NEUROPSYCHOLOGIA

Neuropsychologia 43 (2005) 1189–1203

www.elsevier.com/locate/neuropsychologia

Attentional control parameters following parietal-lobe damage: evidence from normal subjects

Shaun P. Vecera*, Anastasia V. Flevaris

Department of Psychology, 11 Seashore Hall E., University of Iowa, Iowa City, IA 52242-1407, USA

Received 12 February 2004; received in revised form 21 October 2004; accepted 26 October 2004

Abstract

Attentional control involves the factors, or cognitive parameters, that determine which environmental inputs receive attention and which do not. Cognitive studies of attentional control have highlighted two general classes of control parameters, bottom-up (data driven or exogenous) parameters and top-down (goal driven or endogenous) parameters. Which of these control parameters is affected following parietal-lobe damage? In parietal-damaged patients, it is possible that a disorder in one control parameter (e.g. goal driven) would appear as a disorder in another parameter (e.g. data driven). To investigate the control parameters that might be affected in parietal patients, we simulated neglect in normal participants by disrupting data-driven information processing. When half of a computer monitor was degraded by translucent tracing paper while normal participants performed a cued spatial attention task (Experiment 1), the normal participants showed a pattern of results similar to patients with unilateral parietal-lobe damage—the so-called "disengage deficit." This pattern of results replicated when neutral attentional cues were included in the experiment (Experiment 2). However, the disengage deficit was not simulated in normal participants with predictive central symbolic cues (Experiment 3) or predictive peripheral cues (Experiment 4). Because perceptual degradation influences data-driven attentional control parameters, we suggest that these control parameters may be disrupted following parietal-lobe damage.

Keywords: Parietal-lobe damage; Attentional control; Symbolic cue

Of the multiple cortical and subcortical areas that participate in the control of spatial attention, perhaps none has been studied as extensively as the posterior parietal region. Damage to the parietal region (especially the right parietal region) in humans results in a profound attentional impairment referred to as neglect. The performance of neglect patients has provided important insights about the operation and mechanisms of attention. Patients with neglect present with a variety of symptoms (e.g. see Bisiach & Vallar, 1988; Heilman, Watson, & Valenstein, 1993; Heilman, Watson, & Valenstein, 2000; Rafal & Robertson, 1995; Rafal, 2000), including the failure to pay attention to stimuli falling on the side of space opposite to the lesion (the contralesional side); a patient with damage to the right parietal lobe may fail to eat food on the left half of the plate or may not read words on the left half of a page. Neglect patients often do not make head or eye movements in the contralesional direction. These failures to respond to contralesional stimuli are not due to sensory deficits (e.g. a visual scotoma or hemianopia). As a patient recovers and the neglect becomes less severe, patients can process a single stimulus presented in the contralesional visual field. However, these recovering patients continue to show a subtle attentional impairment known as extinction: when two stimuli are presented simultaneously in opposite visual fields, patients will extinguish, or fail to notice, the stimulus in the contralesional field. In other words, extinction patients exhibit neglect of contralesional stimuli only in the presence of ipsilateral stimuli. Although many of these characteristics can follow damage to other brain regions (e.g. frontal lobe areas and subcortical areas such as the pulvinar), our focus is on neglect and extinction phenomena that follow damage to parietal lobe areas. Hence, we use the terms 'neglect' and 'ex-

* Corresponding author. Tel.: +1 319 3350839; fax: +1 319 3350191.
E-mail address: shaun-vecera@uiowa.edu (S.P. Vecera).

0028-3932/$ – see front matter
doi:10.1016/j.neuropsychologia.2004.10.009

tinction' as shorthand for 'neglect (or extinction) following parietal-lobe damage.'

Different interpretations of the attentional deficits in neglect and the mechanisms of those deficits have been offered. For example, neglect has been interpreted as a difficulty with visuospatial attention (see Driver, 1998; Posner, Walker, Friedrich, & Rafal, 1984; Rafal, 2000; Rafal & Robertson, 1995), with object-based attention (see Behrmann & Moscovitch, 1994; Behrmann & Tipper, 1994; Egly, Driver, & Rafal, 1994), and with orienting attention to temporal events (Husain, Shapiro, Martin, & Kennard, 1997), suggesting that the parietal lobe plays a role in many attentional phenomena. In addition to these varieties of attentional impairments, many theorists have proposed different mechanisms to explain the performance of neglect patients. Kinsbourne (1993) proposed that competition between the two cerebral hemispheres could explain neglect; because the damaged hemisphere cannot compete with the intact hemisphere, attention is biased toward the ipsilesional visual field, which is controlled by the intact hemisphere (also see Cohen, Romero, Servan-Schreiber, & Farah, 1994; Làdavas, 1990; Làdavas, Petronio, & Umiltà, 1990; Làdavas, Umiltà, Ziani, Brogi, & Minarini, 1993). Posner et al. (1984) proposed that the parietal lobes are involved in the disengagement of attention; patients with unilateral parietal damage have difficulty disengaging spatial attention from the ipsilesional visual field, making it difficult to direct attention to contralesional stimuli.

Attempts to understand the mechanisms that are damaged in parietal-damaged patients have not always been informed by information processing theories of normal attentional processes (see Posner et al., 1984, for an exception). Information processing, or cognitive, studies of attention in neurologically normal participants focus on two important issues, the control of attention and the effects of attention (see Luck & Vecera, 2002; Vecera & Luck, 2002). Studies of attentional control involve isolating the factors that determine which inputs receive attention and which do not. That is, how does a viewer attend to a red circle when it appears in a scene filled with red squares and green circles? Studies of the effects of attention involve specifying the processing differences between attended and unattended items. We focus on the control of visuospatial attention in neglect following recent theoretical developments on this topic. We ask: What attentional control parameters (i.e. factors) are impaired in parietal-damaged patients?

To address this question, we must consider the possible sources of attentional control because there are different parameters or processes that can influence where attention is directed. Two general sources of attentional control are goal-driven (also called conceptually-driven, top down, or endogenous) sources that arise from the current behavioral goals and data-driven (also called bottom up or exogenous) sources that arise from sensory stimuli present in a scene (Klein, Kingstone, & Pontefract, 1992; Yantis, 1998). We refer to these two sources broadly as "attentional control parameters" because the factors that control attention are parameterized by involving (1) the type of factor affecting attention (top-down or bottom-up, for example) and (2) the value of that factor. The different terms (e.g. endogenous versus top-down) typically are used in different paradigms. For example, in peripheral cuing paradigms, attentional control is discussed in terms of exogenous and endogenous processes, whereas in visual search, attentional control may be discussed in terms of bottom-up and top-down processes. Because we intend to discuss attentional control broadly, we will tend to use the most inclusive terms to discuss control parameters; that is, instead of using a term that typically is tied to a paradigm (e.g. exogenous), we will use a more general term (e.g. bottom-up or data-driven). The terms we have chosen to use will not affect the interpretation of our results.

Recently, Desimone and Duncan (1995) have proposed a "biased competition" account of attention that integrates both goal-driven and data-driven attentional control. The biased competition account was developed to explain visual search in which a subject looks for a target among distractors. The target searched for is held in working memory and guides attention in a goal-directed manner. The image being searched provides sensory information that guides attention in a data-driven manner. The multiple objects present in the scene compete for limited attentional resources. The goal-driven attentional signal serves to bias this competition to favor objects that are similar to the target item. The biased competition account provides a useful conceptual framework for studies of overt orienting (Trappenberg, Dorris, Munoz, & Klein, 2001), visual search, visuospatial attention (Desimone & Duncan, 1995), and object-based attention (Vecera, 2000).

Applying the biased competition account to neglect patients suggests at least two possible processes that might be disrupted in these patients. Attentional impairments following parietal damage could arise from an inability to use goal-directed, or endogenous, attention to orient to the contralesional visual field (the neglected or extinguished field). Patients may have damage to the representation of the contralesional space, and they may be unable to use this representation to control the allocation of attention in a goal-directed manner. Or, the attentional impairments following parietal damage could arise from an inability of perceptual inputs to control attention in a data-driven, or exogenous, manner. Events in the contralesional field may fail to engage attention as quickly or effectively as events in the ipsilesional field (e.g. Làdavas, 1990; Làdavas et al., 1990, 1993).

Although either goal-driven or data-driven control sources might be disrupted in parietal-damaged patients, it is difficult to disentangle the effects of these control parameters in patients. Damage to one control parameter may appear as an impairment in the other parameter. For example, parietal-damaged patients make fewer exploratory eye movements into the contralesional field than in to the ipsilesional field. This suggests damage to goal-driven control parameters which are responsible for visual search via eye movements. If data-driven parameters were disrupted, however, patients might fail to make exploratory eye movements because the