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Research Report

Classification images of two right hemisphere patients: A window into the attentional mechanisms of spatial neglect

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ABSTRACT

While spatial neglect most commonly occurs after right hemisphere lesions, damage to diverse areas within the right hemisphere may lead to neglect, possibly through different mechanisms. To identify potentially different causes of neglect, the visual information used (the 'perceptual template') in a cueing task was estimated with a novel technique known as 'classification images' for five normal observers and two male patients with right-hemisphere lesions and previous histories of spatial neglect (CM, age 85; HL, age 69). Observers made a yes/no decision on the presence of a 'White X' checkerboard signal (1.5°) at one of two locations, with trial-to-trial stimulus noise added to the 9 checkerboard squares. Prior to the stimulus, a peripheral precue (140 ms) indicated the signal location with 80% validity. The cueing effects and estimated perceptual templates for the normal observers showed no visual field differences. Consistent with previous studies of spatial neglect, both patients had difficulty with left (contralesional) signals when preceded by a right (ipsilesional) cue. Despite similar behavioral results, the patients' estimated perceptual templates in the left field suggested two different types of attentional deficits. For CM, the left template matched the signal with left-sided cues but was opposite in sign to the signal with right-sided cues, suggesting a severely disrupted selective attentional strategy. For HL, the left templates indicated a general uncertainty in localizing the signal regardless of the cue's field. In conclusion, the classification images suggested different underlying mechanisms of neglect for these two patients with similar behavioral results and hold promise in further elucidating the underlying attentional mechanisms of spatial neglect.

1. Introduction

1.1. Spatial neglect and cueing

Spatial neglect can occur after a unilateral brain injury and describes a syndrome in which the patient ignores visual information in the hemifield opposite to the side of the lesion (for a review, see Rafal, 1994; Lezak, 1995; Gazzaniga, 1998). It is not a purely visual deficit as it can be dissociated from visual field loss (hemianopia), and it is commonly assumed that hemineglect reflects an attentional deficit (although many have argued that hemineglect also reflects a deficit in the

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representation of space, see Bisiach, 1993; Bisiach and Luzzatti, 1978). Aside from its clinical implications, many cognitive neuroscientists view neglect as an excellent model for examining the brain mechanisms that mediate attentional orienting. While neglect may result from a brain injury to one of many regions, the most common and most severe cases of hemineglect result from brain injuries to the right parietal lobe. This site coincides with a number of primate single-cell recording studies (Mountcastle et al., 1975; Robinson et al., 1995; Colby et al., 1995, 1996; Andersen, 1995) and brain imaging studies on normal human observers (Darby et al., 1996; Corbetta et al., 1978; Courtney et al., 1996) suggesting that a primary responsibility of the parietal cortex is the representation and integration of visuo-spatial information. Typically, neglect is most severe at the onset of injury, and, over the course of a year, the patient recovers to a chronic level of deficit (which can approach normal levels of functionality).

A significant paradigm in the general study of attention is known as the cueing task (Posner, 1980). In this task, observers detect a target stimulus that could appear at one of two or more locations. Before the stimulus appears, a precue appears that indicates the probable location of the forthcoming target. Trials in which the target appears at the cued location are known as valid trials, while those in which the target appears at an uncued location are known as invalid trials. There may also be a neutral cue trial type, in which no reliable information is given about where a target may appear. The typical finding for these different precue conditions is that with normal observers performance is fastest and/or most accurate when a target appears at a validly cued location, worst when a target appears at an invalid (uncued) location, and intermediate for neutral cue trials.

Aside from studies on normal observers, the cueing task has been applied in both the diagnosis and study of neglect. In a now classic investigation, Posner et al. (1984) found that hemineglect patients were severely impaired when the precue appeared in the ipsilesional (good) visual field and the target appeared in the contralesional (bad) visual field. Thus, hemineglect patients, unlike normal observers, manifest a significantly larger cueing effect when the precue appears in the ipsilesional visual field than when it appears at the contralesional visual field. From this study and subsequent investigations like it, Posner and colleagues developed a theory of attention in which the parietal cortex is responsible for disengaging attention from a selected spatial location. Hence, when the parietal cortex is lesioned, as it is for most neglect patients, performance is severely compromised when attention must be disengaged from an ipsilesional cue and shifted to a contralesional target. While this "disengage deficit" provides an accurate qualitative characterization of the attentional deficit that characterizes neglect patients, it fails to provide a quantitative description of the deficit. The aim of the present study is to begin to address this shortcoming.

1.2. *Description of cueing task*

Fig. 1 depicts the cueing task used in the current study. Observers performed a yes/no contrast discrimination of a 3 × 3 checkerboard pattern configured as a 'white X'. On half the trials, the signal appeared for 40 ms (normals) or 140 ms (patients) at either one of two locations (left and right), with a 140 ms precue indicating the probable location of the signal with 80% validity. Observers had to

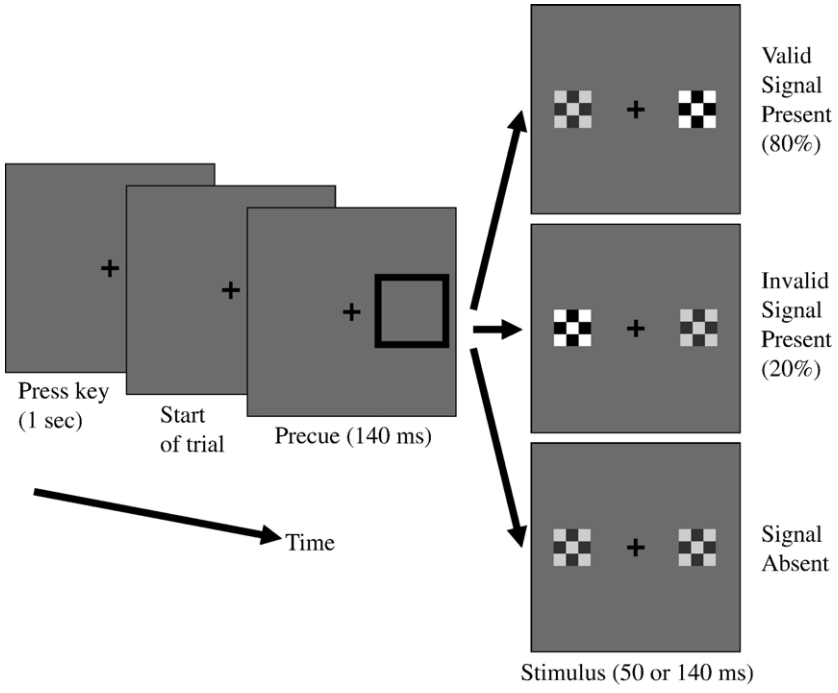

Fig. 1 – Trial types in the cued yes/no contrast discrimination task, right-sided cues only. Observers judged upon the presence of a high contrast checkerboard 'white X' (140 ms, either 2.5° left or right of central fixation) appearing on half the trials. A precue (2.5° square, 140 ms) indicated the signal location with 80% validity on signal present trials.