



PHONOLOGICAL ASSESSMENT OF DEAF CHILDREN'S PRODUCTIVE KNOWLEDGE AS A BASIS FOR SPEECH-TRAINING

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ABSTRACT

Prelingually deaf children unavoidably make deviations in production although they possess an abstract phonological system. The systems differ from those of normal speakers due to the fact that the phonological systems of deaf children are built up through vision, tactilation and maybe some residual hearing. Traditionally, assessments of deaf speech describe what a deaf child is not capable of articulating through conventional error-analyses. Hence, only speech sounds that the child never articulates correctly are treated in the speech clinic. The sounds that the child articulates correctly are disregarded and also taken for granted to be used correctly. However, it has been shown that even if a child knows how to articulate a sound correctly this does not imply that the usage is correct in his spoken language. Furthermore, many of the articulatory deviations made by deaf children are in fact attempts to realize phonological contrasts. Hence, a conventional error-analysis provides no information about a deaf child's usage of his or her productive knowledge and pays no attention to whether a deviant articulation might signal a "correct" contrast. It is more appropriate to base a speech-training programme on a phonological assessment that determines what the speech does express.

INTRODUCTION

Since 1981, sign-language is seen as the primary language and Swedish is the second language in Swedish schools for deaf children. Swedish is mainly learnt in its written form and by the aid of sign-language for instruction and explanation. This has resulted in a dramatic decrease in the time spent on speech training and most children only receive 30-60 minutes of individual training per week. No speech-training or correction is practiced in the classroom during ordinary lessons. The limited opportunities for speech-training has increased the demands for efficient, individualized assessment and speech-training methods.

SPEECH ACQUISITION

The hearing child acquires speech and language spontaneously through a combination of hearing and speech-reading. Auditory and visual input control helps him to compare the vocal output of other speakers with his own production. Visual articulatory movements give concrete cues about how to produce speech sounds while hearing provides a measure of success.

The blind child has no access to visual information. It would then seem likely that this will affect his or her phonological development. In fact, some studies [1] have reported that facial movements in blind children are described as "muted", and the articulation is described as less distinct. Hungarian vowels articulated by blind children were investigated, through electromyography and spectrography. Less lip movements compared to normal sighted children were found. However, the spectrograms showed no deviations in acoustic properties of the productions. According to Mills "...blind children will follow a different and slightly slower path in earlier phonology compared to sighted children and this is attributed to the absence of lip-read information. However, the children studied showed no sign of developing a disordered phonological system in the long term."

Children, who are born with a severe auditory deficit, have no acoustic speech target to imitate and compare their own production

with. Therefore, they develop no spontaneous speech but a built-up speech through vision, tactile sensation and, if possible, residual hearing. They have to rely on the limited visibility of phonetic features in learning oral speech and on orosensory-motor control in maintaining speech movements. Due to these input limitations in speech perception and other factors that they rely on when learning to speak, such as reading the written word and special teaching methods, the speech of prelingually deaf children will contain many deviations.

The fact that the limited information available in visual aspects of speech may be used to develop a phonological system has been discussed by Dodd [2]. She suggests "that strong evidence is provided that lip-read and heard speech are processed in a code insensitive to input modality. A phonological system can be derived from hearing by ear or from hearing by eye, but the resulting systems will differ in some respects."

FACTORS AFFECTING THE INTELLIGIBILITY OF THE SPEECH OF DEAF CHILDREN

The intelligibility of the speech of deaf children will depend on to what extent their phonological system and phonetic realization of this system resemble the norm of the language users in general. The deviations in the speech of a deaf person will be influenced by a number of different factors. In the following a brief description is given.

Degree of hearing loss and functional hearing

Several studies have shown that there is a close relationship between degree of hearing impairment and speech intelligibility of hearing-impaired children [3, 4]. Poor speech accompanies higher hearing loss. On the average, speech intelligibility decreases with increasing hearing loss until a loss of about 90 dB. Above that, the degree of correlation is reduced.

The speech intelligibility of a hearing-impaired child depends not only on the amount of hearing, as measured by pure-tone audiometry, but also on the quality of the hearing sensation and the use the child through training has been able to make of his residual hearing. For a hearing loss above 90 dB, the term "functional hearing" has been used. The functional hearing of a child, that is, the degree to which a child can use his hearing for speech perception and control of his own speech production, will depend on many factors: degree of hearing loss, shape of the audiogram, amount of hearing aid use, amount of auditory training, etc. As pointed out by Monsen [5] "a good audiogram may correlate quite consistently with good speech; but, on the other hand, children with more severe hearing losses may commonly span the whole range from very intelligible to quite unintelligible speech." Hence, the intelligibility of the speech of children with pure-tone averages more than 90 dB cannot be predicted from the degree of hearing loss, as measured by pure-tone audiometry. In these areas, sound might be perceived through vibrotactile rather than auditory receptors. Vibrotactile perception is mostly limited to speech-envelope features like duration and intensity [6]. Auditory perception identifies also spectral features like small differences in fundamental frequency and vowel formant patterns. The audiogram will not differentiate "vibrotactile" from "auditory" children as it provides insufficient information about speech-processing capabilities, like the ability to perceive gap durations and small dif-

ferences both in frequency and intensity.

Speech-processing capabilities and functional hearing are more appropriate to measure by means of a speech-test than by pure tones [7]. Since the range of speech reception skills in profoundly deaf children is quite limited and since they are often low-verbal, speech material might be difficult to use. Sentences might contain words or difficult grammatical constructions that they don't know. Speech-test especially designed for this group must be used. The result of a simple spondee recognition test provides valuable information about a profoundly deaf child's ability to perceive and possibility to develop intelligible speech [8].

The lack of auditory feed-back causes disordered respiratory processes in speech, which affect the intelligibility of the speech of deaf children [9]. They often speak on low lung volumes and even initiate reading and conversation below the residual air capacity without inspiration. The lack of sufficient air is one reason to the bad control and low intelligibility of deaf speech.

Visibility of speech elements

The perception of speech through vision is difficult because many articulatory features of speech are not easily accessible from visual observation. Acoustically each speech sound is unique, but visually many sounds are hard or impossible to discriminate. Some speech sounds have almost identical visual articulatory movements and others have invisible articulation [10]. Lip-reading gives correct identification of about 30-40% of initial consonants and only 20-30% of final consonants [11]. A discrimination of 70% for consonants is required to understand speech efficiently [12]. This can consequently not be achieved by the deaf child, who is mostly relying on lip-reading.

Any set of speech segments that is visually contrastive from another is called a *viseme*. Confusions in both articulation and perception occur within visemes but not between them. The set of visemes varies from study to study due to differences between languages, talkers, subjects' response tasks, and effects of vowel contexts [13]. The vowel /u/ limits the number of contrastive visual units. However, a certain consistency can be seen. For Swedish consonants three visible groups are reported according to place of articulation: bilabials, labiodentals, and 'others' [14]. As much as 82% of the Swedish consonants belong to the group 'others'. Concerning Swedish vowels, two visemes can be identified, rounded and unrounded, due to the visibility of lip-rounding and jaw opening. Hence, the unrounded articulatory extreme vowels /a/ and /i/ are visually contrastive to the rounded /u/ and to each other.

Impact of orthography

The educational method in the Swedish schools for deaf children implies that speech-training methods nowadays must be based on written Swedish and the use of sign-language for instruction and explanation. This means that it is extremely important that the children are well familiar with the pronunciation rules. Insufficient knowledge of these rules causes typical deviations which often are found in the speech of deaf children. Especially the various spellings of the phonemes /j ç o: e:/ give rise to some deviations and the fact that two, and sometimes three, letters are pronounced as one sound in Swedish is not obvious to some children.

Impact of teaching methods

When teaching deaf children articulation skills, "clear speech" is often used by the teacher to improve lip-reading. This "over articulation" is not merely a louder version of normal speech, but might also involve an active reorganization of phonetic gestures. Major differences between conversational speech and clear speech are reported [15, 16, 17]. Among other things, stop bursts are always released with a higher intensity in clear speech and the speaking rate decreases. An increasing number of pauses are used, and the duration of individual speech sounds and pauses is prolonged. This might cause temporal deviations in the speech of the children as well as lack of coarticulation and sound insertions.

Other factors

It has been emphasized that the effect of ethological, educational and other background variables on the intelligibility of the speech of deaf children is of particular interest [4].

SPEECH ASSESSMENT IN A LEARNING SITUATION

In a speech learning program, it is necessary to continuously assess the speech of the deaf children to find the deviations that need to be corrected and the phonological contrasts that must be learned to improve the intelligibility. It is necessary to identify the unique characteristics of each child's system in order to design the most appropriate treatment plan for each child. To identify phonological deviations, the assessment should concentrate on the usage in spoken language of a child's productive knowledge, that is, the sounds that the child articulates correctly without any reference to the contrastive function [18]. Hence, an efficient speech-training program should first concentrate upon a correction of the deviations that occur in spoken language for the productive knowledge of the child. The speech sounds that the child could not yet produce will then be the object of training. In this phase, both their contrastive function and their correct articulation are taught. Otherwise, it could be, that speech training results in mere "articulation gymnastics". By assessing the usage of the productive knowledge of a child, it is also possible to exclude a motoric disorder as a possible explanation of a phonological deviation.

Different levels for the description of deviant speech

Speech can be described at two levels: the phonetic and the phonological. A phonetic description is more or less detailed and shows how consonants and vowels are produced (articulatory phonetics) or what the acoustical signal looks like (acoustic phonetics). A phonetic description does not have to pay attention to a specific language. Phonology on the other hand, is much more than the study of how speech sounds are articulated. It concentrates upon how the articulation is used in spoken language. Each language has its own sound system and sound pattern, i.e., specific rules of how to combine the phonemes to build up meaningful words and utterances. The knowledge of the phonologic system of a specific language includes the knowledge of its pronunciation rules.

Although deaf children make deviations in production, they might possess some kind of an abstract and stable phonological system. Several studies have shown that they often have well-established speech habits since they tend to produce a speech sound in the same deviant manner, in similar contexts [2, 19, 20, 21, 22, 23, 24, 25]

Assessment of phonetic deviations

The speech of congenitally deaf children contains a large number of deviations in the segmental production that can be classified as distortions, substitutions, omissions, and insertions. A distortion is a non-standard production. A substitution is when a standard phoneme replaces another phoneme. When a deviation is defined as an omission, a speech sound is not produced at all at a place where it should be. Finally, in the case of insertions, an improper addition of a speech sound is made. A phonetic deviation is the result of incorrect phonation or articulatory movements, allophonic variants or sounds that are not part of the native language, that has no effect on the speaker's ability to signal meaning differences.

A number of qualitative and quantitative studies have described types of segmental and prosodic deviations, which are typical of the speech of deaf children. A review of acoustical and perceptual studies dealing with phonetic aspects in the speech of deaf children is given by Gold [26]. These phonetic descriptions did not pay attention to the contrastive function in a specific language and can be described as phonetic error-analyses. They compare the articulation of deaf speakers to that of persons with normal hearing and provide information of what deaf speakers are not capable of articulating. Unfortunately, the articulation is usually assessed through a coarse phonetic transcription missing important articulatory details. Phonological aspects that determine what the speech does express or effects of different deviations on intelligibility are seldom investigated. Hence, a traditional error-analysis provides information of the sounds that are present in a child's inventory at least once (productive knowledge) and of the sounds that are absent or never pronounced correctly. However, this information is insufficient as a base for speech training, since it says nothing about the usage of the productive knowledge in spoken language or whether a deviation might signal a "correct" contrast [27].

Assessment of phonological deviations

A phonological assessment is concentrated on deeper aspects of the speech production of a deaf child [19, 20, 21, 22, 23, 24, 25, 28]. Aspects concerning whether a deviant pronunciation in fact is a realization of signalling a contrast of meaning and, if so, in what way the used phonetic element differs from the phonetic element used in normal speech. A phonological deviation is the result of, for example, using a speech sound incorrectly even though the motoric movements can be executed adequately or when a speech sound is missing in the child's pronunciation system so that the meaning of a word is affected.

To be able to assess the speech of deaf children phonologically, the assessment must be based on a phonetic transcription in different word positions. The transcription will form the "raw data" of the phonological assessment. When it comes to the consonants, the transcription must be narrow, otherwise it is possible that articulatory important elements, that the speaker uses to realize a phonological contrast, will be ignored. As concerns vowels, deaf speakers often make systematic substitutions and a broad transcription provides sufficient information.

To assess the speech of deaf children phonologically is not a generally known method in Sweden. However, it has shown its importance in deriving information about underlying rules that control the speech of a deaf child [24] and the necessity to assess the usage of the phonemes for which a child has productive knowledge to investigate what the speech does express [25]. In the latter study it was shown that although deaf children have an articulatory knowledge of certain phonemes, several deviations occur in different contexts due to the limited information of phonetic features and the limited knowledge of the rules of pronunciation, etc.

The need for speech assessment in a learning situation

It is important that the speech-therapist is aware of which level, phonetic or phonological, he or she is working on in a specific situation. If an assessment shows that the child understands a phonological contrast but has difficulties in realizing it correctly, the training can be concentrated on articulatory training. However, the child must first be made aware of his deviant way of expressing this contrast in different contexts. If, on the other hand, the assessment shows that the child does not understand a phonological contrast, this contrast must be learned simultaneously with articulatory training of how to realize it.

If training is made without awareness of a child's phonological system, this may destroy already established couplings between the abstract entities and articulation. The result might even be that the child's phonological system will be messed up and the intelligibility of the speech will decrease after training. The speech therapist must also be aware of how the input limitations and impacts from orthography and teaching methods affect the children's speech to avoid further development of deviant phonological processes.

FINAL REMARKS

A speech-training program based on a phonological assessment of the speech of deaf children will be more directed towards a training of distinctive features and of the correct production of contrasts between often visually similar consonants, rather than towards a correct pronunciation of a specific sound. Misuse or omission of a distinctive feature results in several deviantly articulated speech sounds. If this feature is taught, the articulation of all speech sounds that contain this feature will improve. Computer-based speech training have shown to be excellent to develop contrastiveness in the speech of deaf children. This type of training is making the children aware of their deviant way in expressing contrasts and helps them to train correct contrasts through an immediate and meaningful feed-back.

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