FRENCH DISTINCTIVE FEATURE CONFUSIONS IN ADULT COCHLEAR IMPLANTEES

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ABSTRACT

French distinctive feature confusions were analyzed in a group of ten cochlear implantees. All were post-lingual deaf persons who had undergone cochlear implant surgery at least one year before the time of the examination. Six subjects had a Digisonic (MXM) implant with 15 electrodes and four had a Spectra 22 (Nucleus) implant with 22 electrodes. For the experiment, we used the French minimal pair test in which the two words in a pair differ by only one distinctive feature. The compactness feature was the most adversely affected, with an identification error rate of 32.36%, followed by the graveness feature with 28.26%. The sustention feature was the most robust, with an error rate of only 10.76%. This error pattern is quite similar to the one observed in normal-hearing subjects under various speech conditions. The results showed that place-of-articulation features are the least well discriminated and the most difficult to code in implants.

1. INTRODUCTION

Speech decoding by subjects with cochlear implants is based on perceptual and cognitive processes which are not yet fully understood [3]. It not only requires functional plasticity of the neural pathways and decoding processes, but also a period of learning and adaptation, since the phonetic and linguistic information that is sent to the various electrodes implanted in the inner ear arrives as a transcoded sequence of impulses. Knowledge of the decoding errors (phonetic confusions) made by cochlear implantees could contribute to improving both the coding strategies implemented in designing cochlear implants, and the techniques used to adjust them to fit each individual user.

The present study proposes a quantitative analysis of the confusions made by cochlear implantees between the different distinctive features of French consonants, and discusses some of the possible reasons for the observed confusions.

2. METHOD

2.1 Subjects

Ten adult cochlear implantees (5 men and 5 women) participated in the study. The mean age of the subjects was 56.1 years (range 35 to 72). Eight subjects were native speakers of French, and two had been living in France and speaking French for many years.

All of the subjects were post-lingual deaf persons who had undergone cochlear implant surgery at least one year before the time of the examination. Except for this requirement, no other selection criteria were used. The ten subjects were simply all of the implantees who were available at the center where the study took place (ENT ward of the Timone Hospital in Marseille, France). They were unpaid volunteers and were informed about the general aim of the study (conducted for research purposes only, with no personal benefit), as stipulated by French law and the Helsinki declaration.

Three of the subjects had experienced a sudden onset of deafness, while the others suffered from progressive deafness. The age of onset of deafness ranged between six and sixty-three years. The duration of profound deafness before implantation varied between one and forty-two years (mean 21.9) and the mean number of years with the implant was 3.6 (range 1 to 6 years).

All subjects used their implant on a daily basis. Six subjects had an MXM Digisonic implant with 15 electrodes and four had a Nucleus Spectra 22 implant with 22 electrodes.

2.2 Corpus

The corpus was the French minimal pair test developed by Peckels and Rossi [4]. This test is a DRT (Diagnostic Rhyme Test) composed of 108 pairs of words. The two words in a given pair differ phonologically by a single distinctive feature, as in *pile/bile* (voicing attribute) or *pour/four* (sustention attribute). Each feature occurs 36 times in nine different vocalic environments (four words per vocalic environment).

The corpus was recorded by a native French-speaking male who does not have a pronounced regional accent. This corpus has often been used in speech perception studies conducted by our laboratory.

2.3 Experimental Procedure

Subjects were examined with their normal implant parameter settings. They were tested individually in two sessions held a few days apart. The sessions lasted an average of one hour, with a twenty-minute break in the middle.

Stimulus display and response collection was run in real-time on a PC computer in the Windows environment, using software developed by our laboratory to measure speech quality and intelligibility [1]. The subjects were seated facing a screen and were supplied with a panel of buttons for responding. The auditory stimuli were presented in free field at the normal speech level (65 dB RMS, measured at the subject's head) through a loud speaker located one meter in front of the subject.

The task was as follows. The subject heard a word, looked at two words displayed on the screen and chose the one he thought he had heard, and then pressed the corresponding button (binary forced choice). The subject's responses and response times were recorded automatically. The 216 words in the corpus were presented to each subject four times, in random order.

3. RESULTS

Only the responses themselves will be analyzed here, not the response times. The entire set of responses (8640 in all) was input into an analysis of variance (Anova). The non-response rate was low (2.1%), indicating that the subjects were comfortable with the experimental situation. In the analysis of the results, non-responses were counted as errors.

3.1 Type of Deafness, Duration of Deafness, and Time since Implantation

The type of deafness, its duration, and the time since implantation did not significantly affect the overall error rate (all F's < 1).

3.2 Overall Error Rate

The total number of errors was 1772, making for a mean error rate of 20.51% and a correct response rate of 79.49%.

3.3 Errors by Feature

Although the mean error rate is an interesting indication of overall performance, it does not provide any information about the types of errors made. We obtained this information by conducting a feature-by-feature analysis, which was possible with the DRT we used.

For each feature, the number of errors, the error rate, and the correct response rate are given in Table 1, in decreasing order of confusion.

Feature	No. of errors	Error rate (%)	Correct response rate (%)	No. of responses
Compactness	466	32.36	67.64	1440
Graveness	407	28.26	71.74	1440
Nasality	309	21.46	78.54	1440
Voicing	227	15.76	84.24	1440
Vocality	208	14.44	85.56	1440
Sustention	155	10.76	89.24	1440
Total	1772	20.51	79.49	8640

Table 1. Number of errors, error rate, and correct response rate in cochlear implantees, by distinctive feature, in decreasing order of confusion.

4. DISCUSSION AND CONCLUSION

The overall error rate showed that subjects with cochlear implants are capable of identifying isolated words without the associated visual cues (lip-reading). Despite differences in the experimental procedures, the correct response rate in our study can be regarded as highly superior to that obtained by some of the better cochlear-implant patients tested by Tyler and Moore [5]. The French subjects in the Tyler and Moore study had a correct response rate of only 18% on isolated nonsense words.

The three features nasality, vocality, and sustention, which are linked to the mode of articulation, are known to be the most robust, no matter what type of speech is examined. Among these features, only the nasality feature gave rise here to a fairly large number of errors. This is no doubt related to the fact that the acoustic cues of nasality are difficult to analyze and thus difficult to code.

The two features that were confused the most by our cochlear implantees were graveness and compactness, which are linked to the place of articulation. These features have also proven to be the most fragile ones for normal-hearing subjects when they are listening to speech in the presence of masking noise [2]. This result pattern is not language-dependent either, since these two features are known to be the most fragile ones in English [6]. The present results thus confirm the idea that the acoustic cues associated with the graveness and compactness features are intrinsically fragile; they are sensitive to the type of coding as well as to the transmission conditions and noise. The reason why these features are difficult to code in cochlear implants probably lies in the fact that the amount of frequency information is reduced due to the limited number of frequency bands available for speech coding.

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