CORTEX 46 (2010) 1149–1164

available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/cortex

Research report

Involuntary but not voluntary orienting contributes to a disengage deficit in visual neglect

Bettina Olk [a,*], Helmut Hildebrandt [b,c] and Alan Kingstone [d]

[a] School of Humanities and Social Sciences, Jacobs University Bremen, Germany
[b] Department of Neurology, Klinikum Bremen-Ost, Bremen, Germany
[c] Department of Psychology, University of Oldenburg, Oldenburg, Germany
[d] Department of Psychology, University of British Columbia, Vancouver, Canada

ARTICLE INFO

Article history:
Received 27 May 2009
Reviewed 22 June 2009
Revised 15 July 2009
Accepted 28 July 2009
Action editor Paolo Bartolomeo
Published online 3 August 2009

Keywords:
Attention
Neglect
Extinction
Disengagement

ABSTRACT

Patients with left neglect are particularly slow to respond to visual targets on their left when attention is first engaged to their right. This deficit is known as the disengage deficit (DD). Studies investigating the DD typically employ nonpredictive peripheral onset cues to measure involuntary orienting and predictive central arrow cues to measure voluntary orienting. A DD has been observed with both cues, suggesting that a DD occurs for involuntary and for voluntary orienting. Recent evidence questions this conclusion because nonpredictive central arrow cues trigger involuntary orienting. This implies that predictive central arrows also involve involuntary orienting and do not measure only voluntary attention. This new knowledge suggests a new conceptualization of the DD. While it is undisputed that a DD occurs when attention is shifted involuntarily, it is uncertain whether a DD is produced by voluntary orienting because most previous cuing studies of the DD have involved shifts of involuntary attention. To address this critical question, we tested neglect and control patients with nonpredictive and predictive peripheral onset cues (Experiment 1), nonpredictive and predictive central arrow cues (Experiment 2), and predictive central number cues (Experiment 3). The experiments provide three lines of converging evidence that voluntary orienting does not contribute to a DD. First, the DD was the same whether attention was engaged involuntarily by nonpredictive peripheral cues or engaged involuntarily and voluntarily by predictive peripheral cues (Experiment 1), indicating that voluntary orienting does not modulate the DD. Second, the DD was the same whether attention was engaged involuntarily by nonpredictive central arrow cues or engaged involuntarily and voluntarily by predictive central arrow cues (Experiment 2), replicating the finding of Experiment 1 with very different cues. Third, the DD was not present when attention was only engaged voluntarily by central predictive number cues (Experiment 3).

* *Corresponding author*. School of Humanities and Social Sciences, Jacobs University Bremen, Campus Ring 1, 28759 Bremen, Germany. E-mail address: b.olk@jacobs-university.de (B. Olk).
0010-9452/$ – see front matter © 2009 Elsevier Srl. All rights reserved.
doi:10.1016/j.cortex.2009.07.013

1. Introduction

One of the most influential models of attention, proposed by Posner and colleagues (e.g., Posner and Cohen, 1984), states that attention is engaged on a particular object, or object-feature, such as its spatial location, and that reorienting of attention involves the disengaging of attention from an object or current location so that it can be moved and engaged elsewhere. The most compelling evidence for the process of attentional disengagement comes from studies with brain-injured patients who are suffering from spatial neglect (e.g., Posner et al., 1984). These patients tend to miss stimuli presented opposite to their brain injury, which in most cases is the left hemispace after a right-hemisphere lesion (Vallar and Perani, 1986). If these patients do respond to the stimuli on the left, they are slow to do so.

Studies using the spatial cuing paradigm have provided evidence that these patients show a deficit in disengaging attention from a cued location. Typically, in this paradigm, spatial attention is guided by a visual cue that is followed by a target presented to the cued or noncued location. Response time (RT) to a target presented to the cued location is typically faster than to a target presented to the noncued location, reflecting the fact that before a target at the noncued location can be responded to, the time-consuming operation of disengaging attention from the cued location and orienting it to the noncued location must be performed. The visual cues that control attention can be presented peripherally or centrally. These two types of cues, and their relation to automatic (involuntary) spatial orienting and controlled (voluntary) orienting will be considered briefly in turn.

1.1. *Peripheral cuing*

Peripheral onset cues normally consist of a square that 'flashes' abruptly in the left visual field (LVF) or right visual field (RVF). The cue is then followed by a target at the cued or noncued location. If the target appears at the cued location on only 50% of the trials, the cue is considered to be spatially nonpredictive, as the probability of a target appearing at the cued location is at the level of chance. The ability of a nonpredictive peripheral cue to attract attention is therefore considered to be involuntary in nature because an observer has no reason to expect a target at the cued location any more than at the noncued location.

If the target appears at the cued location more often than not, say on 80% of the trials, then the peripheral cue is spatially predictive. A participant has a reason to expect the target at the cued location on most trials. As a result, the effect of the cue on attentional orienting is thought to engage voluntary, controlled attention. It is very important to note, however, that because a peripheral cue will engage attention automatically when it is spatially nonpredictive, a spatially predictive peripheral cue is understood to engage both involuntary and voluntary attention (Bartolomeo et al., 2001; Olk et al., 2008; Ristic and Kingstone, 2006).

When right-hemisphere-injured spatial neglect patients are examined using the peripheral cuing paradigm, the classic result is that they are very slow to respond to a target that is presented in the LVF. This is especially true when the LVF target is preceded by a peripheral cue in the RVF. This enhanced delay in response performance to a target on the left when the cue is on the right, is understood to reflect a 'disengage deficit' (DD), whereby patients first attend to the cue on the right and then have difficulty disengaging from it in order to orient and respond to the target on the left. This DD has been replicated in several recent studies using spatially nonpredictive (e.g., Bartolomeo et al., 2001; Danziger et al., 1998; Farah et al., 1989) and predictive (Bartolomeo et al., 2001) peripheral cues. Because a peripheral cue, regardless of its reliability, engages involuntary orienting, one can safely conclude that the DD occurs when involuntary orienting is engaged. The relationship between the DD and voluntary orienting is less clear-cut because in the predictive peripheral task the occurrence of voluntary orienting is confounded with involuntary orienting. To address voluntary attention and the DD one needs to turn to the central cuing task.

1.2. *Central cuing*

In the central cuing task participants are presented with a stimulus, typically an arrow that points to the left or right. Since a study by Jonides (1981), which reported that arrow cues need to be spatially predictive to produce a shift in attention to the cued location (e.g., valid 80% of the time), it has been assumed that the predictive central arrow cuing task only engages voluntary attention. In other words, the central arrow cue provides the participant with spatial information as to where a target is likely to appear, and based on that information, the participant forms an expectation as to where a target will appear and allocates attention to that location, i.e., attention is allocated voluntarily to the cued location. Jonides (1981) reported that this allocation of attention only occurred when the arrow was spatially predictive. When the arrow cue was not spatially predictive, and hence, no expectation would be formed as to where a target was likely to occur, attention was not allocated to the cued location. Accordingly, a DD when predictive arrow cues are used (Nijboer et al., 2007; Posner et al., 1984) has been understood to demonstrate a DD for voluntary shifts of attention.

In sum, a DD is observed when attention is shifted involuntarily (nonpredictive peripheral cues) and when it is shifted voluntarily (central predictive arrow cues). For these reasons a DD is considered to be a common characteristic, and a fundamental limitation, of brain-injured patients who are suffering from neglect/extinction. Convergent with such a position, models of human attention do not make any important distinction, behaviourally or with regard to the underlying neural system, between disengaging attention when attention is committed involuntarily or disengaging attention when attention is committed voluntarily (e.g., Corbetta et al., 2008; Posner, 1980).

1.3. *A new perspective*

Recent results have led us to reconsider the long-standing position that the DD is common to both involuntary and