ARTICULATION TRAINING OF TWO HEARING-IMPAIRED GIRLS¹

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Two 4-yr-old hearing-impaired girls were trained to articulate correctly /f/ and /sh/ phonemes in the initial position of words in response to pictures. They were first trained to imitate, and then to respond on demand of "what's this?" As a result, both girls generalized correct articulation to words requiring both phonemes in the initial and final positions.

Results from studies of normal-hearing children with articulation disorders (Elbert, Sheldon, and Arndt, 1967; McReynolds, 1972; McReynolds and Bennett, 1972; Winitz and Bellerose, 1963) indicate that training the correct articulation of speech sounds (phonemes) can be generalized. Thus, if correct articulation of a phoneme is learned in the initial position of a word, that phoneme may then be used in the final position of other words (*e.g.*, if the /s/ phoneme is taught in the context of "saw", this skill will generalize to the /s/ in the final position as in "bus"). Generalization may also occur to other phonemes with the same feature in common; *i.e.*, /f/ and /sh/ are both classified as fricatives and differ from /s/ only in place of articulation, the position of the tongue, teeth, and lips. Therefore, correct articulation of "saw" may generalize to "five" and "shoe".

While the articulation abilities of hearing-impaired children have been described in some detail (Amcoff, *unpublished*; Calvert, *unpublished*; Hudgins and Numbers, 1942), there have been few experimental attempts to train these children to improve the articulation. Ling and Marentic (1971) taught hearing-impaired

children to improve their articulation of consonant-vowel syllables. Stark (1971, 1972) used visual displays of speech to aid hearing-impaired children in improving their articulation. However, none of these studies examined the children's ability to generalize from the training materials to other contexts on which they had received no training.

Since a large proportion of the educators of the hearing-impaired are committed to teaching these children to communicate orally, more studies of articulation training are needed. The goal of normal language expressed in intelligible speech remains paramount in oral communication by the hearing-impaired. Since attainment of this goal requires long and arduous training, efficient procedures for teaching speech to the hearing-impaired child are badly needed. An important aspect of training efficiency is the extent to which generalization will occur from the specific phonemic context in which the speech sound is taught.

The class of phonemes most frequently missing in the speech of hearing-impaired children is fricatives such as /f, v, s, z, sh/ (Lack, Ling, and Ship, 1970). The frequency characteristics of these sounds consist primarily of sound energy above 2000 Hz, which makes them difficult or impossible to hear for many hearing-impaired listeners.

The purpose of the present study was two-fold: (1) to determine if two young hearing-

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impaired girls could be taught to articulate correctly the fricatives /f/ and /sh/ in the initial position of words, and (2) to investigate the generalization of these phonemes to other words with these phonemes in the initial and final positions.

METHOD

Subjects

Two 4-yr-old girls served. Sue was profoundly hearing-impaired and Mich was severely hearing-impaired. Their unaided thresholds for hearing pure tones are shown in Table 1. Sue's profound hearing loss was the result of meningitis at the age of 1.5 yr and Mich had a congenital loss as a result of maternal Rubella. Hearing loss was the only known deficiency of both girls. Since Sue had little or no useful hearing in the speech range, she had to rely heavily upon her lipreading ability; *i.e.*, the use of visual cues for decoding speech. Sue spoke in "word-like" strings but her speech was generally unintelligible. Mich's speech was intelligible. She spoke in simple sentences but with many articulation errors. Both girls articulated most vowel sounds correctly, but in conversational speech they used fricative phonemes (/f/ and /v/) infrequently in the initial position of words and never in the final positions of words. Both girls had been enrolled in the McGill Project for Deaf Children for 2 yr and each had worn two high-powered body type hearing aids for most of that period. Both girls wore their hearing aids during this study.

Table 1

Pure-tone thresholds in dB ISO, 1964, for (R) right and (L) left ears for both Sue and Mich.

Frequencies		250	500	1000	2000	4000
Sue	R	65	85	110	NR	NR
	L	65	85	110	NR	NR
Mich	R	80	95	95	85	85
	L	85	105	100	105	NR

NR = no response with the limits of the audiometer.

Materials

The visual stimuli consisted of 18 colored pictures from a children's book, mounted on 4 by 6 in. (10 by 15 cm) white index cards. There were six pictures depicting words that required each of the two target phonemes /f/ and /sh/ in the initial position and three pictures for each of the target phonemes in the final position. The word pictures were:

	/f/	/sh/
Training Words	fox	shop
Baseline and	fish	sheep
Probe Words:	fire	ship
Initial	four	shoe
	five	shirt
	foot	shell
Final	knife	brush
	leaf	dish
	safe	fish

The pictures *fox* and *shop* were used for training but not in the baseline or probe measures. The remaining 16 pictures were used for the baseline measures and for probes to test generalization.

Procedures

The study was conducted in a small, distraction-free room. The subject sat facing the experimenter across a small table. On the table were stimulus pictures, a small box of tokens, and a score sheet. On the floor next to the experimenter was a small box of assorted candy. Periodically, a Uher 4000 tape recorder was placed under the table with the microphone on the edge of the table so that recordings could be made to assess reliability of the experimenter's judgements of articulation.

To ensure response stability, three baseline measures were obtained of each girl's use of the phonemes /f/ and /sh/ in the initial and final positions of words. These measures were taken on consecutive days. The experimenter presented each of the 16 pictures and asked: "What's

this?". If the child did not know the name, she was told and her response was marked as imitated. Each of the 10 pictures depicting word-initial phonemes was presented twice for each baseline measure and each of the six pictures depicting word-final phonemes was presented three times. Responses were judged correct on the basis of both the sound produced and the appropriate placement of the teeth and lips. Correct responses were not reinforced during the baseline.

Before the girls were taught to articulate correctly the target phonemes /f/ and /sh/, they were introduced to token reinforcement. They were asked to name common pictures and were told "good" and given a token when they responded correctly. After five tokens were earned, they were exchanged for candy. Incorrect responses were ignored. Training began when the subject earned 20 tokens.

Training

The girls were seen individually three to five days a week. One training session, consisting of 100 trials and lasting approximately 20 min, was completed each day.

In the first training step, the girls were trained to imitate "fox", and the second training step was to learn to say this word on demand. Following a generalization probe, they were trained to imitate "shop" and then to say it on demand. A second generalization probe was then presented. Since /f/ and /sh/ differ only in place of articulation, the multiple baseline procedure was used as the control measure.

To train the girls to imitate, the experimenter presented the appropriate picture and provided the required model; e.g., "fox". The experimenter waited until the subject looked at him before he presented the model, thereby affording the girls both auditory and visual cues. If the subject said the required phoneme correctly on her first attempt, she was given a token and told "good". When 25 tokens were earned, they were exchanged for candy and then training continued. Incorrect responses were ignored,

recorded on the score sheet, and the next trial presented. If the subject failed to respond within 5 sec of the imitative model, the trial was scored as incorrect and the next trial presented.

To train the girls to give responses on demand, the experimenter showed the same picture as in the preceding training step (e.g., fox) and asked: "What's this?". Otherwise the procedure was the same as that used in the imitation step.

Each training step consisted of at least two sets of 50 trials which were scored by the experimenter. When the subject scored 80% or more correct on two consecutive sets of 50 trials, she proceeded to the next training step. When the subject reached the 80% criterion for any training step requiring responses on demand, a generalization probe was administered. Probes were presented immediately after criterion was achieved.

Probes consisted of the 16 pictures on which the subjects had received no training. As in the baselines, each of the five pictures requiring the /f/ and /sh/ in the initial position was presented twice, and each of the three pictures requiring the phonemes in the final position was presented three times. Correct responses were not reinforced. If the subject generalized the target phoneme in response to at least seven of the 10 pictures requiring the target phoneme in the initial position, she was considered to have reached generalization criterion.

RESULTS

Reliability

Tape recordings were made of both girls' responses on two occasions in baseline, and on two occasions in Probe 2. An independent judge's transcription of the recordings was compared with the experimenter's scoring sheets in order to assess reliability. Reliability was calculated by dividing the number of responses agreed upon by the total number of responses obtained. The level of agreement thus derived averaged 0.89 and 0.87 on the four reliability samples for /f/ and /sh/ respectively.

Fig. 1. Per cent of responses correct at baseline for the imitation and demand training sets and two probes for Sue. Each data point during training represents 50 trials.

Sue

Sue's responses to the two target phonemes /f/ and /sh/ in the initial position were consistent on the three baseline measures: on /f/, 13 of her 30 responses were correct; and on /sh/, four of the 30 responses were correct. None of her responses to the phonemes in the final position was correct. While nine imitative models were provided because she did not know the names required at baseline, only one imitative response to /sh/ was judged correct and is shown as a correct response in Figure 1.

She needed 350 imitative trials on "fox" to reach criterion before she proceeded to saying "fox" on demand. After the minimum set of 100 trials, she met criterion on demand. On Probe 1, nine of her 10 responses to words requiring the /f/ in the initial position were correct, and five of her nine responses to /f/ in the final position were correct. No response to /sh/, in

either the initial or final position, was correct. Sue did not know the names of two /f/ pictures and one /sh/ picture; consequently models were provided. Of these three items, only one, *safe*, was correctly articulated.

Since Sue had met the generalization criterion on Probe 1, she began training to imitate "shop". After 450 imitative trials, she reached criterion and proceeded to respond on demand to "shop". She required 400 trials on this step to reach criterion for Probe 2. On this probe she used the /sh/ correctly to eight of the 10 items in the initial position and to four of the nine items requiring it in the final position, as compared with no correct responses of /sh/ in both positions on Probe 1. Her correct use of the /f/ was maintained at the same level as in Probe 1, nine of 10 correct for the initial position and five of nine correct for the final position. *Safe* was the only picture on Probe 2 of which Sue did not know the name. When a model was presented,

Fig. 2. Per cent of responses correct at baseline for the imitation and demand training sets and two probes for Mich. Each data point during training represents 50 trials.

she was unable to articulate the /f/ phoneme correctly.

Mich

Mich's responses to the two target phonemes /f/ and /sh/ in the initial position were consistent on the three baseline measures: on /f/, 11 of her 30 responses were correct; and on /sh/, two of the 30 responses were correct. She produced only one correct response in the final position and that was to /f/. While six imitative models had to be provided because she did not know the words pictured, the only two of these that were correct, both to /f/ in the initial position, are shown as correct responses in Figure 2.

Mich required 200 imitative trials of "fox" to reach criterion and proceeded to the next step of training of "fox" on demand. After 250 re-

sponses to "fox" on demand, she met criterion and Probe 1 was administered. On this probe, seven of her 10 responses to words requiring /f/ in the initial position were correct, and two of the nine responses to words requiring /f/ in the final position were correct. Her number of correct responses of /sh/, both in the initial and final position, did not increase from baseline. Mich knew all of the probe words except *safe*, which she was unable to articulate correctly even after a model was presented.

After 200 trials of imitative training for "shop" she reached criterion and proceeded to training of "shop" on demand. She needed 350 trials to reach criterion for presentation of Probe 2. Her correct use of /sh/ in the initial position increased from one of 10 correct at baseline and on Probe 1 to seven of 10 correct on Probe 2, while she used this phoneme correctly

in the final position to one of the nine probe items. Her use of the /f/ in the initial position was maintained at seven of 10 correct and she used it correctly in the final position only once, as compared with twice on Probe 1. On Probe 2, Mich could not remember the word *safe*, and was still unable to articulate the /f/ phoneme when an imitative model was presented.

DISCUSSION

Results of this study showed that operant procedures can be effectively used to teach hearing-impaired children to articulate correctly the phonemes /f/ and /sh/ in the initial position of words. The training procedures used here facilitated generalization of the target phonemes to other words requiring these phonemes in the initial position and final positions of words on which the girls had received no training.

Generally, Sue required more training trials to reach criterion than did Mich. This might be related to their respective hearing losses. Sue had little useful hearing and consequently she had to rely heavily upon her lipreading ability, while Mich, who had much more hearing, relied more upon acoustic cues. This may also have influenced each girl's generalization. Sue performed better than Mich on both probes, possibly because of her greater amount of training. It must also be remembered that Sue had normal hearing for the first 1.5 yr of life and even this limited experience may have some referent for speech production that Mich never had.

Traditionally, "stimulation" has been a key concept in teaching speech and language skills to hearing-impaired children. Scouten (1969) summarized this philosophy in the words, "Talk, talk, talk to the deaf child". He also noted that while adherence to this principle has been steadfast for the past 50 yr, the results of attempts to teach the deaf child speech and language have been consistently unsuccessful and disappointing. Operant conditioning procedures offer a viable alternative to the "stimulation"

approach and have been shown effective in teaching language skills to the hearing-impaired (Bennett, 1973; Bennett and Ling, 1972).

Imitation is widely used as a technique to teach speech to hearing-impaired children. However, it is not known to what extent imitation facilitates speech acquisition by these children. Had imitative baselines and probes been included in this study, further information about the role of imitation might have been provided. Garcia, Baer, and Firestone (1971) and Schumaker and Sherman (1970) offered evidence that imitation can facilitate generalization of both speech and language behaviors. Had generalization probes been presented after each imitation training step, further information about the influence of imitation upon generalization might have been provided. Since hearing-impaired children are taught to rely heavily upon imitation, responses on demand may be a very different response mode. If this supposition is correct, training these children to imitate may not influence generalization greatly. This is not to suggest that hearing-impaired children should not be trained to imitate, for this tactic probably allows them to realize the task requirements, but training them to imitate to a high criterion level may not be necessary or even desirable. Training time might be shortened by training subjects to imitate correctly to 50% and then proceeding to responses on demand.

Little is known about the ability of the hearing-impaired to generalize from training materials to other similar contexts, primarily because few training studies have been undertaken. The question of generalization by this population is important, for when it does occur, it makes training procedures more effective and efficient, thereby shortening the total training process of hearing-impaired children.

Unintelligible speech continues to be one of the hearing-impaired child's major disabilities; yet few experimental studies have attempted to improve the speech skills of this population. Further investigation along the lines of the present experiment would provide valuable in-

formation relative to the speech development of the hearing-impaired.

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