



Can the exploration of left space be induced implicitly in unilateral neglect?



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ABSTRACT

The purpose of the present study was to explore the ability of neglect patients to detect and exploit the predictive value of a cue to respond more quickly and accurately to targets on their contralesional side in a Posner spatial cueing task. The majority of the cues (i.e. 80%) were invalid, indicating that the target would appear on the opposite side, although patients were not informed of this bias. Our results demonstrate that some neglect patients were able to extract the cue's predictability and use it to orient faster toward the left. This cueing effect was present even in patients who were subsequently unable to describe the predictive character of the cues, and thus was not modulated by reportable awareness of the cue-target relation.

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1. Introduction

Left visual neglect is a common disorder resulting from unilateral hemispheric damage, often as a consequence of resulting dysfunction in fronto-parietal networks in the right hemisphere (Bartolomeo, Thiebaut de Schotten, & Doricchi, 2007), which include networks that are important for the spatial orienting of attention (Bartolomeo, Zieren, Vohn, Dubois, & Sturm, 2008; Corbetta & Shulman, 2002). Neglect patients tend to explore mainly ipsilesional locations, and are unable to orient, report, or respond to events contralateral to the side of the brain lesion (Heilman, Watson, & Valenstein, 2011). Typically associated with patients' unawareness of their difficulties (anosognosia), neglect is often difficult to rehabilitate (Bartolomeo, 2014). Although different impairments may contribute to the syndrome, attentional disorders play a prominent role in visual neglect, including disorders of impaired spatial orienting, which is heavily rightward-biased (for a review, see Bartolomeo, Thiebaut de Schotten, & Chica, 2012).

The orienting of attention does not rely on a unitary system. Spatial attention can be oriented either endogenously (i.e., in a voluntary or top-down fashion) or exogenously (i.e., in an automatic or bottom-up fashion; Chica, Bartolomeo, & Lupianez, 2013; Chica, Bartolomeo, & Valero-Cabre, 2011; James, 1890; Posner, 1980). The Posner spatial cueing task has been widely used to study the spatial orienting of attention in healthy participants (e.g. Chica, Bartolomeo, et al., 2011; Chica, Lasaponara,

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et al., 2011; Lopez-Ramon, Chica, Bartolomeo, & Lupianez, 2011; Ruz & Lupianez, 2002) as well as in brain-damaged patients (e.g. Bartolomeo, Decaix, Siéoff, & Chokron, 2001; Bartolomeo et al., 2012; Chica et al., 2012; Losier & Klein, 2001; Natale, Posteraro, Prior, & Marzi, 2005; Posner, Walker, Friedrich, & Rafal, 1984). In one version of this paradigm, targets are preceded by peripheral cues (e.g., a brief brightening) at various stimulus onset asynchronies (SOAs). The cues are either valid or invalid: i.e., they indicate either the target's location or the opposite location. Spatially non-predictive cues—i.e. targets that appear with equal proportion in the cued or in the uncued locations—are used to orient attention exogenously or automatically (Muller & Rabbitt, 1989). In this condition, a validity effect is usually observed, with lower response times (RTs) for valid cue-target trials as compared to invalid trials at short SOAs (<300 ms). The reverse pattern appears at SOAs longer than 300 ms, with faster RTs on invalid than on valid trials, a phenomenon known as inhibition of return (IOR: see Klein, 2000; Lupianez, Klein, & Bartolomeo, 2006 for details).

As the predictive value of the cue is increased, the initial exogenous bottom-up orienting mechanisms are replaced by an endogenous, top-down, shift of attention. This endogenous orienting is generally described as involving controlled attentional mechanisms: according to this view, it is awareness of the cue's spatial utility (i.e., the degree to which the cue location predicts the target location) that enables subjects to strategically allocate attention in response to the cue (Bartolomeo & Chokron, 2002; Santangelo & Spence, 2008). In this situation, the cueing effect increases considerably and persists at longer SOAs, to an extent that depends on the proportion of valid trials (Bartolomeo, Decaix, & Sieroff, 2007; Risko & Stolz, 2010).

To investigate attentional orienting in visual neglect, Bartolomeo, Decaix et al. (2001) used peripheral cues with different degrees of predictive value (20%, 50%, and 80% of cued trials). Participants were informed of the predictive value of the cue before each session and encouraged to use it to respond as quickly and precisely as possible. The results showed that exogenous orienting was particularly impaired in visual neglect: there was no evidence of IOR for right targets and a disproportionate cost when left targets were preceded by invalid right cues (Losier & Klein, 2001; Posner et al., 1984). Nevertheless, endogenous orienting seemed to be relatively spared, albeit slowed, in neglect patients. When the cues predicted the appearance of the target at the opposite location in 80% of trials, neglect patients were able to respond as quickly for the left as for the right targets. However, this happened only at the longest SOA (1000 ms), whereas age-matched controls were already able to take advantage of the information provided by the cues at an SOA of 550 ms. The apparent ability of the neglect patients in this study to take advantage of the predictive value of the cue to respond more accurately and quickly to left targets has been interpreted to suggest preservation of endogenous controlled processes (see also Ladavas, Carletti, & Gori, 1994; Smania et al., 1998). Interestingly, although Bartolomeo, Decaix et al. (2001) participants were informed of the cue's predictability, in the informal debriefing following reaction time task some claimed not to have paid attention to the cues at all, but simply to have tried to respond to the targets as quickly as possible. The conclusion that these cueing effects were the result of motivated strategic considerations or expectancies could thus be challenged.

In fact, some authors have questioned the purely explicit and “controlled” nature of endogenous attentional orienting (Bartolomeo, Decaix, et al., 2007; Lambert, 2003; Lambert, Naikar, McLachlan, & Aitken, 1999; Lopez-Ramon et al., 2011; Risko & Stolz, 2010). To better understand the phenomenology of endogenous orienting in healthy subjects, Bartolomeo et al. (2007) used a Posner procedure but manipulated the information given to the participants before the testing session: half were informed of the cue-target relation, and the other half were not. They observed that participants from the non-informed group benefited as much from the cues to orient quickly towards the targets as the participants in the informed group—regardless of their ability to verbally report the cue-target relation. These results suggested that the subjects' sensitivity to the probabilistic association between the cue and the target in the Posner paradigm might be sustained by more implicit mechanisms that can function in the absence of awareness of the cue-target relation (see also Bartolomeo et al., 2008; Chica & Bartolomeo, 2010; Lopez-Ramon et al., 2011). Lambert et al. (1999) distinguished this component of visual orienting as the *implicit peripheral cueing effect*. This implicit process is separate from both reflexive (i.e., bottom-up) and voluntary (i.e., top-down) orienting, and can guide visual attention depending on spatial regularities (Lambert, Norris, Naikar, & Aitken, 2000).

In daily life, neglect patients seem to be unable to consciously use their preserved endogenous abilities to compensate for their attentional difficulties, i.e., to orient their attention toward the contralesional side in a controlled way. On the other hand, it has been shown that right brain-damaged patients with and without neglect can be sensitive to environmental regularities, as shown by their statistical learning abilities for target positions in visual search (spatial repetition: Saevarsson, Joelsdottir, Hjaltason, & Kristjansson, 2008), and also in spatial priming, albeit to a lesser extent (Shaqiri & Anderson, 2012, 2013).

If implicit learning abilities are preserved in neglect patients, and if their ability to detect the predictive value of cues presented in RT tasks (cueing paradigm) is based on their implicit sensitivity to environmental regularities, then a further question of interest is whether these implicit attentional processes could be used to help patients detect and respond to stimuli presented to their neglect side. The main purpose of the present study was thus to determine whether neglect patients are able to use the predictive value of the cue to respond more quickly and accurately to targets, without being informed in advance of the cue-target relationship. More particularly, we explored neglect patients' ability to inhibit ipsilesional capture and reorient their attention toward contralesional targets. To this end, we used a cueing paradigm (Posner et al., 1984) in which the majority of the cues (80%) were invalid, indicating that the target would appear on the opposite side.

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