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Are memory deficits dependent on the presence of aphasia in left brain damaged patients?

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ABSTRACT

While memory deficits in aphasia have been reported in several studies, it has been suggested that these deficits are not due to the presence of aphasia, but rather to the left hemisphere lesion per se. In order to investigate this hypothesis, we tested 64 aphasic and 15 non-aphasic patients with left brain damage on verbal and visuospatial span tasks. Analyses revealed lower than expected performance on all four primary memory tasks for the aphasic, but not for the non-aphasic group. Moreover, comparison of the three lesion-location groups (posterior, anterior, and global) did not reveal statistically significant differences. The present data show that aphasic patients demonstrate memory deficits, which are not specific to the verbal modality, and contradict the notion that primary memory impairment is not due to the presence of aphasia, but rather to a lesion in the left hemisphere per se. Overall our study suggests that verbal and visuospatial, primary memory deficits in patients with left hemisphere lesions are possibly dependent on the presence of aphasia, but not on lesion location or lesion size.

1. Introduction

Several studies have already reported that aphasic patients suffer from memory deficits (Beeson, Bayles, Rubens, & Kaszniak, 1993; Laures-Gore, Marshall, & Verner, 2011; Martin & Ayala, 2004). It has been suggested that these deficits are not due to the presence of aphasia, but rather due to a left hemisphere lesion per se. Burgio and Basso (1997) compared left brain damaged (LBD) patients with and without aphasia on several memory tasks and concluded that a) primary memory impairment was due to a left hemisphere lesion independent of the presence of aphasia and b) lesion location did not differentiate between patients regarding memory task performance.

To our knowledge, there is no study replicating the work of Burgio and Basso (1997), by comparing LBD patients with and without aphasia regarding short-term and working memory (henceforth STM and WM, respectively) capacity. Lang and Quitz (in press) recently showed that aphasic patients perform significantly worse on STM and WM tasks than non-aphasic brain damaged patients (a mixed group of patients with left, right, or bilateral lesions), in both verbal and spatial modalities. However, even if such a direct comparison (aphasic vs. non-aphasic patients) within a LBD patient group has not been replicated, several researchers have investigated STM and WM using verbal and spatial span tasks, with a variety of neurological patients.

There are conflicting results regarding the role of posterior and anterior cortices in the brain circuits responsible for verbal STM/WM. Lesion studies suggest a relation between posterior regions and STM/WM, while brain imaging studies generally report consistent activation of prefrontal areas during verbal STM/WM tasks. Regarding verbal STM, left posterior lesions are associated with immediate serial recall deficits (Beeson et al., 1993). Moreover, Leff et al. (2009) have shown that the structural integrity of the posterior region of the superior temporal gyrus and sulcus independently predicts auditory STM capacity (digit span). The posterior parietal cortex (PPC) is generally considered to be essential for WM, being involved in attention (Berryhill, Chein, & Olson, 2011). Thus, in healthy participants, performance of digits forward and digits backward tasks elicits hemodynamic responses in the inferior parietal lobule (Gerton et al., 2004). This association between posterior lesions and poor performance on verbal span tasks has been also confirmed by meta-analyses (e.g., Vallar & Papagno, 1995) and PET studies (e.g., Paulesu, Frith, &

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Frackowiak, 1993). On the other hand, patients with frontal lobe lesions seem to be unimpaired on verbal span tasks (Alexander, Stuss, & Fansabedian 2003; Owen, Downes, Sahakian, Polkey, & Robbins 1990), and such lesion loci are shown to contribute little to any observed decline of performance in these tasks (Della Sala, Gray, Spinnler, & Trivelli, 1998). The independence between frontal lobe lesions and verbal span performance was confirmed by a meta-analysis carried out by D'Esposito and Postle (1999), suggesting that lesions located in the prefrontal cortex do not result in STM/WM impairment as indexed by verbal span tasks, such as digit span. However, a meta-analysis of functional brain imaging studies of WM in neurologically intact participants (Wager & Smith, 2003), stressed the link between the left lateral frontal cortex (BA 44, 45, 46, and 6) and performance on verbal WM tasks. Concurrent activation of both frontal and parietal regions in the context of digits backward and forward tasks has also been reported in healthy participants (Gerton et al., 2004).

Impaired performance on visuospatial primary memory tasks (e.g., Corsi blocks) is traditionally linked to right hemisphere lesions (De Renzi & Nichelli, 1975; D'Esposito et al., 1998; Kessels, van Zandvoort, Postma, Kappelle, & de Haan, 2000). However, recent research indicates the involvement of the left hemisphere in spatial memory. There are studies demonstrating impaired performance of LBD patients on Corsi blocks (Baldo & Dronkers, 2006; Kessels, Kappelle, de Haan, & Postma, 2002). Moreover, several researchers report comparable performance between LBD and right Brown, Fitch, & Tallal 1999; van Asselen et al., 2006; Nys, van Zandvoort, van der Worp, Kappelle, & de Haan, 2006).

Regarding the regions involved in the brain circuit responsible for primary visuospatial memory, the role of the parietal lobe has been highlighted by recent studies (Berryhill & Olson, 2008; Olson & Berryhill, 2009). A meta-analysis carried out by D'Esposito and Postle (1999) revealed that lesions located at the prefrontal cortex do not result in STM/WM impairment as indexed by spatial span tasks, such as Corsi blocks. They claim that simple spatial span performance is not dependent on prefrontal cortex integrity. Nevertheless, recent studies implicate a fronto-parietal network, which includes the posterior parietal cortex, the dorsolateral prefrontal cortex and the anterior cingulate (Ricciardi et al., 2006). This claim is supported by lesion studies. For example, Beeson et al. (1993) did not find any differences in performance on the Visual Memory span subtest of the Wechsler Memory Scale-Revised (WMS-R; a task similar to Corsi blocks) between LBD aphasic patients with posterior and anterior lesions.

The current study is an extension of an earlier report from our group demonstrating memory deficits in both verbal and visuospatial modalities among aphasic patients, and showing that the severity of these deficits correlated with the severity of their language impairment (Potagas, Kasselimis, & Evdokimidis, 2011). The present research report focuses on two hypotheses, derived from the study of Burgio and Basso (1997): First, is STM/WM impairment following left hemisphere damage independent of the presence of aphasia? If this were true, then LBD patients with and without aphasia would be equally impaired on STM/WM memory tasks. Second, is the location of the lesion, within the left hemisphere, associated with the severity or type (verbal, spatial) of memory impairment? If this were true, then we expect to find differences on memory scores according to lesion location (posterior, anterior, deep, and global).

2. Methods

2.1. Tests

Aphasia was assessed using the Boston Diagnostic Aphasia Examination-Short Form (BDAE-SF; Goodglass & Kaplan, 1972), adapted in Greek (Tsapkini, Vlahou, & Potagas, 2009). Memory span was tested in the verbal and spatial modalities through the WAIS-III Digit Span (Wechsler, 1997), and the Corsi block-tapping tasks (Corsi, 1972), respectively. Both tasks provide separate scores for forward and backward recall. Given that STM refers to retaining information in consciousness for a short period of time and WM to manipulating the transiently available information, Digit Span forward (where the participant is asked to simply retain a series of numbers) and backward (where the participant is asked to recite the numbers in reverse order) conditions assess verbal STM and WM respectively.

2.2. Participants

Sixty-four aphasic (14 women), and fifteen (8 women) non-aphasic patients with left hemisphere lesions participated in this study. Mean age for the two groups was 60.19 (SD=14.44) years and 57.93 (SD=11.04) years, respectively ($p>.05$). Mean educational level (years of formal schooling) for the two groups was 11.16 (SD=4.26) years and 10.33 (SD=4.64) years, respectively ($p>.05$). All patients underwent neurological examination. No visual deficit was reported by the neurologist. CT and/or MRI scans were obtained for 61 patients (50 aphasic patients) and lesion sites were identified by a neuroradiologist blind to the neuropsychological results. Lesion size was calculated based on the ABC method suggested by Kothari et al. (1996). As a group the aphasia patients presented with larger lesion size (M=75.94, SD=66.56) than the non-aphasic group (M=25.17, SD=24.49), Mann-Whitney U=62.00, p=.020. Presence of aphasia was determined on the basis of BDAE-SF performance.

2.3. Exclusion criteria for aphasic patients

Severe fluency and/or comprehension deficits could lead to serious underestimation of immediate memory capacity. Based on span score alone, a patient with language disturbance could be wrongly classified as memory-impaired, simply because of inability to produce even short utterances or understand what he/she is asked to do. In order to overcome this issue, patients with severe language deficits were excluded based on the criteria employed in our previous study (Potagas et al., 2011), before conducting the statistical analyses: For Digit Span forward and backward, patients who could not repeat at least one 2-syllable word (of the BDAE-SF word repetition subtest) or lacked the ability to execute a simple, one-item command (from the BDAE-SF sentence comprehension subtest) were excluded. Thus, 49 patients (11 women) with a mean age of 59.80 (SD=15.21, range=24–84) years were included in the analyses regarding digit span forward and backward. For the Corsi block-tapping task, since a verbal response is not required, only patients who could not execute a simple, one-item command (from the BDAE-SF sentence comprehension subtest) were excluded. In this case, 54 patients (12 women) with a mean age of 60.15 (SD=14.75, range=24–84) years were included in the respective analyses.

2.4. Analyses

The analytic strategy was similar to our previous research report (Potagas et al., 2011). Product scores (span length * span score) were first calculated separately for forward and backward Digit Span, and for forward and backward spatial span, based on performance on WAIS-III verbal span tasks and the Corsi block-tapping task respectively. Then a critical value was estimated for the difference between each of the four mean product scores obtained for each subgroup in the present study and mean product scores reported in a normative study for 246 healthy older adults (Kessels, van den Berg, Ruis, & Brands 2008).

3. Results

Results of the one sample t-tests and critical values for each comparison are reported in Table 1. As a group, patients with aphasia displayed lower than expected performance on all four memory tasks. In contrast, the performance of patients with left hemisphere lesions who did not develop aphasia did exceed the critical value on all memory indices. Independent sample t-tests, revealed significant differences on all memory tasks (product scores) between the two groups (forward digit span: t [62]=−4.787, $p<.001$; backward digit span: t [62]=−4.275, $p<.001$; spatial forward span: t [67]=−2.030, $p<.05$; backward spatial span: t [67]=−484, $p<.01$). Given that the two groups differed on average lesion size, these results were complemented with ANCOVAs with Group (aphasic, non-aphasic) as the between subjects variable and lesion size as a covariate. Inclusion of lesion size a s a covariate, did not affect the significance of the group effect on forward digit span ($p<.001$), backward digit span ($p<.05$), and