Processing of Linguistic Stress in the Damaged Left and Right Hemisphere

Author(s): James R. Solomon

Proceedings of the Ninth Annual Meeting of the Berkeley Linguistics Society (1983), pp. 245-256

PROCESSING OF LINGUISTIC STRESS IN THE DAMAGED LEFT AND RIGHT HEMISPHERE

James R. Solomon
California State University, Hayward

The purpose of this study is to investigate the effect of variations in prosody on the auditory comprehension of English sentences by brain-damaged adults. The area of prosody has a fairly extensive literature in terms of its place in language production. This literature consists of a variety of research studies and clinical and other observations of both children and adults, and from a number of different languages. From such studies we gain the impression that prosodic features are early acquired by children and relatively resistant to loss in language-impaired adults, including people with fairly severe aphasia of one type or another.

There is a considerably smaller body of literature on the place of prosody in language comprehension, particularly in aphasia. I know of only six studies in which the ability of aphasic subjects to comprehend prosodic information has been investigated --one of phonemic pitch accent in Japanese (Sasanuma et al. 1976), one of correct vs. incorrect placement of syllabic stress in Rumanian (Mihailescu et al. 1970), and four in English, including Blumstein and Goodglass' 1972 study of the perception of syllabic stress as a means of making syntactic distinctions between noun-verb pairs like *tránsport* and *transpórt*, and semantic-syntactic distinctions between noun-noun phrase pairs like *yéllowjacket* and *yellow jácket*. More recently Baum and her colleagues (1982) found that compared to normals, Broca's aphasics were unable to make distinctions between phonemically similar sentences on the basis of either sentential stress or juncture, or to profit from increased stress on functors in sentences.

One impression that emerges from this body of research, as well as from a study preliminary to the current study (Solomon and Aronson 1976), is that however robust prosody may be in terms of resistance to loss, it is a delicate feature to investigate experimentally. When subjects, either normal or brain-damaged, sense that suprasegmental features are being manipulated, they tend to ignore them and rely on the segmental information alone.

The prosodic feature investigated in the current study is English contrastive stress. What contrastive stress is has been a vexed question (Schmerling 1976); it is used here to mean those variations in pitch, loudness and length that have the effect of highlighting or emphasizing differences in meaning between phrases or sentences. Such variations are related to one of the apparent benefits (and perhaps also one of the purposes) of the use of contrastive stress, that of focussing the listener's attention on particular words. For example, in a series of commands such as

(1) Touch the red square.
(2) Touch the <u>blue</u> square.

even if the listener cannot recall (1) after having performed it, he may be able to perform (2) correctly because the use of contrastive stress has drawn his attention to the word <u>blue</u>, whereas in the absence of such stress he might select a square of another color.

Contrastive stress may also be of value as a mnemonic device; its use may allow for retrieval of information lost or obscured by 'noise' in the communication system, either in the literal, acoustic sense or in the sense of internal interference with auditory processing, such as may be created by brain damage. That is, if part of a message is lost, reference to it by use of contrastive stress in another (usually later) part of the message may allow for its successful reconstruction.[1]

MATERIALS AND METHODS

<u>Stimuli</u>

The stimuli for this study were two series of commands based on those found in the <u>Token Test</u> (De Renzi and Vignolo 1962), a widely used test of auditory comprehension in aphasia that holds extralinguistic or contextual cues to a minimum. The test uses a limited repertoire of five colors (blue, green, yellow, white and red), two shapes (circle and square), and two sizes (large and small). There are five parts to the test; they consist of commands ranging in length from 'Touch the red square' (typical of Part I) to 'Touch the large green circle and the small green square' (typical of Part IV). Such commands seem well suited to highlighting words by means of contrastive stress. In the current study only Parts I and IV were chosen as models for the stimuli; Part I was chosen because it presents items of a level of complexity that would allow subjects with even severe impairments of auditory processing to perform at least some items correctly, and Part IV because it is challenging enough to be likely to elicit errors from subjects with relatively mild impairments.

In Part I the commands take the following form:

I-1. Touch the red circle.
I-2. (B) Touch the red <u>square</u>.
I-3. (A) Touch the <u>blue</u> square.
I-4. (AB) Touch the <u>yellow</u> <u>circle</u>.
I-5. (AB) Touch the <u>green</u> <u>square</u>.

The numbers before each of these commands indicate that they are the first five stimuli used in the first part of the current study; they are not the identical to those used in any existing version of the <u>Token Test</u> and thus will be referred as <u>Part I-type</u> stimuli. These commands were presented to subjects verbally in separate sets with two distinct readings. One of the readings used contrastive stress, emphasizing the differences in content between each succeeding sentence, as suggested by the underlining in the examples above. In the discussion of results that follows, this reading will be referred to as the Contrastive Stress condition.

It may be noted that in a series of sentences such as (I-1) to (I-5) above, there are three possibilities for the use of contrastive stress, depending on the word or words in the sentence at hand that contrast with words in the immediately preceding sentence that occupy the same syntactic position. In (I-3), only the color contrasts with the immediately preceding sentence; it is labelled and will be referred to as Shift Type A, as indicated. In (I-2), only the shape contrasts with the preceding sentence; this will be referred to as Shift Type B. In (I-4) and (I-5) both the color and shape contrast; sentences of this type will be referred to as Shift Type AB. There were 5 commands using each of these 3 shift types, arranged randomly in the 15 items that comprised the Part I-type stimuli for the study. (There were, in fact, 16 stimuli in this part of the study; the first command, because it contrasts with nothing, was a dummy item and was unscored).

Precisely the same set of 16 stimuli was used for the other condition in the study. This reading, the Control condition, used a uniform rising intonation at the end of each command,[2] ignoring the inherent contrasts between commands. This may be what the authors of the original Token Test, De Renzi and Vignolo (1962:671), had in mind when they said that the commands should be read 'without any special prosodic emphasis' (see also De Renzi and Faglioni 1978:42).

In Part IV the commands take the following form:

IV-1. (X) Touch the small yellow circle
and the small blue circle.
IV-2. (Z) Touch the small red circle
and the large white square.
IV-3. (Y) Touch the large blue square
and the small red square.
.
.
IV-5. (X) Touch the small white square
and the small white circle.
.
.
IV-7. (X) Touch the small red square
and the large red square.
IV-8. (Y) Touch the large blue circle
and the large yellow square.
.
.
IV-10. (Y) Touch the large green circle
and the small green square.

When each of the 15 items in this part of the study was presented in the Contrastive Stress condition, the first object noun phrase in each sentence was read with the same uniform rising intonation used at the end of the Control condition reading of the Part I-type stimuli. In the second NP, the words that contrast with words occupying the same syntactic position in the first NP were read with contrastive stress, as suggested by the underlining in the examples above. Thus the domain of contrastive stress in the Part IV-type stimuli was the command itself (the second NP with reference to the first), whereas with the Part I-type stimuli it was the immediately preceding stimulus; these may be termed, respectively, intrastimulus versus interstimulus uses of contrastive stress.[3] When presented in the Control condition, the Part IV-type stimuli were read with a uniform rising intonation at the end of each object NP.

Given this 'intrastimulus' use of contrastive stress, there are various possibilities for the realization of stress in the second NP, all of which depend on which words in it contrast with words in the first NP. In (IV-1), for example, there is only one item that is different in the second NP--the color. In (IV-5), only the shape changes, and in (IV-7), only the size. Among the total of 15 Part IV-type stimuli, there are five with only one difference between the first and second object NPs; they have been labelled and will be referred to as Shift Type X. Another five demonstrate differences in two elements--changes in size and color (IV-3), color and shape (IV-8), and size and shape (IV-10); these have been grouped and labelled Shift Type Y. There are also five sentences in which all three elements change in the second NP, such as (IV-2); these will be referred to as Shift Type Z.

All the commands were presented by tape recording, including a screening test to determine whether the subject's auditory comprehension and visual and motor abilities were sufficient to identify separately each of the nine target words (the colors, shapes and sizes) used in the test and to perform the task in general; this also served the function of finding a comfortable listening level for each subject. Half of the subjects heard the sets of stimuli with the Contrastive Stress condition first (first the 16 Part I-, then the 15 Part IV-type stimuli); then they heard the identical stimuli read in the Control condition. The other half of the subjects heard them in the order Control, then Contrastive Stress.

The stimuli were tape recorded with careful attention to loudness levels and intonation. They were then analyzed as to the duration and intensity of both the carrier and target phrase by means of VOCAL, a manipulation program for producing tapes of verbal utterances developed at the Haskins Laboratories. This analysis revealed no significant differences in length between the carrier phrase in either testing condition, and it allowed for comparisons between the same target phrase when read with the two different prosodic styles.

The output tapes produced by the VOCAL program contained equal intervals between separate stimuli--7 seconds for the Part

I-type stimuli and 9 seconds for the longer, Part IV-type commands. When played during testing, the tape could be stopped inobtrusively by a remote control switch if it appeared that a subject would require more time to respond; however, no limit was placed on the time to respond. Response time information was recorded acoustically by means of a second tape recorder for later analysis. Actual responses were noted as they occurred during testing and later scored as to correctness in terms of both a pass-fail criterion and a more sensitive system of weighted (partial-credit) scoring, in which each element of the target phrase was given a value of 1; thus a correct response to a Part I-type stimulus yielded a score of 2 (1 each for the color and shape), and a correct response to one of the Part IV-type stimuli a score of 6 (1 for each of elements in the two object NPs).

Subjects

There were 42 subjects in the study, all of whom had had a single cerebrovascular accident of either the left or the right hemisphere. Discrete site of lesion information was not available on all subjects, but that was not one of the selection criteria in the design of the study. None of the subjects had a history of alcohol abuse, mental retardation, senile or presenile dementia, psychiatric problems or significant hearing loss. All were right-handed, and all were native speakers of American English. There were 15 subjects with single lesions of the right hemisphere and 27 with single lesions of the left hemisphere. All subjects were neurologically stable at the time of testing, and all were a minimum of one month post-onset. Some subjects were as much as 18 years post-stroke, but a careful review of their medical histories revealed that none of them had had more

Table 1. Demographic Information

		Aphasics (Lefts)			Non-aphasics
		All	Severe	Mild	(Rights)
Number:		27	9	18	15
Sex:	Male:	18	6	12	9
	Female:	9	3	6	6
Age in years:	Mean:	57.7	57.4	57.9	55.3
	Range:	38--75	43--75	38--74	32--72
Education in years:	Mean:	13.2	11.7	13.9	12.9
	Range:	8 - 20	8 - 14	9 - 20	9.5-19
Months post-onset:	Mean:	39.1	52.1	32.6	37.9
	Range:	1--217	1.5--134	1--217	6--120

than one neurological event with permanent sequelae. Additional information on time post-onset, as well as other demographic information, is presented in Table 1.

All of the subjects with left hemisphere lesions had received an independent diagnosis of aphasia, usually from a speech-language pathologist. Subjects with right hemisphere lesions were determined to be not aphasic, on the basis of their performance on the Boston Diagnostic Aphasia Examination (BDAE; Goodglass and Kaplan 1972), which was part of the testing protocol for this study. The subjects with left hemisphere lesions were further subgrouped according to their degree of aphasic impairment, mild or severe; this was done independently by an experienced aphasiologist, on the basis of a recording of some 10 minutes of conversational and expository speech by each subject (i.e. Part I of the BDAE).

RESULTS AND DISCUSSION

Contrastive stress appears to make a difference in the ability of aphasic patients to comprehend relatively short verbal commands, such as those in Part I of the Token Test. In this study the 27 left hemisphere damaged (i.e. aphasic) subjects as a group demonstrated a statistically significant difference in performance with the Part I-type stimuli, as measured by the weighted scoring method (Table 2); this difference favored the Contrastive Stress condition over the Control condition ($p < .05$). There were no significant differences for the two subgroups of mildly and severely impaired aphasic subjects; this is probably

Table 2. Results: Weighted Scores

		Percent Correct							
		Aphasics (Lefts)						Non-aphasics (Rights)	
Stimulus type	Condition	All (n = 27)		Severe (n = 9)		Mild (n = 18)		(n = 15)	
		Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Part I	Control	89.8	16.1	73.3	18.4	98.0	4.6	100	0.0
		**		NS***		NS		NS	
	Stress*	92.5	12.0	80.4	14.3	98.5	3.1	99.8	1.0
Part IV	Control	84.8	15.3	69.2	12.4	92.6	9.7	99.6	0.8
		NS		NS		NS		NS	
	Stress*	84.7	14.6	68.8	11.4	92.7	8.0	99.7	1.0

*Contrastive Stress **$p = .037$ ***$p = .057$

due to the smaller *ns* involved (18 and 9 subjects, respectively, vs. the aggregated *n* of 27), the apparent simplicity of this task for the mildly impaired subjects, and the considerable variability in performance of the severely impaired subjects, as suggested by the larger standard deviations for that subgroup as compared to the mildly impaired aphasic subjects. However, it may be noted that the performance of the severely aphasic subjects approached statistical significance ($p = .057$), the difference again favoring the Contrastive Stress condition. The right hemisphere damaged (i.e. non-aphasic) subjects performed the Part I-type stimuli perfectly (or nearly so) in both conditions.

For the longer, Part IV-type stimuli, there were no significant differences in performance between the Contrastive Stress and Control conditions for any of the subject groups or subgroups. The right hemisphere damaged subjects again performed essentially like normal subjects, making very few mistakes, randomly scattered. The aphasic subjects, both as a group and as subgroups, also performed these longer stimuli with virtually the same level of correctness in the two conditions, but with more errors than the non-aphasic subjects.

One reason for this outcome may be that this task in itself (i.e. in terms of the information content of the segmental phonemes alone) was too difficult for the aphasic subjects to allow the difference in prosodic styles, evident and significant with the Part I-type stimuli, to emerge. Evidence for this may be observed in the lower mean level of correctness in both testing conditions for the longer vs. the shorter stimuli, with the greatest change occurring with the severely impaired aphasics in the Contrastive Stress condition (a decrease in weighted score correctness of 11.6%, from 80.4% to 68.8%; note that this decrease is much greater than the 4.1% decrease in the Control condition).

Performance was also analyzed in terms of the previously mentioned 'shift types' for the Part I- and Part IV-type stimuli, i.e. in terms of which elements change in successive commands in the Part I-type stimuli and which elements change within each of the Part IV-type stimuli. In 72 separate comparisons of performances of the various groups and subgroups of subjects, only one significant difference between the Contrastive Stress and Control conditions emerged.[4] Thus whatever advantage contrastive stress may confer in performing the Part I-type stimuli as a set, it was not observable in subsets of those stimuli, nor did it appear in subsets of the Part IV-type stimuli (perhaps because the size of the subsets is too small for statistical purposes).

In addition to such between-condition comparisons, performance was also examined by shift types within testing conditions. Differences here appeared not in terms of correctness but in response time. For the 15 non-aphasic subjects there was a significant difference in response time for the Part I-type stimuli for Shift Type B as compared to Shift Type A ($p < .05$) and a difference that approached statistical significance for Shift Type B compared with Shift Type AB (p = .053). In both cases these differences were realized as faster response times for the type B stimuli; that is, the non-aphasic subjects performed faster when the shape element of the command changed with respect to the immediately preceding stimulus, faster than when either the color (in this case, significantly faster) or both color and shape changed. This difference in response time was not associated with any difference in performance in terms of correctness, but that is not surprising, since these subjects performed at perfect or near-perfect levels.

There was a significant difference in response time with the Part I-type stimuli for the nine severely impaired aphasic subjects as well, but with two interesting differences. These subjects' response times were also significantly different for Shift Type B as compared with Shift Type AB ($p < .01$) and approached a statistically significant difference with Shift Type B compared to Shift Type A ($p = .054$), but they were slower rather than faster (as was the case with the right hemisphere damaged subjects). These slower response times for Shift Type B appeared in both testing conditions, but they attained or approached statistical significance in only the Control condition, whereas with the non-aphasic subjects the significant differences for Shift Type B appeared in only the Contrastive Stress condition. Once again these differences were not associated with any differences in correctness of performance.

Because Shift Type B involves the final word of the commands, these combined results suggest that a recency effect is operative with these two groups of subjects. However, the effect is not the same: with the non-aphasic subjects it is positive, in the sense of being associated with decreased processing time, whereas wthe non-aphasic subjects it is positive, in the sense of being associated with decreased processing time, whereas with the severely impaired aphasics the effect is negative, in that it is associated with increased processing time.

The non-aphasic subjects also showed differences in speed of response to the longer, Part IV-type stimuli. In the Contrastive Stress (but not the Control) condition, they performed the Shift Type X commands significantly faster than the other two types ($p < .05$ in both cases). This outcome agrees with an a priori assumption that a change of only one element presents an easier processing task than either two or three elements' changing.

The 18 mildly impaired aphasic subjects also demonstrated a significant difference in response time in the Contrastive Stress condition for the Part IV-type stimuli, but in a rather surprising way: they performed the Shift Type Z stimuli significantly faster than the Shift Type Y ($p < .01$). (The same is true for the Shift Type X versus Z comparison, but this difference, also in favor of Type Z, is not statistically significant.) This outcome is counterintuitive; one would expect response times for these presumably more complex stimuli to be greater (i.e. slower) than for commands in which only two elements were changing. One possible explanation for this result is that subjects (particularly the aphasic subjects) perceived the Shift Type Z commands as very difficult and, suspecting that they could not perform them correctly, wanted to be done with them as quickly as possible. However, analysis of the Part IV shift types in terms of correctness (as opposed to response time) does not support this. There was no significant difference in correctness of performance among the stress types of the Part IV-type stimuli, in either the Contrastive Stress or Control condition, for either the mildly impaired aphasic subjects or the non-aphasic subjects.

CONCLUSIONS

The implications of the response time data for various shift types and groups of subjects, beyond those discussed above, are not yet clear and warrant further study. However, the implications of the earlier mentioned results for all the stimuli taken together (i.e. not considering differences in shift types) seem quite clear: when given an auditory language processing task that is manageable, such as stimuli like those in Part I of the _Token Test_, aphasic individuals (particularly those more severely impaired) perform that task significantly better in the presence of contrastive linguistic stress than with a neutral reading of the same material. When the task is more difficult, as in Part IV of the _Token Test_, the advantage conferred by contrastive stress disappears; in fact, if the listener's processing capacities are already overburdened by segmental information, the addition of suprasegmental information may result in poorer rather than better performance.

Darley et al. (1975) have defined prosody generally as 'all the variations in time, pitch, and loudness that accomplish emphasis, lend interest to speech, and characterize individual and dialectal modes of expression.' This definition suggests a peripheral role to prosody, that if prosodic features were not present in a message, there would be little or no effect (in English, at least) on the understanding of its semantic content. The findings of this study, on the other hand, suggest that prosodic features such as contrastive stress convey not only a speaker's affect and attitude but also part of the core of his message, and that even severely impaired aphasic individuals retain the ability to comprehend the linguistic as well as the paralinguistic information that prosody conveys.

NOTES

1. In some instances stress is of value _only_ if the listener remembers previous information. In the examples cited, contrastive stress might be of little value in performing the second command correctly if the listener could not recall the first, particularly if he did not remember whether that sentence contained the word _circle_ or _square_. Stress might help him to un-

derstand and remember the word *blue*, but it would not allow him to make the correct choice of the circle in (2) with any more accuracy than choosing the square.

2. This reading was suggested by Dr. Frederic Darley, to whom I am indebted.

3. At least two other readings of the Part IV-type stimuli are possible. With one, the domain of contrastive stress would be both interstimulus (as is the case with the Part I-type stimuli) and intrastimulus. The second and third Part IV-type stimuli would thus be read in the following manner:

IV-2. Touch the small red circle
and the *large* *white* *square*.
IV-3a. Touch the large *blue* square
and the *small* *red* square.

However, such a use of contrastive stress, with emphasis now placed also on *blue* in (IV-3a), seems unlikely to assist a person--particularly a brain-damaged person--in performing the command correctly. Stressing *blue* may help in the correct selection of that color, but only if one remembers the second NP in the immediately preceding sentence; that is, the advantage of such a use of contrastive stress may come only with an additional investment of memory (and impairments in auditory memory, it should be noted, are not infrequently a source of auditory processing deficits in brain-damaged individuals).

Furthermore, that investment may yield diminishing returns: If a subject were to hear stress on the penultimate word in (IV-3a), *red*, and for some reason did not comprehend or hold in memory the immediately preceding word, *small*, then the presence of stress on *blue* in the first part of the command, together with the lack of stress on the preceding word, *large*, might lead him to suspect that the word not comprehended was also *large*. That is, if a subject were to hear

IV-3b. Touch the large *blue* square
and the _____ *red* square,

and did not comprehend or hold in memory) the antepenultimate word *small* (as suggested by the blank underlining), then his knowledge of rules of English prosody might lead him to make the incorrect choice of the large red square.

Another possible reading of the Part IV-type stimuli is to allow the first object NP to 'forecast' the contrast present in the second NP. If this were done, then the third stimulus would be read in the following manner:

IV-3c. Touch the large *blue* square
and the small *red* square.

One reason that this reading might be employed, rather than the one adopted in the current study (a uniform rising intonation at the end of the first NP), is that a subject might think that the stimulus was complete and might proceed to respond prematurely; the use of contrastive stress in both NPs would tend to discourage this. In fact, use of the uniform rising intonation did not produce such problems and indeed may have prevented them. Furthermore, subjects were instructed (and, if necessary, reminded) not to respond before the entire command was complete.

4. With Shift Type AB (both color and shape changing) for the Part I-type stimuli, the severely impaired aphasic subjects made significantly fewer errors in the Contrastive Stress condition.

REFERENCES

Baum, Shari R., Joanne Kelsch Daniloff, Raymond Daniloff, and Jeffrey Lewis. 1982. Sentence comprehension by Broca's aphasics: effects of some suprasegmental variables. Brain and Language 17.261-71.

Blumstein, Sheila, and Harold Goodglass. 1972. The perception of stress as a semantic cue in aphasia. Journal of Speech and Hearing Research 15.800-6.

Darley, Frederic L., Arnold E. Aronson, and Joe R. Brown. 1975. Motor speech disorders. Philadelphia: W. B. Saunders.

De Renzi, Ennio, and P. Faglioni. 1978. Normative data and screening power of a shortened version of the Token Test. Cortex 14.41-9.

De Renzi, Ennio, and Luigi A. Vignolo. 1962. The Token Test: a sensitive test to detect receptive disturbances in aphasics. Brain 85.665-78.

Goodglass, Harold, and Edith Kaplan. 1972. The assessment of aphasia and related disorders. Philadelphia: Lea and Febiger.

Mihailescu, Lucretia, M. I. Botez, and A. Kreindler. 1970. Decoding of correct and wrong word stress in aphasic patients. Revue Roumaine Neurologique 7.65-74.

Sasanuma, Sumiko, Itaru F. Tatsumi, and Hiroya Fujisaki. 1976. Discrimination of phonemes and word accent types in Japanese aphasic patients. Proceedings of the XVIth International Congress of Logopedics and Phoniatrics, Interlaken, 1974, ed. by E. Loebell, 403-8. Basel: Karger.

Schmerling, Susan F. 1976. Aspects of English sentence stress. Austin: University of Texas Press.

Solomon, James R., and Arnold E. Aronson. 1977. Administering the Token Test senza intonazioni particolari: does it make any difference? Clinical Aphasiology Conference Proceedings, 1977, ed. by Robert H. Brookshire, 269-83. Minneapolis: BRK Publishers.