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Kinematics of goal-directed arm movements in neglect: Control of hand in space

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Abstract—The present study investigated unrestrained, three-dimensional arm movements during goal-directed pointing in five patients with clinically manifest neglect to targets positioned either in the center or the left and right hemispace. Five patients with unilateral right hemispheric lesions without neglect and six healthy subjects served as controls. All subjects were able to point to these targets. Terminal accuracy of pointing did not differ between the three groups along the horizontal, vertical and anterior–posterior axis. Subjects' hand trajectories did not reveal direction-specific deviations from a straightline hand path. Our data show that deviations in the trajectories toward the ipsilesional side are not characteristic for patients with spatial neglect. We argue that exploratory and goal-directed motor behavior might not share the same egocentric, body-centered reference frame. A spatial reference frame for exploratory behavior is disturbed in patients with neglect resulting in a failure to explore the contralesional part of space by eye or limb movements. Its failure does not induce a spatial bias in hand trajectory formation during goal-directed arm movements in peripersonal space. Such deviations of reaching or pointing rather seem to be characteristic for patients with optic ataxia. © 1997 Elsevier Science Ltd. All rights reserved.

Key Words: human; brain damage; parietal lobe; spatial neglect; endpoint kinematics; arm movements.

Introduction

To establish co-ordination among limb segments during voluntary movements, the brain has to consider both spatial and temporal movement parameters. Yet, a rigid distinction between these two aspects is artificial, because position, distance, direction, and velocity are just various aspects of spatial information. However, there is increasing evidence that velocity and position are derived from different sensory cues and can be processed independently in the human brain [4, 18, 21]. To address this dichotomy, we here define *spatial* as related to position and orientation of body segments, and *temporal* as related to reaction time and movement speed.

Several studies that investigated possible motor deficits in patients with brain damage and neglect reported both spatial as well as temporal motor deficits in these patients (recently reviewed in [16]). The present paper addresses the issue of organizing hand movement in space, while we discuss the temporal aspects of co-ordination elsewhere [15]. Concerning the spatial control of movement abundant clinical and experimental findings indicate that patients suffering from neglect after right-hemispheric brain lesions fail to explore the contralesional part of egocentric space with limb [1, 7] or eye movements [12]. Although this asymmetry in exploratory motor behavior is observed in neglect, the terminal accuracy of goal-directed hand movements to single targets seems to be unaffected [19]. However, kinematic analyses of how the hand is moving to a target are still rare in patients with right hemispheric lesions and reveal, in part, different results.

Goodale *et al.* [8] investigated visually guided pointing movements in patients with right hemispheric lesions who exhibited signs of spatial neglect early in their clinical history. Yet, by the time they were tested, all patients had recovered and no longer showed evidence for clinically manifest neglect. Subjects were required to point with the index finger of the right hand to a small light-emitting diode (LED) which could appear at one of five locations in front of the subjects. In a second task, two LEDs were illuminated simultaneously and the subjects were required to place the index finger at the point perceived to be mid-distance between the two LEDs. The patients were able to accurately position the finger on a single target, while they noticeably deviated to the right in the bisection task. However, even during pointing to single

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