Durational Characteristics of the Speech of Apraxics and Conduction Aphasics

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ABSTRACT

This study examined the vowel production of an individual with aphasia and accompanying apraxia of speech during both imitation and reading tasks producing CVC syllables within a carrier phrase. Listener judgments revealed a predominance of errors for the short, front vowels /ɪ/ and /ɛ/ for both conditions. Although duration measures of perceptually correct productions revealed a relatively preserved durational distinction for the long and short vowels, the magnitude of this difference was shorter than reported in previous studies, as were the overall durations of all vowels measured. In contrast to previous studies, perceived vowel errors exceeded consonant errors, suggesting that assumptions regarding the complexity of vowel production be reconsidered.

1. INTRODUCTION

It is generally accepted that damage to different areas in the left cerebral hemisphere can result in identifiable clusters of discrete, albeit overlapping, speech symptoms. These clusters serve to characterize groups of affected speakers according to factors such as fluency of speech production and the type and variability of errors. Thus, they play an important role in the classification and differential diagnosis of neurogenic communication disorders. They have also formed the basis of theories about differential impairment of speech and language processing in these disorders. Because symptoms overlap, however, reliable differential diagnosis can sometimes be problematic. This has been particularly troublesome in differentiating the speech errors of apraxia of speech, which usually coexists with nonfluent aphasia, from the phonemic paraphasias that are characteristic of conduction aphasia.

Profiles of typical speech behaviors in each disorder include a number of differentiating features [1]. Dysprosody is a clinical hallmark of apraxia of speech, whereas conduction aphasic speakers produce fluent speech that is prosodically normal [2], [3]. Apraxic errors are reported to increase with articulatory complexity to a greater degree than paraphasic errors, although conduction aphasic speakers are also likely to err more frequently as articulatory complexity increases [4], [5]. Apraxic errors are generally more predictable with regard to their location and type than the paraphasias produced by conduction aphasic speakers [6]. Both groups make inconsistent errors on successive attempts at a target [2], [3]. Some have reported that paraphasic speakers tend to move further from the target phonetically on these successive attempts [5], while others report that they are more likely to achieve the target than apraxic speakers [6].

A number of investigators have characterized the errors of conduction aphasics as phonemic substitutions, whereas apraxic errors are often ascribed to difficulties in articulatory programming (e.g., [3], [7]). This characterization appears to be based on the types of errors observed and performance across sound classes. For example, conduction aphasics have been shown to demonstrate similar error rates across vowels and consonants [5], [7], whereas nonfluent aphasics have shown either substantial increases in errors for consonants as compared to vowels [5], [8] or almost exclusive consonant errors [7]. The traditional interpretation of these data has been that consonants are more phonetically complex than vowels and that the increased error rate reflects a motoric as opposed to a phoneme substitution problem (see for example, Monoi et al. [7]).

The notion that vowels are less 'gesturally' complex than consonants, so that the extent to which they are produced correctly can provide an indication as to the nature and origin of speech sound errors, has motivated a number of studies of vowel production in individuals with apraxia of speech and conduction aphasia. Acoustic investigations of vowels in these two groups have focused on perceptually accurate productions [9], [10], [11], [12], [13], [14], as well as perceptually inaccurate productions [13]. Seddoh et al. [12] found that the correct productions of apraxic subjects were longer and more variable in duration (particularly for high front vowels) than the productions of either conduction aphasics or speakers without neurologic deficits. Ryalls [10], however, found that this variability, while evident for the apraxic group, was not statistically significant for either vowel duration or F1/F2 frequencies. Furthermore, although vowel durations for both aphasic groups were somewhat longer on average than those for normal speakers, 'tense-lax' distinctions were clearly preserved [10].

A few studies have examined the effect of elicitation condition on accuracy of production in aphasic speakers [5], [15]. A prevalent notion in the literature is that conduction aphasics' performance is worse in repetition than in oral reading tasks [15]. However, Monoi et al. [7] did not find

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that, for Japanese, elicitation condition (naming vs. repetition) had a "differential effect on the performance of [their] aphasic subjects" (p. 186), while Canter et al. [5] found that *both* groups of aphasics demonstrated superior performance in consonant production in the repetition as compared to the spontaneous naming task. Thus, Canter et al. [5] suggest that, if it exists, this deficit in repetition may be elicited only by stimuli that are sufficiently complex.

The purpose of the present investigation was to examine vowel production in different consonantal contexts and under different elicitation conditions (oral reading versus repetition) in two groups of speakers: nonfluent aphasics with apraxia of speech and conduction aphasics. In addition to characterizing the errors produced by the two groups, we wanted to examine notion of complexity of vowel production using acoustic analyses, especially of vowel duration (both overall and as a mechanism for signaling final consonant voicing), for a series of vowels for which control of some rather precise parameters is essential.

2. METHODS

Subjects: There are two groups of subjects for this study: persons with conduction aphasia (C) and persons with nonfluent aphasia and accompanying apraxia of speech (A). In this preliminary report, we present data for one subject (A1), a 63-year-old right-handed male college graduate, 79 months post onset of a left CVA resulting in a right hemiparesis and aphasia. He achieved an Aphasia Quotient of 67 on the Western Aphasia Battery, with subtest scores consistent with a diagnosis of Broca's aphasia.

Speech stimuli: The 12 utterance types were CVCs in which C1 was /b/ or /p/, C2 was /t/ or /d/, and V was from the set /i, ɪ, ɛ, æ, ɑ/; not all possible combinations were used.

Recording procedures: All speech samples were recorded in a sound-proof audiometric booth using a Marantz PMD 430 portable cassette recorder and a Shure 16A low-impedance condensor microphone positioned 20 cm in front of the speaker's mouth. Two conditions, repetition and oral reading, were recorded in separate sessions on two different days. Instructions for each condition were given at the beginning of the recording session. In the repetition condition, the speaker was instructed to repeat the sentence after it was read aloud by the examiner. If he was unable to repeat the item within 5 seconds, the examiner repeated the sentence. In the reading condition, the examiner placed a 3x5 index card containing a stimulus sentence (Say CVC again) in front of the speaker, who read it aloud.

Analysis: Recordings were digitized at using Macquirer software at a sampling rate of 11250Hz. Measurements were made of VOT, vowel duration, and final stop closure. In addition, listener judgments were obtained for each token; error productions were grouped according to the intended utterance and the type of error (vowel and/or consonant) perceived.

3. RESULTS

Characterization of errors: Confusion matrices were created to examine the types of perceived vowel errors made by Subject A1. The similarity between the error patterns in the two elicitation conditions can be seen in Tables 1a and 1b. That is, the short, mid-vowels /ɪ/ and /ɛ/ have the lowest accuracy levels of all of the stimulus vowels. Furthermore, there are virtually no errors for /i/, and /i/ is also the single most commonly perceived substitution for both /ɪ/ and /ɛ/. [This finding is particularly dramatic for /ɪ/ in the reading condition.] In addition, while there are differences in the absolute level of errors across conditions, it should be noted that there is more scatter in the errors produced in the reading compared to the repetition condition.

Table 1a: Confusion matrix of vowels in the repetition condition (in percent)

	i	ɪ	ɛ	æ	ɑ	eɪ	distortions
i	**100**						
ɪ	44	**39**	3				14
ɛ	8		**75**	4	4		8
æ	8			**84**	4		4
ɑ					**92**		8

Table 1b: Confusion matrix of vowels in the reading condition (in percent)

	i	ɪ	ɛ	æ	ɑ	eɪ	distortions
i	**93**				5	2	
ɪ	17	**50**	7	13		3	10
ɛ	13		**62**	7	2	5	11
æ	3		27	**67**			3
ɑ					**80**		13

Duration measurements: Although duration measurements were made of all vowels, this paper will discuss these measurements only for those vowels perceived to be produced as intended. The mean vowel durations are compared both across elicitation conditions (repetition vs. reading) and as a function of context (initial consonant /p/ or /b/) (Table 2).

Table 2: Mean vowel durations in CVt utterances produced as intended, and means and standard deviations for durations averaged across initial consonant contrasts, for repetition and reading conditions; mean vowel durations for subject GEP reported by [16].

	Repetition			**Reading**			
	b	p	**mean** (*sd*)	b	p	**mean** (*sd*)	**GEP**
i	140	123	**132** (***16.9***)	138	111	**123** (***19.4***)	**206**
ɪ	131	103	**117** (***21***)	106	106*	**106** (***6.2***)	**160**
ɛ	134	113	**123** (***18.8***)	130	100	**113** (***19.6***)	**203**

*represents the single token produced as intended

The effect of phonetic context is immediately apparent, and follows the expected pattern: for both the repetition and reading conditions, vowel duration following the voiceless stop is substantially shorter than duration following the voiced stop. (The duration of /ɪ/ in the reading condition is the exception; however, because there was only one correct token of /ɪ/ in the /p/ context, meaningful comparisons cannot be made.) This effect has been reported in previous research [16], although the magnitude appears to be somewhat greater for this subject.

Elicitation procedure also appears to be a factor in these data: for all three vowels, mean durations are shorter in the reading than the repetition condition. However, the overall durations for both conditions are substantially shorter than in previously reported data for the same vowels [16], which are indicated in the last column of Table 2. Moreover, the difference between /i/ and /ɪ/ seems particularly reduced for this subject.

Consonants vs. Vowels: Table 3 shows the percentage of perceived errors for consonants and vowels. Although errors on vowels exceed those for consonants in both conditions, this is particularly striking in the reading condition. (It should be noted that, because the stimuli were CVC syllables, there were twice as many opportunities for errors to occur on consonants.) In fact, consonant errors remain relatively constant across tasks; it is the vowel errors that appear to vary substantially.

Table 3: Comparison of perceived vowel and consonant errors in both elicitation conditions (in percent).

	Vowels	**Consonants**
Repetition	19.7	10.2
Reading	32.3	9.8
Mean	**26**	**10**

4. CONCLUSIONS

The results of this study of one speaker with apraxia of speech suggest a pattern of vowel errors in which short, mid vowels are more prone to be produced erroneously than are longer, more extreme vowels. Specifically, across elicitation conditions, our subject produced substantially more errors on /ɪ/ than any other vowel. On the other hand, productions of /i/, a vowel that is slightly higher and more forward, were perceived to be virtually without error. At the same time, however, the durations of the three vowels that we have measured (i, ɪ, ɛ) are significantly shorter than those we have found reported in the published data for the same vowels [16], especially in the context of the initial voiceless stop [p]. This finding differs from those of other studies where apraxic vowel durations were longer than normal [9], [12].

The notion that vowels are relatively unaffected, or at last less affected than consonants, in apraxia of speech [8], [7] is also not supported by these data. Vowel errors exceeded consonant errors in both elicitation conditions, but especially in the reading condition. Thus, the results suggest that, in the absence of a model, the realization of vowels is problematic. Moreover, the fact that the numbers of perceived errors on /i/ and /ɪ/ are so strikingly different in the two conditions suggests that the articulatory precision is a significant issue, at least in apraxia of speech. Whether this pattern will be found for conduction aphasics will shape the way that we characterize their speech production.

Monoi et al.'s [7] statement that an "impairment at the level of articulatory programming tends to affect the more complicated articulatory gestures of consonants to a greater extent than the less complicated articulatory gestures of vowels" (p.189) is not unsupported by our data. In fact, it would seem that assumptions about the complexity of vowels vs. consonants need to be reconsidered, both in general and with regard to these clinical populations.

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