The Effects of Low Pass Filtering on Consonant Perception as a Function of Experience

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ABSTRACT

The effects of low pass filtering on consonant perception as a function of experience was investigated. The speech samples were Kindergarten F0 words low pass filtered at 1000 Hz. Low pass filtering at this point resulted in the inability of seventh grade students to correctly identify any of the stimulus words; therefore, the words were re-filtered at 2,000 Hz. First grade, fourth grade and college age students were the subjects in the speech discrimination task. Results of analysis of variance was significant (p < .01).
Research in speech science has indicated that the speech wave can consist of several simultaneous cues, each of which is sufficient for identifying a particular speech sound (Denes and Pinson, 1963). The perception of a given sound may either be enhanced or degraded by the coarticulation effects of the adjacent phoneme due to the coupling effects existing for different consonant and vowel sequences. The articulatory and acoustic properties of a given phoneme often depend upon those of the adjacent phonemes (Guy, 1970).

Analysis of the relative contribution to intelligibility of the various parts of the speech spectrum designated the high frequencies as the information bearing and the low frequencies as the energy bearing portion of the speech signal (Fletcher, 1929). Fletcher (1953) stated: "A consonant sound may sometimes be identified by the modifications produced on the following or preceding vowel even though it is below the threshold as determined by an isolated sound. It might seem logical to consider this modification of the vowel as part of the consonant. If it is so considered, then it is evident that as long as the vowel is heard there is always a chance of identifying the consonant preceding or succeeding it..." (p. 418)

The most important frequencies for the vowels are in the area of the first two formants approximately between 200 and 2000 Hz. The greatest frequency concentration for voiced consonants, particularly fricatives and plosives, is between 1500 and 4000 Hz. The voiceless fricatives and plosives have frequency concentrations between 2500 and 5000 Hz. (Hoops, 1969).
Speech discrimination for persons with a hearing loss depends on several factors including the severity and type of the loss. The degree of handicap produced by a hearing loss also depends to a considerable extent on its time of onset with the congenitally hard of hearing child affected to a greater degree than the child who acquires a hearing loss after the formation of both receptive and expressive language, or for the adult who becomes hard of hearing (Newby, 1952; Sanders, 1971).

Speech discrimination is primarily an auditory function. Under favorable listening conditions a normal-hearing person can obtain high intelligibility scores from the acoustic signal alone. However, distortion of the acoustic stimulus results in a decrease of the intelligibility of speech (French and Steinberg, 1947; Fletcher, 1953). The difference in speech discrimination ability between the congenitally hard of hearing child and that of the adventitiously hard of hearing child or adult may be due to the lack of experience in using the simultaneous cues present in the speech wave.

This study investigated the effect of experience in using vowel transitions to identify consonants in a speech discrimination task so designed as to simulate a high frequency hearing loss. To satisfy the experience variable, normal hearing subjects were chosen according to age groups.

METHOD

Subjects

Subjects were chosen from groups being given routine hearing
screening in the Marion, Indiana public school system. Twenty subjects were randomly chosen from each of the first, fourth, and seventh grade classes at one elementary and one junior high school. Twenty subjects were also randomly chosen from a speech science class at Ball State University, Muncie, Indiana. These students were, for the most part, college sophomores. Subjects were excluded from the study if he failed in either ear a pure tone sweep test at 15 dB (ISO) for 250, 500, 1000, 2000, 4000, or 8000 Hz.

Test Materials

Speech samples consisted of the Kindergarten P3 Word Lists, one through three. The P3 words are lists of 50 monosyllables which are selected for familiarity and phonetic representation of everyday conversational speech.

The examiner recorded these lists onto a new Scotch recording tape using a Roberts model 771X recorder at a level at which the vowel /ə/ peaked at zero on the recorder's VU meter. Each list was preceded by five practice words taken from the first five words of one of the other two lists. Practice words were intended as a conditioning procedure to assure that the subjects were responding to the test items in an appropriate manner.

The 55 words per list were recorded separately with a carrier phrase, "Say the word..." preceding each word. A five second pause was allowed between each word and the next carrier phrase to allow time for the response.

After taping the three lists, this master tape was then
played into a B & K Filtering System using the Summing Panel 1612/SP, Band-pass Filter Set Type 1612/STA, and Microphone Amplifier Type 2603. This system was used to filter out frequencies above 1000 Hz, in the test words only. These test words were filtered twice to assure the 1000 Hz, low-pass cut-off point, and were then re-recorded onto a new Scotch recording tape on the Roberts 771X recorder.

Procedure

In the test situation two methods were employed. The two younger groups were tested by having one child at a time listen to one list of the filtered words while the examiner wrote down his verbal responses. These tests were conducted in a non-sound treated room with a playback level sufficiently loud to be approximately 30 to 40 dB above the subjects' SRT. The Roberts 771X recorder was the sound source in all testing situations.

The directions given the first and fourth graders were:

"We are going to play a listening game where you will be told to 'Say the word...'. and then a word will be given. It is very important that you listen carefully and say exactly what you think you heard the speaker say. At first you will be able to hear the words clearly, but after a few words it becomes harder. Even when it becomes hard to tell what the word might be, you should guess, even if you are not sure. Now, try very hard."

During the conditioning procedure the subjects were reinforced with a nod and a smile for making verbal responses. If a subject did not respond with any verbal answers, he would be excluded. As this did not occur, no subjects were excluded.
from the test for this reason.

The two older groups were tested in a group situation in a non-sound treated room with the sound source located in a central position. The playback level was again sufficiently loud to be approximately 30 to 40 dB above the subjects' SRT. The responses of these groups were written on a form provided by the examiner with spaces for 50 responses.

The directions for the two older groups were given in this fashion:

"This is a research project you are taking part in. You will be listening to a tape recording of 55 words following a carrier phrase. The first five words are practice words which you will listen to only. Do not write anything until I say, 'Begin'. Listen to the practice words to get an idea of the type of words used and the amount of time between words. There is a carrier phrase, 'Say the word...' followed by a word and then a 5 second pause. You will be required to write the word you hear in that five seconds, so listen carefully as they may be difficult to hear. If you do not understand the word, guess at it, but under no circumstances will you speak as you will disturb others and perhaps miss the next word. If you cannot even guess as to what the word may be, put an 'x' in the blank. I thank you for participating. Your score on this project will in no way count toward your grade in this class, so listen carefully and please guess even if you are not absolutely sure."

The first group tested was the seventh grade students. Upon evaluation of the results it was discovered that no correct responses were made.

The master tape of the three lists of PnK test and practice
words was again played into the B & K Filtering System in the same manner with the exception that the low-pass cut-off frequency selected was 2000 Hz. The words were filtered but one time. These lists were re-recorded onto a new tape.

Since the seventh grade group was unavailable for further testing at the new cut-off frequency, their scores were excluded from the study. The results of the speech discrimination task were based only on scores from the first grade, fourth grade, and college students at the low-pass cut-off frequency of 2000 Hz.

RESULTS

The mean scores for the three groups are presented below:

- First grade: 25.1%
- Fourth grade: 25.7%
- College: 33.5%

Analysis of variance was used to examine the effects of age/experience for the groups. Results were significant (p < .01).

DISCUSSION

In order to understand the inability of the seventh grade students to discriminate any of the words on the test with the 1000 Hz. low-pass filtering reference was made to previous research done with filtered speech.

Using nonsense syllables it was found that low pass and high pass filtering at frequencies of 100 through 10000 Hz. produced curves which crossed over at 1800 Hz. with an articulation score of 67% at this point. Low pass filtering with a cut-off at 1000 Hz. resulted in an articulation score of
approximately 28 per cent (Denes and Pinson, 1963). Several other research studies (Fletcher, 1929; Kryter, 1966; French and Steinberg, 1947; Franklin, 1969) done with the intensity of the speech signal and "interband masking" have noted that when complex sounds are amplified, the low frequencies gain in loudness faster than the high frequencies; thus, the high tones begin to be masked as the low tones become more prominent. This may explain the inability of the students to recognize any of the words they were hearing, as the intensity level of the recorder may have been such that it was sufficiently loud for all subjects to hear the tape, but the intensity of the low frequencies were masking the information carrying higher frequency vowel transitions.

The results obtained in this study indicated that groups did differ with the college age students attaining a mean discrimination score increase of 7.8 percentage points over the next higher group. If this difference is due to experience in using vowel transitions for consonant identification, thereby being able to correctly identify the stimulus word, then this has implications in planning a therapy program for children and adults alike.

Therapy approaches vary from gross sound discrimination to discrimination of conversation with listening conditions ranging from ideal to difficult. Part of this training may be considered as teaching the client to make the most of what he hears. Isolated sound discrimination has been recommended as a means of assisting the person in improving his recognition of troublesome sounds. The redundancy of the spoken message
is also relied upon with other cues such as content of the message, and speechreading skills being emphasized to aid in discrimination (O'Neil, 1964; Ewing and Ewing, 1954; Hirsh, 1970).

If speech discrimination is primarily an auditory function and normal hearing persons can obtain high intelligibility in using the acoustic signal alone, might this not be a logical beginning for planning a training program. A program of this nature would assist the hearing impaired person by emphasizing practice or experience in the use of that portion of the speech spectrum which they retain as a means of assisting them in identifying the missing portions.

Making use of the residual hearing, especially in high frequency losses, by implementing a therapy program to provide intensive practice in consonant identification through training in perceiving differences in the acoustical properties of the vowel in differing consonantal environment would seem to be a valuable asset to already existing programs which emphasize speechreading, varying listening conditions, and contextual cues to aid in rehabilitating those with hearing losses.

Other studies have shown that test vocabularies make a difference in the ease of intelligibility of the materials (Hoops, 1962). This factor might also indicate that the vocabulary available to the subject could possibly effect the scores obtained; therefore, further research in this area should be undertaken to determine if the results obtained in this study were truly those of experience and not an artifact
of the increased vocabulary of the college students.

Replication of this study with more groups of subjects should also be undertaken to determine if there is a steadily increasing improvement in the articulation curve as experience increases. Studies of this nature in which the low-pass cut-off frequency point is varied between 1000 and 2000 Hz, using language samples rather than phonemes or nonsense syllables might also be useful in determining the relative usefulness of residual hearing in high frequency losses.
BIBLIOGRAPHY


