Clinical Application of Computer-Driven Methods for the Assessment and Treatment of Speech Perception Disorders

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The relationship between speech perception and speech production errors in children with impaired phonological skills has been a controversial issue in the practice of speech-language pathology for many decades. During the past 20 years speech-language pathologists have largely ignored the perceptual abilities of their phonologically impaired clients as a consequence of vigorous critiques of clinically available methods for assessing and treating speech perception disorders (6,10). As Locke observed in 1980 (6), "much of our thinking on this issue is weakened by the fact that efficient perception measures have not been in general use. Because perceptual questions, historically, have not properly been asked in the laboratory, it is not obvious that perceptual questions currently should be answered in the clinic (p. 432)." Fortunately, since that time, perceptual questions are being properly asked in the laboratory by researchers who are borrowing methods from the study of the perceptual abilities of adults learning a second language. These methods include the use of : synthetic or digitally altered speech stimuli for both the assessment and treatment of perceptual difficulties; microcomputers to present large numbers of stimuli to subjects for identification, with motivating feedback when appropriate; and, acoustic analysis of speech samples in order to carefully relate speech perception to speech production abilities in the same subject. This paper describes a series of studies designed to apply these methods to the assessment and treatment of speech perception errors in phonologically impaired children who misarticulate fricatives. The contributions of this line of research to phonological theory and clinical practice will be summarized.

Rvachew & Jamieson (8) constructed 2 synthetic speech continnua, one contrasting the sounds /s/ and /ʃ/, the other contrasting /s/ and /θ/, in the prevocalic position of a single syllable real word (i.e., seat-sheet, or sick-thick). Normal speaking adults, normal speaking 5 year olds, and phonologically impaired 5 year old children identified multiple tokens of the /s/ - /ʃ / stimuli, while normal speaking adults, normal speaking 7 year olds, and phonologically impaired 7 year old children identified the /s/ - /θ/ stimuli. In both cases, 16 repetitions of each of the 7 stimuli in the continuum were presented for identification by pointing to the appropriate picture . The normal speaking children were not as reliable as adults in their identifications, but clearly perceived the stimuli in each continuum as belonging to 2 distinct sound categories. Some of the phonologically impaired children identified these stimuli in a manner similar to their normal speaking peers, but others were completely unable to categorize the stimuli appropriately. Some of these children placed all of the stimuli in the /s/ category while others responded in essentially random fashion to all of the stimuli in the continnum.

As a logical follow-up to this study, the effect of speech perception training on children's speech production errors was investigated (5). The "fading technique" (3) was used in 5 single subject studies to train phonologically impaired children to identify synthetic syllables containing a prevocalic fricative (/ʃ/ misarticulators listened to /sa/ and /ʃa/ syllables and /s/ misarticulators listened to /sa/ and /θa/ syllables). After 2 hours of sound identification training, small but significant improvements in production performance were observed for 3 children who demonstrated poor identification performance prior to training, and improved identification performance following training. Improved production performance as a consequence of sound identification training was not observed for a subject who failed to learn the identification task, nor for a subject who demonstrated good identification of the stimuli prior to training.

Another study was undertaken to enhance the clinical utility of the fading technique by incorporating a computer game format which was expected to increase the child's enjoyment and compliance during sound identification training. In this study, natural speech stimuli were used so that the target sound (/ʃ/) could be contrasted with a range of error sounds. Twenty-seven phonologically impaired children who misarticulated /ʃ/ in a variety of ways were assigned to 1 of 3 groups: Group 1 listened to correct versions of the word "shoe" contrasted with a variety of incorrect productions recorded from other phonologically impaired children (i.e., /tu/, /tʃu/, /su/, etc.); Group 2 listened to the words "shoe" and "moo", both produced by an adult talker; and Group 3 listened to the words "cat" and "Pete", recorded from an adult talker. Children in Groups 1 and 2 were required to point to a picture of a "shoe" when they heard a correct version of this word, and to an "X" when an incorrectly produced version of this word was presented. The response alternatives for Group 3 children were pictures of a cat and an "X". The auditory training stimuli were presented over headphones, and visual reinforcement was presented via the monitor, using the Experiment Control System of the Canadian Speech Research Environment (4). The children enjoyed the computer game format and readily agreed to complete 60 consecutive training trials during each 15 minute session of sound identification training. Each child in all 3 groups also received traditional sound production training, targeting the /ʃ/ sound, concurrently with sound identification training, for 6 consecutive weekly sessions.

Following training, the children's sound production abilities were assessed by asking them to name five objects representing words containing the /ʃ/ sound in prevocalic position, and to produce a single isolated /ʃ/ sound. The isolated /ʃ/ productions were submitted to acoustic analysis using CSRE (4). The results indicated that children who were taught to identify correct and incorrect versions of the word "shoe" progressed further in production training, produced more correct /ʃ/ sounds during the spontaneous naming task, and produced better quality /ʃ/ sounds with more appropriate acoustic characteristics, in comparison to control children who learned to identify the words "cat" and "Pete".

These findings are consistent with the results of other studies which have employed synthetic speech to demonstrate that phonologically impaired children have concomitant speech perception difficulties (e.g., 1). The use of acoustic analysis to describe children's phonological systems and to document progress in therapy is also occurring with increasing frequency (e.g., 2,7). However, the studies described above constitute the only published support to date for the efficacy of speech perception training in the treatment of sound production errors, and continued research on this topic is clearly required.

The primary theoretical implication of this line of research is that some phonologically impaired children possess a system of underlying phonemic contrasts which differs from that of their adult models (c.f., 9). With respect to a given sound contrast, 3 patterns of perceptual and productive error may occur: both members of the sound contrast may be absent from the child's system; both members of the sound contrast may belong to a single phonemic category in the child's system; or, both members of the contrast may exist in the child's system but are differentiated in terms of nonstandard acoustic cues. All 3 patterns involve a correspondence between the child's perceptual performance with the sound contrast and the child's articulation of the sounds.

When treating such a child, the clinical task is to help the child resolve the mismatch between his or her underlying system and the adult system. This can best be achieved when an accurate description of the child's perceptual and productive abilities is obtained. The studies cited above have shown that perceptual abilities cannot be adequately assessed with natural speech stimuli, especially when presented live-voice; rather, effective perceptual testing must involve careful control of stimulus characteristics, which can be obtained by synthesizing speech or digitally altering natural speech recordings. In addition, it has been shown that children's speech production skills are best described using a combination of phonetic and acoustic analyses.

To paraphrase Locke (6), perceptual questions have been properly asked, and answered, in the laboratory; we have now reached the point where perceptual questions can and should be answered in the clinic. The clincal application of the research methods discussed above has been made possible by the availability of relatively inexpensive and user friendly systems for speech synthesis and analysis, such as CSRE (4). Currently, the primary impediment to clinical application is a shortage of clinicians with the necessary technical knowledge, and a lack of funding for research in clinical settings which would serve to expand and enhance the clinical utility of these technologies.

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