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Processing of basic speech acts following localized brain damage: A new light on the neuroanatomy of language

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Abstract

We examined the effect of localized brain lesions on processing of the basic speech acts (BSAs) of question, assertion, request, and command. Both left and right cerebral damage produced significant deficits relative to normal controls, and left brain damaged patients performed worse than patients with right-sided lesions. This finding argues against the common conjecture that the right hemisphere of most right-handers plays a dominant role in natural language pragmatics. In right-hemisphere damaged patients, there was no correlation between location and extent of lesion in perisylvian cortex and performance on BSAs. By contrast, processing of the different BSAs by left hemisphere-damaged patients was strongly affected by perisylvian lesion location, with each BSA showing a distinct pattern of localization. This finding raises the possibility that the classical left perisylvian localization of language functions, as measured by clinical aphasia batteries, partly reflects the localization of the BSAs required to perform these functions.

Keywords: Pragmatics; Speech acts; Neuroanatomy; Aphasia; Stroke

1. Introduction

Natural language and its study are often divided into four parts: (i) sound, studied in Phonetics and Phonology, (ii) grammar, studied in Syntax, (iii) meaning, studied in Semantics, and (iv) use in context, studied in Pragmatics. A common view is that in most right-handers the anterior left hemisphere (LH), particularly the inferior–posterior frontal lobe, controls phonology and syntax, that more posterior LH structures, particularly in the temporal lobe, control semantics, whereas the right hemisphere (RH) may have a selective role in controlling pragmatics. However, there is much confusion in what encompasses pragmatics. The RH has been variously implicated in the control of emotional context conveyed by facial expression and speech prosody, as well as in the control of humor, of metaphor, of indirect requests and of discourse. However, those are all complex abilities that bear little relation to each other and have never been described and explained within the framework of a unified theory. By contrast, in the present study we focused on the speech-act (SA) level, rather than on the word, sentence, or discourse level. We studied systematically those constructions that are fundamental and prerequisite to others.

Beginning with Austin, philosophers of language have agreed that the proper unit of analysis in studying language is not the sentence but the SA, i.e., the utterance of a sentence in a particular context (Grice, 1989;

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Searle, 1969; Sperber & Wilson, 1995). Here, not only sentences but also speakers who put them to use and contexts in which they are appropriately uttered are the objects of study. Whereas truth-conditional semantics accounts for the meanings of indicative sentences out of context, SA theory accounts for meanings of sentences used in appropriate contexts (Kasher, 1977).

Some SAs are of a basic type. Usually a BSA is performed by uttering a specific kind of sentence which is linguistically marked as appropriate for it. Common examples are assertions, questions, and directives. Many languages have distinct syntactic forms of indicative, interrogative, and imperative sentences. Others mark the distinction using lexical or intonational devices (Hebrew uses syntactic as well as lexical and intonational devices). Basic types of SAs are interesting not just because they involve the use of marked sentences, but mainly because many other types of SAs depend on them. Assertion has been argued to be the most basic SA because every other SA which is governed by rules that refer to the speaker's beliefs, depend on the availability of assertion (Kasher, 1981). Additional concepts and cognitive abilities are required for the SAs of commanding, requesting (representation of desire and fulfillment), and asking (representation of problems and solutions), and many others are needed for the introduction of the whole variety of SA types in natural languages (Kasher, 1994).

There is a remarkable paucity of studies of the effect of hemispheric lesions on SAs. This is especially surprising for left brain-damaged aphasics because any standardized aphasia battery, and each subtest within such a battery, inevitably employs SAs whose integrity is not assessed independently of the language functions analyzed, such as auditory language comprehension, naming, repetition, or spontaneous speech. Green and Boller (1974) showed that aphasics often produce pragmatically appropriate responses to commands, questions, and requests, even when they are semantically incorrect. Prinz (1980) contrived to elicit requests from Broca's, Wernicke's, and global aphasics and found successful illocutionary responses regardless of severity or type of aphasic impairment. Foldi (1987) studied the ability of aphasics and right brain-damaged patients to understand wh-questions. The results suggest that some pragmatic functions are controlled by the LH although they are independent of linguistic comprehension per se, while others are specialized in the RH.

2. Method

We compared the performance of 27 right- and 31 left-brain-damaged (RBD, LBD) adult, first-event stroke patients and of 21 age-, sex-, and education-matched normal controls, on a new pragmatics battery, focusing on BSAs, including assertions, questions, requests, and commands. Examination took place 11 ± 4 weeks after the onset of stroke. Most patients (25/27 in RBD, 27/31 in LBD group) had lesions in the territory of the middle cerebral artery. To quantify lesion extent in different regions of interest (ROIs), lesion information derived from high quality follow-up (later than 6 weeks post-onset) CT scans was digitized and reconstructed, separately for each patient, on a set of standard templates, using a normalization procedure based on Talairach's proportional-grid-system. Performance level in each BSA was correlated with lesion extent in left and right, anterior and posterior perisylvian ROIs.

To overcome the problem of an unnatural setting in formal testing we created interactive situations that elicit the appropriate BSA in a natural way. We used a tester–subject dialogue format, utilizing asking–answering sequences and different kinds of role playing. A graded series of tasks assessed the level of control of a particular BSA, from appreciation of its nature, through comprehension of its actual meaning, to the ability to produce it. As our aim was to compare performance on the four BSAs among patients with differently localized lesions and a large variety of acquired language disturbances, it was impossible to precisely control for the phonologic, semantic and grammatical variables involved in the sentences used. However, we tried to construct phrases that are syntactically simple and semantically trivial, in the sense of referring to the subject's immediate environment or regular experience. There were 55 items in the *questions* test, 48 items in the *assertions* test, and 36 items in both the *requests* and *commands* tests.

Patients were examined also with a Hebrew version of the Western Aphasia Battery (HWAB; Kertesz) and with a Hebrew version of the Grammatical Comprehension Test (Curtiss). Twenty-nine of the 31 LBD patients manifested language problems of different kinds.

3. Results

An ANOVA of percent-correct responses was performed including Group (LBD, RBD, control) and SA (assertion, question, request, command) as independent variables. There was a main effect of Group [$F(2,59) = 11.03$, $p = .001$] reflecting the disadvantage of the pathological groups relative to normal controls. The effect of SA and the interaction between SA and Group were not significant. A repeated ANOVA restricting the Group variable to LBD and RBD revealed a main effect of Group [$F(1,41) = 7.93$, $p = .007$] reflecting a significant LBD disadvantage. Again, the effect of SA and the interaction between SA and Group were not significant. An ANOVA with the Group variable restricted to RBD and control revealed a main effect of Group [$F(1,40) = 11.69$, $p = .001$]. Here also, the effect of SA and the interaction between SA and Group were not significant. Finally, an ANOVA with the Group variable restricted to LBD and control revealed a main effect of Group [$F(1,37) = 14.32$, $p = .0005$]. As in the previous analyses, the effect of SA and the interaction between SA and Group were not significant.

Impairments of the four BSAs correlated significantly with the extent of damage in left perisylvian cortical regions. Most important is the finding of a distinct localization pattern for each BSA (Fig. 1). Following damage to the RH, the only BSA that showed significant negative correlation with lesion extent was production of requests, which correlated with lesions in the right middle frontal gyrus.

In the LBD group, there were significant correlations between the four BSAs and almost all the components of the HWAB (The WAB tests for the following communicative abilities: spontaneous speech, auditory verbal comprehension, repetition, naming, reading, and writing. There are also subtests that test for praxis, construction, visuospatial perception, and calculation abilities). Pearson r correlations revealed a significantly different pattern in the RBD group. While question and assertion performance correlated with the majority of HWAB subtests, requests, and commands showed only a small number of correlations with the HWAB subtests' scores.

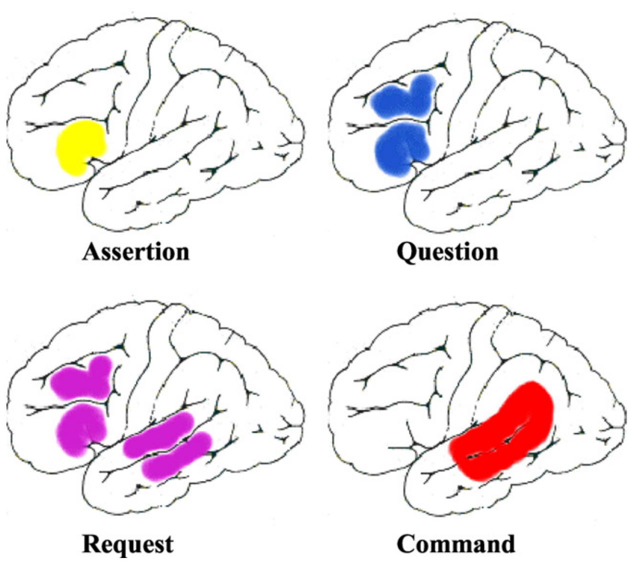

Fig. 1. The figure depicts in a schematic way the different localization patterns of the four BSAs. The colored areas are those where the negative correlation between the extent of damage (number of involved pixels within the region of interest) and performance level reached statistical significance at the .05 level. *Assertion*: left inferior frontal gyrus ($r = .53$, $p = .02$); *Question*: left inferior frontal gyrus ($r = .57$, $p = .006$) and middle frontal gyrus ($r = .56$, $p = .008$); *Request*: left inferior frontal gyrus ($r = .64$, $p = .0009$) and middle frontal gyrus ($r = .53$, $p = .009$) plus superior temporal gyrus ($r = .58$, $p = .004$) and middle temporal gyrus ($r = .55$, $p = .006$); *Command*: left superior temporal gyrus ($r = .53$, $p = .01$) and middle temporal gyrus ($r = .57$, $p = .006$) plus the supramarginal gyrus ($r = .52$, $p = .01$) and angular gyrus ($r = .57$, $p = .005$). In the right hemisphere (not shown) only one correlation reached significance: *requests* correlating negatively with lesion extent in the right middle frontal gyrus ($r = .57$, $p = .01$).

There were generally no significant correlations between the four BSAs and the grammatical comprehension test in either patient group. The only significant correlation was between "requests" and grammatical comprehension in the LBD group (Pearson $r = .85$, $p = .0037$).

4. Discussion

The present study clearly shows that while pragmatic competence depends on the integrity of both LH and RH mechanisms, pragmatic control is implemented differently in the two hemispheres. First, there is systematic localization of BSAs in the LH but not in the RH. Thus, assertions have a narrow inferior left frontal localization, questions have a wider left frontal localization, requests have a left fronto-temporal localization and commands have a left temporo-parietal localization. This anatomical progression has a theoretical rationale since requests have elements in common with questions, on the one hand, and with commands, on the other. These results support the mutual independence of the neural mechanisms involved in processing the BSAs of assertion, question and command, but not of request. By contrast, the RH has little or no localization of BSAs. Requests are exceptional in showing localization in the right middle frontal gyrus. Thus, pragmatic control in the LH is localized whereas in the RH it is distributed.

The abnormal processing of BSAs by non-aphasic RBD patients is of special interest as these patients clearly demonstrate that pragmatic functions can be lost also in cases where syntax, semantics, and phonology (controlled mainly by LH structures) are relatively preserved. This dissociative pattern implies a degree of functional independence in the RH processing of BSAs. This finding also has an important clinical implication, as impairment in processing pragmatic aspects of verbal communication might be associated with significant handicap, even in the absence of overt aphasia. In the LBD group, an important, though not surprising, finding is the intimate association between BSAs and the components of functional communication assessed by a standard aphasia battery. We propose the radical interpretation that aphasia batteries commonly assess language functions, such as auditory language comprehension, naming, reading or speech, using formal tests that presuppose (but do not directly test) control over BSAs. Thus, the anatomical localization of the language functions traditionally measured by aphasia tests may reflect in part the localization of the BSAs required to perform these functions.

The localization of BSAs observed here is unlikely to reflect the localization of their syntactic, semantic or phonological components because the correct responses within each BSA varied widely in these dimensions. Indeed, in general, the BSAs did not correlate with grammatical ability. Nonetheless, further research is needed to analyze explicitly the effects (or lack thereof) of phonological, lexical, and syntactic variables on processing different BSAs. On the other hand, neurolinguists studying the neural substrate of such linguistic processes should consider the possibility of bias derived from uncontrolled usage of different BSAs in their tests. Finally, the finding of a distinct localization pattern of the different BSAs may be of much clinical importance. It suggests marked differences in the abilities of aphasic patients to process sentences according to their SA context. Recognition of individual patterns of preservation and loss of BSAs should guide speech pathologists in planning an appropriate treatment strategy for each patient.

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