Localizing lesion locations to predict extent of aphasia recovery

Abstract

Extensive research has related specific lesion locations to language impairment in aphasia. However, far less work has focused on the patterns of brain damage that predict prognosis in aphasia. The current study examined brain damage as a predictor of language recovery in acute patients with aphasia caused by stroke. Damage to the left posterior middle temporal gyrus (MTG) and left *pars triangularis* predicted poor recovery of speech production and MTG damage predicted less recovery of speech comprehension. These findings suggest that brain changes associated with language recovery rely on preservation and recruitment of the aforementioned areas in the left hemisphere.

Introduction

Recovery from stroke can vary substantially among patients, even in cases where the initial severity of impairment may be similar (Lazar & Antoniello 2008; Lazar et al., 2008). The prognosis for aphasia recovery depends in large part upon the underlying etiology and location and extent of brain damage (Pedersen et al., 1995). Most patients with post-stroke aphasia improve to some extent (e.g. Inatomi et al., 2008; Berthier, 2005; Wade et al., 1986; Pedersen et al., 1995; Ashtary et al., 2006; Laska et al., 2001), but some only make minimal improvement. The severity of the initial aphasia strongly correlates with the long-term deficit; those with milder degrees of aphasia at onset are the most likely to recover completely (Pedersen et al., 2004; Bakheit et al., 2007; Lazar et al., 2010).

Advances in neuroimaging have greatly improved our understanding of stroke not only in the acute, but also in the subacute and chronic stages of recovery. MRI and computed tomography allow clinicians to more accurately diagnose stroke subtypes, optimize treatment, and predict prognosis. Thus, neuroimaging in stroke may also be utilized to monitor response to both medical treatment as well as physical rehabilitation (Gale & Pearson, 2012). Although some early studies may have argued that lesion volume was likely to be more important than lesion location when predicting outcome (e.g. see Brott et al., 1989), more recent studies have increasingly demonstrated the importance of lesion location (Gale & Pearson, 2012).

In the current study we sought to determine sites and extent of brain damage that predicted less aphasia recovery as determined by neuropsychological testing.

Method

Participants. The participants included in this study were 34 stroke patients (female=18; mean age = 67.78; range = 40-79 at time of recruitment) admitted to the Landspitali – University Hospital in Reykjavik, Iceland. All participants had incurred a single event ischemic stroke to the left hemisphere and provided informed consent for study inclusion.
Participants did not need to present with aphasia to qualify for this study. All participants were tested at the acute phase of stroke and again at chronic phase of stroke (2-5 years post-onset).

Procedure. All participants were administered a neuropsychological workup, which included the Bedside Evaluation Screening Test, 2nd edition (BEST-2; West, Sands, & Ross-Swain, 1998).

The BEST-2's Conversational expression sub-test served to quantify the severity of speech production impairment and the "Pointing to Parts of Picture" subtest served to quantify the severity of speech comprehension impairment. Each subtest includes five items where the level of presentation of each item is titrated based on patients' success with the previous item. Each item includes: 1) complete sentence; 2) phrase; 3) single word. Based on the BEST-2 overall aphasia severity scale, six patients had severe language impairment, eight had moderate impairment, while twenty patients presented with mild or no language impairment. At time of retesting only one person had severe language impairments, three had moderate impairments and thirty patients presented with mild or no language impairment. See table 1 for demographic information, test scores and severity scores.

All participants underwent a 1.5T MRI scanning sequences (using a Siemens Avanto system) that included T1, T2* and diffusion weighted imaging (DWI) sequences. For the purpose of predicting recovery based on lesion location, the location and extent of brain damage was demarcated on the DWI scans by a neurologist with extensive experience using this methodology.

Data Analysis. A voxelwise correlation analysis of structural damage as a predictor of recovery was conducted in MATLAB (Mathworks, Inc.) via custom software. The dependent factor was change in scores on the two subtests; the independent factor was structural damage as demarcated on T2-MRI. In order to control for severity of the initial language impairment, baseline scores were included in the model as a cofactor. The crucial question here was whether patients with common damage to specific brain region(s) tended to make less recovery compared to those patients in which the same region remained intact following stroke.

Results

Damage to the left posterior middle temporal gyrus (MTG) and left *pars triangularis* was found to predict less recovery on subtest 1, Conversational Expression, on the BEST-2. Damage to a similar, but distinct region in the left posterior MTG was associated with less recovery on subtest 6, Pointing to parts of picture, on the same test (Figure 1).

Discussion

The application of neuroimaging has revealed much about the physiology of early stroke recovery, including that of aphasia. Although it is not entirely clear how this informs early treatment of aphasia, it is possible that a better understanding of the neurophysiological dynamics of stroke will allow us to manage our resources better during each phase of recovery and thereby maximize long-term aphasia recovery. For patients with chronic aphasia, neuroimaging has revealed that successful aphasia treatment, along with improving communication ability, does influence both brain function and brain structure. Although the obvious goal of aphasia treatment is to improve the patients' ability to communicate, understanding how aphasia treatment influences the brain may, in turn, improve the selection of the specific treatment approach.

Our findings suggest that brain changes associated with recovery of both speech production and comprehension rely on preservation and recruitment of aforementioned areas of cortex in the left hemisphere. In general, it also seems likely that a similar relationship between cortical preservation and recruitment may also pertain to recovery from other functional impairments in chronic stroke. Our findings contribute to research regarding the neuroanatomical mechanism of aphasia recovery, and may ultimately improve its treatment.

References

Ashtary F, Janghorbani M, Chitsaz A, et al. A randomized, double-blind trial of bromocriptine efficacy in nonfluent aphasia after stroke. Neurology 2006; 66:914-916.

Bakheit AM, Shaw S, Carrington S, Griffiths S. The rate and extent of improvement with therapy from the different types of aphasia in the first year after stroke. Clin Rehabil 2007;21(10):941-949

Berthier ML. Poststroke aphasia: epidemiology, pathophysiology and treatment. Drugs and Aging 2005; 22:163-182.

Brott, T, Marler JR, Olinger CP, Adams HP, Tomsick T, Barsan WG, Biller J, Eberle R, Hertzberg V, Walker M. Measurements of acute cerebral infarction: lesion size by computed tomography. Stroke 1989;20(7):871-875.

Inatomi Y, Yonehara T, Omiya S, et al. Aphasia during the acute phase in ischemic stroke. Cerebrovasc Dis 2008; 25:316-323.

Gale SD, Pearson CM. Neuroimaging predictors of stroke outcome: Implications for neurorehabilitation. NeuroRehabilitation 2012;31(3):331-344.

Laska AC, Hellblom A, Murray V, et al. Aphasia in acute stroke and relation to outcome. J Intern Med 2001; 249:413-422.

Lazar RM, Antoniello D. Variability in recovery from aphasia. Curr Neurol Neurosci Rep 2008;8:497–502.

Lazar RM, Speizer AE, Festa JR, Krakauer JW, Marshall RS. Variability in language recovery after first time stroke. J Neurol Neurosurg Psychiatry 2008;79:530–534.

Lazar RM, Minzer B, Antoniello D, et al. Improvement in aphasia scores after stroke is well predicted by initial severity. Stroke 2010; 41:1485-1488.

Matlab (2007a) Natick, Massachusetts: The MathWorks Inc

Pedersen PM, Jørgensen HS, Nakayama H, et al. Aphasia in acute stroke: incidence, determinants, and recovery. Ann Neurol 1995; 38:659-666.

Pedersen PM, Vinter K, Olsen TS. Aphasia after stroke: type, severity and prognosis. The Copenhagen aphasia study. Cerebrovasc Dis 2004; 17:35-43.

Wade DT, Hewer RL, David RM, Enderby PM. Aphasia after stroke: natural history and associated deficits. J Neurol Neurosurg Psychiatry 1986; 49:11-16.

West J, Sands E, Ross-Swain D. Bedside Evaluation Screening Test. Austin, TX: Pro-Ed; 1998.

Figure 1. Areas that predict less recovery. For the conversational expression measure, there are clusters (red in image) in *pars triangularis* (BA45) and the posterior middle temporal lobe (BA21) where damage predicts less recovery, and for the pointing to parts of picture measure, there is one cluster (blue in image) in the posterior middle temporal lobe (also BA21) where damage predicts less recovery.

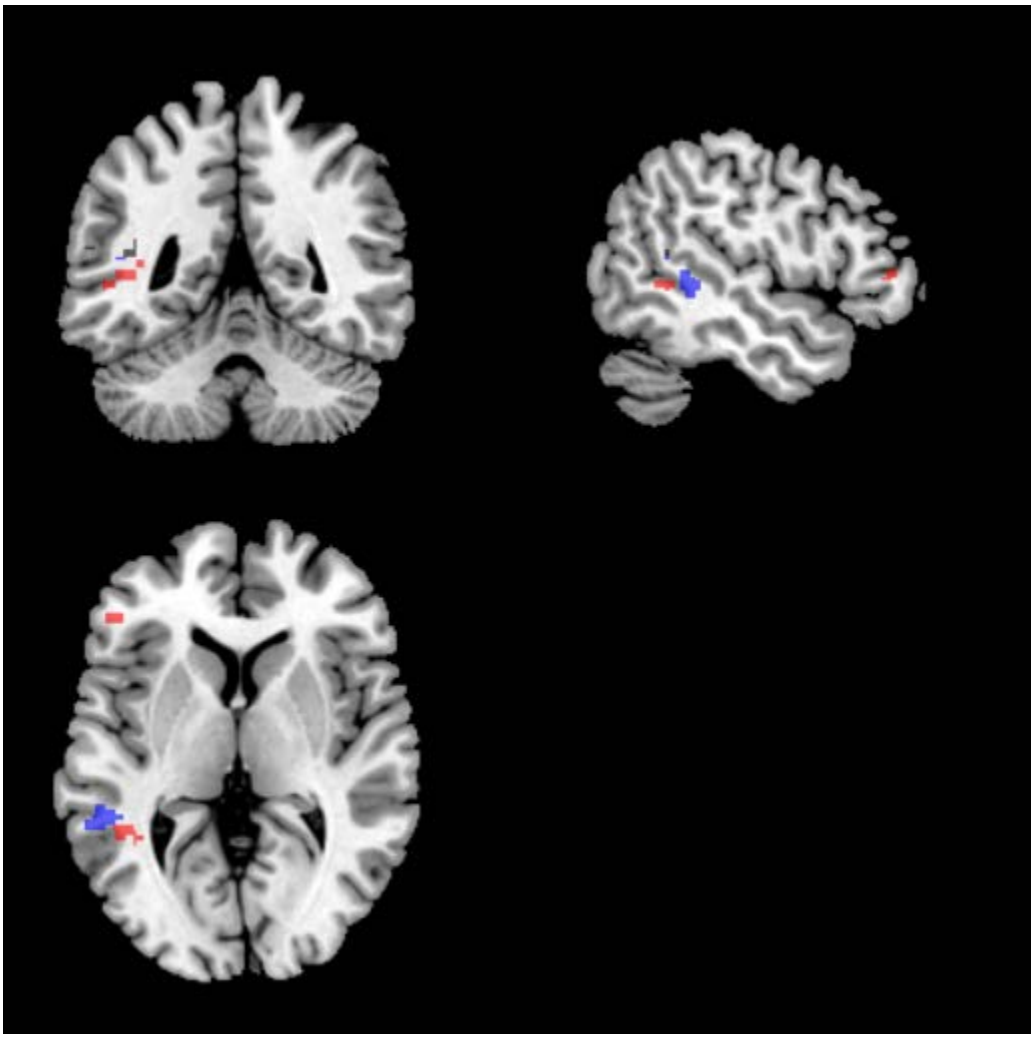

Table 1. *Demographic information and BEST-2 scores at baseline-retesting for all patients. Individual scores for the two subtests are raw scores. The Quotient is a sum of standard scores for all subtests and the severity score for each patient is based on the Quotient.*

			BASELINE				RETEST			
Patient	**Age**	**Gender**	**Subtest 1**	**Subtest 6**	**Quotient**	**Severity**	**Subtest 1**	**Subtest 6**	**Quotient**	**Severity**
1	56	F	30.00	30.00	116.00	none/mild	30.00	30.00	115.00	none/mild
2	54	F	29.00	29.00	110.00	none/mild	30.00	30.00	114.00	none/mild
3	56	M	28.00	30.00	111.00	none/mild	30.00	30.00	117.00	none/mild
4	44	F	24.00	30.00	101.00	moderate	30.00	30.00	120.00	none/mild
5	46	F	30.00	30.00	113.00	none/mild	30.00	30.00	120.00	none/mild
6	59	M	30.00	30.00	120.00	none/mild	30.00	30.00	120.00	none/mild
7	62	M	12.00	20.00	83.00	severe	26.00	24.00	96.00	moderate
8	75	M	30.00	30.00	123.00	none/mild	30.00	30.00	123.00	none/mild
9	75	F	23.00	20.00	100.00	moderate	30.00	29.00	118.00	none/mild
10	67	F	0.00	30.00	96.00	moderate	29.00	28.00	102.00	moderate
11	56	M	30.00	28.00	107.00	moderate	30.00	30.00	114.00	none/mild
12	61	F	30.00	30.00	120.00	none/mild	30.00	30.00	121.00	none/mild
13	60	M	0.00	18.00	75.00	severe	26.00	28.00	103.00	moderate
14	45	F	30.00	30.00	117.00	none/mild	30.00	30.00	115.00	none/mild
15	72	F	28.00	25.00	103.00	moderate	30.00	28.00	116.00	none/mild
16	65	M	30.00	30.00	121.00	none/mild	30.00	30.00	120.00	none/mild
17	75	M	30.00	30.00	121.00	none/mild	30.00	30.00	123.00	none/mild
18	61	F	30.00	29.00	104.00	moderate	30.00	30.00	119.00	none/mild
19	68	M	0.00	0.00	70.00	severe	24.00	30.00	117.00	none/mild
20	62	M	30.00	30.00	116.00	none/mild	30.00	30.00	117.00	none/mild
21	74	F	30.00	30.00	120.00	none/mild	30.00	30.00	119.00	none/mild
22	74	M	30.00	30.00	119.00	none/mild	30.00	30.00	125.00	none/mild
23	72	F	30.00	30.00	112.00	none/mild	30.00	30.00	123.00	none/mild
24	60	M	23.00	24.00	94.00	moderate	30.00	30.00	120.00	none/mild
25	58	F	30.00	30.00	120.00	none/mild	30.00	30.00	120.00	none/mild
26	70	M	30.00	30.00	121.00	none/mild	30.00	30.00	121.00	none/mild
27	72	F	9.00	22.00	87.00	moderate	30.00	26.00	113.00	none/mild
28	79	M	30.00	30.00	117.00	none/mild	30.00	30.00	119.00	none/mild
29	65	M	30.00	30.00	117.00	none/mild	30.00	30.00	117.00	none/mild
30	78	F	20.00	6.00	83.00	severe	30.00	28.00	115.00	none/mild
31	65	F	30.00	21.00	104.00	moderate	30.00	30.00	121.00	none/mild
32	63	M	4.00	17.00	79.00	severe	29.00	30.00	111.00	none/mild
33	40	F	0.00	26.00	75.00	severe	26.00	26.00	84.00	severe
34	77	F	30.00	22.00	115.00	none/mild	30.00	30.00	121.00	none/mild