

Voice Pitch as an Aid to Speechreading in Young Children

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Introduction

For the majority of the profoundly hearing impaired population, speechreading, or 'lipreading', is essential for the perception of speech in everyday communication. None of the aids to communication available to the profoundly deaf - whether conventional hearing aids, vibrotactile aids, visual aids or electrocochlear devices - are, as yet, able to provide good, consistent speech discrimination in the absence of speechreading.

However, for a number of reasons, the perception of speech through speechreading alone, even in ideal conditions, is extremely problematic [1,2,3]. The visual cues available in speechreading mainly give information about the place of articulation of a consonant. Even leaving aside the obvious problems caused by articulatory movements which are not visible to the speechreader, confusions arise because visible configurations of the lips, tongue and teeth are almost never unique to one particular phoneme. Manner and voicing information, required to allow consonants sharing the same place of articulation to be distinguished from one another, is not readily available through visual perception of the speaker's facial features. One would therefore assume that provision of this information to the speechreader should greatly improve his/her ability to directly identify consonants in everyday speech.

A number of recent studies have concentrated on trying to determine what sort of acoustic information could afford good speech discrimination to the profoundly deaf subject when presented alongside the visual information available through speechreading [4,5]. Because of the nature of profound, sensorineural hearing losses it is generally neither possible nor desirable merely to present hearing impaired subjects with the whole amplified speech signal. These subjects will generally have little or no perception of higher frequency components of the speech signal, will have drastically reduced dynamic range and may have impaired perception of frequency, amplitude or temporal changes in the incoming auditory signal [5].

There are several reasons for considering fundamental frequency or voice pitch information as a potential aid to speechreading in the profoundly deaf [6]. It is a major and invisible cue to consonant identification. As well as providing segmental information through consonantal voicing contrasts, variations in fundamental frequency can provide a great deal of information about suprasegmental, prosodic aspects of the speech signal. There is also evidence that most profoundly hearing impaired people are able to perceive the temporal patterns which relate to changes in fundamental frequency, while many appear unable to detect more complex speech perceptual cues [4,7]. It has been suggested that the extraction and presentation of simple cues, matched to the perceptual abilities of the subject, may be a more effective way of aiding speechreading performance than presenting a "whole speech" signal in which cues such as fundamental frequency may be less explicit.

Studies using hearing subjects can allow experimenters to control the quality and amount of auditory information provided as a supplement to visual speech cues. Experiments with hearing adults have shown that presentation of voice pitch information along with speechreading can result in considerable improvements in the speed at which speech is

perceived in a Connected Discourse Tracking task [8]. The primary aim of the present study was to investigate the effect of voice pitch information on the speechreading performance of young hearing children.

Investigations of speechreading skill in both adults and children have often produced confusing and conflicting results, usually as a result of the use of many different methodologies. Previous studies have differed widely in terms of the subjects tested, the speechreading materials used and the manner in which those materials were presented [9]. As yet there are no definitive answers on how speechreading skills should best be defined and tested. The methodology applied in the present study was largely dictated by the age of the subjects taking part.

Method

Subjects

22 children with normal hearing took part in the study. The age range of the subjects was 5.9 - 6.75 years (Mean age = 6.3 years, S.D. = 0.3 years). No subject had any history of hearing impairment, visual impairment or severe learning difficulty.

Test Materials and Procedure

The speechreading test was made up of 60 items. For each test item subjects were shown three black and white drawings, these drawings corresponding to the 'target' word, a visually similar 'distractor' word and a 'random' word (eg. 'book', 'bike' and 'fish'). Both the vocabulary and drawings used in this experiment were taken from the Manchester Picture Test (1984) [10], which has been validated with children of 5 years old and over. All of the words included in the test were monosyllabic.

A videotaped presentation of the target stimuli was used. An adult female speaker, whose head and shoulders only were visible on the television screen, presented each target word, preceded by the carrier phrase "point to the.....". Subjects were required to respond by pointing to the picture corresponding to the word spoken. The test was devised such that, for half of the test items, discrimination of the target word from the distractor would be expected to be facilitated by the ability to perceive voicing contrasts (eg. 'dog', 'duck' and 'ball').

Each subject was tested individually and performed the speechreading task twice, once in the silent condition and once with voice pitch information present. To control for order effects the subjects were randomly allocated to two groups, one group performing the silent condition first, the other performing the voice pitch condition first. The voice pitch information was extracted from the speech signal during the recording of the test stimuli using an electro-laryngograph. This auditory signal was presented simultaneously with the visual speechreading stimuli in the voice pitch condition.

Results

(a) Speechreading Ability Related t-tests showed that the difference between the number of words identified correctly and the number of errors made was significant both for the silent condition ($t = 5.4$, $df = 21$, $p < 0.001$) and for the voice pitch condition ($t = 10.8$, $df = 21$, $p < 0.001$) with subjects making more correct responses than errors for both conditions. When the errors themselves were analyzed, related t-tests showed that

the difference between the number of distractor items chosen and the number of random items chosen was also significant for both the silent condition ($t = 11.42$, $df = 21$, $p < 0.001$) and the voice pitch condition ($t = 15.98$, $df = 21$, $p < 0.001$) with more distractor items being chosen than random items.

(b) The Effect of Voice Pitch Information A MANOVA showed that there was no significant effect on test scores of the order in which subjects performed the silent and voice pitch conditions. There was also no significant difference between the total correct scores obtained in the silent condition and those obtained in the voice pitch condition ($F = 2.83$). However, when scores with the two different types of test item ('voicing contrast' and 'no voicing contrast') were analyzed separately there was found to be a significant effect of condition ($F = 4.29$, $p < 0.01$). Related t-tests showed that there was no significant difference between scores obtained in the silent condition and those obtained in the voice pitch condition for items which did not involve a voicing contrast ($t = 0.78$, $df = 21$). However, a significant difference was found between scores obtained in the silent and voice pitch conditions for those items which did involve a voicing contrast ($t = 3.93$, $df = 21$, $p < 0.001$), with speechreading scores being higher when voice pitch information was provided.

Discussion

Hearing children of 5 - 6 years of age, with no known speechreading experience, have been shown to be able to identify familiar words using the visual speech signal only. It therefore seems probable that visual information has a role to play in everyday speech perception, even for those for whom the auditory modality alone can generally provide sufficient information for accurate speech discrimination. These young children have also been shown to be able to make use of voice pitch information to assist them in a speechreading task where the perception of voicing contrasts was required. However, it is not clear from these results that the benefits of this limited auditory signal would be enough to produce a significant improvement over speechreading alone in the perception of everyday conversational speech.

A number of studies have suggested that both visual and auditory aspects of phonology may be integrated in a common phonological store [11,12]. The apparent ease with which the young children in the present experiment were able to use visual information to access phonological knowledge certainly lends support to these theories. The results of this study also imply that the normal speech perception process involves the use of specific speech features as cues to the identity of speech sounds and that these speech features can be used in isolation from the whole speech signal.

It is not clear how beneficial the provision of simple speech pattern signals, such as the voice pitch signal, might be to a young, profoundly hearing impaired child. The enormous differences between the hearing subjects used in this study and the majority of profoundly hearing impaired children of a similar age, in terms of their language knowledge and experience of auditory speech perception, would make generalizations from one group to the other extremely problematic. It is the belief of some researchers that a hearing impaired child should be given as much auditory input as possible if he/she is to acquire language in a relatively natural way and develop auditory neural systems as fully as possible [13,14]. Others suggest that profoundly hearing impaired children may need specific auditory training in the use of a particular speech feature, such as voice pitch, if they are to benefit fully, or at all, from the provision of this kind of auditory signal [15].

However, we can surmise that any auditory information provided to a hearing impaired child must surely increase that child's chances of acquiring knowledge of spoken language, and we can speculate that for some profoundly hearing impaired children the provision of simple voice pitch information may be better matched to their perceptual capabilities than a more complex whole speech signal.

References

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