Brain & Language 147 (2015) 21–29

Contents lists available at ScienceDirect

Brain & Language

journal homepage: www.elsevier.com/locate/b&l

Right unilateral spatial neglect in aphasic patients

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ARTICLE INFO

Article history:
Received 7 September 2014
Accepted 2 May 2015

Keywords:
Leftward deviation
Aphasic patients
Language task
Directional attention
Left brain damage
Right unilateral spatial neglect
Severe aphasia
Moderate aphasia
Mild aphasia

ABSTRACT

To investigate spatial responses by aphasic patients during language tasks, 63 aphasics (21 severe, 21 moderate, and 21 mild) were administered two kinds of auditory pointing tasks—word tasks and sentence tasks—in which the spatial conditions of the stimuli were controlled. There were significantly fewer correct responses on the right side of a space than on the left side in both the word and sentence tasks, but the left deviation of correct responses was more prominent in the sentence task than in the word task. Additionally, the severe aphasics exhibited a prominent leftward deviation that may have been the result of deficits in rightward attention controlled by the left hemisphere. This phenomenon also seems to reflect the directional attention that is subserved by the right hemisphere, which attends to the left side of a space and, less predominantly, the right side of a space.

1. Introduction

Unilateral spatial neglect (USN) is a symptom in which patients fail to report, respond, or orient to meaningful stimuli presented to the spatial side opposite a brain lesion (Heilman, 1979). Generally, the severity and frequency of USN after right brain damage (RBD) are not equal to those that occur after left brain damage (LBD); RBD tends to cause salient left USN whereas LBD may cause mild right USN. The neural substrates for these asymmetric phenomena have been discussed previously (Bisiach & Vallar, 2000; Halligan & Marshall, 1993; Heilman, 1979; Heilman, Valenstein, & Watson, 1985; Heilman & Van Den Abell, 1980; Hillis, 2006; Kinsbourne, 1977, 1987, 1993; Mesulam, 1981, 1985, 2000).

Kinsbourne (1977) argued that the brain has control centers for rightward and leftward orientations that are mutually inhibitory and that the rightward-orienting tendency subserved by the left hemisphere is more powerful than the leftward-orienting tendency subserved by the right hemisphere. Kinsbourne also argued that the two hemispheres are reciprocally interactive and maintain a functional balance; if one hemisphere is damaged, then the other might be disinhibited and take over to the extreme of its behavioral range. Thus, the function of the left hemisphere may be released and dominate after RBD while the function of the right hemisphere may dominate after LBD.

Heilman and Van Den Abell (1980) proposed that the left hemisphere attends to contralateral stimuli while the right hemisphere attends to both contralateral and ipsilateral stimuli. This hypothesis proposes that after RBD the intact left hemisphere attends to only the right side of space and causes profound left USN while after LBD the intact right hemisphere attends to both the right and left sides of space and right USN is less prominent. Mesulam (1981, 1985, 2000) added to this hypothesis by proposing that the rightward attention that is subserved by the right hemisphere is less predominant than leftward attention. Kashiwagi, Kashiwagi, Nishikawa, Tanabe, and Okuda (1990) observed the phenomenon of USN in a callosal-damaged patient following a cerebral infarction, which seems to support Mesulam's hypothesis. This patient exhibited remarkable left USN in activities that required left hemisphere functions, such as language tasks and copying or pointing with the right hand, but mild right USN in activities that required right hemisphere functions, such as copying or pointing with the left hand.

An increasing amount of evidence from recent activational studies using positron emission tomography (PET), functional magnetic resonance imaging (fMRI) (e.g., Corbetta, Miezin, Shulman, & Petersen, 1993; Gitelman et al., 1999), and transcranial magnetic stimulation (TMS) (e.g., Duecker, Formisano, & Sack, 2013) supports the hypothesis that functional differences

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http://dx.doi.org/10.1016/j.bandl.2015.05.001
0093-934X/

exist in directional attention subserved by the right and left hemispheres.

Right USN, although mild, has been described in clinical studies of aphasic patients (Benson, 1979; Darley, 1982; Shewan & Bandur, 1986). During rehabilitation, aphasics may occasionally fail to attend to a stimulus in the right side of space during tasks such as auditory pointing to pictures or objects with the normal left hand. However, there have been significantly fewer investigations of USN in aphasic patients than in RBD patients.

To date, studies of USN or selective attention in LBD patients have primarily used nonverbal tasks (Maeshima, Shigeno, Dohi, Kajiwara, & Komai, 1992; Petry, Crosson, Rothi, Bauer, & Schauer, 1994; Posner, Inhoff, Friedrich, & Cohen, 1987) and aphasic patients have been included in these studies. For example, Petry et al. (1994) administered the covert orientation of visual attention task (COVAT) to 13 LBD patients with aphasia and found that there was a positive correlation between the severity of aphasia and the attenuation of a response to a stimulus on the right side of space. Although Kleinman et al. (2007) investigated right USN in LBD patients using both nonverbal and verbal tasks, such as the reading of words and sentences and oral spelling, the cited authors did not provide information on aphasics. To date, only a few studies have investigated USN in aphasics using language tasks. Lecours et al. (1987) investigated the difference in responses between LBD and RBD patients using auditory comprehension tasks that required them to match verbal stimuli consisting of simple and complex sentences with line-drawn pictures. These authors reported that right USN in LBD subjects primarily manifested with complex sentences whereas left USN in RBD subjects manifested regardless of the complexity of the target sentences. However, the relationship between these results and aphasia remains unclear because no information about aphasia, such as the number of aphasics or the severity of the aphasia in the 99 LBD subjects, was provided. Additionally, the spatial position of the stimuli was not controlled in their study.

To our knowledge, no studies have investigated the appearance of USN in aphasics using language tasks with well-controlled spatial conditions. If USN is accompanied by aphasia, responses considered to be aphasic symptoms may in fact be complicated by problems of spatial attention. A clarification of the tendencies of the spatial responses by aphasics in language tasks will not only be useful for aphasic rehabilitation, such as designing language tests for aphasia, appropriately evaluating higher brain disorders in aphasics, setting clinical situations for speech therapy, and advising the family and clinical staff how best to make contact with aphasics in daily life, but also for determining the function of spatial attention in humans as well. Thus, the present study used language tasks in which the spatial conditions of the stimuli were controlled to investigate spatial attention in aphasic patients.

2. Materials and methods

2.1. Subjects

The present study included right-handed aphasic patients with LBD but no apparent damage in the right hemisphere according to computed tomography (CT) or MRI scans. Patients who could not point to the pictures because of severe apraxia, tremors, and/or optic ataxia or who could not understand how to perform the tasks because of severe intellectual disabilities were excluded from the study. In total, 63 aphasic patients (35 males and 28 females) who provided informed consent for the experiments participated. The ages of the subjects ranged from 36 to 81 years (mean ± standard deviation [SD]: 61 ± 10.7 years) and the post-onset duration was 1 to 180 months (mean: 17.4 ± 27.8; median: 10 months). There were 28 cases of cerebral infarction, 26 cases of cerebral hemorrhage, 7 cases of subarachnoid hemorrhage, and 2 cases of closed head injuries. Visual field defects were observed in 9 patients and unclear in 1; the other 53 patients did not exhibit visual field deficits during confrontation testing. Aphasic severity was classified into three levels[1] based on oral language scores of auditory comprehension and spoken tasks on the Standard Language Test of Aphasia (SLTA; Hasegawa, Takeda, Tsukuda, Takeuchi, & Wada, 1977): severe ($n = 21$), moderate ($n = 21$), and mild ($n = 21$). The characteristics of each group are summarized in Table 1.

2.2. Task and procedure

A word picture pointing task (word task) and a sentence picture pointing task (sentence task) that were based on the auditory comprehension tasks in the SLTA were modified and developed for the present study. Patients who completed the SLTA before the experiments were administered these modified tasks at least 1 month after the SLTA had been given. The original tasks in the SLTA consisted of 1 example and 10 items in both the word and sentence tasks. In the word task, patients were asked to point to one of six line-drawn pictures that corresponded to a spoken word one at a time. One printed page was used for each two items (e.g., "sun" and "car") (Fig. 1A). In the sentence task, patients were asked to point to one of four line-drawn pictures that corresponded to a spoken sentence. One printed page was used per item (e.g., "A girl is reading a book") (Fig. 1C).

To compare the patients' responses to the targets on the right and left sides of the pages in each task, new pages were created in which the pictures on the right and left sides of the original pages were exchanged for the same targets as the original tests and 10 more items were added to each of the word and sentence tasks (Fig. 1B and D). Thus, the word task consisted of 20 total targets: 7 targets on the left, 7 targets on the right, and 6 targets in the center. The responses to the targets in the center were excluded and scored as dummies and the target words used for scoring were as follows: horse, sun, socks, telephone, water, glasses, and house. The sentence task consisted of 20 total targets: 10 targets on the left and 10 targets on the right. To make the maximum scores in the word and sentence tasks the same, the responses to the first three sentences of the original sentence task and the responses to the same three sentences in which the right and left pictures had been exchanged in the modified task were excluded from scoring. The target sentences used for scoring were as follows: "A boy gets on a bus," "A bird is flying," "A child is inflating a balloon," "A girl is reading a book," "A boy is watching the girl who is drawing pictures," "A train is crossing a railway bridge," and "A girl is being hit by the boy." One point was given for a correct response; thus, there was a maximum score of 7 for each of the right and left sides (total score of 14) in both the word and sentence tasks. The auditory stimulus was given once, and each patient was asked to use his/her left hand to point to the picture on the printed page that

[1] The auditory comprehension tasks used to assess aphasic severity in the present study consisted of 10 word comprehension items, 10 sentence comprehension items, and 10 oral command items. Full scores were converted to 10 for the word and sentence comprehension tasks and to 20 for the oral commands such that the maximum score was 40 in the auditory comprehension task. The spoken tasks used to assess aphasic severity consisted of 20 instances of the confrontation naming of line-drawn pictures items, 10 word repetition items, 10 action description items, 5 sentence repetition items, a description of a 4-frame comic, and word fluency in the animal category. Full scores for each task were converted to a value of 10 such that the maximum score was 60 for the spoken tasks. The sums of the scores for the auditory comprehension and speech tasks ranged from 0 to 32 in the severe group, 33–65 in the moderate, and 66–100 in the mild group. This distribution closely paralleled the clinical impressions of the severity of each patient's ability to communicate.