suggesting this alternative interpretation of our results.

appeared to be driven by a process very different from that which actually guided behaviour (see Perruchet, Cleermans, & Destrebecqz, 2006 for a similar dissociation).

Finally, whereas we have argued against the idea that expectancy is the mechanism that produces IOR effects, it is worth considering whether the opposite might be the case. Could a mechanism that favours encoding of novelty contribute to the pattern of subjective expectancies reported here?. To understand how this might be the case, consider that the generation of subjective expectancies on the part of participants may be a constructive process. That is, participants may not have direct conscious access to their internal states of preparation, and instead may have to engage in a constructive retrieval process to infer their state of preparation (Nisbett & Wilson, 1977). To do so in the present study, participants may have responded to the empty probe rectangle (i.e., the cue to report their expectancy) by attempting to simulate repeated and alternated probes, and then evaluating the ease with which they were able to do so (Schacter, Addis & Buckner, 2007). They might then report expecting the type of target, repeated or alternated, that they were able to simulate with the most ease. To fit the present results, it would have to be the case that participants found it easier to simulate an alternated future event than a repeated future event. Although we have no direct evidence that this is the case, it seems a worthwhile hypothesis to pursue in future studies. In particular, if one of the constraints on participants' attempts to simulate a future event is to create an episode that is distinct from anything recent that they have experienced, then they may well be able to simulate a distinct future event that involves an alternated target more easily than a repeated event. Moreover, the underlying principle that produces this difference in the ease of simulation could well be the same as that which makes it easier for participants to detect and encode a novel (uncued) target relative to a familiar (cued) target in more conventional studies of IOR. In other words, speed of responding might well be limited by the efficiency with which a target can be detected and encoded as a distinct event from the cue (Lupianez, 2010; Milliken, Tipper, Houghton & Lupianez, 2000; Milliken & Rock, 1997).

Conclusion

This article highlights problems associated with an assumption that performance is directly related to subjectively reported expectancies. In the present study, subjective expectancies aligned with performance in just one of the two intervening event conditions. Participants reported that they

expected alternated events to occur more often than repeated events for both intervening event conditions. In contrast, responses were faster for alternated than for repeated events in the intervening event condition whereas the opposite effect was observed in the no-intervening event condition. Together, the results fit with the idea that response to the intervening event disrupts a process that speeds responses to repeated trials relative to alternated trials, and reveals a process that produces the opposite effect; that is, a process that favors the encoding of relative novel events over familiar events. Rather than assuming that participants' subjectively reported expectancies cause performance effects in tasks like that used here, it seems instead that the cause of subjective expectancies themselves requires further study.

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