CHAPTER

29

Contextual Influences on the Auditory Comprehension of Normally Stressed Targets by Aphasic Listeners

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Clinicians can enhance the probability that an aphasic patient will comprehend a verbal message. Our clinical bag-of-tricks holds a plethora of techniques that may be effective. These techniques include linguistic manipulations such as reducing syntactic complexity or message length (Goodglass, Blumstein, Gleason, Hyde, and Statlender, 1979) or manipulations of the physical characteristics of the signal such as speech rate reduction (Lasky, Weidner, and Johnson, 1976; Weidner and Lasky, 1976). However, there are limitations to these techniques, including inconsistent and poor predictability of their effectiveness (Brookshire and Nicholas, 1984) and, perhaps more importantly, a lack of understanding of how and why the techniques actually work.

Stress is a physical phenomenon that has great linguistic impact. By definition it increases the salience of a message (Bolinger, 1961). Stress consists of acoustic modifications involving duration, fundamental frequency (F_0) and intensity that serve to highlight important portions of a speaker's message (Lehiste, 1970). The ability to use these acoustic modifications to facilitate comprehension of salient portions of a verbal message has appeal as a technique for treating auditory comprehension deficits.

Several studies have explored the effect of stress on the auditory comprehension of aphasic listeners. Some investigations demonstrated that stress yields a significant enhancement of auditory comprehension for aphasic subjects (Blumstein and Goodglass, 1972; Pashek and Brookshire, 1982; Solomon, 1983; Turco, 1986) and for normal subjects (Bean and Folkins, in press); however, other studies suggest that aphasic listeners derive no benefit from the presence of stress (Baum, Daniloff, Daniloff, and Lewis, 1982; Solomon and Aronson, 1977). While inconsistency of findings predominate, a study by Pashek and Brookshire (1982) was successfully replicated by Kimelman and McNeil (1987). The data from both studies demonstrated that aphasic listeners comprehended paragraph-length stimuli better when target words were stressed than when they were normally stressed. However, it is not clear whether it was the processing of the stressed words or the acoustic changes that are known to precede stressed segments that signaled the presence of the upcoming stressed words, which produced the improvement in auditory comprehension. Evidence from the speech perception literature suggests the presence of this type of cuing mechanism. Data from a series of reaction time studies revealed that normal listeners process stressed phoneme targets faster than unstressed targets (Cutler, 1976; Cutler and Foss, 1977; Shields, McHugh, and Martin, 1974). These data also indicated that normal listeners reduced their reaction times to target words while using pre-target cues to predict the upcoming presence of stressed targets (Cutler, 1976; Shields et al., 1974). This raised the question as to whether aphasic listeners utilized cues that preceded the stressed segment or whether it was the stress-bearing target words themselves that facilitated the comprehension of the target words. It was, therefore, the purpose of this investigation to determine if the preceding context, produced with a stressed prosodic pattern, would significantly improve the auditory processing and comprehension of normally stressed target words by aphasic listeners.

METHODS

SUBJECTS

Subjects were 11 men and 5 women with aphasia resulting from a left-hemisphere lesion. Their ages ranged from 26 to 79 years, with a mean of 58.3 years. They were from 5 to 97 months post-onset, with a mean of 30.9 months. Site of lesion varied greatly across subjects (Table 29-1). All subjects were premorbidly right-handed, demonstrated pure-tone averages at or better than 35 dB HL in at least one ear at 500, 1000, and

TABLE 29-1. INDIVIDUAL MEAN BIOGRAPHIC DATA AND LESION SITES FOR 16 APHASIC SUBJECTS

Subject	*Gender*	*Age (years)*	*MPO*	*Lesion Location*	*Classification**
1	Male	64	7	MCA distribution	Mixed
2	Female	26	22	F-P	Mixed
3	Female	67	5	P	Mixed
4	Male	68	25	T-P	Mixed
5	Male	70	28	Left hemisphere	Mixed
6	Male	60	97	T-P	Mixed
7	Male	76	46	T-P	Mixed
8	Male	54	29	F-T	Mixed
9	Female	55	16	F	Mixed
10	Male	55	18	F-T-P	Mixed
11	Male	61	26	Left hemisphere	Broca
12	Female	79	10	MCA distribution	Wernicke
13	Female	31	62	Subarachnoid hemorrhage	Mixed
14	Male	43	12	F-T-P	Mixed
15	Male	71	70	MCA distribution	Mixed
16	Male	52	21	T-P	Mixed
Mean	—	58.3	30.9	—	—
SD	—	15.0	25.5	—	—

* Classification was done by two experienced listeners and was based on audio-recorded descriptions of the Cookie Theft picture and the auditory comprehension sections of the BDAE (Goodglass and Kpalan, 1983).
MPO = months post-onset; F = frontal lobe; T = temporal lobe; P = parietal lobe; MCA = middle cerebral artery.

2000 Hz, and scored at or better than the 20th percentile on the five-item Revised Token Test (RTT) (Arvedson, McNeil, and West, 1985).

STIMULI

Four of the paragraphs and their accompanying questions developed by Pashek and Brookshire (1982) and re-recorded by Kimelman and McNeil (1987) were modified for use in this study. Each paragraph contained eight sentences and 93 to 96 words and had been equated for reading level and syntactic and lexical complexity (Pashek and Brookshire, 1982). The paragraphs were recorded by a male speaker at a normal speech rate of 202.9 syllables per minute ±10 percent (Yorkston and Beukelman, 1980). Each paragraph was recorded twice — once with normal stress and a second time with one target in each sentence receiving emphatic stress.*

Stressed and normally stressed target words were computer-edited† out of each sentence in each paragraph. All targets were then replaced with normally stressed versions. Therefore, the experimental paragraph stimuli were composed of normally stressed target words surrounded by context that had been produced as part of sentences containing stressed elements. The control paragraph stimuli were composed of normally stressed targets surrounded by context that had been produced as part of sentences containing normally stressed elements.

Sixteen yes/no questions per paragraph, two for each target, were recorded at a slow-normal speech rate of 190 syllables per minute ±10 percent. Both questions pertaining to a target had to be answered correctly for a subject to receive credit for comprehending that target. This resulted in a maximum score of eight for each paragraph. These questions had been used by both Pashek and Brookshire (1982) and Kimelman and McNeil (1987).

For practice purposes, a fifth paragraph and accompanying questions were randomly selected from the corpus used by Pashek and Brookshire (1982). This paragraph had been equated with the other paragraphs, and was recorded once with a normal stress pattern, using the same procedures as for the other paragraphs.

Randomly ordered sets of stimuli consisting of all four paragraphs were created. A different random order was used for each subject and each condition. Condition (i.e., stressed or normally stressed context) was homogeneous within each set. Questions pertaining to the paragraphs were randomized for each subject and condition and were presented following the appropriate paragraph.

* See Kimelman and McNeil (1987) for details of stimulus construction.

† All computer-editing and subsequent interactive analyses were conducted using the VOCAL software program available at the Waisman Center for Mental Retardation and Human Development, University of Wisconsin — Madison.

To ensure that the computer-editing procedures did not render the paragraphs unintelligible, four women and one man with self-reported normal hearing listened to the stimuli. The 64 sentences composing the four paragraphs from both conditions were presented to the listeners through a loudspeaker in a single random order at a comfortable listening level. Listeners were asked to repeat each sentence verbatim. Errors were recorded on less than 2 percent (51) of the 3840 words repeated (768 words times five subjects). No two listeners erred on the same word. Therefore, all words were repeated correctly a minimum of 80 percent of the time.

PROCEDURES

Testing was divided into two sessions of 1 to 2 hours each with breaks provided as necessary to limit fatigue. Fourteen of the subjects participated in both sessions on the same day separated by 30 to 45 minutes. Three subjects were tested on consecutive days with sessions separated by approximately 24 hours.* One subject (subject 2) was tested in a laboratory setting. The remaining subjects were tested in their homes. No observable difference was noted in this single subject's performance compared to the performance of the other 15 subjects.

Session one consisted of a hearing screening, the five-item RTT, the practice paragraph and questions, one set of stimuli and questions, and the Porch Index of Communicative Ability (PICA) (Porch, 1973). Training included a description of the task and instructions to answer the questions as quickly and as accurately as possible. Subjects were also instructed to adjust the volume control on the tape recorder to a comfortable listening level. Once this listening level was established, no further volume adjustments were allowed, and all additional stimuli were presented at that volume setting. Cues to respond correctly and rapidly were provided in a standardized format at predetermined times. After the subjects answered the questions accompanying a paragraph, they were asked to count backwards from 100 until the examiner was ready to present the next paragraph and questions.

The second session began with the collection of a speech sample based on a description of the Cookie Theft picture from the Boston Diagnostic Aphasia Examination (BDAE) (Goodglass and Kaplan, 1983). This was followed by the administration of the auditory comprehension subtests of the BDAE (i.e., subtests A–D in secton II) and the Auditory Comprehension for Sentences (ACTS) (Shewan, 1979) (Table 29-2). Finally, the second set of stimuli and questions was presented. The time interval between stimulus sets, the intervening tests (i.e., PICA, BDAE, ACTS),

* Previous research by Kimelman and McNeil (1987) revealed no between-subject performance differences on an almost identical task based on intersession time interval.

TABLE 29-2. INDIVIDUAL AND MEAN DESCRIPTIVE DATA FOR 16 APHASIC SUBJECTS

Subject	*5-item RTT Percentile*	*PICA Percentile*	*ACTS (% correct)*	*BDAE Auditory Comprehension (% correct)*
1	28	75	95	97.6
2	84	78	90	97.5
3	89	75	100	99.2
4	22	42	71	73.1
5	23	45	76	72.7
6	85	83	100	97.5
7	65	68	90	94.5
8	24	29	38	39.1
9	59	68	67	86.6
10	33	69	71	87.4
11	41	31	62	71.4
12	45	79	90	97.6
13	53	85	90	95.8
14	21	74	76	73.1
15	80	68	71	95.4
16	45	59	86	90.3
Mean	49.8	64.3	79.6	85.6
SD	25.6	17.9	16.3	16.1

and the counting task between paragraphs was included to interfere with the subjects' ability to rehearse and recall the content of the paragraphs from one session to the next.

RESULTS

AUDITORY COMPREHENSION

Tabulation of correct responses yielded a mean auditory comprehension score of 4.00 (SD = 1.85) for the normally stressed condition and 5.17 (SD = 1.40) for the stressed context condition (Table 29-3). A repeated measures ANOVA revealed that subjects demonstrated statistically significantly better auditory comprehension ($F[1,14] = 21.04 = p \leq .05$) of the normally stressed target words when the surrounding context was stressed versus normally stressed. The main effects for learning ($F[1,14] = 0.01$, $p > .05$) and order of presentation ($F[1,14] = 2.73$, $p > .05$) were

TABLE 29-3. NUMBER OF CORRECT RESPONSES FOR EACH SUBJECT (MAXIMUM = 8) FOR EMPHATICALLY AND NORMALLY STRESSED PARAGRAPHS

		Paragraphs							
		Stressed context				*Normally stressed context*			
Subject	**Order**	**1**	**2**	**3**	**4**	**1**	**2**	**3**	**4**
1	2	4	6	5	5	6	5	3	4
2	1	8	7	4	6	7	5	6	7
3	1	6	5	5	6	8	6	5	7
4	1	4	3	4	3	1	2	2	2
5	2	5	4	4	5	3	4	2	2
6	2	7	7	6	8	6	6	5	6
7	2	6	7	3	7	4	5	3	3
8	1	4	4	4	5	1	0	1	4
9	2	7	6	4	7	5	4	4	5
10	1	5	3	6	6	3	1	5	5
11	2	3	4	4	4	2	2	2	1
12	1	4	6	7	6	5	6	3	7
13	2	6	7	4	6	2	4	3	3
14	1	5	4	4	3	6	2	2	5
15	2	6	5	5	6	5	4	5	4
16	1	6	7	6	6	5	6	5	4
Mean		5.38	5.31	4.38	5.63	4.31	3.88	3.50	4.31
Grand Mean		5.17				4.00			
SD		1.40				1.85			

$F(1, 14) = 21.04, p \leq 5$

*Order indicates which condition subjects received first: 1 = normally stressed context first, 2 = stressed context first.

not statistically significantly different across conditions. Therefore, the main finding was that performance was better in the stressed context plus normally stressed target condition than the normally stressed context plus normally stressed target condition.

Pearson product-moment coefficients for the performance difference score (calculated by subtracting performance in the normally stressed from the stressed conditions) and several biographical and descriptive measures were calculated (Table 29-4). Moderately strong, statistically significant negative correlations were noted for the PICA, ACTS, and BDAE.

RESPONSE TIME

In addition to comprehension accuracy, vocal response times (RT) to the questions were also analyzed. Tape recordings of the questions and the subjects' responses were digitized. Vocal RTs, the interval between the question offset and the response onset, were measured interactively on the acoustic waveform using cursors that could be moved in 1 ms steps. First the duration of the 64 questions was determined. The total duration of the question plus RT interval was then determined for each question-response set for each subject. The duration of the questions was then subtracted to yield the RTs.

Only RTs to accurate responses were measured. The RTs were log-transformed to normalize the data. Mean log-transformed RTs using all subjects' data by condition and paragraph filled missing data points for two subjects on one paragraph each. The mean of the log-transformed

TABLE 29-4. PEARSON PRODUCT-MOMENT CORRELATION COEFFICIENTS (WITH t-TEST VALUES) FOR BIOGRAPHICAL AND DESCRIPTIVE DATA CORRELATED WITH AUDITORY COMPREHENSION DIFFERENCE SCORES (NUMBER CORRECT STRESSED CONDITION − NUMBER CORRECT NORMALLY STRESSED CONDITION)

	Age	*MPO*	*5-item RIT*	*PICA*	*ACTS*	*Auditory Comprehension BDAE*
Auditory comprehension difference score	−.13 (.49)	.37 (1.50)	−.38 (1.54)	−.57 (2.60*)	−.64 (3.13*)	−.63 (3.02*)

MPO = months post onset.
* Significant at $p \leq .05$.

RTs across subjects for the normally stressed condition was 2.75 (SD = 0.33) and 2.73 (SD = 0.36) for the stressed condition. A repeated measures ANOVA did not find statistically significant differences in RTs across conditions ($F[1,14] = 0.45$, $p = > .05$) or for order of presentation ($F[1,14] = 0.46$, $p > .05$).

RELIABILITY

Intrajudge reliability measures were made on a randomly selected sample of 110 (10%) of the 1056 RT measures made. Differences between the two measurements on these tokens were calculated. Errors ranged from 0 to 39 ms, with a mean error of 2.38 ms (mean log error = 0.38).

ACOUSTIC ANALYSES

Selected acoustic analyses, chosen from heuristics in the literature (Weismer and Ingrisanno, 1979; Cooper, Soares, Ham, and Damon, 1983), were conducted on the paragraph stimuli. For the word preceding each target the duration, maximum F_0 and minimum F_0 were determined. Also, the relative duratoin, operationally defined as the difference between the onset of a sentence and the onset of a constituent word, of each word preceding each target word was measured. Comparisons of the relative duration of each sentence as well as pretarget word durations and F_0s were made across conditions.

DURATION

A paired t-test revealed that the duration of the pretarget words was statistically significantly longer in the stressed context condition than in the normally stressed context condition ($t[31] = 3.04$, $p \leq$). Of the 32 pretarget words (4 paragraphs, 8 sentences [targets] per paragraph), 28 were longer in the stressed condition. For these 28 pretarget words, the duration differences across condition ranged from 9 to 813 ms, with a mean of 77.7 ms (SD = 144.4 ms).

FUNDAMENTAL FREQUENCY

Due to extensive artifact, F_0 measures could only be made on 30 of the 32 pretarget words. A t-test on the difference between the maximum F_0 in the two conditions was not statistically significant ($t[29] = 1.41$, $p > .05$). The mean maximum F_0 of the pretarget words was 119.7 Hz (SD = 9.4) for the stressed condition and 115.8 Hz (SD = 11.8) for the normally stressed condition. The mean minimum F_0 of the 30 pretarget words was 98.7 Hz (SD = 7.6) and 97.8 Hz (SD = 11.3) for the stressed and normally stressed conditions, respectively. The minimum F_0 was not statistically significant across conditions ($t[29] = 0.44$, $p > .05$).

RELATIVE DURATION

The relative durations were consistently longer (the relative duration of each word was longer than its cognate) in the stressed condition than in the normally stressed condition for 10 (31%) of the 32 sentences composing the paragraph stimuli. The opposite pattern was true for 13 (41%) of the sentences. In 9 cases (28%), the relative durations were not consistently longer for either condition. No clear pattern emerged that could differentiate the stressed from the normally stressed conditions on this measure.

DISCUSSION

The primary finding of this investigation was that aphasic subjects' auditory comprehension of normally stressed target words was significantly better when the targets were preceded by stressed context than by normally stressed context. These results coupled with those of Kimelman and McNeil (1987) and Pashek and Brookshire (1982) suggest that the positive effects of stress on aphasic listeners' auditory comprehension are due, at least in part, to acoustic factors preceding the target words.

The finding that performance on four measures of aphasia, the PICA, ACTS, BDAE, and five-item RTT, negatively correlates with the magnitude of the benefit on auditory comprehension derived from stressed context is not surprising. This may indicate that as the severity of aphasia increases reliance on nonlexical information to process, what is heard may also increase. This inverse relationship is appropriate because individuals with milder deficits comprehend better under all conditions, thereby relying less on such factors as stress to improve their performance.

Statistically significant differences were not found between conditions for vocal RT measures. Differences in RT might not have been found due to three major factors. First, the experimental design was not intended to deal with the unexpected degree of inter- and intrasubject RT variability. Second, because subjects made many errors and only accurate responses were measured, the analyses may have been unduly biased by the small sample size. Finally, even though attempts were made to instruct the subjects to give equal importance to the accuracy and speed of their responses, it was apparent that the subjects favored performance accuracy over response speed.

Consistent with the report by Weismer and Ingrisanno (1979), acoustic analyses of the paragraph stimuli demonstrated that when a speaker stresses a target word, the duration of the word preceding the target is lengthened. The analyses failed to confirm the Cooper and colleagues (1983) finding of a declination of maximum F_0 in words preceding stressed target words. Furthermore, no consistent differences in patterns of relative duration, as hypothesized by Martin (1974), were observed across conditions. The failure to find statistically significant differences in F_0 and relative duration does not rule out the presence of these differences. The small sample size and variety of linguistic forms grouped for analyses weighed heavily against the probability of finding statistically significant differences. Further research should continue to pursue analyses of this nature.

These data supply additional evidence supporting aphasia as a performance rather than a competence deficit. Improved auditory comprehension in the presence of stress is consistent with an information processing system that has post-insult linguistic and extralinguistic competence.

Clinically, the use of stress in some meaningful treatment regimen remains futuristic. However, these data provide a much needed basis for additional research investigating how aphasic, and for that matter normal listeners, process auditory information. Knowing that the positive effect stress has on aphasic subjects' auditory comprehension is due, at least in part, to some form of cuing mechanism opens a new arena of research. Consistent with a performance deficit perspective, investigations to determine what cues are active, their relationship to each other and to the linguistic structure of the utterance, and possibly to provide a neurophysiological understanding of the processing of these events are some of the appropriate next steps. That data could subsequently lead to research on how auditory comprehension may be actively manipulated in the clinic.

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DISCUSSION

Q = question; A = answer; C = comments.

Q. You mentioned that severity might make some difference. And I don't recall, did you either rate the severity of your subjects or try to separate your own subjects in terms of severity levels?

A. I didn't try to separate them into groups. We were looking to see what the effect would be on aphasia as a whole across the spectrum of type and severity. The relation of performance to severity was a post hoc finding. We do have severity measures based on the PICA overall scores, the RTT overall scores, and the Boston auditory comprehension scores. There was quite a range of severity levels.

C. I guess what I was really getting at is that you did say that for more severe patients the stress probably would be more useful and that subjects who are more mildly impaired probably wouldn't benefit as much. So I was just trying to clarify a little bit more where that was really coming from in terms of your own subjects.

A. Correlations were calculated between the amount of improvement on the paragraph comprehension task due to stress and several descriptive measures such as the RTT, PICA, BDAE auditory comprehension subtests, ACTS, and biographical data like age and months post-onset. Statistically significant negative correlations were found for the PICA, ACTS, and BDAE auditory comprehension subtests.

These measures of aphasia yield a score that supposedly has some relation to severity. Therefore, the data seemed to show that the poorer a patient's score on these tests, the greater they benefitted from the presence of stress.

C. I just read a paper in the latest *Brain and Language* that I want to re-read based on hearing your talk. They looked at intonation effects on grammaticality judgments in Broca aphasic patients and found no beneficial effect.

We just finished some production data. One of the things we found is that we use very neutral bland sentences. And just before the terminal contour, which marks the inflectional ending of sentences, we found longer pauses in language-impaired individuals. And it was not at a juncture boundary at all. What we hypothesized is that it may have something to do with the information processing for the production of the information. I think maybe the reverse may happen for your data.

A. I think you may be right.