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Research report

The influence of distracters, stimulus duration and hemianopia on first saccade in patients with unilateral neglect

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ABSTRACT

The aim of the present study was to assess the influence of visual distracters, stimulus duration and the presence of contralesional hemianopia on direction of the first saccade in right brain damaged (RBD) patients affected by left unilateral neglect (UN).

During a visual search task we recorded eye movements in five RBD patients with UN and hemianopia (N+H+), nine RBD patients with UN but no hemianopia (N+H−), four RBD patients with neither neglect nor hemianopia and four normal controls. Two task variables were orthogonally manipulated: (a) presence or absence of distracters and (b) short or long stimulus duration.

A significant interaction was found between groups, presence of distracters, stimulus duration and the direction of the first saccade made in the search. Independently of the temporal duration of targets, in N+H+ patients the presence of distracters enhanced the frequency of saccades directed ipsilesionally (i.e., rightward). In N+H− patients, distracters biased the first saccade toward the right side only at short stimulus duration.

These data show that bias of attentional orienting toward stimuli in the right half of space is specific of UN. This pathological mechanism (a) is enhanced and prolonged, over the period of exploration, by concomitant complete contralateral hemianopia and (b) is most evident, even in the absence of concomitant visual field defects, when voluntary planning of attention and eye movements are precluded by the short duration of stimuli to be inspected.

1. Introduction

Unilateral spatial neglect (UN) frequently follows right brain damage (RBD) and consists of the failure to report, respond or orient toward stimuli in the contralesional side of space. Several authors (e.g., Anderson et al., 2000; Colombo et al., 1982; Friedland and Weinstein, 1977; Ishiai et al., 1993; Halligan and Marshall, 1992; Small and Ellis, 1994) have observed that in most patients UN can show a remarkable degree of variability over time or across tasks. Some authors have attributed this variability to the heterogeneous nature of UN and to the possibility of fractionating UN into more homogeneous entities,

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according to various criteria. Thus, it has been proposed to distinguish: (a) 'allocentric' from 'egocentric' and 'object centered' forms of UN, on the basis of the reference frame predominantly or exclusively affected by UN; (b) 'personal' from 'peri-personal' and 'extrapersonal' forms, on the ground of the sector of space affected by UN and (c) perceptual ('visual–spatial') from motor ('directional hypokinesia') and from 'representational' forms, on the basis of the cognitive domain affected by UN (see Bartolomeo and Chokron, 2002; Gainotti, 1993, 1996; Halligan and Marshall, 1992, 1994; Kerkoff, 2001 for reviews). Some authors (e.g., Bartolomeo and Chokron, 2002; Gainotti, 1993, 1996; Vallar, 1998) have, however, argued against a strong version of the fractionation hypothesis (Halligan and Marshall, 1992, 1994; Kerkoff, 2001), stressing the similarity among the various forms of UN in terms of laterality of symptoms, localisation of damage and positive response to manipulations that can improve UN temporarily (e.g., caloric vestibular stimulation) or persistently (e.g., rehabilitation).

Another explanation of the variability of UN over time and across tasks is that some clinical and experimental variables might importantly influence its clinical expression. A model of UN emphasizing this possibility was proposed by Gainotti (1996) and expanded by Bartolomeo and Chokron (2002) basing on the review of a large amount of clinical and experimental data. One of the cornerstones of this model is the evidence that the presence of 'distracters' on the right half space markedly increases the severity of neglect for the left half space. Fisher (1956) first described a strong tendency of some RBD patients to automatically orient the gaze toward the right as soon as the examiner stretched his/her arms and prior to the actual administration of confrontation stimuli for visual field testing. Later on, Cohn (1972) called this clinical phenomenon 'magnetic gaze attraction'. Drawing on this classic clinical observations, several other authors (e.g., D'Erme et al., 1992; Gainotti et al., 1991; Mark et al., 1988; Natale et al., 2005; Seki et al., 1996) have shown that the presence of irrelevant stimuli in the right half space automatically captures the attention of neglect patients, increasing the severity of the syndrome. However, in patients with UN the exogenous capture of the patient's attention by the ipsilesional stimuli does not necessarily co-occur with the impairment of other components of spatial orienting of attention. The reflexive–automatic components could be selectively or preponderantly biased toward the ipsilesional right space, whereas the endogenous-controlled components could show much weaker or no lateral imbalance. This is supported by the efficacy of cueing procedures, aiming to intentionally orient toward the left the patient's attention in UN (Riddoch and Humphreys, 1983; Robertson et al., 1994). The sparing of endogenous-controlled components of spatial orienting suggests that part of the variability observed over time or across tasks in UN could be ascribed to two factors: (a) the different degrees of automatic versus controlled orienting of attention required by each task (see a discussion of this issue in Bartolomeo and Chokron, 2002; Bartolomeo et al., 1994; Gainotti, 1993) and (b) the influence of compensatory strategies linked to preserved voluntary orienting and/or elicited by increased awareness of the deficit. Several authors have, indeed, shown that in patients with some degrees of recovery from neglect, residual deficits can be observed on exploratory tasks, particularly in the earliest stages of oculomotor exploration (Goodale et al., 1990; Mattingley et al., 1994; Olk et al., 2002; Pflugshaupt et al., 2004).

Another factor that could explain part of the variability of the performance of neglect patients across different tasks is the presence of concomitant left-sided hemianopia. The relevance of visual field defects in the modulation of neglect phenomena had already been suggested by Gilliatt and Pratt (1952) and by Chedru (1976), who had shown that the presence of a left-sided hemianopia worsens the exploration of the ipsilateral space in neglect patients. The problem had been, however, subsequently disregarded due to the difficulty of disentangling in neglect patients the effects of hemianopia from those of neglect proper. More recently, several authors (e.g., Doricchi, 2002; Doricchi and Angelelli, 1999; Ferber and Karnath, 2001) have refocused attention on this problem, showing that neglect-related phenomena (as the ipsilesional deviation in the bisection of horizontal lines and the correct evaluation and reproduction of horizontal distances in the ipsilesional and the contralesional space) are more strongly influenced by the combination of hemianopia and neglect than by pure neglect. It is, therefore, possible that hemianopia may have a different influence on results obtained on different visual–spatial tasks.

The aim of the present research was to study the influence that three main factors, namely the presence of 'distracters', the duration of stimuli and the presence of concomitant hemianopia, could have on the direction of the first saccade in UN. We focused our investigation on the early stages of oculomotor exploration, because abnormalities in the very first stages of the exploratory activity were consistently documented in patients with recovered neglect and, in particular, when right-sided distracters are present in the array to be explored (Cohn, 1972; D'Erme et al., 1992; Gainotti et al., 1991; Mattingley et al., 1994; Olk et al., 2002; Pflugshaupt et al., 2004). Our study was based on the analysis of the direction of the first fast eye movement (i.e., saccade) performed at the beginning of visual search, immediately after the offset of the central fixation reference. We examined RBD neglect patients with and without hemianopia, RBD controls without neglect and hemianopia and healthy subjects. Eye movements were recorded in four different experimental conditions resulting from the crossed combination of (1) the presence versus absence of visual distracters and (2) the short (150 msec) duration of stimuli (i.e., making stimuli disappear before the beginning of the first saccade) versus the long (3 sec.) duration of the same stimuli (i.e., allowing for the voluntary planning of saccadic inspection). We reasoned that, on the one hand, short duration of stimuli should trigger and make necessary immediate automatic orienting whereas longer duration of stimuli should prompt and allow the use of intentional strategies of exploration during inspection. In summary, our experimental design allows for checking whether in neglect patients the influence of right-sided distracters on visual search behaviour is in turn modulated by the presence of hemianopia and the time of stimulus presentation.

The following set of predictions was advanced.

1. The presence of distracters should be a strong source of variance, orienting eye movements toward the right, irrespectively, of the duration of stimulus presentation.