

Introduction

The dorsolateral prefrontal cortex (DLPFC) serves as a major locus for organization, integration of sensory and mnemonic information, and cognitive regulation. Information regarding the DLPFC's role in language is emergent although the frontal lobes have long been implicated in language functioning. Barbizet and colleagues (1975) noted that localized frontal lesions greatly diminished complex propositional language while basic language skills were preserved. The impairments in spontaneous discourse were observed regardless of the side of the lesion.

In efforts to increase our understanding of functional frontal lobe organization, the roles of specific prefrontal areas in language processing have been examined. The left DLPFC has been implicated in linguistic organization (i.e., sequencing of an utterance) and left orbitofrontal cortex with goal-oriented narrative development (Kaczmarek, 1984). Processing of nonlinguistic information (i.e., gestalt) in narratives has been attributed to the right frontal areas (Kaczmarek, 1984).

Recently, the notion of dynamic aphasia has been applied to the language deficits associated with damage to the DLPFC (Alexander, 2006; Frattali & Grafman, 2004; Luria, 1970). Individuals with dynamic aphasia demonstrate impoverished language, characterized by a reduction in propositions, response length, and sentence complexity. Essentially, dynamic aphasia is a disruption of complex syntax that occurs during open-ended sentence formulation, such as spontaneous discourse. Narrative discourse impairment has been proposed as a similar but separate syndrome attributed to frontopolar damage (Alexander, 2006). The hallmark of the syndrome includes temporal sequencing problems, repetitions, and lack of references. However, Alexander (2006) admits that there is "no fixed line separating dynamic aphasia from narrative discourse impairment" (p. 239).

In the present study we examine narrative discourse performance following right and left DLPFC damage to determine the presence of characteristics described in the research literature on frontal lobe lesions and language. It is hypothesized that DLPFC lesions result in impoverished language at the macrolinguistic and superstructural levels (i.e., coherence, completeness, and story grammar) but not at the microlinguistic and microstructural levels (i.e., response length, sentence complexity, and cohesion).

Methods

Participants

DLPFC groups. Two groups of participants with circumscribed DLPFC lesions from penetrating head wounds received during the Vietnam War participated, six with left (L DLPFC) and nine with right (R DLPFC; Figures 1 & 2). All were native English-speaking males, 53-64 years of age. Education ranged from 10-20 years. Scores ranged from 1-94 on the Armed Forces Qualification Test (AFQT), 41-60 on the Boston Naming Test (BNT), and 91-100 on the Token Test (TT).

Normal controls. Forty-six male, Vietnam War veterans, 55-76 years of age with no history of neurologic disease or injury also were studied. All were native speakers of English. Years of education ranged from 12-20 years, scores ranged from 14-95 on the AFQT, 46-60 on the BNT, and 94-100 on the TT.

Discourse Analysis Procedure

Task. Participants were shown a multi-frame picture story with no soundtrack on a computer screen. Upon completion, each participant was instructed to “tell me that story you just watched.” Each retelling was digitally video-recorded. Recordings were transcribed verbatim and segmented into T-units.

Analyses. The story narratives were analyzed using 7 measures that tapped four levels of narrative analysis. Microlinguistic measures examined within-sentence processes, such as elementary lexical and grammatical abilities. Response length was analyzed using a word count per T-unit. Grammatical complexity was gauged by tallying the number of subordinate clauses per T-unit.

Cohesion comprised the microstructural analysis. Cohesive ties establishing relationships through references between sentences were rated according to the adequacy of usage (i.e., complete or incomplete).

Macrolinguistic analyses or thematic unity of the story consisted of measures of local and global coherence. Local coherence was the relatedness in theme between consecutive sentences within the story while global coherence was the thematic relatedness between the sentence and the story as a whole. Both involved 5-point Likert rating scales.

Superstructural analyses reflect the organization of the narrative and are captured through story grammar measures. Story grammar guides comprehension and expression of logical relationships (temporal and causal) between people and events. Story grammar analyses yielded the proportion of T-units within episodes.

Story completeness was indexed by tallying the number of critical story components mentioned by the storyteller. By combining organizational (story grammar) and completeness measures, story goodness was quantified.

Data Analysis

A MANOVA was performed using the 7 discourse measures as dependent variables and group (i.e., normative, L DLPFC, R DLPFC) as the fixed factor.

Results

All four multivariate tests were significant with $p < .001$, Pillai's trace = .587, $F = 3.147$ (14, 106); Wilks' lambda = .472, $F = 3.381$ (14, 104); Hotelling's trace = .992, $F = 3.61$ (14, 102); and Roy's largest root = .842, $F = 6.38$ (7, 53). Follow-up univariate tests were significant for 3 measures as discussed below.

Microlinguistic level

No microlinguistic measures were significant for the word count or for the subordinate clause count (see Table 1).

Microstructural level

The cohesion measure approached significance ($p = .054$) (see Table 1).

Macrolinguistic level

Mean local coherence ratings were highest in the control group with 3.73, followed by the R DLPFC group with 3.19 and the L DLPFC group with 2.75 (Table 1). Performance on global coherence scales showed a similar pattern with 4.20 for the control group, 3.67 for the R DLPFC group, and 2.91 for the L DLPFC group (Table 1). Both coherence measures were significant with $p < .001$.

Macrostructural level

The proportion of T-units in episodes, reflecting story grammar structure, was greatest in the control group (Table 1). Left and right DLPFC groups were comparable but not significantly different from the controls.

Story completeness analyses indicated that this measure was significant, $p = .001$. Distribution patterns on the story goodness measure differed between L and R DLPFC (Figures 3 and 4), as evidenced by the L DLPFC group being represented primarily by Quadrants 2 and 3 and the R DLPFC group by Quadrants 1 and 2.

Discussion

Results will be discussed with regard to the following:

- 1) Macrolinguistic and superstructural measures (i.e., local coherence, global coherence, and story completeness) rather than microlinguistic and microstructural measures distinguished narrative discourse performance between DLPFC groups and normal control participants.
- 2) The primary features of dynamic aphasia (i.e., response length and grammatical complexity) were not significant factors in distinguishing between normal and brain-injured groups. This finding suggests that DLPFC lesions may affect more global aspects of language functioning than proposed in the literature. Results should be interpreted cautiously given the sample sizes.
- 3) Replication of this pilot study is warranted in order to better understand the role of the DLPFC in language functioning.

References

- Alexander, M. (2006, March). Impairments of procedures for implementing complex language are due to disruption of frontal attention processes. *Journal of the International Neuropsychological Society*, 12(2), 236-247.
- Barbizet J., Duizabo P., and Flavigny R. (1975). The function of the frontal lobes in language. An experimental neuropsychological study. *Revue Neurologique*, 131(8), 525-544.
- Fratalli, C., & Grafman, J. (2005). Language and Discourse Deficits Following Prefrontal Cortex Damage. *Aphasia and related neurogenic language disorders (3rd ed.)* (pp. 51-67). New York, NY US: Thieme New York.

- Kaczmarek, B. (1984, January). Neurolinguistic analysis of verbal utterances in patients with focal lesions of frontal lobes. *Brain and Language*, 21(1), 52-58.
- Luria, A. (1970). *Traumatic aphasia: Its syndromes, psychology and treatment*. Trans. M. Critchley. Oxford England: Mouton.

Table 1.

Analysis level	Measure	Normal control group	Left DLPFC group	Right DLPFC group	Sig.
Microlinguistic	Word count per T-unit	11.43 (SD=2.65)	10.46 (SD=1.95)	12.59 (SD=2.07)	.265
Microlinguistic	Subordinate clauses per T-unit	.22 (SD=.15)	.12 (SD=.08)	.19 (SD=.15)	.242
Microstructural	Cohesive adequacy	.68 (SD=.17)	.51 (SD=.25)	.61 (SD=.09)	.054
Macrolinguistic	Local coherence	3.73 (SD=.49)	2.75 (SD=.96)	3.19 (SD=.53)	<.001
Macrolinguistic	Global coherence	4.20 (SD=.48)	2.91 (SD=1.39)	3.67 (SD=.44)	<.001
Superstructural	Proportion of T-units in episodes	.70 (SD=.21)	.54 (SD=.37)	.58 (SD=.12)	.115
Superstructural	Story completeness	4.41 (SD=1.07)	2.50 (SD=2.07)	3.56 (SD=1.33)	.001

Figure 1. Composite overlay of L DLPFC lesions

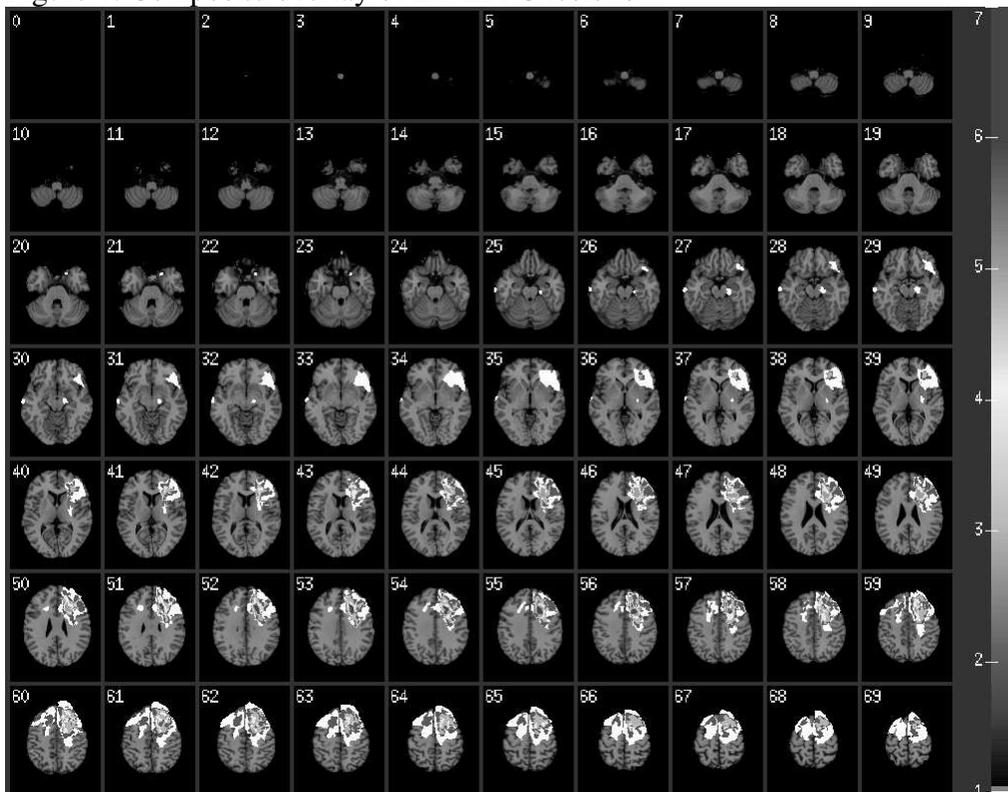


Figure 2. Composite overlay of R DLPFC lesions

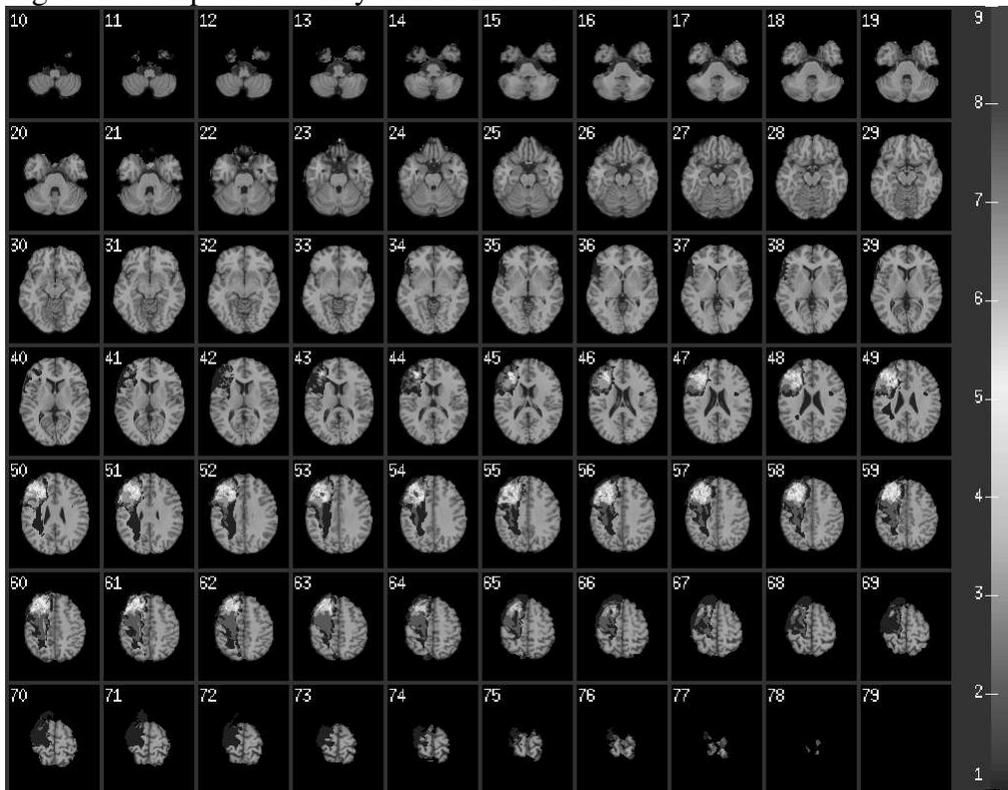


Figure 3

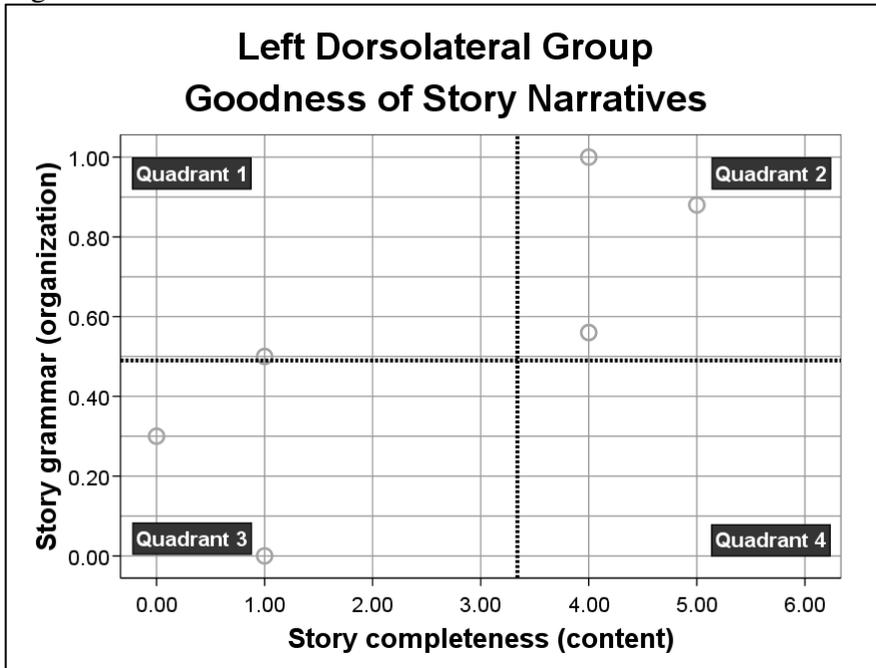


Figure 4

