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Anatomical and psychometric relationships of behavioral neglect in daily living

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ABSTRACT

Spatial neglect has been related to both cortical (predominantly at the temporal–parietal junction) and subcortical (predominantly of the superior longitudinal fasciculus) lesions. The objectives of this observational study were to specify the anatomical relationships of behavioral neglect in activities of daily living (N-ADLs), and the anatomical and psychometric relationships of N-ADLs on one hand and components of neglect (peripersonal neglect and personal neglect) and anosognosia on the other. Forty five patients were analyzed for behavioral difficulties in daily living (on the Catherine Bergego scale) and the main components of neglect (using conventional clinical assessments) during the first months post right hemisphere stroke. Voxel-based lesion-symptom mapping was used to identify brain areas within which lesions explained the severity of bias in each assessment (non-parametric permutation test; $p < 0.01$, one tailed). N-ADLs was associated with lesions centered on the posterior part of the superior temporal gyrus and extending to the temporo-parietal junction, temporo-occipital junction and subcortical white matter (including the superior longitudinal fasciculus). Peripersonal neglect resulted from extended cortical lesions centered on the superior temporal gyrus and the inferior parietal gyrus, with subcortical extension. Personal neglect resulted predominantly from lesions centered on the somatosensory cortex and at a lesser degree on the superior temporal sulcus. Anosognosia resulted from lesions of the posterior inferior temporal gyrus and superior temporal gyrus. In anatomic terms, N-ADLs was strongly related to peripersonal neglect, and those relationships were also shown by the psychometric analysis. In conclusions, superior temporal gyrus and superior longitudinal fasciculus lesions have a pivotal role in N-ADLs. N-ADLs is principally related (anatomically and psychometrically) to peripersonal neglect, and at a lesser degree to anosognosia and personal neglect.

1. Introduction

The neuroanatomic bases of left spatial neglect have generally been explored in patients who were defined as neglect on the basis of spatial biases in clinical visual-motor tests. On this basis, researchers have identified neglect-related cortical lesions in the inferior parietal gyrus (IPG) (Vallar and Perani, 1986), IPG and temporo-parietal junction (TPJ) (Mort et al., 2003; Chechlacz et al., 2010; Saj et al., 2012), superior and middle temporal gyri (STG and MTG) (Karnath et al., 2001; Chechlacz, et al., 2010; Ptak and Schnider, 2011; Saj et al., 2012), temporal–occipital junction (TOJ) (Saj et al., 2012), insula (Karnath et al., 2004) and inferior frontal gyrus (IFG) (Husain and Kennard, 1997) in the right hemisphere. Lesions of the subcortical white matter (SCWM) most frequently involved the superior longitudinal fasciculus (SLF) (Karnath et al., 2009; Thiebaut de Schotten et al., 2014) (especially the SLF II branches for chronic neglect), striatum and pulvinar (Karnath et al., 2002). However, the relationships between brain lesions and neglect depend on the tests used for defining its presence (Saj et al., 2012). In addition, neglect has several dissociable components, and different lesions have been implicated in extrapersonal and personal neglect (Committeri et al., 2007).

The voxel-based lesion-symptom mapping (VLSM) technique (Bates et al., 2003) can investigate relationships between the presence of a lesion in small brain areas and the severity of patient difficulties (presented as a continuous variable) in tests representative of specific neglect components. A recent study reported that the perceptual component was related to IPG lesions, the exploratory and motor components to dorsolateral prefrontal cortex lesions, and the allocentric component to deep temporal lesions (Verdon et al., 2010).

In the patient perspective, spatial neglect is characterized by behavioral difficulties in activities of daily living (ADLs), (neglect in

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ADLS: N-ADLs) such as omitting eating foods or grooming in the contralesional space, and it has been proposed that measuring these difficulties provides a better estimation of the reality of neglect than its assessment by paper and pencil tests (Bergego et al., 1995; Azouvi et al., 2003; Goedert et al., 2012). The psychometric relationships of N-ADLs with classical neglect components (i.e. relationships observed on the basis of neglect tests) have been partially explored. One recent study suggested that the neglect behavior in an ecological test was in close relationships with anosognosia for visuospatial deficits, before motor-intentional and perceptual–attentional neglect (Vossel et al., 2013). In contrast, another study described that N-ADLs was principally associated with peripersonal neglect (Nijboer et al., 2014); however, relationships with anosognosia were not explored. In an anatomic point of view, the first study suggested that neglect behavior resulted from middle frontal gyrus (MFG) and SCWM lesions (Eschenbeck et al., 2010; Vossel et al., 2013). All these studies are important, but three main points can be emphasized (i) the anatomic substrate of neglect behavior in daily living activities is somewhat divergent from previous descriptions of neglect-related temporo-parietal lesions (ii) the relationships between N-ADLs and neglect components are relatively divergent between studies, and the possible influence of anosognosia has to be confirmed (iii) the exploration of anatomic convergence between N-ADLs and the main neglect components may help explain the psychometric convergences.

In a population of patients with right hemisphere stroke, we analyzed the anatomic substrate of N-ADLs and the anatomic relationships with peripersonal neglect, personal neglect and anosognosia. In parallel, we explored the psychometric relationships of N-ADLs with these classical neglect components. As regards the aforementioned influence of peripersonal neglect and anosognosia on N-ADLs, we made the hypothesis that the anatomic investigation would contribute to explain the psychometric convergences.

2. Methods

2.1. Participants

We performed a retrospective cohort analysis of prospective data collected in the Neurorehabilitation department at Lille University Medical Centre (Lille, France). Patients were admitted to the study within five months of a right hemisphere stroke. All participants gave their written informed consent to participation. This observational study was performed in accordance with the precepts of the Declaration of Helsinki. We excluded patients with bilateral lesions, previous neurological or psychiatric disorders, impaired primary visual perception (except for visual field defects), behavioral disorders, and pusher syndrome (i.e. contralateral trunk deviation with active resistance of any attempted external correction).

2.2. Patient assessment

N-ADLs was explored by the Catherine Bergego scale (CBS) (Bergego et al., 1995; Azouvi et al., 2003), a questionnaire assessing the severity of neglect in 10 ADLs (with a focus on the contralesional side): grooming/shaving, adjusting the sleeve or slipper, eating, cleaning mouth after eating, looking towards the left, forgetting about a left part of the body, paying attention to noise or people, colliding with people or objects, finding his/her way in familiar places, and finding his/her personal belongings. The questionnaire was presented to the patient's occupational therapist (hetero-evaluation, the most reliable way of assessing neglect), who rated the severity of neglect for each ADL in real life conditions from 0 (never) to 3 (almost always). It was also filled out by the patient (self-evaluation). The difference between the two ratings provides a validated measure of anosognosia (Azouvi et al., 2003). We considered that patients presented with N-ADLs when the score of difficulties was ≥ 6 out of 30.

We explored two main components of neglect (peripersonal neglect and personal neglect) and anosognosia.

The peripersonal neglect tasks were line bisection (Schenkenberg et al., 1980) and target cancellation (Gauthier et al., 1989). We used bisection of 18 horizontal lines presented on the central, left or right parts of a horizontal A4 sheet. The dependent variable was the average percentage of deviation from the objective mid-lines. The cut-off score for spatial neglect was a deviation $\geq 11\%$ (Schenkenberg et al., 1980). Target cancellation used the bell test, in which the participant had to cancel 35 bells placed in 7 columns on a horizontal A4 sheet; 15 were placed on each side (left and right) of 5 others in a central column. The dependent variable was the numbers of left omissions. In that task, the cut-off score for spatial neglect was a number of left omissions ≥ 2 (Rousseaux et al., 2001). We considered that patients presented with peripersonal neglect when pathological performance was observed in at least one of the two tests.

Personal neglect tasks were reaching the contralesional hand with the healthy hand (Bisiach et al., 1986) and a test of the subjective straight-ahead (SSA) (Richard et al., 2004). The first one explores neglect of a lateral part of the body and the second one neglect for the body midline. Reaching the hand located at the lateral part of the trunk was performed with the eyes open and eyes closed; in each subtest, performance was evaluated from 0 (target reached without hesitation) to 3 (no movement towards the target). The cut-off score for pathological performance was a score ≥ 1. In the SSA test, the participant had to place a luminous rod (movable in the frontal plane) straight ahead of the middle part of the trunk in the dark. Six trials were performed, in order to measure the mean deviation (in centimeters) from the objective straight-ahead. The cut-off score for pathological performance was a deviation ≥ 2.5 cm. We considered that patients presented with personal neglect when pathological performance was observed in at least one of the two tests.

For anosognosia, we used the difference between the examiner's evaluation and the patient's evaluation on the CB scale and a specific test for anosognosia of deficits (Bisiach et al., 1986). The first score represents anosognosia of behavioral difficulties (Azouvi et al., 2003). The second one investigates anosognosia of hemiplegia and anosognosia of visual perception disorders, each scored from 0 (disorder spontaneously reported or mentioned after a general question) to 3 (disorder not recognized by the patient, even after demonstration). In the CBS scale, we considered that patients had behavioral anosognosia when the difference between the examiner and patient evaluations was greater than 4. In the Bisiach's test, anosognosia was defined by a score > 1.

We analyzed the presence of ocular and cephalic deviation, which was coded from 0 (no deviation) to 1 (inconstant deviation), 2 (constant deviation, reducible upon verbal incitation) and 4 (non reducible deviation). Visual field defects were assessed clinically. The patient had to detect and discriminate between two-second finger movements (two trials) and catch trials (two trials) in each quadrant, following demonstrations of movement and no movement in the unaffected hemifield. We considered that hemianopia was probable when a “no” response was produced repeatedly. The visual field was examined instrumentally using kinetic (Goldmann) perimetry. The defect was coded from 0 (no deficit) to 1 (partial deficit: quadrantanopia or partial hemianopia), and 2 (complete hemianopia).

We also examined the severity of motor deficit scored from 0 (no deficit) to 1 (deficit, walking possible) and 2 (severe motor

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