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Inhibition of return: A phenomenon in search of a definition and a theoretical framework

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Abstract In a study of scientific nomenclature, we explore the diversity of perspectives researchers endorse for the phenomenon of inhibition of return (IOR). IOR is often described as an effect whereby people are slower to respond to a target presented at a recently stimulated or inspected location as compared to a target presented at a new location. Since its discovery, scores of papers have been published on IOR, and researchers have proposed, accepted and rejected a variety of potential causes, mechanisms, effects and components for the phenomenon. Experts in IOR were surveyed about their opinions regarding various aspects of IOR and the literature exploring it. We found variety both between and within experts surveyed, suggesting that most researchers hold implicit, and often quite unique assumptions about IOR. These widely varied assumptions may be hindering the creation or acceptance of a central theoretical framework regarding IOR; and this variety may portend that what has been given the label "IOR" may be more than one phenomenon requiring more than one theoretical explanation. We wonder whether scientific progress in domains other than IOR might be affected by too broad (or perhaps too narrow) a range of phenomena to which our nomenclature is applied.

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Introduction

When a newly discovered phenomenon is named there is, initially at least, agreement about what phenomena the name refers to. *Learned helplessness* (Seligman, 1975; Maier and Seligman, 1976), for example, was proposed as a theoretical explanation for a psychological state induced through specific methods. Despite the possibility of some over- or under-generalization, there is usually good agreement about what our names for things refer to. Unfortunately, sometimes a name is at risk of losing its meaning because it is too often inconsistently applied or creatively (over-) extended. From the realm of cognitive psychology, this paper is about such a term: *Inhibition of return* (IOR).

We will begin with a description of the original and some subsequent use(s) of the term and then describe the results from a survey of experts' understandings of the term. In Psychology surveys of experts have been used to help select an appropriate assessment tool (e.g., in forensic situations: Lally, 2003); to understand the meaning of an everyday term (e.g., wisdom: Jeste et al., 2010); and to determine the content validity of items in a behavioral instrument (e.g., sluggish cognitive tempo, Penny et al., 2009). In an effort to determine what leaders in the field of IOR research explicitly and implicitly think about the phenomenon, we conducted a survey of experts that targeted some of the ambiguities surrounding IOR. We believe our approach might serve as a model for investigators in other areas of psychological science (or other sciences) who are, like us, concerned about nomenclature.

Inhibition of return

Inhibition of return is often described as an effect wherein responses are slower to a target presented at a recently stimulated or inspected location compared to when the target is presented at a new location (Posner et al., 1985). IOR has been proposed to function as a novelty seeking mechanism (Posner and Cohen, 1984) and as a foraging facilitator (Itti & Koch, 2001; Klein and MacInnes, 1999); it has been likened to the gambler's fallacy (Lyons et al., 2013); it has been observed in newborn human infants (Valenza et al., 1992) and in the archer fish (Gabay et al., 2013); its neural underpinnings have been explored using a wide variety of neuroimaging modalities, including ERPs (e.g., Prime and Ward, 2006), fMRI (e.g., Mayer et al., 2004), single unit recording (Dorris et al., 2002; Mirpour et al., 2009) and transcranial magnetic stimulation (e.g., van Koningsbruggen et al., 2010); and changes in its manifestation have been studied as a function of the administration of a wide variety of pharmaceuticals and the presence of a wide variety of neuropathologies.

The traditional paradigm (see Fig. 1) involves presenting a spatially uninformative cue at one of two peripheral locations followed by a target at one of the two peripheral locations (Posner and Cohen, 1984; see also, Berlucchi et al., 1981), and the effect (represented by the upward pointing arrows in Fig. 1) is typically observed when the time interval between the cue and target is longer than 250–500ms (Klein, 2000; see also Lupianez et al., 1997) though it can be seen earlier (Danziger & Kingstone, 1999). Berlucchi (2006; see also Klein and Taylor, 1994, p. 136) describes the canonical interpretation of the effect: attention is first drawn to the location of an uninformative stimulus, after a short period attention abandons that location and "develops a bias against returning to it" (pp. 1065).

Since its first descriptions, many papers have been published on IOR (circa January, 2014, "inhibition of return" as a topic, when submitted to the Web of Science, retrieved over 800 publications, with 260 published in the last 5 years). A variety of methods have been used in these studies to observe the phenomenon, some of them quite different from the traditional cueing paradigm used by Posner and Cohen (1984) in what is often regarded as the launching document for IOR research. With no intention of conveying a value judgment, but simply for the purpose of nomenclature, we will refer to studies of IOR that use the Posner cuing paradigm as "traditional" and all others as "non-traditional".

Posner et al. (1985), after using the traditional paradigm to explore the inhibitory aftereffect in patients with brain damage to different orienting networks, pioneered methods that can be considered non-traditional. In one such experiment they measured the effect of an uninformative peripheral cue on two tasks in which targets were presented almost simultaneously at both the cued and uncued locations. When a non-speeded, manual temporal order judgement (Spence and Parise, 2010) was required there was no effect of the cue on the "which was first" judgment. However, when observers were instructed to simply move their eyes to the first perceived target, more movements were made away from than toward the cued location. From this they inferred that the effect of cue was to bias overt orienting (eye movements) away from the originally cued location. In another experiment from the same paper, a pair of digits was presented simultaneously to the left and right of fixation and observers were asked to make an eye movement in the direction of a centrally presented arrow toward

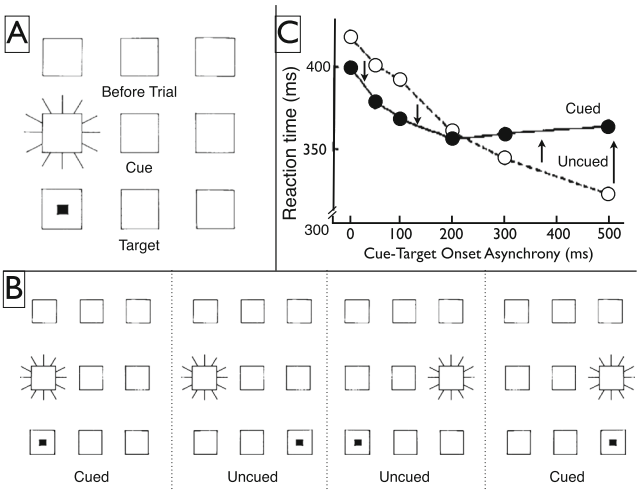
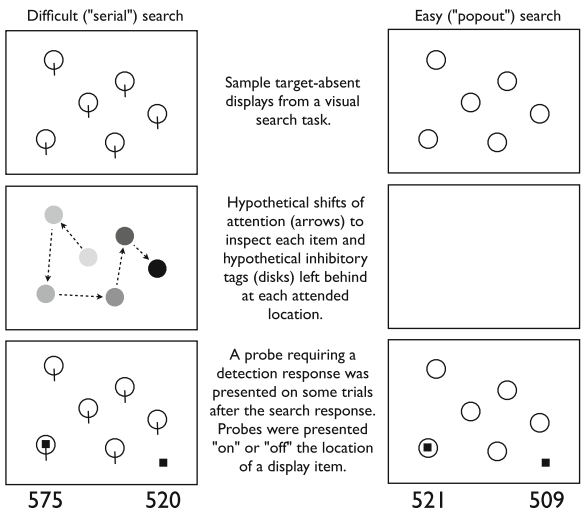


Fig. 1 Prototypical methods (**A**, **B**) and results (**C**) from a Posner cuing paradigm using uninformative peripheral cues. (**A**) Sequence of events begins with a display consisting of a central and two peripheral boxes. First a brief cue (brightening of one of the peripheral boxes) and then a target (stimulus inside one of the boxes) are presented with the interval between their onsets (cue-target onset asynchrony, or CTOA) varied. Observers are instructed to remain fixated on the central box and to make a simple, speeded, detection response when the target's appearance is detected. Not illustrated, to discourage anticipatory responses no target is presented following some cues (catch trials). (**B**) The four possible sequences of cues and targets results in two types of trial: those with targets presented at the cued and uncued locations. Because the cues are uninformative these 4 possible sequences are equiprobable. (**C**) Typical pattern of results Presumed to reflect the capture of attention by the cue, detection response time is faster (represented by downward pointing arrows) for cued than uncued targets when the CTOA is short. In contrast at longer CTOAs the relation reverses and cued RT is slower than uncued RT (represented by upward pointing arrows). This is the prototypical IOR effect

one of these digits. After reporting the digit and returning gaze to the original fixation (in response to a cue presented there) observers were slower to signal the detection of targets at the previously fixated location. From this pattern of results they inferred that the inhibition was caused by activation of the oculomotor system and not by the asymmetric stimulation of the visual periphery that characterize cues in the traditional paradigm. It was in this paper that Posner and colleagues coined the term "inhibition of return". Here are a few other examples of "non-traditional" studies of IOR.

Using a pair of visual search tasks modelled on those of Treisman and Gelade (1980), Klein (1988) measured reaction time to a dot-probe presented immediately after a visual search episode.The methods, hypothesized inhibitory tags, and results from this study are illustrated in Fig. 2. Observers were slower to respond to the dot-probe when it



[a]It has been hypothesized that brightness of the oscilloscope in Klein's study was such that the array persisted on the screen even after active refreshing had terminated

Fig. 2 Illustration of the methods (top and bottom panels), hypothesized inhibitory tags (middle panel), and results (averaged across 2 experiments and shown below the bottom panel) from the probe-following-search experiments of Klein (1988). The target (not shown) was a circle for the difficult search task and a circle with a line for the easy search task. Another pair of tasks, not shown, was used in which a circle with a gap replaced circles with lines. The strength (darker is stronger) of the hypothetical inhibitory tags in the middle panel is assumed to decay with time. The easy search task, for which the target pops out and hence the individual items need not be inspected, was used to provide a baseline. IOR was operationalized as the ON-probe cost (ON probe RT minus OFF probe RT) in the difficult search task minus the ON-probe cost in the easy search task. In Klein's experiments plotting of the search array was terminated at the time of the search response, but it was subsequently demonstrated (for a review, see Wang and Klein, 2010) that when the array is removed so are the inhibitory tags. Hence, illustrated in the bottom panel is the method that works: probes are added to the search array

appeared at the same location as a distractor in the search array when the search task was difficult, but not when the search task was easy (the target "pops out" of the array). Because it is generally assumed that attention inspects distractors to determine if they are the target when search is difficult, Klein (1988) and others using this task (Müller & von Mühlenen, 2000, and Takeda & Yagi, 2000) attributed this pattern to IOR. Boot et al., (2008) found an IOR-like pattern involving saccadic responses to sequentially presented stimuli: participants were less likely, and slower, to fixate the target when it appeared at a previously fixated location. Welsh et al., (2005) found that participants were slower to respond to a target when it was presented at a location previously responded to by a partner participant and attributed this to "social IOR."

Many researchers who explore IOR using the Posner cueing paradigm (Lupianez et al., 2006; Wolf et al., 2009) incorporate non-traditional IOR ideas and papers into their introductions or discussions (e.g., Dodd & Pratt, 2007; Lupianez et al., 1997; Tipper, Weaver, Jerreat & Burak, 1994). The converse is equally true (e.g., Klein and MacInnes, 1999; Ogawa, Takeda & Yagi, 2002). These practices suggests that many researchers implicitly endorse the notion that traditional and non-traditional observations of IOR are observations of the same phenomenon. A possible consequence of such an assumption is that any effect labeled as IOR would be considered part of the IOR puzzle. In contrast, several researchers have suggested that the term IOR should be confined to those effects observed under very specific circumstances, or that there are different forms of IOR depending on the specific conditions under which the effects are generated. Berlucchi (2006), for example, took the position that IOR effects observed in traditional cue-target paradigms are different from the IOR-like effects observed in tasks involving saccades in static displays. Similarly, in trying to provide a habituation-based interpretation of the effect, Dukewich (2009) limited IOR to effects generated by repetitive stimulation using uninformative (non-predictive) cues.[1] Despite these examples, the zeitgeist in the IOR literature has been the lumping together, under the umbrella term "IOR," all effects that seem to slow responding to previously inspected or stimulated locations. Consequently, non-spatial (Francis and Milliken, 2003; Mondor et al., 1998; Morgan and Tipper, 2007), multi-modal (Poliakoff et al., 2002),

[1]Author KD was limiting the definition of IOR in Dukewich (2009) as a way of limiting the generalizations of habituation to other effects also labeled IOR in the literature.

memorial (Johnson et al., 2013), motor/reaching (Cowper-Smith et al., 2013) and other forms of IOR have been proposed and explored.

Whether, when generated and measured under such a diverse set of conditions, all inhibitory aftereffects that have been called "IOR" are due to the same processes or mechanisms should be carefully examined. If these phenomena are not the same, then scientists trying to determine the mechanisms, components, consequences and neural underpinnings of "IOR" are setting themselves up to fail. Such an effort would be akin to asking what soup is made of: It depends on the kind of soup in question. It seems that implicit inconsistencies may be obstructing the creation of a coherent theoretical framework – no theory or framework will be satisfactory to the majority of IOR researchers if they all have different understandings of what IOR actually is.

Survey of IOR experts

The survey results do not tell us anything about IOR per se, only what experts in IOR think about the phenomenon. We asked researchers: 1) what they thought was meant by causes, effects, mechanisms and components of IOR; 2) which criteria they used for identifying IOR; 3) about their views on potential explanations for the effect; and 4) about their views on non-spatial forms of IOR, and IOR in visual search. Because we wanted to keep the focus of this observation on the implications of the survey results rather than highlighting the methods and procedures for data collection, our presentation of the survey methods will be brief (see Appendices A & B for a more detailed description of the methods). We have also made the data set available in the online Supplementary data.

We selected experts in the field of IOR research by searching for "inhibition of return" in the Web of Science database. Results were screened for those publications with the highest numbers of citations, and the authors of those publications were further screened for the number of IOR publications in the database. In the end, 63 researchers with at least 4 IOR publications in the database were contacted to complete the survey; 37 researchers accepted and completed the survey (during the period from July 18^{th}, 2011 to August 31^{st} 2011). A more detailed description of the selection process is described in Appendix A.

Criteria for identifying IOR

One of the first questions we asked our experts was *what criteria researchers felt were necessary for an effect to warrant the label"IOR"*. Table 1 presents the proportion [p(yes)] and number [n] of experts selectingeach criterion, as well as the similarity matrix scores (frequency of co-endorsements) for the different criteria. The most frequently endorsed criterion is *slower responses to previously stimulated or inspected location*, with 0.92 proportion of the surveyed experts selecting it. Endorsed by such a large proportion of experts one might be tempted to identify this as a defining feature. It is perhaps worth noting that the way we wrote this criterion it implies one effect (slowed responding) and two possible causes (stimulation and inspection).

The remaining criteria were selected in varying degrees, but none approached even 0.5 selection among participants. A *shift of attention* (0.43), the *presentation of a target* (0.43) and *non-predictive cues* (0.32) were the next most selected criteria. Each similarity score in Table 1 represents the number of participants who selected a criterion listed on a row given they had selected the criterion for the corresponding column. Surveyed experts tended to cluster their selections around the *slowed responding to a previously stimulated location*, *presentation of a target*, *shifts of attention*, and *the use of non-predictive cues*. Importantly, experts who endorsed one of these three criteria were not particularly likely to also endorse either of the other two (there was no pair of criteria from this group for which the agreement of the endorsing experts exceeded 50 %).

The most striking aspect of the data from Table 1 is the inconsistency of the participants' selections. For example, no criterion we listed was selection by 100 % of our participants, not even the criteria that is most often used to define IOR (slowed responding to a previously stimulated location). The variety of responses to the open-ended question, listed at the bottom of the table, suggests that the results are not simply because we failed to include some essential criterion when designing the survey. None of the criteria we listed were completely ignored by the participants. Based on these responses, it appears that we cannot eliminate any criteria from the list. The low rate of endorsement of *fixating eyes on centre* (0.08 participants) might be taken to suggest that most researchers believe that the IOR generated when the eyes are allowed (or required) to move is substantially the same as the IOR generated when eye movements are forbidden (but see Berlucchi, 2006; Hilchey, Klein & Satel, 2014; Taylor and Klein, 2000).

Two perspectives: Is there one IOR or are there many IORs?

Several of our questions probed whether respondents viewed IOR as one specific phenomenon or as a rubric that

Table 1 Responses to the question, "Which of the following criteria do you feel are necessary for an effect to be called IOR? Check as many as you think are necessary to warrant the label 'IOR'?"

	p(yes) n/37	Slower resp. to prev. stim. location	Presentat'n of a target	Shift of attention	Non-predictive cues	Reflexive orienting	Peripheral cues	Early facilit'n	Fixating eyes on centre
Slower responding to a previously stimulated or inspected location	0.92 34	–	15	14	12	7	5	3	3
Presentation of a target	0.43 16	15	–	7	6	2	2	3	2
Shift of attention	0.43 16	14	7	–	6	4	1	3	1
Non-predictive cues	0.32 12	12	6	6	–	5	4	2	1
Reflexive orienting	0.19 7	7	2	4	5	–	3	2	0
Peripheral cues	0.14 5	5	2	1	4	3	–	2	1
Early facilitation	0.14 5	3	3	3	2	2	2	–	0
Fixating eyes on centre	0.08 3	3	2	1	1	0	1	0	–

P(yes) represents the probability of selection. The remainder of the table lists the similarity matrix; given that an item was selected on the far left column, entries in the remaining columns indicate how many participants also selected each item listed on the top row. To facilite exploration, the results (above the diagonal) have been reflected into the corresponding cells below the diagonal

Other written-in responses:

- Cues that are either non-predictive, or predict that the target will occur in the same location as the cue
- [Regarding] the first box, previously stimulated location or object
- Search across space
- Response bias away from a previous location/object/stimulus (i.e. doesnt just have to be a slowing of RT)
- The shift of attention must be exogenous (which would include shifts of gaze or attention in a scene

was used to refer to collection of different phenomena that share a surface similarity but might have different causes and effects and might be mediated by different underlying mechanisms.

Almost 80 % of the experts surveyed reported that they had read an article claiming to be about visuospatial IOR that they thought was not actually IOR (Table 2, #1). Fromthis high rate rate of "red herring" assertions we might infer that researchers implicitly view IOR as a particular combination (or combinations) of cause, effect and possibly mechanism. Were this the case generally, then we would expect a similar proportion of experts to reject the view of IOR as rubric for similar-looking effects. Explicitly probing this assumption yielded a split: as many as 43 % of the experts agreed that IOR is an umbrella term for similar-looking effects (Table 2, #6) and conversely 57 % rejected the idea that IOR was an umbrella term. The correlation of this response with responses to the "red-herrings" in the literature question (Table 2, #1) was low. Although one might infer from this pattern an internal inconsistency, mitigating against this inference is the likelihood that some endorsers of the "umbrella" idea have encountered assertions of IOR in the literature that they view as over-generalizations of the umbrella term as they construe it. We also thought it logical to assume that researchers who endorsed the umbrella term would not limit the IOR label to only those results that could be explained by a single theory (i.e. neural implementation would not limit nomenclature). However, almost half of the experts identified IOR as an umbrella term, and almost half indicated that phenomena that could not be explained by a comprehensive theory could still be called IOR (Table 2, #14), yet there is very little overlap among two these groups. Only about half of the experts felt that a biological or cognitive explanation of IOR would have to

Table 2 Probability of participants endorsing statements about IOR and the strength of relation (Phi Coefficients; bolded values are significant) between responses to statements

Statement*	Proportion Endorsing	Strength of Relation**
1. You have read an 'IOR' article that you did not think was about IOR	0.76	] –.06] .05] – .15
6. IOR is an umbrella term for similar looking effects	0.43	
14. If a theory explained 80% of IOR phenomena, the remaining 20% is still IOR	0.46	
7. A biological explanation of IOR will have to explain all IOR results	0.51	] **.78**
8. A cognitive explanation of IOR will have to explain all IOR results	0.51	
4. As you define it, there is more than one mechanism involved in IOR	0.86	
5. [if yes to #4, $n = 32$] "These mechanisms contribute equally when IOR is observed	0.03	
11. The IORs in visual search and in a cueing paradigm are the same effect	0.62	] .31] **.48**] .24
12. The IORs in visual search and in a cueing paradigm have the same mechanism(s)	0.62	
13. The IORs in visual search and in a cueing paradigm have the same cause(s)	0.65	
9. Non-spatial IORs are based on the same mechanism(s) as visuospatial IOR	0.32	] **.43**
10. Non-spatial IORs have the same cause(s) as visuospatial IOR	0.51	

*These statements are paraphrases of the actual questions, which can be found in the appendix. Endorsements entailed selecting "yes" or "probably".

**Phi coefficients of association tested for significance using a 2-tailed Fisher Exact Probability Test after conversion to chi square.

explain all of the IOR literature (Tables 2, #7 & #8).

There is a third perspective. A researcher could believe that IOR is an effect with certain properties that are present in some IOR-like phenomena but absent in others. However, there is little consistency among the criteria experts used to identify IOR (Table 1), with the possible exception of slowed responding to a previously inspected location. Presumably, then, there would also be very little agreement regarding which characteristics differentiate 'real' IOR effects from imposters. Hence, how one would decide which effects to include or exclude would be idiosyncratic and relatively specific to individual researchers.

Different exemplars of IOR?

Two possible exemplars of IOR would be its observation in a spatial cueing paradigm and its observation in a visual search paradigm. Spatial cueing IOR is typically generated by peripheral cues and measured by peripherally presented targets with participants instructed to maintain fixation centrally. Visual search IOR is generated, not by a cue, but by the shifts of attention and/or gaze direction that occur naturally in many visual search situations. Indeed, in most search tasks that have been used to elicit and measure IOR, eye movements are usually necessary both to complete the task and to observe the effect. At the very least, experts largely agree that IOR has more than one mechanism, and that these mechanisms are not always contributing equally to the observed effects (Table 2, #4 & #5). Given this agreement among experts, one task now is to determine which mechanisms contribute to which effects under different circumstances. Indeed, this is the direction in which IOR research is moving (e.g., Klein, 2004).

The survey revealed that some IOR researchers view these possible variants of IOR as distinct effects (Table 2, #11, #12 & #13). Almost 40 % of the experts surveyed endorsed this view. We were interested to discover that while 62 % of the experts reported that they believed these two exemplars of IOR probably shared the same mechanisms, and 65 % reported that they believed these two exemplars shared the same causes, there was considerable non-overlap between these groups as the correlation between these responses was only .47. This suggests that causes and mechanisms are not the same things in the minds of some IOR experts (see the "Ambiguous terms" section below for more on how these terms are used by researchers). Given the relatively low correlations in Table 2, an expert could believe it probable that spatial cueing IOR and visual search IOR are the same effect(s), have different mechanisms, but share the same cause(s). (In fact, four researchers fit this profile.) A similar pattern was found in response to questions regarding spatial versus non-spatial forms of IOR.

Table 3 Probabilities for classifying a concept as a cause, mechanism, effect or component of IOR

Concept	Cause	Mechanism	Effect	Component	None of these	Not familiar
reflexive orienting	0.54*	0.35	0.03†	0.16	0.05	0.00
Inhibition	0.37	0.62*	0.38	0.22	0.11	0.03
Sensitivity change	0.22	0.19†	0.46*	0.19†	0.11	0.03
Attentional capture	0.62*	0.19	0.03†	0.14	0.11	0.00
sensory adaptation	0.46*	0.38	0.11†	0.11†	0.14	0.03
attentional momentum	0.27	0.35*	0.16†	0.24	0.14	0.03
habituation	0.41*	0.41*	0.08†	0.16	0.14	0.03
occulomotor programming	0.38	0.59*	0.00†	0.30	0.14	0.03
motor bias	0.22†	0.43*	0.35	0.27	0.14	0.03
exogenous stimulation	0.57*	0.16	0.03†	0.19	0.16	0.00
repeated stimulation	0.45*	0.08†	0.11	0.19	0.24	0.00
spatial working memory	0.08†	0.35*	0.08†	0.27	0.37	0.00

*the most likely selection for each concept from cause, mechanism, effect, component

†the least likely selection for each concept from cause, mechanism, effect, component

Experts surveyed were much more likely to think that non-spatial forms of IOR have the same causes than the same mechanisms (Table 2, #9 & #10). These apparent inconsistencies may be rooted in the ambiguous status of the terms.

Ambiguous terms

One of the most illuminating components of the survey (Question 2) involved having IOR experts classify concepts from the literature as a *cause*, *mechanism*, *effect* or *component* of IOR, selecting any and all categories that they thought applied to each concept irrespective of whether they supported a role for that concept in IOR. Experts also had the option of selecting *none of these* and *I'm not familiar with that concept*. Table 3 illustrates the probabilities of classification for each concept.

The goal of this question was to determine whether these terms (*cause*, *mechanism*, *effect*, *component*) are used consistently among researchers, as they are often used in the literature without the benefit of explicit definition.[2] A general trend was that concepts classified as a *cause* were likely to be classified as a *mechanism*, and vice versa. Another trend was that those concepts most likely to be classified as a *cause* or *mechanism* were the least likely to be called an effect, and vice versa (with *inhibition* being the sole exception to this generalization). These findings suggest that (a) researchers believe there is considerable overlap between the definitions of *cause* and *mechanism* but they are somewhat distinct, and (b) the definition of effects is very distinct from *causes*/*mechanisms*. All of the listed concepts were identified as a *component* with only moderate frequency (ranging from 14 % to 30 %), and no one concept was endorsed by a majority of experts as a *component*.

Based on these trends in classifying concepts, researchers tend to use the term mechanism to refer to anything that might slow responding to a previously stimulated or fixated location. Concepts such as *sensory adaptation* and *inhibition* tended to be classified as mechanisms. Researchers tend to use *causes* to refer to the environmental or procedural factors that are present and considered necessary to produce an IOR effect, like eye-movements or manual responses to a centrally-presented symbolic cue (Taylor and Klein, 1998) or repeated stimulation of a location (Dukewich, 2009). From among the concepts listed, *sensitivity change*, *response bias* and *inhibition* were the most frequently classified as effects.

The term *component* as applied to IOR is much more flexible. Each of the listed concepts was selected as a *component* with moderate frequency regardless whether the concept was primarily endorsed as a cause, mechanism, or effect. This suggests that when used in the context of IOR, *component* tends to refer to neurocognitive modules that implement either *causes* or *effects*. These neurocog-

[2]Indeed, two participants complained that the task would have been much easier if we had provided definitions for what we meant by cause, mechanism, effect and component. That fact supports our notion that these terms are somewhat ambiguous, even to experts.

nitive modules have been identified with some consistency already: sensory/perceptual/input (c.f. Dukewich & Boehnke, 2008), motor/oculomotor/output (c.f. Klein and Taylor, 1994; Posner et al. 1985), and cognitive/attentional (c.f. Hunt & Kingstone, 2003; Reuter-Lorenz et al., 1996) (see also Berlucchi (2006) for a discussion of IOR components with these categories).

Conclusions

In a 2000 review of IOR Klein addressed the topic of nomenclature hopefully: "As our knowledge of the characteristics of IOR and its neural implementation grows, there will hopefully be increasing agreement on the use of the term" (Klein, 2000, p. 145). Our survey reveals that Klein was overly optimistic: 14 years later there remains a surprising variety of views regarding the causes and effects of IOR, the mechanisms that link them, and consequently the range of phenomena that have been given this label.

Greenwald (2012) recently published an articled entitled, "There is nothing so theoretical as a good method". Greenwald describes theoretical debates in cognitive and social psychology that never seem to resolve – with an average age of 44 years in the literature. He also notes a substantial bias in the allocation of Nobel Science Prizes to methodological rather than theoretical contributions to their fields. There are two things to consider based on Greenwald's paper; (1) theoretical debates are difficult to resolve and (2) methods are easier to value than theory. Greenwald does not explicitly speculate as to why methods appear to be valued over theory. However, he does suggest that researchers involved in theoretical debates collaborate to identify commonly acceptable empirical findings that are germane to the debate. The purpose of collaboration would be to resolve debate boundaries and to help develop inter-translations between theories – differences in conceptual language among theories that, given similar empirical predictions, may not be semantically distinct. Herein may lie the reason methods are easier to advance than theory: methods are defined operationally and explicitly, while conceptual arguments that contribute to theory are often defined implicitly, or not at all.

We see the heterogeneous and idiosyncratic nature of researcher's views and definitions of IOR as problematic. Our purpose here is not to advance a particular view of the causes, effects and underlying mechanisms for IOR. Rather we end with some recommendations that we believe will move the field away from covert semantic problems in the literature and provide a foundation for inter-translations that might help to resolve controversies around theory (Greenwald, 2012).

One way to minimize the ambiguities our survey has identified is for researchers to be as explicit as possible in defining the IOR that they are exploring. The challenge is to be explicit and precise about the context of any given experiment to avoid over-generalizing, both in terms of previous research and new results. For example, researchers ought to be cautious when generalizing data from spatial-cueing to visual search, and vice versa.

The variability among researchers in their views of IOR indicates that current theories and explanations of IOR are unlikely to explain everything in the IOR literature. This variability might be interpreted to imply that no such pressure really exists to explain everything, since there is so little agreement on what IOR is. Thus, for theoretical frameworks that are attempting to explain IOR or a variant of it, authors should be explicit about what phenomena are covered by their theory. Researchers attempting to validate different explanations or theories related to IOR simply need to define the parameters that limit their proposals. We believe that to the extent such a recommendation is heeded, increasing agreement on the usage of the term will follow.

A few researchers have already adopted such a careful approach. Consider, for example, Berlucchi's (2006) commentary about the future direction of IOR research. Berlucchi was very specific about the kind IOR he was addressing at any given point; he very carefully noted when he was referring to IOR caused by peripheral spatial cues followed by peripheral spatial targets, and when he was referring to IOR caused by saccades in static displays. He specifically suggests that IOR generated in a traditional spatial cueing paradigm involving "changes in light energy" (pp.1071) has a different mechanism than IOR generated by saccadic shifts in static displays. He discusses some of the consequences of peripheral cueing besides IOR, including changes in sensitivity. Finally, his commentary discusses components in a consistent and coherent manner, suggesting that some IOR effects have sensory and attentional components, and some forms have a motor/oculomotor component. One may or may not agree with the content of Berlucchi's (2006) IOR commentary, but its specificity, consistency, and careful avoidance of over-generalizing make it a good model for IOR researchers and for researchers in other fields.

Authors Notes Our title pays homage to Giovanni Berlucchi's (2006) publication, "A phenomenon in search of a mechanism and a better name". After reading Berlucchi's unique and self-admittedly idiosyncratic perspective regarding IOR we wanted to find out what other

experts thought about the phenomenon normally given this label. In that way, Berlucchi's paper was also part of the motivation for conducting the survey presented and discussed here. This work was supported by a Natural Sciences and Engineering Research Council of Canada Discovery Grant awarded to R. M. Klein.

Appendix A: Expert selection criteria & list of participants

In selecting experts, we sought criteria that would achieve the following: (1) encompass both established IOR researchers as well as up-and-coming IOR researchers, (2) would be easily reproducible, and (3) would have surface validity. By using an established database, we assumed an acceptable level of construct validity in the criteria for selection. The original search was conducted on June 12, 2011.

The following steps were taken to select potential participants for contact:

1. In the Web of Science database, "inhibition of return" (including quotation marks) was searched in topic.

2. Results were sorted by *times cited*; this excluded publications that had relatively low citation rates.

3. *Analyze results* was selected as a tool (top of list, right location).This was used to refine the list of 638 results by Author, using the following optional selections within the tool:
   (a) Analyze: up to 500 records (*note:* this option is no longer available)
   (b) Show the top 250 results, Minimum record count = 1
   (c) Sort by: Record Count

4. Initially, the top 50 authors were to be selected for invitation to complete the survey; however, that list terminated in the middle of the list of authors who had 4 records (i.e. publications listed in Web of Science) included in the search, so the inclusion criteria was extended to include all authors with 4 records. This yielded a list of 70 authors.

5. Subjective evaluations were used to evaluate the records of each author. Authors whose entire record concerned using IOR in clinical research for the purposes of learning about clinical conditions were excluded from the top 70 list. Six authors were excluded, yielding a possible sample size of 64 participants.

6. Of those 64, email contact information was found for 63 possible participants. An invitation to participate was sent out to those researchers; 37 researchers chose to participate.

The following is a list of the authors who participated in the survey and agreed to have their names published in order to improve the perceived validity of the survey.

Dr. Richard Abrams
Dr. Paolo Bartolomeo
Dr. Andrea Berger
Dr. Ana B Chica
Dr. Michael Dodd
Dr. Digby Elliott
Dr. Shai Gabay
Dr. Avishai Henik
Dr. Bernhard Hommel
Dr. Glyn Humphreys
*Dr. Raymond Klein
Dr. Juan Lupianez
Dr. Bruce Milliken
Dr. Jay Pratt
Dr. Tony Ro
Dr. Arthur Samuel
Dr. Ayelet Sapir
Dr. Anne Sereno
Dr. Eric Sieroff
Dr. Jan Theeuwes
Dr. Carlo Umilta
Dr. Troy Visser
Dr. Ana B Vivas
Dr. Adrian von Muhlenen
Dr. Lawrence Ward

Eleven other experts chose to maintain their anonymity.

*Dr. Klein helped to shape the questions included on the survey early in the development stage. While he is a co-author, his participation was still included because (a) he was an expert that fit our selection criteria and (b) the survey was administered after it's creation with a long enough delay that Dr. Klein could not recall the specifics of the questions.

Appendix B: Survey

The following are a list of the items included on the survey. Note that participants did not have an opportunity to go back and change answers. Questions were presented in groups; a break (——) indicates questions were presented on a new page. The options for each question are written in capital letters. Withdrawal from the study was implied by a failure to complete the survey, including the section "Your Confidentiality & Anonymity Level" on the last page.

1. Have you ever read an article claiming to be about visuospatial IOR, but thought that the effect was not actually IOR? YES/NO

2. We are interested in finding out if researchers all define "causes", "mechanisms", "effects" and "components" of IOR in the same way. Please define the following entries as a proposed *cause*, *mechanism*,

effect, or *component* of IOR. We are only interested in how you would classify the concept, not whether you think it is actually involved in IOR. For example, you may not believe that attentional momentum is involved in IOR, but you should still classify it as a proposed *cause*, *mechanism*, *effect*, or *component*. **Please check all that apply to each term**.

	CAUSE	MECHANISM	EFFECT	COMPONENT	None of these	I'm not familiar with that concept
Attentional momentum						
habituation						
Sensory adaptation						
Motor bias						
Repeated stimulation						
Occulomotor programming						
inhibition						
Attentional capture						
Reflexive orienting						
Exogenous stimulation						
Spatial working memory						

3. Which of the following criteria do you feel are necessary for an effect to be called IOR? Check as many as you think are necessary to warrant the label "IOR".

   SLOWER RESPONSES TO PREVIOUSLY STIMULATED OR INSPECTED LOCATION

   PERIPHERAL CUES

   NON-PREDICTIVE CUES

   A SHIFT OF ATTENTION

   EARLY FACILITATION

   REFLEXIVE ORIENTING

   PRESENTATION OF A TARGET

   FIXATING EYES ON CENTRAL STIMULUS

   OTHER (please specify)

4. Do you think there is more than one mechanism involved in IOR, as you define it? YES / NO

5. If yes, do you think these mechanisms are always in the same proportion when IOR, as you define it, is observed? YES/ NO / NOT APPLICABLE

6. Do you think of IOR as an umbrella term for effects that all look relatively similar? YES / NO

7. Do you think that a biological explanation of IOR will have to explain all IOR results? YES / NO

8. Do you think that a cognitive explanation of IOR will have to explain all IOR results? YES / NO

9. Do you think that non-spatial forms of IOR (i.e. shape-based or color-based IOR) are based on the same mechanism(s) as visuospatial IOR? PROBABLY / PROBABLY NOT

10. Do you think that non-spatial forms of IOR (i.e. shape-based or color-based IOR) have the same cause(s) as visuospatial IOR? PROBABLY / PROBABLY NOT

11. Do you think IOR in visual search and IOR in a cueing paradigm are the same effect? PROBABLY / PROBABLY NOT

12. Do you think IOR in visual search and IOR in a cueing paradigm have the same mechanism(s)? PROBABLY / PROBABLY NOT

13. Do you think IOR in visual search and IOR in a cueing paradigm have the same cause(s)? PROBABLY / PROBABLY NOT

14. If a comprehensive theory of IOR were proposed that only explained 80 % of the IOR literature, would you still call the remaining 20 % "IOR"? YES / NO

15. Please share any other comments that you would like to add regarding the way you think about IOR that might be relevant.
    If you respond to this question, your response may be quoted in future publications associated with this survey. Whether you would like your response to remain anonymous or to be attributed to you by name is

an option available below ("Your Confidentiality & Anonymity Level").

16. Please enter your name and university affiliation. Your participation will remain anonymous and confidential unless you specify otherwise below. Your name and affiliation are being collected so we may evaluate survey completion.

    Name:
    University Affiliation:

    YOUR CONFIDENTIALITY & ANONYMITY LEVEL
    Below you may select your desired level of anonymity. All answers to survey questions with the exception of the open-ended question (Question 15) will be reported in aggregate or summary form only. Please indicate below whether you are willing to be named as a participant in this survey, and whether your response to Question 15 can be attributed to you in possible publications associated with this survey.

17. Our goal is to survey experts in the field of IOR. It would assist in the face validity of the survey if we could report specifically who completed the survey. If you give permission for us to report your participation in this survey, we will NOT link your name with your specific responses.

    "You may reveal my participation in this survey to other researchers, and in any possible future publications associated with the survey results. While my participation may be reported, my responses should not be linked to my name."

    If you response "No", the fact that you participated in this survey will remain completely confidential. YES / NO

18. "You may attribute my open-ended response in Question 15 to me when discussing the results with other researchers, and in possible future publications associated with the survey results."

    If you response "No", any comments you made in response to Question 15 will remain completely anonymous, but may still be included in future publications. YES / NO

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