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Brief article

Is inhibition of return a reflexive effect?

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Abstract

The inhibition of return (IOR) phenomenon is routinely considered an effect of reflexive attention because the paradigm used to generate IOR employs peripheral cues that are uninformative as to where a target will appear. Because the cues are spatially unreliable it is thought that there is no reason for attention to be committed volitionally to them, and hence, the IOR effect is considered reflexive. What has been generally overlooked, however, is that the cues provide reliable temporal information as to when a target will occur. This predictive information is used by participants to prepare volitionally for when a target is likely to appear. We investigated whether the IOR effect is a product of the volitional application of attention to peripheral cues for the use of their temporal information. To test this idea we rendered the temporal information provided by peripheral cues unreliable. While this eliminated participants using the cues volitionally, it did not abolish the IOR phenomenon. These data demonstrate two new findings. First, the IOR effect is fundamentally a reflexive phenomenon. Second, when peripheral cues are not used volitionally, the IOR effect is attenuated. Together, the present findings indicate that the IOR effect can be modulated by volitional (top-down) processes but it is not the product of them. We argue that an intimate link between fronto-parietal regions and the superior colliculus provide a functional neural mechanism for this volitional effect to impact IOR.
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The IOR effect refers to the phenomenon in which about half a second following an abrupt peripheral cue, responses are slower to targets appearing at the cued location than to

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targets appearing elsewhere (see Klein, 2000 for an excellent review of the IOR effect). While it is widely accepted that IOR is a reflexive phenomenon, there is no direct empirical evidence for this assumption.

1. IOR as a reflexive phenomenon

One line of evidence supporting the view that IOR is reflexive concerns the superior colliculus (SC), a primitive subcortical neural system. Posner, Rafal, Choate, and Vaughan (1985) were the first to suggest that IOR may be mediated by the SC. They found that patients suffering from degeneration of the midbrain, including the SC, do not produce an IOR effect, whereas comparable patients without midbrain damage do exhibit IOR (see also Danziger, Fendrich, & Rafal, 1997). More recently, IOR has been found to be biased preferentially towards the temporal visual field, which is thought to be connected more richly with the SC than the nasal field (Berger & Henik, 2000). The IOR effect is also found in newborn infants whose visual orienting is driven largely by the SC (Simion, Valenza, Umilta, & Dalla Baraba, 1995). The most direct link between the SC and IOR, however, comes from a patient with a rare unilateral lesion to the SC, who exhibited the IOR effect only for the hemifield that projected to the intact SC (Sapir, Soroker, Berger, & Henik, 1999).

It is essential to note that while there is compelling evidence implicating the SC in the IOR effect, this does not demand the conclusion that the IOR effect is reflexive. The SC enjoys rich connections with a number of cortical brain regions, including frontal and parietal cortices, which are known to be crucial to volitional processes (Corbetta & Shulman, 2002; Hunt, Olk, Von Mühlenen, & Kingstone, 2004). Indeed, it has been demonstrated that volitional mechanisms alone are sufficient for activating the SC and generating an IOR effect (Rafal, Calabresi, Brennan, & Sciolto, 1989).

The single most important reason that IOR is considered reflexive is the paradigm that is used to produce it. In Posner and Cohen's (1984) original study, as in current investigations, the IOR effect is triggered by an onset in the periphery whose location *does not predict* where the target will appear. Because the location of the onset is unreliable as a cue for where a target will appear, it is assumed that people do not attend volitionally to it. Thus the key to the position that the IOR effect is reflexive is the assumption that there is no reason for people to attend to the peripheral cue.

2. Is the IOR effect really a reflexive phenomenon?

While it is true that the cue does not predict *where* a target will appear, the cue is highly predictive as to *when* a target will appear. In other words, although there is no reason to attend to the cue based on its unreliable spatial information, there is good reason to attend to the cue because of its reliable temporal information (Milliken, Lupianez, Roberts, & Stevanovski, 2003; Mondor, 1999; see also Kingstone, 1992; Snyder & Kingstone, 2001 for demonstrations that spatial attention is allocated to a signal to extract its temporal information). Indeed, even a cursory look at the body of IOR research provides clear

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