EFFECTIVENESS OF TWO PHONOLOGIC SPEECH TRAINING STRATEGIES FOR HEARING-IMPAIRED CHILDREN

by

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ABSTRACT

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Effectiveness of Two Phonologic Speech Training
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Two experiments studied the effectiveness of Imitation and Listener Uncertainty as speech training techniques for profoundly hearing-impaired children. In the first study, a single-subject design was employed with two children who were trained on /ʃ/ and /r/ in words using alternating treatments. Results showed short term benefits for both treatments, but better retention and better generalization to spontaneous speech for the Listener Uncertainty approach. In the second study, 33 children were matched as closely as possible and randomly assigned to the Imitation Group, Listener Uncertainty Group or Control Group. Students in the treatment groups were trained on fricatives in words, phrases and sentences. Plosives were used as control phonemes. Results indicated significant improvement on production of trained and untrained words for both treatments, with higher scores for Listener Uncertainty. However, there was no difference between the treatment groups and control group on ability to generalize target sounds to spontaneous speech. Effects of context and phoneme position were also examined.

Résumé

Christina Barris Perigoe
Efficacité de deux méthodes d'entraînement de la parole au niveau phonologique pour des enfants avec surdité profonde
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Dans la présente étude, deux expériences ont été menées dans le but d'examiner l'efficacité de deux méthodes particulières d'entraînement de la parole pour des enfants avec une surdité profonde: l'imitation et la demande de reformulation par l'auditeur a cause de son incertitude. Dans la premiere expérience, un plan à sujet unique ("single-subject design") avec traitements alternés a été utilisé pour l'entraînement des phonèmes /ʃ/ et /r/ au niveau des mots. Les deux méthodes dans d'entraînement ont été utilisées avec deux enfants. Les résultats ont montré un progrès à court terme pour les deux méthodes, mais une meilleure rétention et une meilleure généralisation au langage oral spontané ont été obtenues avec la méthod de la demande de reformulation par l'auditeur. Dans la deuxième expérience, 33 enfants ont été appariés et assignés au hasard à l'un des groupes suivants: Imitation, Demande de reformulation ou Contrôle. Les enfants dans les deux groupes expérimentaux sont entraînés à prononcer des fricatives dans des mots, des syntagmes et des phrases. Les occlusives ont été choisies comme phonèmes contrôles. Les résultats ont indiqué une amélioration significative de la production des mots

Suite...

Résumé

(Suite)

entraînés et des mots non entraînés avec les deux méthodes. Les résultats étaient plus élevés pour la méthode de la demande de reformulation par l'auditeur. Cependant, il n'y avait pas de différence entre les deux groupes expérimentaux et le groupe contrôle quant à la généralisation des sons-cible en langage oral spontané. L'influence de la position du phonème et celle du contexte linguistique ont aussi été étudiées.

To my family.

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Chapter 1

INTRODUCTION

Educators of the hearing-impaired have long been concerned with improving the spoken communication skills of their students. Despite their best efforts, few deaf individuals have intelligible speech. Recent investigations have indicated that only about 20 to 30 percent of the speech of deaf persons is understood by the average listener (Gold, 1980; Markides, 1970; Smith, 1975). Although Ling stated that "...deafness, in itself, is not an insuperable barrier to the acquisition of speech" (Ling, 1980, p.243), he described the speech intelligibility of most profoundly hearing-impaired children as often inadequate for oral communication (Ling, 1976; 1980).

Many profoundly hearing-impaired individuals continue to face frustration and failure when they attempt to communicate verbally. They continue to exhibit many of the speech errors which have been traditionally associated with deaf speech. These include both suprasegmental or prosodic errors - problems with breath control, duration, intensity, pitch, intonation, nasality and voice quality - and segmental errors in the production of vowels, diphthongs, consonants and consonant blends or clusters.

There are at least three dozen descriptive studies of the nature and extent of the speech errors of the deaf (cf. Geffner, 1980; Hudgins & Numbers, 1942; Levitt & Stromberg, 1983; Markides, 1970; Monsen, 1974, 1976a, 1976b, 1978, 1979; Nickerson, 1975; Nober, 1967; Parkhurst & Levitt, 1978; Smith, 1975). However, relatively few researchers have studied strategies to improve the speech of profoundly hearing-impaired individuals (Ling & Milne, 1981; Monsen & Shaugnessy, 1978; Osberger, Johnstone, Swarts, & Levitt, 1978).

The development of techniques to teach speech to hearing children with speech disorders has largely evolved through clinical experience rather than systematic study (Muma, 1978; Nation, 1982; Perkins, 1977). Techniques used with hearing-impaired children have been developed in a similar fashion. Trybus (1980) found that speech skills of hearing-impaired students in special programs do not improve with schooling beyond the age of seven. This failure to achieve intelligible speech has been attributed to the quality and quantity of speech training (Ling & Milne, 1981; Subtelny, 1980). However, few training studies to assess the efficacy of various training procedures have been conducted.

In particular, there are few studies in the literature which examine techniques used to develop phonologic speech skills (i.e. speech in meaningful language) or to correct phonologic speech errors of hearing-impaired children (Abraham & Weiner, 1985, 1987; Bennett, 1974, 1978; Novelli-Olmstead & Ling, 1984 ; Perigoe & Ling, 1986; Solomon, 1981). Because of the lack of research in this area, teachers tend to rely on their training and their teaching experiences. There is, therefore, a pressing need to assess the effectiveness of phonologic level speech correction techniques used with hearing-impaired children.

Ten possible strategies for improving speech production at the phonologic level have been proposed by Moog (1985). These techniques are based on her many years of experience in working with hearing-impaired children. Two of the proposed strategies are Imitation and Listener Uncertainty.

Imitation of the teacher's model is one of the most common strategies used by teachers and clinicians working with hearing-impaired children. It is used extensively in phonetic level speech teaching (i.e. practice of speech sounds in nonsense syllables), (Ling, 1976), but its effectiveness in improving phonologic level speech skills has not been established. If teachers/clinicians continue to use imitation of the teacher's model as a strategy to improve the speech of hearing-impaired students, further research concerning the effectiveness of this technique is necessary.

A second strategy which Moog characterizes as "a most important correction technique" is providing feedback to the child indicating when the teacher/clinician does not understand the child's utterance (Moog, 1985, p.7). This listener uncertainty strategy can take the form of statements such as "What?", "Pardon me?", "Tell me again.", "I didn't understand you." or even a non-verbal gesture or facial expression. There is currently no published research regarding the effects of Listener Uncertainty on the articulation of hearing-impaired children. If teachers and clinicians wish to utilize this strategy with hearing-impaired students, we need to assess its effectiveness.

The purpose of speech training is to provide hearing-impaired children with spoken language skills which enable them to interact successfully in oral communication. Phonetic level skills alone cannot accomplish this. Generalization of learned phonetic level phonology is necessary. It is only when speech sounds are internalized to the extent that they are automatic in spontaneous speech, that they can be said to be truly acquired. Teachers, therefore, need to assess generalization and retention of learned speech skills, in addition to the students' productions of syllables or words used in training (Boothroyd, 1985).

In summary, the effectiveness of various teaching techniques for promoting speech skills in hearing-impaired children, particularly at the phonologic level, has not been systematically researched. The present investigation involves two studies designed to examine two phonologic level speech correction strategies. These strategies are:

1. Imitation, a motor-speech approach in which the clinician responds to the child's incorrect utterance by providing a verbal model which the child attempts to imitate; and
2. Listener Uncertainty, a language-based approach in which the clinician indicates that he/she doesn't understand the communication, and the child attempts to self correct.

Training effectiveness was measured by examining generalization and retention of speech skills. It is hoped that the present research design will provide a methodology for examining other speech teaching techniques, so that teachers and speech clinicians can discard less effective strategies and employ those strategies which have been proven to be more effective in teaching speech to hearing-impaired children.

Chapter 2

REVIEW OF THE LITERATURE

This review will address the following topics: studies of speech errors of the hearing-impaired; methods of teaching speech to hearing-impaired children; the strategies of Imitation and Listener Uncertainty; and, generalization of speech skills taught to hearing-impaired children. This will be followed by a brief description of the present research.

Speech Errors of the Hearing-Impaired

The past fifty years of research on speech of hearing-impaired individuals has focused primarily on descriptions of typical speech errors. In their seminal study of speech errors of hearing-impaired children, Hudgins & Numbers (1942) found both segmental and suprasegmental errors. These included problems with voicing and nasality, neutralization or diphthongization of vowels, substitutions, omissions or distortions of consonants, intrusive voicing, and errors in clusters or blends. Since then, studies have confirmed these findings, and technological advances have allowed researchers to describe the types of errors made with more precision (Brown & Goldberg, 1990; Mahshie & Contour, 1983; McGarr & Lofqvist, 1982, 1988; McGarr & Whitehead, 1992; Metz, Whitehead & Whitehead, 1984; Monsen, 1976c; Rothman, 1976; Samar, Metz, Schiavetti, Sitler, & Whitehead, 1989; Stevens, Nickerson, Boothroyd, & Rollins, 1976;

Waldstein & Baum, 1991; Whitehead, 1991; Whitehead & Barefoot, 1980, 1983).

A direct relationship has been found between speech production ability and hearing levels (Boothroyd, 1984, 1985; Markides, 1970; Smith, 1975). The number of speech errors tends to increase as hearing loss increases, and the speech of those who have better hearing tends to be more intelligible (Markides, 1970; Smith, 1975). Subjects who have pure tone averages of 90dB or greater typically demonstrate greater problems with articulation and consequently poorer speech intelligibility (Boothroyd, 1984, 1985; Blood, Blood & Danhauer, 1978; Monsen, 1978).

Suprasegmental Errors

Suprasegmental aspects of speech are believed to influence intelligibility (Ling, 1976; Parkhurst & Levitt, 1978; Smith, 1975; Stoker & Lape, 1980). Profoundly hearing-impaired speakers exhibit difficulties with several aspects of suprasegmental speech production. The major difficulties include problems with respiration, phonation, durational aspects such as speech rate, intensity, rhythm, pitch, and intonation patterns.

As early as 1942, Hudgins and Numbers had suggested that speech errors may well be the result of a lack of coordination between articulation and the respiratory system in hearing-impaired speakers. Whitehead (1983) found that hearing-impaired persons with poor speech intelligibility failed to take in sufficient amounts of air prior to initiating speech. Problems with phonation have also been reported, indicating that some hearing-impaired speakers lack complete closure of the vocal cords during phonation, resulting in increased breathiness (Metz et al., 1984; Monsen, 1979).

Hearing-impaired persons typically speak at a much slower rate than normal hearing persons (Boone, 1966; Boothroyd Nickerson & Stevens,1974; Brown & Goldberg, 1990), possibly due to problems associated with increased phoneme duration (Leeper, Perez & Mencke, 1980; Parkhurst & Levitt, 1978; Whitehead, 1991), excessive pausing (Boothroyd et al., 1974), intrusive voicing (Parkhurst & Levitt, 1978), and increased duration of unstressed syllables (Boothroyd et al., 1974).

Problems with respiration and phonation necessarily lead to poor control of overall vocal intensity. Remediation of intensity can be problematic, due to the hearing-impaired child's confusion of high pitch with loud sounds and low pitch with quiet sounds (Ling, 1976). In continuous discourse, differences in intensity are exhibited in stressed and unstressed words and syllables, as the speaker accentuates one aspect of the linguistic message.

The co-ordination of intensity and the durational aspects of speech comprise speech rhythm. A relationship between speech rhythm and intelligibility has been found (Hood & Dixon, 1969) and the importance of using both accurate articulation and appropriate rhythmic patterns has been demonstrated (Boothroyd et al., 1974).

Deaf speakers may experience difficulty in controlling vocal pitch, and often produce voices with a pitch somewhat higher than normal (Boone, 1966; Martony, 1968; Pickett, 1968). It has been suggested that this higher pitch is due to increased tension on the vocal folds and increased subglottal pressure (Pickett, 1968). Excessive and uncontrolled pitch changes or pitch breaks have also been reported (Martony, 1968; Parkhurst & Levitt, 1978).

Control over pitch change is essential for production of appropriate intonation patterns. Monsen (1979) found that hearing-impaired speakers produce four different kinds of deviant intonation contours as compared to normally hearing speakers. The type of intonation contour appeared to be the most important characteristic separating poorer from better deaf speakers.

In addition, hearing-impaired speakers have shown evidence of other deviant suprasegmental characteristics, such as abnormal voice quality, pharyngeal resonance (Subtelny, Whitehead & Orlando, 1980), hypo- or hyper-nasality (Stevens et al.,1976), and poor breath control (Nickerson, 1975). While the relationship between the type of suprasegmental error and its effect on speech intelligibility is not clear (Gold, 1980), deaf speech has often been described by teachers as "tense", "breathy", "harsh" and/or "throaty" (Calvert, 1962).

Segmental Errors

Vowels and Diphthongs

Numerous studies have reported errors in vowel and diphthong production by deaf speakers. These include substitutions, neutralization, distortions, diphthongization, and omissions (Levitt & Stromberg, 1983).

Substitutions of vowels not closely related to the target vowel were reported by Hudgins and Numbers (1942). More recently, researchers have found a higher incidence of tense-lax confusions, e.g. /ɪ/ - /i/ (Smith, 1975), and substitutions of adjacent or neighboring vowels, e.g. /ɪ/ - /ɛ/ (Levitt & Stromberg, 1983; Mangan, 1961).

A specific category of substitutions is neutralization of the vowel (Hudgins & Numbers, 1942). Vowel overlap due to overlapping formant frequencies (Monsen, 1976a; 1978) can lead to distortions and, in extreme cases, neutralization to produce a schwa-like vowel (Monsen & Shaughnessy, 1978). Smith (1975) found /æ/ and /ɛ/ to be the vowels most often neutralized in this manner. These types of errors may be due to restricted tongue movement or attempts to differentiate vowels by using jaw and lip movements rather than tongue positions (McGarr & Gelfer, 1983; McGarr & Whitehead, 1992; Monsen & Shaughnessy, 1978).

Diphthongization of vowels has been reported (Hudgins & Numbers, 1942; Markides, 1970; Smith, 1975) with /u/ and /ʊ/the two vowels displaying this type of error most often (Levitt & Stromberg, 1983; Hudgins & Numbers, 1942). Errors of diphthongs have also been reported, with either one element of the diphthong deleted, producing a simple vowel, or prolongation of the separate elements, producing two distinct, uncoordinated phonemes (Hudgins & Numbers, 1942).

Omission of vowels has been reported as the least frequently occurring identifiable type of vowel error (Levitt & Stromberg, 1983). Nasalization of vowels (Stevens et al., 1976) and vowel prolongations (Smith, 1975) have also been reported.

The importance of accurate vowel production for speech intelligibility should not be underestimated (Maasen & Povel, 1985). Studies of the relationship between vowel production and speech intelligibility of deaf children have shown that poor articulation of front vowels affects speech intelligibility (Mangan, 1961), and that vowel errors systematically decrease as intelligibility increases (Smith, 1975).

Consonants

Consonant errors in the speech of hearing-impaired children include voiced-voiceless errors, omissions, nasalization, substitutions, distortions, and intrusive voicing (addition of a vowel after a consonant or between abutting consonants).

In their study of 192 children in two schools for the deaf, Hudgins and Numbers (1942), found errors of voicing, omission or distortion of initial consonants, and nasalization to be the most common speech errors of the more severely hearing-impaired children. Other consonantal errors included substitutions, omission or distortion of final consonants, intrusive voicing between abutting consonants, and misarticulation of consonant blends or clusters. In later research it was found that errors involving final consonants occurred more frequently than initial consonant errors in the speech of the hearing-impaired (Abraham, 1989; Geffner, 1980; Levitt & Stromberg, 1983; Markides, 1970; Nober, 1967). Smith (1975) found intrusive voicing to be the most frequent type of error.

Nober (1967) attempted to categorize speech errors with spectrographic analyses of the speech productions of 46 deaf children. His rank-ordering of correct consonant productions with respect to place of articulation (from best to worst) were: bilabials, labiodentals, glottals, linguadentals, lingualveolars, linguapalatals and linguavelars. Nober's classification of productions according to manner of production (from best to worst) was: glides, stops (plosives), nasals and fricatives. These ranks appear to correspond to the relative visibility of the speech sound on the lips, the amount of acoustic information available, and ease of production (Ling & Ling, 1978; Nickerson, 1975).

In a study of 65 hearing-impaired children, Geffner (1980) compared the speech errors of six year old hearing-impaired children's spontaneous speech with their errors on an imitative speech task. The consonants most often misarticulated were /k/, /ʒ/, /ʃ/, /z/ and /dʒ/. Those most often produced correctly were /w/, /f/, /b/, /p/, /v/ and /l/. These findings held true for both imitated and spontaneous tasks.

In an analysis of the speech of 77 school-aged hearing-impaired children it was found that certain error types occurred with higher frequency in certain positions (Levitt, Stromberg, Smith and Gold, 1980). Plosives were most often omitted in the final position and glottal stops (when used) were most often substituted for consonants in the medial and final positions. In further analysis of the same data, Levitt and Stromberg (1983) found an interaction effect for frequency of consonant omission as a function of consonant type, place of articulation, and word position. Omissions were the most frequent speech error, followed by substitutions and then voicing errors. In the production of affricates, deletion of the first component (stop) occurred more frequently than deletion of the second component (fricative). They also reported that subjects omitted consonants produced in the middle of the mouth more frequently than back consonants, with front consonants omitted infrequently. Consonants were omitted more frequently than vowels, with word-final consonants omitted most frequently; followed by word-medial consonants. Word-initial consonants were omitted least often. Levitt and Stromberg (1983) found substitution to be the second most frequently occurring consonant error in hearing-impaired speech. The most frequent type of substitution was stops (or plosives) for fricatives. Voicing errors were identified as the third most commonly occurring error. Voiced-to-voiceless substitutions occurred more frequently for plosives, while for fricatives, both voiced-to-voiceless and voiceless-to-voiced errors occurred about equally.

Abraham (1989) studied consonant production in the speech of 13 hearing-impaired students. An analysis of consonant accuracy with respect to consonant type, showed that stops were produced significantly better than affricates and that nasals were produced with greater accuracy than affricates, fricatives and liquids. The greatest variability was in the production of fricatives in the final position with /z/ (which has linguistic importance in English) being produced with only 2% accuracy in the final position.

Acoustic and physiological studies of consonant production in deaf speech have supported earlier observations by providing measurable data on inappropriate laryngeal gestures in the production of fricatives and plosives (Mahshie & Contour, 1983;

McGarr & Lofqvist, 1982, 1988), poor control of air flow rates (Whitehead & Barefoot, 1980, 1983), atypical lingual-palatal contact patterns (Dagenais & Critz-Crosby, 1991), overlapping of voice onset times for voiced and unvoiced phonemes (McGarr & Lofqvist, 1982), and prolonged consonant duration (Whitehead, 1991). Studies of formant frequency transitions, (Monsen, 1976c; Rothman, 1976) have shown that formant transitions in the speech of hearing-impaired persons may be short in duration, missing, or limited because formant frequencies of surrounding vowels may be neutralized. This has led researchers to speculate that hearing-impaired speakers may place articulators accurately, but have difficulty with coarticulation of syllables (McGarr & Whitehead, 1992; Waldstein & Baum, 1991; Whitehead, 1986).

Speech Teaching Methods

Speech may be viewed as a desirable but not essential skill for a hearing-impaired child (Vernon, 1972), or as a basic means for communication, integrated into every school subject and every aspect of the child's life (Ling, 1976; Silverman, Lane & Calvert, 1978).

Since the early work of Juan Pablo Bonet in the 17th century, the teaching of speech through lip-reading and sound associations has been employed successfully with the deaf (Giangreco & Giangreco, 1970). Since that time, various approaches have been developed which focus on auditory (Beebe, 1977; Griffiths, 1964; Pollack, 1964, 1967), visual (Bell, 1906; Worcester, 1885; Vorce, 1974); visual and tactile (Haycock, 1933); and, multisensory methods (Calvert & Silverman, 1975; Cole & Paterson, 1984; Ling, 1976, 1989; Secord, 1981).

These various sense modalities may be employed in teaching speech to the hearing-impaired by analytic or synthetic methods. Analytic speech teaching emphasizes phonetic level drill of non-meaningful syllables prior to their incorporation into meaningful words, phrases, and sentences (Avondino, 1918; Ling, 1976). Synthetic speech teaching emphasizes practice with meaningful words prior to the formal teaching of individual speech sounds (Haycock, 1933; Vorce, 1974).

Analytic Speech Teaching Methods

Analytic speech teaching methods are essentially motor-based approaches in which speech sounds are seen as articulated oral motor movements (Stetson, 1951). Articulation, then, is viewed as separate from language. As a result, speech is often taught as a separate subject during the school day (Nittrouer & Hochberg, 1985).

Analytic methods focus on articulation or motor aspects of the speech disorder. (Secord, 1985; Van Riper, 1939, 1972). In assessment, the child's error types are categorized as substitutions, omissions, distortions or additions. (Van Riper, 1939, 1972). These errors in production are analyzed according to initial, medial, or final position in the word.

Training of the speech-disordered child is conducted by means of a part-to-whole process concentrating on individual speech sounds. The clinician focuses on phonetic level drill, including practice of sounds in isolation and non-meaningful syllables. These nonsense syllables are the building blocks for the development of words and longer utterances. Component speech sounds are practiced until tactile-kinesthetic patterns are established and automaticity in speech production is achieved (Ling, 1976). Learning to speak involves building on previously learned skills in a "bottom-up" process. Higher order cognitive processes need not necessarily be involved at this stage in learning to produce what are considered automatic responses.

The best known strategies are motor-based or analytic. They have focused on the practice of syllables, words, phrases and then sentences in a fairly structured format. Generalization of speech skills to spontaneous speech can be problematic. In order to improve generalization, authors and researchers have used programs which include structured practice and practice in a variety of phonetic environments (LeBlanc, 1990; Ling, 1976, 1989; Solomon, 1981).

Synthetic Speech Teaching Methods

In a synthetic or language-based approach, speech sounds are seen as linguistic units that carry meaning. Speech is an integral part of the linguistic function of spoken language and phonology is one aspect of the developing language system. There exists an interactive relationship between the phonology of spoken language and the syntactic, semantic and pragmatic components of language. This approach has been supported by studies which have found that speech intelligibility decreases as linguistic complexity of the utterance increases (Abraham & Weiner, 1987; Camarata & Leonard, 1986; Camarata & Schwartz, 1985; Panagos, Quine & Klich, 1979).

In a language-based approach, the child is viewed as a dynamic communicator and linguistic rule-user, who develops a knowledge of the phonologic system of the language. Assessment and teaching focus on the child's ability to use these rules. Assessment and categorization of errors is based on phonological processes and/or linguistic context. Processes involve rules or patterns affecting classes of sounds and include categories such as final consonant deletion, fronting of consonants, stopping of consonants, deletion of unstressed syllables, and reduction of consonant clusters (Ingram, 1976).

Teaching may involve minimal contrasts between words to create differences in meaning such as changes in vowels, e.g., "bit" vs. "bat", or changes in consonants, e.g., "bat" vs. "cat". Instruction may also focus on communication competence and seek to develop speech skills within appropriate discourse and pragmatic functioning of spoken language (Low, Newman & Ravsten, 1985; Ling, 1989). "Top-down" processing is used, where whole-to-part analysis is encouraged.

Generalization practice is often incorporated into training from the outset. To promote generalization, authors and researchers have used minimal pair contrasts, self-monitoring skills and communication repair strategies (Ling, 1989; Loeding, 1979; Whitehead & Barefoot, 1992).

Imitation and Listener Uncertainty

Although both Imitation and Listener Uncertainty can operate at the level of meaningful speech and can therefore be said to be "synthetic" in nature, Imitation, which provides a speech model for the child to imitate, is more closely associated with motor-speech theory. In imitation tasks, the child's task is to execute the articulatory movements prescribed by the teacher or therapist (Weiner & Ostrowski, 1979). Listener Uncertainty, which is based on a linguistic model, may be viewed as a language- or communication-based approach, making it more closely associated with synthetic methods.

In imitation teaching, the learner is taught to repeat after the instructor, with the expectation that the student will acquire some aspect of the spoken language model (Guess & Baer, 1973). Radical behaviorists use imitation as the main method for training behavior (Guess & Baer, 1973; Guess, Sailor & Baer, 1974). The technique of having the child imitate the teacher's model has been widely used with hearing-impaired children, perhaps because it allows the teacher to monitor the child's ability to auditorily or visually perceive the words presented (Bennett & Ling, 1972). But the effectiveness of using imitation, even with hearing children, to facilitate the carry-over of speech skills to spontaneous speech has been questioned (Wright, Shelton, & Arndt, 1969).

Listener Uncertainty may be described as a conversation-based approach as it focuses on pragmatic use of spoken language. By indicating that the spoken message has not been conveyed, the listener creates a situation in which the speaker must self-correct in some way. The responsibility for evaluation of the communication breakdown is on the speaker. Self-assessment and self-correction become part of the process of communication.

Both of these strategies for developing the child's speech may have something to offer, but neither has been systematically studied with hearing-impaired children.

Imitation: Studies with Hearing-Impaired Speakers

Some training studies with hearing-impaired subjects have used imitative production tasks for training articulation skills in their subjects, but the Imitation strategy itself was not the focus of the research (Abraham & Weiner, 1985; Bennett, 1974, 1978; Ling & Maretic, 1971; McReynolds & Jetzke, 1986; Novelli-Olmstead & Ling, 1984; Perigoe & Ling, 1986; Solomon 1981). In other studies, imitation was only one component of training and therefore its effects cannot be separated from other elements of training (Osberger, 1987; Osberger et al., 1978; Subtelny & Snell, 1988).

In a study of frequency transposition hearing aids designed to compare three different listening conditions, Ling and Maretic (1971) successfully trained 18 severely hearing-impaired children to produce 64 CV syllables using imitation of an auditory model.

Improvement in both vowel and consonant production was significant for all three groups of subjects.

In two studies of articulation training with hearing-impaired children, Bennett (1974, 1978) found imitation to be successful for training subject responses. In the 1974 study, Bennett found imitation successful for training /f/and /ʃ/ in the initial position in words with two hearing-impaired girls. The measurement of success of training was generalization to untrained words. In his 1978 study, Bennett used imitation for training plosives/stops in initial and final positions with three hearing-impaired children. Training was considered successful because subjects generalized speech skills to improved production of untrained words containing the target sound and because the control phoneme /m/did not improve. These two studies will be discussed further in the section on generalization of speech skills in hearing-impaired children.

Imitation was used successfully by Abraham and Weiner (1985) in a study designed to compare analytic and synthetic methods in teaching articulation skills to severely and profoundly hearing-impaired children. Two groups of five children were trained with each child having one trained phoneme and one control phoneme. One group imitated the target phoneme in nonsense syllables following a verbal model. The other group imitated meaningful words after a verbal model which was accompanied by a picture stimulus. Nine of ten subjects achieved 100% correct production of trained phonemes in less than three hours of training. After training, both groups of children performed significantly better on production of trained phonemes than control phonemes for both imitated production tasks and spontaneous naming of pictures containing untrained words. The group trained on words performed significantly better on the spontaneous naming task than the group trained on nonsense syllables, demonstrating better generalization to untrained words.

In a study of eight severely and profoundly hearing-impaired students, McReynolds and Jetzke (1986) trained subjects to produce final consonants /t/ or /d/ and /k/ or /g/ using imitation of syllables. They contrasted production of the vowel alone with production of the vowel plus the target consonant. After reaching criterion (85% correct), the students were tested for generalization of syllable practice to words. If generalization criteria were not met (50% correct) the subject was re-trained using spontaneous naming in response to pictured stimuli. Imitation was successful for training all eight of the subjects and for training six of eight subjects to generalize to untrained words containing the target sounds.

Studies which used the Imitation strategy within the framework of the Ling Speech Teaching Model, have found Imitation successful for developing acquisition of trained phonemes in syllables and in meaningful speech and for generalization of trained targets to untrained words in spoken language (Novelli-Olmstead & Ling, 1984; Perigoe & Ling, 1986). The results of these studies will be presented in greater detail in the section on generalization.

Solomon (1981) used Imitation to train five hearing-impaired children on production of /k/. The shaping of /k/ in the CV syllable /kʌ/ took the greatest number of training sessions (2-17). Subsequent items (syllables, words and phrases) took less training time. For four subjects, Imitation was an effective technique. The total number of training sessions ranged from eight to 20 sessions for these four children, who were able to reach criterion on the trained items and generalize speech skills to untrained syllables, words and phrases. These four subjects also completed both a reversal phase of training, in which their pre-training error productions were re-taught (2-5 sessions), and a re-acquisition phase of training, in which /k/ was re-trained in fewer sessions (2-5) than was originally required. Imitation training was unsuccessful with one subject, who was unable to generalize to untrained probe items, even after 33 training sessions.

Listener Uncertainty: Studies with Hearing Speakers

As there is little published research on the effects of Listener Uncertainty on the speech of hearing-impaired children, related studies with hearing speakers will be briefly presented.

Studies of Listener Uncertainty focus on the effects of listener feedback on spoken language productions of the speaker. Some of the authors have used the term "revision behaviors" (Gallagher, 1977; Gallagher & Darnton, 1978) or "recoding" (Wilcox & Webster, 1980) to describe the changes in the speaker's articulation or language. The results of studies of the effects of listener feedback on the communication attempts of hearing speakers, have indicated that speakers modify their communication strategies, their language and/or their speech productions in response to expressions of uncertainty (Brinton, Fujiki, Loeb, & Winkler, 1986; Gallagher, 1977;

Gallagher & Darnton 1978; Longhurst & Siegel, 1973; Weiner & Ostrowski, 1979; Wilcox & Webster, 1980).

Studies of the effects of listener feedback on the speaking behaviors of normal adults have found that speakers modify their spoken language to facilitate or repair communication when it fails. These modifications may take the form of increased utterance length or verbal description (Krauss & Weinheimer, 1966; Longhurst & Seigel, 1973; Maclay & Newman, 1960; Ratner & Rice, 1963), repetition (Longhurst & Siegel, 1973; Ratner & Rice 1963), and/or reduction of speech rate (Longhurst & Siegel, 1973).

Both normal (Gallagher, 1977) and language-disordered children (Gallagher & Darnton, 1978) have been shown to revise their spoken language in response to "What?" queries. Most relevant to the interests of this study, is that language-delayed children and normal children with less sophisticated language made significantly more "phonetic change" revisions - changes in the phonology of the spoken message - than did more sophisticated normal children, who used linguistic revisions more than phonologic changes. Normal hearing children have also been shown to respond differentially to type of listener feedback (Wilcox & Webster, 1980). In response to "What?", Wilcox and Webster (1980) found repetitions significantly higher, perhaps because phonological variations of the same lexical items were classified as repetitions, rather than as revised or recoded messages. They found recodings and abandonments of the message more prevalent in their "misunderstand" condition, when the experimenter misinterpreted the child's request as a statement.

The effects of incorporating a "misunderstood" condition into a study of Listener Uncertainty and articulation was examined by Weiner and Ostrowski (1979). In a study of 15 misarticulating children, the authors examined the effects of three types of listener responses on accuracy of fricative and affricate production in words. After the child's first response to the pictured stimulus the experimenter asked, "Did you say (1, 2 or 3)?" providing, 1. the correct production of the word, 2. a model of the child's error, or 3. a misarticulated response different from the child's error. The child's second response, "Yes/No I said ______," contained significantly fewer misarticulations, when the listener pretended to be uncertain of what the child said (response number 3). The authors concluded that Listener Uncertainty may increase the effectiveness of speech teaching.

The use of Listener Uncertainty as a speech correction technique finds support from two studies of self-monitoring of speech skills. In a study of self-monitoring of articulation, Koegel, Koegel, Voy & Ingham (1988) studied seven children who substituted /θ/ and /ð/ for /s/ and /z/. Prior to training, the children showed no generalization of /s/ and /z/ production to spontaneous speech outside the clinic setting. When taught to self-monitor, correct production of target phonemes to spontaneous speech within the clinic improved dramatically, but there was little improvement to spontaneous conversation outside the clinic. When the procedure of self-monitoring outside the clinic was introduced, the children generalized /s/ and /z/ training to spontaneous speech outside the training situation and maintained these skills eight weeks after the termination of training. Children began to rely on their own judgments and were able to use improved articulation in spontaneous speech outside the training situation.

In a group study on planning and self-assessment of articulation skills, Ruscello & Shelton (1979) trained two groups of subjects to produce either /s/ or /r/. Subjects practiced their target sound in isolation, syllables, words, sentences and conversation. For the isolation, syllable and word level practice, one group of students was asked to mentally plan speech movements prior to producing the target sound and to assess speech performance. The second group was not. Efficacy of training was measured by generalization to spontaneous speech. The subjects in the group trained to pre-plan and self-monitor improved more in measures of generalization to spontaneous speech.

Listener Uncertainty: Studies with Hearing-Impaired Speakers

It is not known whether or not listeners typically inform the hearing-impaired speaker when they do and do not understand the spoken communication (Loeding, 1979). Even if this feedback is given, the speaker may not know which specific part of the communication has failed or how to correct it. Boothroyd (1985) has cautioned that communication failure may cause the child to use a different strategy, rather than to improve his speech.

There are no published articles on the use of Listener Uncertainty with hearing-impaired children, but an unpublished

Master's thesis (Loeding, 1979) on work with a deaf adolescent was found. In a single-subject design study with a 15 year old deaf student, Loeding found the Listener Uncertainty treatment approach more effective in improving speech intelligibility than in decreasing errors of grammar or meaning. She used a Listener Uncertainty strategy to signal communication failure when all or part of the subject's utterance was unintelligible, non-meaningful or ungrammatical.

Loeding's study revealed a fairly steady decrease in unintelligible utterances, from 22.3% at session 1 to 0% unintelligible utterances by sessions 17 and 18 at the end of the study. She interpreted her findings to suggest that the Listener Uncertainty procedure enabled her subject to modify his articulation successfully.

Related to Listener Uncertainty are the strategies of self-monitoring and self-assessment. Self-monitoring during therapy is seen as a prerequisite to successful carry-over of speech skills to everyday communication (Whitehead & Barefoot, 1992). Conversation-based level therapy to help the speaker self-monitor, self-correct and ultimately prevent errors has been employed with young hearing-impaired adults at the National Technical Institute for the Deaf (Whitehead & Barefoot, 1992), but the effects of these therapy strategies have not been systematically assessed.

Generalization of Speech Skills

Generalization is said to occur when the learning of one activity facilitates the learning of another (Mowrer, 1982). One form of generalization which has been examined in studies of speech skill acquisition is "stimulus generalization," which occurs when the stimulus evoking a learned response is different from that which is present during training. For example, a subject taught to produce /s/ in a given list of words then generalizes this ability to the production of /s/ in words not practiced during training. This generalized response should occur spontaneously and without the need for reinforcement (Costello & Bosler, 1976).

Generalization also occurs when the speech sounds acquired in the training situation are correctly used by the child in another situation (Griffiths & Craighead, 1972). The use of newly acquired speech sounds in real-life situations, outside of the speech teaching session, is often referred to as "carry-over" (Powers, 1957). Most therapists would agree that generalization to spontaneous speech is the ultimate goal of therapy (Gerber, 1973). Even with normally hearing children, failure to achieve carry-over has been identified as the most serious clinical problem (Mowrer, 1982), and difficulties in achieving carry-over outside of the therapy environment have been documented (Griffiths & Craighead, 1972; Costello & Bosler, 1976).

In order to generalize phonetic level speech skills to the phonologic level, the child must demonstrate some control over the newly learned speech sound. Accuracy, speed, flexibility and economy of effort in producing phonemes are essential for carry-over of sounds into real-life situations (Engel, Brandrier, Erickson, Gronhovd & Ganderson, 1966; Ling, 1976).

Generalization may be achieved from the phonetic to the phonologic level or may take place within these levels. At the phonetic level, speech skills may generalize between features, phonemes and syllables. At the phonologic level, generalizations may be made between word, sentence and discourse levels. A schematic representation of these aspects of generalization and the underlying variables which may influence the hearing-impaired child's ability to generalize speech sounds is presented in Figure 2.1 (Ling, 1981a, p.327).

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Generalization of Speech Skills in Hearing-Impaired Children

Generalization of learned speech skills to spontaneous speech has been described as "not just *a* problem, but *the* problem" in speech training with hearing-impaired children (Boothroyd, 1985, p. 8).

> Those of us who have invested research effort on the design of instrumental aids for speech training have had to deal with the realization that we were assisting only with the simpler, and preliminary, stages of speech instruction while contributing little or nothing to the more complex issues of generalization and retention.
> (Boothroyd, 1985, p. 8).

The generalization problem has been demonstrated by Abraham (1989), whose hearing-impaired subjects could produce sounds at the phonetic level, but did not generalize these skills to meaningful speech. Thus, generalization of speech skills from syllable production to spontaneous speech is not necessarily automatic in profoundly hearing-impaired children (Ling, 1976; Perigoe & Ling, 1986).

While generalization from training sessions to spoken language use may spontaneously occur without direct training for some normally hearing-children with speech disorders (Elbert, Dinneson, Swartzlander & Chin, 1990), hearing-impaired children with speech problems are unlikely to achieve such generalization in the absence of systematic programs to promote the carry-over process (Abraham & Weiner, 1987; Ling, 1989).

In spite of the obvious gravity of this problem, comparatively few researchers have systematically investigated which teaching strategies can best facilitate generalization of speech in hearing-impaired children. (Abraham & Weiner, 1985; Bennett, 1974, 1978; McReynolds & Jetzke, 1986; Metz, Card & Spector, 1980; Novelli-Olmstead & Ling, 1984; Perigoe & Ling, 1986; Solomon, 1981). Most of these researchers have used Imitation as their training strategy.

The review of studies of generalization of speech skills of hearing-impaired children will be organized according to five areas of interest relating to the present research:

1. Generalization from trained to untrained words containing the same target phonemes.
2. Generalization to a different phoneme position in the word: initial, medial, or final.
3. Generalization to untrained phonemes of similar type.
4. Generalization to different linguistic contexts: word, phrase, or sentence.
5. Generalization to spontaneous speech.

Some studies are referred to more than once because they address more than one of these areas.

Trained to Untrained Items Containing the Same Target Phonemes

Bennett (1974, 1978) used generalization to untrained words as a measure of effectiveness of training in two studies of hearing-impaired children. In a study of two hearing-impaired girls, Bennett (1974) trained /f/ and /ʃ/ in the initial position in two words, "fox" and "shop". The subjects both successfully generalized to production of the target phonemes in the initial position in untrained words. On the untrained probe words, the severely hearing-impaired child made gains of 30 and 60 percent on /f / and /ʃ/ production respectively, and the profoundly hearing-impaired child made gains of 50 and 70 percent.

In a study of three profoundly hearing-impaired children, Bennett (1978) trained plosives in the initial and final position in words. All subjects successfully generalized training to target phonemes produced in the same position in untrained words. Initial position training led to greater gains (30%-80%) than did final position training (30%-50%). Subjects did not improve on the untrained, control phoneme /m/.

Abraham and Weiner's (1985) study of syllable and word practice, discussed earlier, demonstrated that hearing-impaired children can generalize to untrained words from training on syllables or training on words. Differences found between the groups led the authors to conclude that meaningful speech practice (words) resulted in greater degrees of generalization to untrained words than does non-meaningful speech practice (syllables). Greater generalization by subjects in the word group may also have been due to the additional visual stimuli provided during training which may have enhanced memory. For subjects in the word group, the training situation (word cards) was also more similar to the testing situation (words cards) than for subjects in the syllable group.

Generalization of target phonemes from syllable practice to untrained words was also demonstrated by McReynolds and Jetzke (1986). In their study, eight severely and profoundly hearing-impaired students ages six to 13, were trained using Imitation to produce stops in the final position in syllables. Six of their eight subjects successfully generalized to final production of target phonemes in untrained words.

In a study of five severely to profoundly hearing-impaired children, production of /k/ was trained in syllables, words and phrases (Solomon, 1981). Solomon used a single-subject forced-reversal design (abab) and measured correct productions of /k/ on untrained probe items. Four of Solomon's five subjects completed the experimental conditions and met the criteria for generalization. Training was proven effective because generalization from trained to untrained items occurred, was reversed during the forced reversal phase of the study, and then occurred again during the re-training phase.

Different Phoneme Positions

In the two studies by Bennett cited earlier (Bennett, 1974, 1978), generalization of target phonemes to untrained positions in words was investigated. In a single-subject design study of two hearing-impaired girls (Bennett, 1974), training on words with the target phoneme, /f/ or /ʃ/, in the initial position generalized to production of the words with the target phoneme in the final position. The severely hearing-impaired child made only modest gains of 20 and 10 percent for /f/ and /ʃ/ respectively, but the profoundly hearing-impaired subject made substantial gains of 55 and 45 percent.

In a second study with three hearing-impaired subjects, Bennett (1978) found across-position generalization for plosives/stops.

Training in initial position in words was shown to successfully generalize to targets produced in final position in words. Training on /d/ or /p/ in initial position produced gains in final position production of between 40 and 60 percent for all three subjects. Training on /g/ in initial position produced gains in final position production of 20 to 50 percent. Initial position training was less successful in achieving generalization to medial position. The subjects trained on /d/ in initial position improved in medial position production by 40 percent, but the two subjects trained on /p/ in initial position had poorer scores on /p/ in medial position after the completion of initial position training. Training of stops in final position was only marginally successful in achieving generalization to initial and medial production, with increases of between 10 and 20 percent.

Solomon (1981) found no evidence of generalization from training of /k/ in the initial or medial positions to production of final /k/. Improvement in /k/ in the final position was only achieved after direct training of the phoneme in that position.

Generalization to Untrained Phonemes of Similar Type

In his study of two hearing-impaired girls, Bennett (1974) failed to find generalization from training on /f/ to production of /ʃ/. Specific training on /ʃ/ was required before any gains in articulation of /ʃ/ was shown.

In a subsequent study, Bennett (1978) found that hearing-impaired children can use similarities between phonemes to generalize across phonemic boundaries. Three profoundly hearing-impaired children were trained on plosive/stop productions. The first subject was trained on /d/ in the initial position in words and generalized this ability to improved production of /b/, /p/ and /t/ in untrained words. The other two subjects were trained on /p/ in the initial position and generalized to /b/, /d/ and /t/ in untrained probe words. After reaching criterion (70% correct production on the trained target in untrained words), training of /d/ in the final position was begun for all three subjects. Generalization of /d/ training to /b/, /p/ and /t/ was found for two subjects, but one subject generalized only to the voiceless cognate /t/. None of the subjects generalized from /p/ or /d/ training to production of /g/ or /k/, possibly because none of them could produce /g/ or /k/ in any position prior to training. After specific training on /g/ in the initial position, subjects generalized to production of /k/ with varying degrees of success. Bennett's conclusions about generalization of /g/ training to bilabial and lingual-alveolar plosives/stops should be viewed with caution, since the children had already received training on /p/ and /d/. Two subjects maintained or slightly improved on /b, p, d/ and /t/ production after training on /g/, but one subject's scores declined slightly in some areas.

Another study of stop production and generalization by hearing-impaired children was conducted by McReynolds and Jetzke (1986). Eight students were trained on /t/ or /d/ and /k/ or /g/. Four of the eight subjects generalized syllable training on /d/ and /g/ to correct production of the voiceless cognates /t/ and /k/ in untrained words. There was little or no generalization of training on /t/ and /k/ to the voiced cognates /d/ and /g/. The authors concluded that generalization from training on voiced target to its voiceless cognate can be expected in most cases, but the reverse is less predictable.

In a study of eight hearing-impaired college students, Metz et al. (1980) utilized a distinctive feature approach to contrast /s/ and /z/. Training was comprised of five phases, with the target phonemes taught in syllables, words, phrases, sentences and structured conversation over a ten week period. Students were required to produce /z/ correctly with 90% accuracy before progressing to the next phase of treatment. The authors' hypothesis was that the students would generalize the learning of the voiced production of /z/ to the untrained phonemes /v/ and /ð/. Generalization was measured on the basis of accuracy of phonemes in sentences read aloud. In spite of the fact that the students could explain the voicing rule for /v/ and /ð/, they were unable to adequately produce these phonemes. The authors suggest this may have been due to the age of the students (19-22 years) or to the need for specific training on /v/ and /ð/ to correct habituated speech errors. They also concluded that the articulation errors of hearing-impaired speakers cannot be adequately characterized solely on the basis of the presence or absence of specific distinctive features.

Different Linguistic Contexts

Training on syllables has been shown to generalize to correct production of target phonemes in words (Abraham & Weiner, 1985; McReynolds & Jetzke, 1986; Solomon, 1981). In Abraham and Weiner's (1985) study, three of the five children in their syllable trained group were able to generalize speech skills to untrained words.

As described earlier, McReynolds and Jetzke (1986) used syllable training with eight hearing-impaired students in production of stops. Six of the eight students successfully generalized production of target phonemes in the final position in syllables to production of the targets in final position in untrained words.

Solomon (1981) trained hearing-impaired students on /k/ production in a series of syllables, words and phrases. Subjects were tested for generalization to other contexts during each phase of training. Generalization from training on syllables to production of /k/ in untrained words and phrases (or short sentences) was achieved by four of five subjects. For three of the subjects, the target phoneme was more accurately produced in words than in phrases. One subject generalized to production in words and phrases about equally. Generalization from training of the target phoneme in words to production of /k/ in phrases or short sentences was also demonstrated by four subjects. There was a wide variety in the number of training sessions and probe sessions required by individual subjects before generalization to untrained word and phrase contexts could be achieved, but decreases in generalization of speech skills during the reversal phase of training and sharp increases in skills during the re-training phase were evident.

Spontaneous Speech

Studies which have provided hearing-impaired children with structured speech training in syllables, words, phrases and short sentences have been shown to promote generalization to spontaneous speech (Novelli-Olmstead & Ling 1984; Perigoe & Ling, 1986). In a study of seven matched pairs of profoundly deaf children ages 5 to 7, Novelli-Olmstead and Ling (1984) trained "speaking" subjects to listen and orally produce selected targets and "listening" subjects to auditorily discriminate. The authors' measure of generalization of speech skills was spontaneous speech. They found improved production in phonologic level speech skills for both groups after training in syllables, words, phrases and then short sentences. However, children in the listening only group were variable in their generalization scores. Group means obscured the fact that three of seven listening students made no improvement. All of the students in the speaking group improved in measures of spontaneous speech.

In a study of generalization of speech skills into the spoken language of profoundly hearing-impaired children, Perigoe and Ling (1986) studied twelve subjects, ages five to nine, in two groups of six subjects each. Subjects in the Content group practiced transfer of phonetic level speech skills into content words and subjects in the Function group practiced transfer within the context of function words. Results showed that the subjects of both groups improved on both phonetic and phonologic level measures after training (Ling, 1976), and that subjects in the Function group also improved in language measures (Tyack & Gottsleben, 1974). Significant increases in spontaneous speech scores after training for both groups of hearing-impaired children demonstrated generalization of training from syllable, word, phrase and simple sentence practice to untrained words in spontaneous speech.

The Present Investigations

The main purposes of these investigations were:

1. to determine whether Imitation and Listener Uncertainty are effective phonologic speech correction techniques with hearing-impaired children;
2. to evaluate which is more effective.

Previous research suggests that either of these techniques may improve the phonologic level speech of hearing-impaired children (Abraham & Weiner, 1985; Bennett, 1974, 1978; Loeding, 1979; McReynolds & Jetzke, 1986; Novelli-Olmstead & Ling, 1984; Perigoe & Ling, 1986, Solomon, 1981), but it is not known if one is more effective than the other. Intuitively, one could suggest that Imitation might be more appropriately used with hearing children, who would have a better chance of monitoring their efforts to accurately approximate the teacher's model. Though the effectiveness of using Imitation with hearing children has been questioned (Wright et al., 1969), it has been used successfully with hearing-impaired children (Abraham & Weiner, 1985; Bennett, 1974, 1978; Ling & Maretic, 1971; Novelli-Olmstead & Ling 1984; Perigoe & Ling 1986; Solomon, 1981).

Hearing-impaired children might require more listener feedback for communication, making Listener Uncertainty an advantageous approach. Based on previous research findings with hearing (Gallagher, 1977; Gallagher & Darnton, 1978; Weiner & Ostrowski, 1979) and hearing-impaired speakers (Loeding, 1979), one could predict significant changes in phonologic coding of speech in response to Listener Uncertainty. Listener Uncertainty has also been shown to be successful in decreasing misarticulations of fricatives and affricates in young hearing children (Weiner & Ostrowski, 1979).

In the present study, two experiments were designed to address the research questions. The first experiment was a single-subject design study using an alternating treatments approach with two profoundly hearing-impaired students. The second experiment adapted successful methodological elements of the first study in a group study with thirty-three students from an oral school for the deaf. In designing the two studies, choices of subject parameters, targets for training, target position in the word, other phonemes for consideration, linguistic context, and evaluation procedures were based on previous research findings and teaching experiences.

Since children with profound hearing losses tend to have poorer high frequency hearing and greater speech problems (Boothroyd, 1985; Ling & Ling, 1978), profoundly hearing-impaired students with pure tone averages of 90dB or greater were selected for the present investigations. In the present study, children from oral schools were chosen as they would have more opportunities to use speech skills.

The observation that fricatives are the class of sounds produced most poorly (Nober, 1967), led to the selection of fricatives for remediation in this study. Fricatives are the least audible sounds (Ling, 1989) and misarticulations of /s/ and /ʃ/are common among hearing-impaired children, perhaps because children with sensorineural losses typically have poor acuity and discrimination in the high frequencies (Boothroyd & Huber, 1977). In the first experiment of the present study /ʃ/ and /r/ were trained using the two different strategies. In the second study, fricatives were trained and plosives were used as control sounds.

Training of target sounds in a particular position in words, (initial, medial, or final) may have an effect on accuracy of sounds produced in other positions (Bennett, 1978). The first study was designed to assess the effects of serialized training of sounds in initial, final, medial and medial abutting (i.e. consonants are preceded or followed by other consonants) positions in words. In the second study, phonemes in initial, medial and final positions in words were trained concurrently, which did not allow for an analysis of generalization effects to other phoneme positions. Accuracy of phonemes in different positions in the word could, however, be assessed with respect to different linguistic contexts and type of training.

Hearing-impaired speakers have been shown to have the ability to generalize from training on plosives/stops to other plosives/stops (Bennett, 1978), but have failed to generalize training on fricatives to other fricatives (Bennett, 1974; Metz et al., 1980). The second study was designed to probe other fricative sounds, to see if training on fricatives would generalize to other sounds produced in the same manner.

Generalization from word level training to production of the target phoneme in phrases and short sentences has been demonstrated (Solomon, 1981). In the first experiment of the present study, training was conducted at the word level and tested for generalization to sentences. In the second experiment, training was conducted at word, phrase and sentence levels concurrently. The effects of training were evaluated with probes of trained and untrained words at the word, phrase and sentence levels.

Structured training of targets in syllables, words, phrases and sentences has been shown to improve spontaneous speech production (Novelli-Olmstead & Ling, 1984; Perigoe & Ling, 1986). For both of the experiments undertaken in the present investigation, spontaneous speech was used to measure effectiveness of training. Spontaneous speech measures allow for evaluation of whether specific speech skills have been incorporated into the child's speech system (Morrison & Shriberg, 1992; Nittrouer & Hochberg, 1985; Osberger, Robbins, Todd, Hesketh & Sedey, 1991.)

Since not just generalization of speech skills, but retention of skills is important (Boothroyd, 1985), both of the present studies tested for retention of speech skills. Retention was measured by re-administration of probe items and re-evaluation of spontaneous speech after a break in training.

The primary hypotheses for the two experiments were:

- Both Imitation and Listener Uncertainty would improve phonologic level speech skills, especially on trained phonemes in trained words.
- Trained phonemes would improve more than control phonemes (Experiment 2 only).
- Imitation would produce more correct productions than Listener Uncertainty on trained words.

- Listener Uncertainty, because of its reliance on self-correction, would produce more correct productions on untrained words, phrases, sentences and spontaneous speech.
- Listener Uncertainty would also lead to greater retention of speech skills.

Secondary hypotheses were:

- Differences would exist in the production of target phonemes in different positions in the word (initial, medial or final), depending on the type of treatment.
- Differences would exist in the production of target phonemes in different linguistic contexts examined (words, phrases, sentences, and spontaneous speech), depending on the type of treatment.
- Training on target fricatives would generalize to improved production of other fricative sounds (Experiment 2 only).

Chapters 3 and 4 present the Methods, Results and Discussion for Experiment One. Chapters 5, 6, and 7 present the Method, Results and Discussion for Experiment Two.

Chapter 3

METHOD - EXPERIMENT ONE

Research Design

The research design for this study was a single-subject, within session, alternating treatments design (Hersen & Barlow, 1976; McReynolds & Kearns, 1983; Tawney & Gast, 1984). This design is characterized by the alternation of two different interventions or treatments with a single learner to evaluate the relative effectiveness of the two approaches. The treatments are alternated within sessions, and order effects are controlled by changing the order of presentation of the treatments.

The use of the single-subject alternating treatments design eliminates the possibility of confounding subject variables, because each subject serves as his/her own control. Time effects are also controlled because treatments are administered concurrently. It is an appropriate design for this kind of study, where a reversal design (in which the child would be taught the correct production, then "retaught" the incorrect production) would be undesirable.

Generalization effects from one type of treatment to the other were controlled by careful selection of speech targets to ensure that phonemes differing in manner of articulation were presented for the two treatments. Targets were randomly assigned to treatments for each subject in such a way that targets, hence treatment approaches, were counterbalanced between subjects. The study was originally designed for four subjects, two boys and two girls. The two girls completed only three weeks of training, so only the performance of the two boys will be reported.

Individual performance was recorded before, during, and after training. Baseline and probe measures were taken prior to training (Baseline 1, 2, 3 and 4 and Probe 1). Training was then implemented for the two treatments, and probes were administered after every fourth training session to test for the effectiveness of training (P2, P3, P4, P5). A retention score was obtained four months after the completion of the study (P6). Spontaneous speech was also assessed before and after training to test for the use of learned speech skills in spontaneous spoken language.

The following is a summary of the testing and training schedule for the two treatment groups, where:

B = Baseline measure for phonemes to be trained.

T = Training session score for trained words.

P = Probes of trained and untrained words.

S = Spontaneous speech score, (use of trained phonemes in untrained, spontaneous words).

Week 1 -	B1	B2	B3	B4	P1	S1
Week 2 -	T1	T2	T3	T4	P2	
Week 3 -	T5	T6	T7	T8	P3	
Week 4 -	T9	T10	T11	T12	P4	
Week 5 -	T13	T14	T15	T16	P5	S2
No training for four months -					P6	S3

Subjects

The subjects were two profoundly hearing-impaired boys from the Montreal Oral School for the Deaf who were matched as closely as possible in age, grade level, hearing loss, language level and speech production. Both subjects were pre-linguistically hearing-impaired with bilateral sensorineural hearing losses. Both had unaided pure tone averages (PTA) of the frequencies 500 Hz, 1000 Hz, and 2000 Hz of 100 dBHL (re ANSI, 1969) or greater in the better ear. The two subjects had no additional handicapping conditions and were assessed as having above-average nonverbal intelligence as measured by Raven's test of Standard Progressive Matrices (Raven, 1960). They both had average language abilities relative to normal hearing children, as measured by the Spoken Language Quotient (SLQ) of the Test of Language Development-Intermediate (Hammill & Newcomer, 1982) and the Written Language Quotient (WLQ) of the Test of Written Language (Hammill & Larsen, 1983).

The two subjects were also rated on overall speech intelligibility using the criteria set out by Subtelny, Orlando and Whitehead (1981). The subjects were independently rated by two judges, using samples of their spontaneous spoken language. There was 100% agreement between the two judges, who were the experimenter and a graduate student in applied linguistics. Both subjects received a rating of "3+" in speech intelligibility, indicating that the listener could understand more than 50% of the spoken message.

Table 3.1 summarizes the subject data.

Table 3.1

Subject variables for matched subjects in Experiment 1.

	Subject 1	Subject 2
Gender	M	M
Age	11.5	12.6
Grade	6	6
Pure Tone Average (Hearing Level)	103.3	100.0
Etiology	unknown	maternal rubella
Age at Onset	0	0
Raven's Test of Standard Progressive Matrices	90th percentile for age	90th percentile for age
Test of Language Development (SLQ)	105	100
Test of Written Language (WLQ)	107	99
Speech Intelligibility Rating	3+	3+

Equipment

Test probes and spontaneous speech were recorded on a portable Beta video cassette recorder with an external, omni-directional, electret condenser microphone with a frequency range from 50 to 15,000 Hz. The subjects were simultaneously audio taped using a Bell & Howell audio cassette recorder and an external lapel microphone similar to the one used with the video cassette recorder. The speech evaluations and all training sessions were audio taped using the above equipment. The training sessions were periodically videotaped to check for uniformity in presentation of training.

Both students were binaurally aided with behind-the-ear personal hearing aids. During training the students used a Phonic Ear FM receiver 445 R in conjunction with a Phonic Ear FM microphone transmitter 441 T. The FM hearing aids were individually fitted by the school audiologist. Additional hearing aids and FM units were available in case of amplification problems.

See Appendix A for a list of equipment.

Materials

Testing and training words were illustrated by a set of 104 color drawings with no text, mounted on 7 cm by 10.8 cm white cards (Word Making Cards and Artic STICKS, Pro Ed). Words were of simple vocabulary and were selected to provide a variety of vowel contexts for both consonants /r/ and /ʃ/. See Appendix B for the list of trained and untrained words.

For elicitation of the spontaneous spoken language samples, books, toys and food were used. These were selected to elicit as many of the target sounds as possible, such as the story "Little Red Riding Hood" for /r/ . See Appendix C for a list of elicitation materials used in collection of the language samples.

Testing

Pre-tests

Speech Production Tests

The subjects were evaluated in a quiet, distraction-free room. They were pre-tested using the Phonetic Level Speech Evaluation (Ling, 1976) and the Phonetic Analysis of Imitated Speech (LeBlanc, 1990). The Phonetic Level Speech Evaluation (PLE) and Phonetic Analysis of Imitated Speech (PAIS) were administered by the experimenter, who was experienced in administration and scoring. Both tests require the child to imitate the teacher's production and use visual (speechreading) cues as well as audition.

The Phonetic Level Speech Evaluation (Ling, 1976) is an imitation test of syllable production that assesses neuromusculature co-ordination in production of nonsense syllables. It was developed for hearing-impaired children and is based on a hierarchy of simple to more difficult sounds, involving 7 stages:

1. Suprasegmentals (duration, intensity and pitch),
2. Vowels and Diphthongs,
3. Step 1 consonants (/b/p, f/v, θ /ð, w, h, m/ and stop /p/);
4. Step 2 consonants (/d/t, ʃ/ʒ, s/z, l, j , n/ and stop /t/);
5. Step 3 consonants (/g/k, tʃ/dʒ, r, ŋ/ and stop /k/);

6. Step 4 consonants (alternation of voiced-voiceless syllables);
7. Initial and final blends.

Consonants are tested in single and repeated syllables and most are tested with the three main vowels /a/, /i/ and /u/. Scoring of the PLE is (√) for correctly produced, (+) for sounds produced inconsistently, and (-) for sounds produced incorrectly or not at all.

The PLE's were scored live by the experimenter and later independently re-scored by a trained teacher of the hearing-impaired who had several years of experience in administering and scoring the test. The interjudge agreement between the live scoring (experimenter) and the audio taped score (teacher) was 89% for the PLE Total and 96% for the PLE Consonants. Most of the disagreements were due to the greater difficulty in scoring suprasegmentals and vowels, particularly from a tape recording. Live scores for the two subjects on consonant production in single and repeated syllables are presented in Table 3.2.

The Phonetic Analysis of Imitated Speech (LeBlanc, 1990) is an imitation test in which phoneme production is evaluated within sentences. The focus is on proper co-articulation in context. The original test, by Hudson (1987), has been adapted for hearing-impaired students by LeBlanc to follow the same order of consonant assessment (Steps 1, 2 and 3) as the PLE (Ling,1976).

The PAIS was scored by transcribing the target phonemes produced by the child and comparing them to the accepted phoneme production. The target productions were transcribed from audio tapes by two transcribers, the experimenter and a graduate student in applied linguistics. The procedure for phonetic transcription by consensus by Shriberg, Kwiatkowski & Hoffman, (1984) was used. In this procedure, the transcribers listen to the audio tape at the same time. Each word or target is independently transcribed and then a comparison of the transcriptions is made. If the transcriptions are the same, the transcribers go on to the next word. If the transcriptions are not the same, the transcribers listen to the audio taped production a second time and try to agree on the child's production. This is done for a maximum of three times, until a consensus is reached. One hundred percent consensus was reached on correct versus incorrect production for the specific consonant phonemes used in this study. The percentages of correct production of all consonants on the PAIS for each subject are listed in Table 3.2.

Performance on the PLE and PAIS determined the target phonemes chosen for study. The consonants /ʃ/ and /r/ were chosen because they could be produced by both subjects at the syllable level (PLE), but were inaccurately produced at the sentence level (PAIS). See Appendix D for a copy of the PAIS.

Selection of Targets

Speech targets were selected on the basis of errors made in the pre-testing. Subjects had to be able to produce the speech sound at the phonetic level, as assessed by phonetic level mastery on the PLE, but have inadequate control over correct production at the phonologic level, as tested in the PAIS.

Table 3.2
Speech production scores and speech targets
for matched subjects in Experiment 1.

Consonants	Subject 1 PLE Single	Subject 1 PLE Repeated	Subject 2 PLE Single	Subject 2 PLE Repeated	Subject 1 PAIS % correct	Subject 2 PAIS % correct
Step 1						
/b/	√	√	√	√	83%	67%
/p/	√	√	√	√	100%	100%
/f/	√	√	√	√	100%	100%
/v/	√	√	√	√	100%	83%
/θ/	√	+	√	√	67%	17%
/ð/	√	+	√	√	67%	0%
/w/	√	+	√	√	100%	100%
/h/	√	√	√	√	100%	75%
/m/	√	+	√	√	100%	100%
Step 2						
/d/	√	√	√	√	83%	100%
/t/	√	√	√	+	83%	67%
/ʃ/	√	√	√	√	33%**	33%*
/ʒ/	√	√	√	+	50%	75%
/s/	√	√	√	√	17%	67%
/z/	√	√	√	√	17%	33%
/l/	√	√	√	√	100%	33%
/j/	√	√	√	√	100%	100%
/n/	√	√	√	√	50%	83%
Step 3						
/g/	√	√	√	√	67%	83%
/k/	√	-	+	+	100%	83%
/tʃ/	-	-	-	-	17%	17%
/dʒ/	-	-	-	-	67%	0%
/r/	√	√	√	√	25%*	17%**
/ŋ/	√	+	√	√	0%	0%

* Listener Uncertainty
** Imitation

The targets chosen for this study were /r/ and /ʃ/. Both subjects produced both sounds correctly on the PLE. Scores on the PAIS showed that Subject 1 could produce /ʃ/ correctly 33% of the time and /r/ correctly 25% of the time. PAIS scores for Subject 2 showed 33% mastery of /ʃ/ and 17% mastery of /r/.

The targets were chosen to differ in terms of manner of production, so that carry-over effects from one type of training to another would be minimized. Targets were randomly assigned to treatment method. This resulted in Subject 1 receiving training on /ʃ/ using "Modeling and Imitation" and training on /r/ using a "Listener Uncertainty" approach. The assignment of phonemes to training method was reversed for Subject 2, who received training on /r/ using Imitation and training on /ʃ/ using Listener Uncertainty.

Baseline

One hundred and four picture cards were used to elicit the baseline measures. There were 56 picture cards used to elicit /r/ and 48 cards used to elicit /ʃ/. Target phonemes were elicited in initial, medial, final and medial abutting (i.e. the target consonant is preceded or followed by another consonant) positions.

The experimenter showed the card to the student, who then named the picture shown. The picture stimuli were randomly presented for each phoneme at each testing session. All picture cards for trained and untrained words were presented. (See Appendix B).

No reinforcement or feedback for correct or incorrect speech production was provided during the elicitation of the baseline measures. Responses were recorded for later scoring.

Probes

As with the baseline, 104 picture cards for the trained and untrained words were used to elicit the probe measures. Probe words were elicited in the context of words, simple sentences, and creative sentences.

For the word level elicitation, the experimenter followed the same procedure used for elicitation of the baseline measures. For the simple sentence level, the carrier phrase "This is a ______" was used. The experimenter gave an example of the sentence, using a word and picture card with a speech target not involved in the study. For example, "This is a boat." For the creative sentence level, the student was asked to make up his own sentence using the word pictured on the card. Before beginning the test probes at the creative sentence level, the experimenter gave two or three examples of sentences, using a word with a speech target not involved in the study. The examples used the word in different positions in the sentence. For example, "My father has a boat."; "The boat was floating on the water."; "He gave the boat to his friend." The students in the study had good spoken language and therefore had no difficulty creating simple sentences for each of the probe words.

The order of presentation of stimuli to elicit the probe measures was randomized for each student for each testing session. The order of presentation of context for elicitation of each of the probes was randomized for each target phoneme.

No reinforcement or feedback for correct or incorrect speech production was provided during this procedure. Probe word responses were recorded for later scoring.

Scoring of Baseline and Probe Words

Baseline and probe words were scored from the audio tapes by two judges, the experimenter and a graduate student in applied linguistics. Both were experienced transcribers, and both had received training in characteristics of deaf speech using the audio tape training program Speech and Voice Characteristics of the Deaf (Subtelny et al., 1981). They used a procedure for phonetic transcription by consensus proposed by Shriberg, Kwiatkowski and Hoffmann (1984). This led to 100% agreement of correct and incorrect productions of the target sounds. Baseline and probe measures for the target phonemes, /ʃ/ and /r/, were scored for targets appearing in the initial, medial, medial abutting and final positions in the words. The number of correct productions was divided by the number of attempted productions to give a percentage score.

Spontaneous Speech

Spontaneous speech samples were collected as outlined by Ling (1981b). Samples were collected by the experimenter on three occasions: before training (S1); after training (S2); and, after a four-month break in training (S3). A list of materials used to elicit the spoken language sample is presented in Appendix C.

The language samples were orthographically transcribed from the video tapes by the experimenter and the graduate student working together. One operated the equipment while the other wrote down each student's utterances. Small sections of the video tapes were listened to and repeated until accurate transcriptions were made. Any unintelligible words were indicated by a blank. Once an orthographic transcription was completed, the video tape was watched in its entirety and re-checked against the orthographic transcription. One hundred utterances from each of the orthographic transcriptions were then phonetically transcribed by both judges. For the phonetic transcriptions, the guidelines provided by Shriberg and Kent (1982) were used. A broad transcription was used for vowels and consonants not involved in this study. A narrow transcription, using the phonetic transcription by consensus method (Shriberg, Kwiatkowski and Hoffmann, 1984), was used for the targeted phonemes /r/ and /ʃ/. Most disputes were with regard to diacritical markings (kind of error), but the two judges were in 100% agreement with regard to correct vs incorrect scorings. Any co-articulation effects which would be considered acceptable allophonic variations of the target phoneme were not considered errors.

Training

Subjects received 30 minutes of daily, individualized speech training, four days a week. The fifth day of the week was used for administration of the test probes. The children completed 16 training sessions.

During each training session, subjects received approximately 15 minutes of training using each of the treatment methods, with a short break between treatments.

The testing and training for this study took place during the summer months. The students received no other speech teaching. Therefore, any gains in speech skills are assumed to be the result of the training.

Testing and training were conducted in a quiet room. The child and experimenter sat at two adjoining sides of a small table at approximately a 90 degree angle. This was to encourage listening, but not discourage speechreading when it was required.

Prior to each training session, the subject's hearing aids were checked by use of the Five Sound Test (Ling & Ling, 1978) and any adjustments to or replacements of the hearing aids or earmolds were made in order to ensure optimum listening levels.

For training, 40 picture cards were used. Twenty picture cards were used for training each of the two phonemes: five for final position; five for initial position; five for medial position; and five for medial abutting position production of the target sound. Five cards for each of the two phonemes were presented each week.

During training, subjects were required to produce one of the target sounds in five words, and the experimenter used one of the strategies. Stimuli (picture cards) were randomly presented with ten presentations for each card. After a short break, the subject was required to produce the other target sound (and the experimenter used the other strategy) in five words. Again, each picture card was randomly presented five times. The experimenter kept a record of correct and incorrect responses during each session. Responses during treatment were also recorded on audio cassette.

Order of Training

Subject 1 had poorest speech production in the final position for both phonemes as assessed by the baseline measures. Subject 2 had poorer speech production in the final position for /r/. For this reason, final position was selected first for training.

The target phonemes were taught using five randomly selected picture cards for each position, according to the following training schedule (T = training session):

Week 1 : final position (T1, 2, 3, 4)
Week 2 : initial position (T5, 6, 7, 8)
Week 3 : medial position (T9, 10, 11, 12)
Week 4 : medial abutting position (T13, 14, 15, 16).

Training Procedures

Imitation

Imitation training consisted of the following procedure:

1. The picture card was presented and the subject named the illustrated word.
2. If the subject's production was correct, the experimenter recorded the response as correct (√) and presented the next picture card.
3. If the subject's production was incorrect, the experimenter recorded the response as incorrect (-) and presented an auditory-visual model of the same target word in a normal speaking voice, and without exaggeration.
4. The subject repeated the model.
5. If the subject's production was correct, the experimenter recorded the response as correct (√) and presented the next picture card.
6. If the subject's production was incorrect, the experimenter recorded the response as incorrect (-) and presented the next picture card.

The picture cards were randomly presented until each word had been presented ten times.

Listener Uncertainty

Training for the listener uncertainty condition was as follows:

1. The picture card was presented and the subject named the illustrated word.
2. If the subject's production was correct, the experimenter recorded the response as correct (√) and presented the next picture card.

3. If the subject's production was incorrect, the experimenter recorded the response as incorrect (-) and said "What?" or "I don't understand."
4. The subject had an opportunity to self-correct or modify his production, and responded again to the pictured stimuli.
5. If the subject's production was correct, the experimenter recorded the response as correct (√) and presented the next picture card.
6. If the subject's production was incorrect, the experimenter recorded the response as incorrect (-) and presented the next picture card.

In the Listener Uncertainty condition, the subjects had no speech model provided. They had to rely on previously learned skills. As in the Imitation condition, the picture cards were randomly presented until each card had been presented ten times.

Scoring

On each production, subjects were scored live, by the experimenter, as correct (√) or incorrect (-). Each word card was presented ten times in random order. If each target was produced successfully the first time (100%), then the student had 50 opportunities to produce the phoneme in that position. If the child was incorrect on the first attempt and was presented with the word card a second time, he could have as many as 100 opportunities to say the sound correctly.

The subjects were scored only on the correct or incorrect production of the target phoneme and not on other sounds within the word that may have been produced incorrectly.

Reinforcement

During training, correct productions were socially reinforced with phrases such as "Good," or "That's right." for the Imitation treatment condition, and by showing understanding for the Listener Uncertainty condition. Students were also given stickers to place on 21.6 cm by 28 cm pages to show progress and completed sessions. At the end of each session, the students were rewarded with games and puzzles. They were also offered treats, such as juice and cookies.

Analysis

For each subject, percentages of correctly produced target phonemes were calculated, making the following measures available for analysis:

1. Baseline responses (word level).
2. Training responses (word level).
3. Probe responses for trained and untrained words (word, sentence, and creative sentence levels).
4. Spontaneous speech (creative sentence level).

Scores for baseline words (B), probes (P), training words (T) and spontaneous speech (S) were graphed for each subject. Scores for probes were then analyzed according to context, so that words, sentences, and creative sentences could be graphed for comparison. In addition, percentages for correct production of phonemes in initial, medial and final position were graphed over time.

Chapter 4

RESULTS AND DISCUSSION OF EXPERIMENT ONE

Results

Figure 4.1 shows the percentage of correct productions of the target phonemes for each subject, where each point represents a baseline measure (B), a probe measure (P), a training score (T), or a score for the target as produced in spontaneous spoken language (S). For probes, results of trained words and untrained words were pooled. Results for both conditions, Listener Uncertainty and Imitation, are presented for both subjects.

Baselines 1, 2, 3, Probe 1, and Spontaneous Speech Score 1 constitute measures of untrained words taken prior to training. Probes 2, 3, 4 and 5 are measures of speech skills on trained and untrained words taken at the end of each week of training. Probe 6 is a measure of the amount of retention of speech skills for both trained and untrained words four months after the termination of training.

Spontaneous Speech Score 2 is a measure of generalization of the target phoneme to the spoken language level after the completion of training. Spontaneous Speech Score 3 is a measure of target phoneme production in spoken language after a four month break in training.

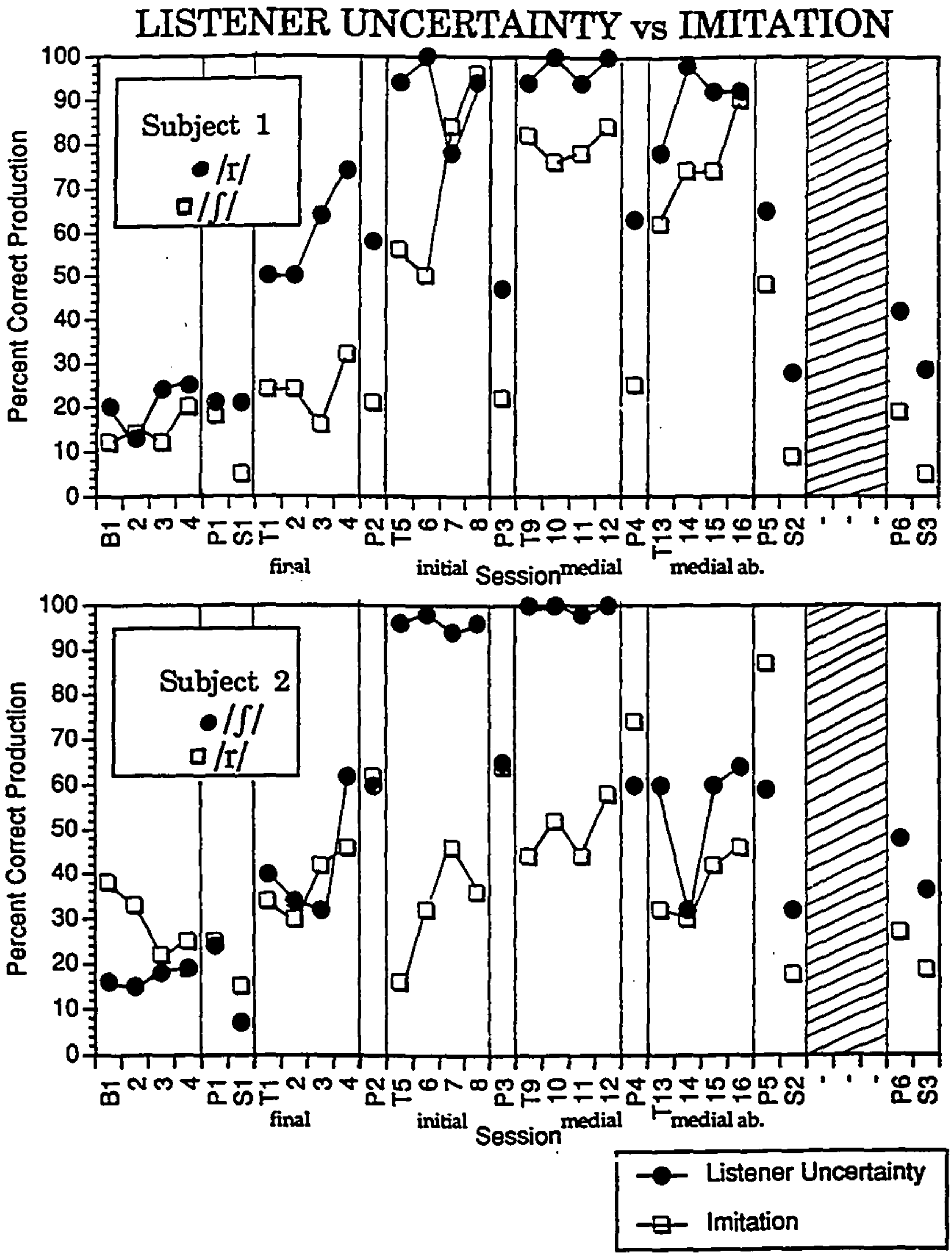

Figure 4.1 Percent correct production of treated phonemes in untrained words for baseline (B), trained words for training (T), untrained and trained words for probe (P) sessions and in untrained words in spontaneous speech (S) for imitation and listener uncertainty conditions for Subjects 1 and 2.

Subject 1

Baseline and Probe 1

Subject 1 showed a fairly consistent performance on both target phonemes before training, with scores between 13% and 25% correct production for /r/ and between 12% and 20% for production of /ʃ/.

Training

For the first week of training with the Listener Uncertainty technique, Subject 1 showed an immediate improvement to 50% correct production of /r/ in the final position on the first session, and had improved to 74% by the fourth session. During the remaining three weeks of training, where words were trained in the initial, medial, and medial abutting positions, performance ranged from 90% to 100% correct production except for one session in the second week and one session in the fourth week.

In the Imitation condition, Subject 1's improvement in production of /ʃ/ in the final position was much slower, but did reach levels of 90% or greater at the end of the second and fourth weeks of training. There was little improvement from baseline performance during Week 1, but an improvement from 50% to greater than 90% by the end of Week 2, after training in the initial position. There was fairly steady performance at about 80% on medial position production of /ʃ/ during Week 3 and an increase from about 60% to 90% during Week 4, when /ʃ/ was trained in the medial abutting position.

Probes

For the Listener Uncertainty condition, Subject 1 improved from pre-training performance of 21% on the probes to 47% after the first two weeks of training, and to over 60% after the two remaining weeks. There was a reduction to 42% after the four-month break in training.

For the Imitation condition, Subject 1 had fewer correct productions on the probes than in the Listener Uncertainty condition. There was little improvement from the pre-training level of 18% after the first three weeks, improvement to 48% correct after four weeks of training, and then a decrease to the baseline level four months after the conclusion of the training.

Spontaneous Speech

Subject 1 showed little generalization of speech skills to spontaneous speech using either approach, but the results for the phoneme trained by the Listener Uncertainty method were somewhat better. Scores for /r/, which had been trained with the Listener Uncertainty approach, improved from 21% before training to 28% after training, and remained at 29% four months later. Scores for /ʃ/, which had been trained using the Imitation approach, improved from 5% to 9% after training, and returned to the pre-training level of 5% after four months.

Subject 2

Baseline and Probe 1

Before training, Subject 2 had scores of between 22% and 38% on production of words containing /r/ and scores of between 15% and 24% on production of /ʃ/.

Training

During the first week of training, there was improvement from baseline performance to about 60% on final production of /ʃ/ which was trained using the Listener Uncertainty approach, as compared with an improvement to 46% on final production of /r/which was trained using Imitation. There was a much larger difference between the two approaches by the second week, with scores for the Listener Uncertainty condition exceeding the Imitation condition for training in the initial position. All scores for initial production of /ʃ/ during week two exceeded 90%. This held for the third week of training, where training in the medial position produced scores at or near 100% for the Listener Uncertainty condition. By the fourth week, however, scores for training in the medial abutting position dropped sharply for the Listener Uncertainty condition, with most scores at about 60%.

Scores for training of /r/using Imitation were much lower than those for the Listener Uncertainty condition for the second and third weeks of training. They ranged from 16% to 36% for week two (initial), and from 44% to 58% for week three (medial). On week four (medial abutting), the scores of 30% to 46% for Imitation were close to the decreased scores for the Listener Uncertainty condition.

Probes

For the Listener Uncertainty condition, Subject 2 showed an improvement in scores on the probes from the pre-training level of 24% to 60% after the first week of training. This level was maintained, with scores on probes during and just after training remaining at about 60%, but there was a decrease to 48% after the four-month break in training.

For the Imitation condition, Subject 2 achieved scores on /r/ production that increased from the pre-training level of 25% to about 60% after the first and second weeks of training. These scores were about the same as his scores for /ʃ/. After the third and fourth weeks of training, where phoneme production was trained in the medial and medial abutting positions, probe scores on /r/ improved to 74% and 87% respectively, surpassing his scores for /ʃ/After the four-month break in training, probe scores for the Imitation condition returned to pre-training levels (27%).

Spontaneous Speech

In the Listener Uncertainty condition, Subject 2's scores for correct production of /ʃ/ improved from 7% before training to 32% after the completion of training. After the four-month break in training, the increased score was maintained at 36%, indicating a retention of speech skills in spontaneous spoken language. In the Imitation condition, scores on production of /r/ in spontaneous speech remained fairly consistent at 15% before training, 18% after training and 19% after the four-month break.

Probes of Phoneme Production by Context

Figures 4.2 and 4.3 show the percentage of correct production of trained phonemes in words, sentences and creative sentences for each of the subjects in the two training conditions. The results for simple sentences and creative sentences were quite similar to those for words for both subjects in both treatment conditions.

Subject 1

Before training in the Listener Uncertainty condition, Subject 1 had the lowest scores for /r/ production at the word level and the highest score for creative sentences. During training, however, there were no consistent differences between the three contexts, and performance was about the same for all contexts after the four-month break in training.

In the Imitation condition, scores on sentences and creative sentences were lower than scores on words for the pre-training probe and the first two training probes, but were inconsistent on the three remaining probes.

Subject 2

In the Listener Uncertainty condition for Subject 2, there was no difference between words and sentences before training, but creative sentences were about 40% better. After the onset of training, there were inconsistent differences between words, sentences and creative sentences. After the four-month break in training, speech production scores for all three contexts were at about 50%.

LISTENER UNCERTAINTY vs IMITATION

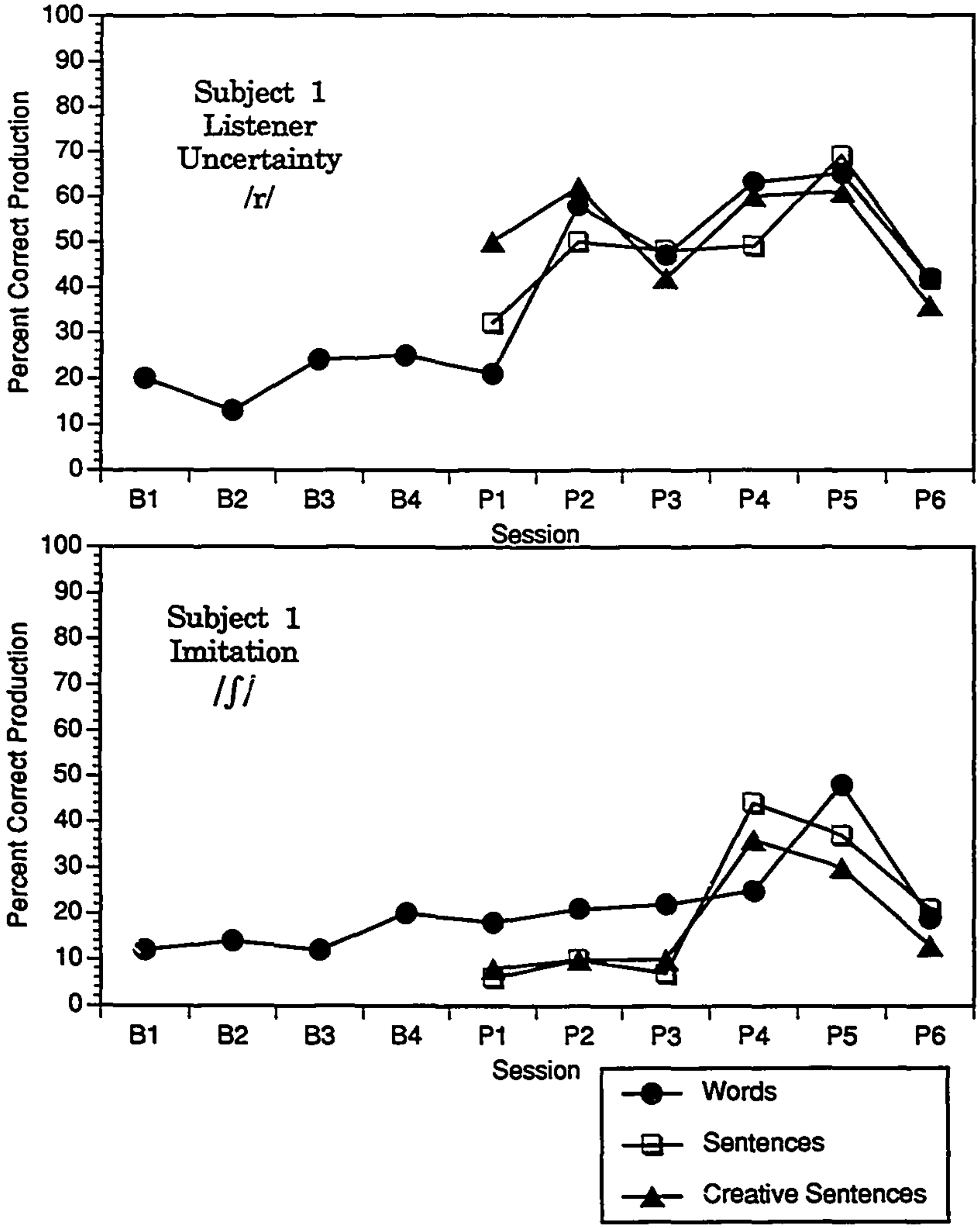

Figure 4.2 Percent correct production of treated phonemes in trained and untrained words for baseline (B) and probe (P) sessions in words, sentences and creative sentences for listener uncertainty and imitation conditions for Subject 1.

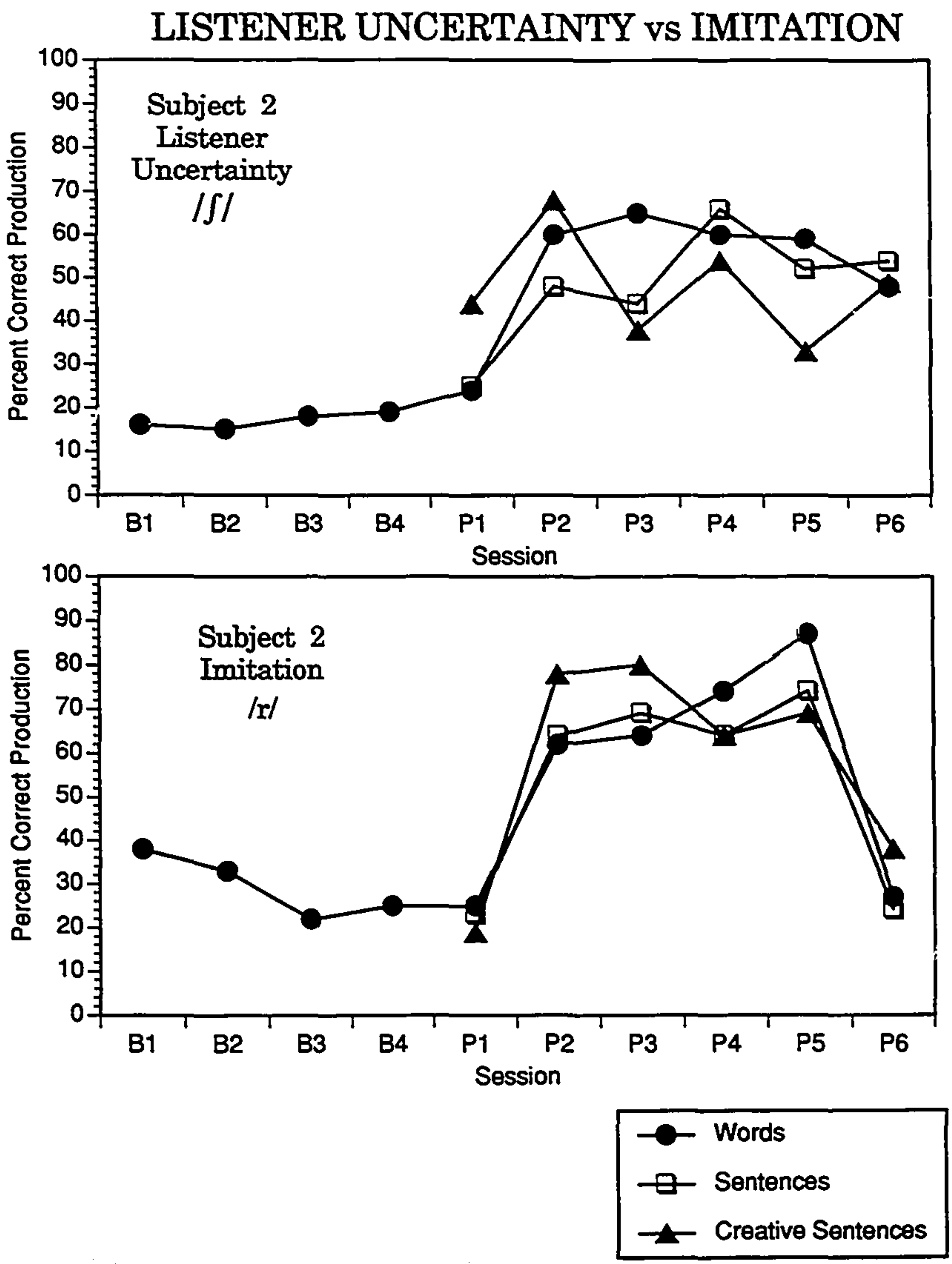

Figure 4.3 Percent correct production of treated phonemes in trained and untrained words for baseline (B) and probe (P) sessions in words, sentences and creative sentences for listener uncertainty and imitation conditions for Subject 2.

In the Imitation condition, there were no differences between words, sentences and creative sentences before training. After the onset of training, there were no consistent differences between words, sentences and creative sentences; and, after the four-month break, the scores for all three contexts decreased to about the same level.

Probes of Phoneme Production by Position

The percentages of correct production were graphed for initial, medial and final position of the target phonemes in words, with scores for medial and medial abutting words combined. The results for baseline and probes are shown in Figures 4.4 and 4.5.

Subject 1

For Listener Uncertainty, differences between positions were consistent prior to training, with scores ranging between about 30% to 50% correct for initial position, 10% to 20% for medial position and remaining at or close to 0% for final position. The rankings of position were maintained before, during and after training, with highest scores in initial position and lowest scores in final position. After training of /r/ in the final position during the first week, modest improvement in scores were made for final position production and large improvements in the other positions, with 100% correct scores achieved in the initial position. Initial position scores declined thereafter, despite training in initial position during the second week. Scores for medial position remained about the same

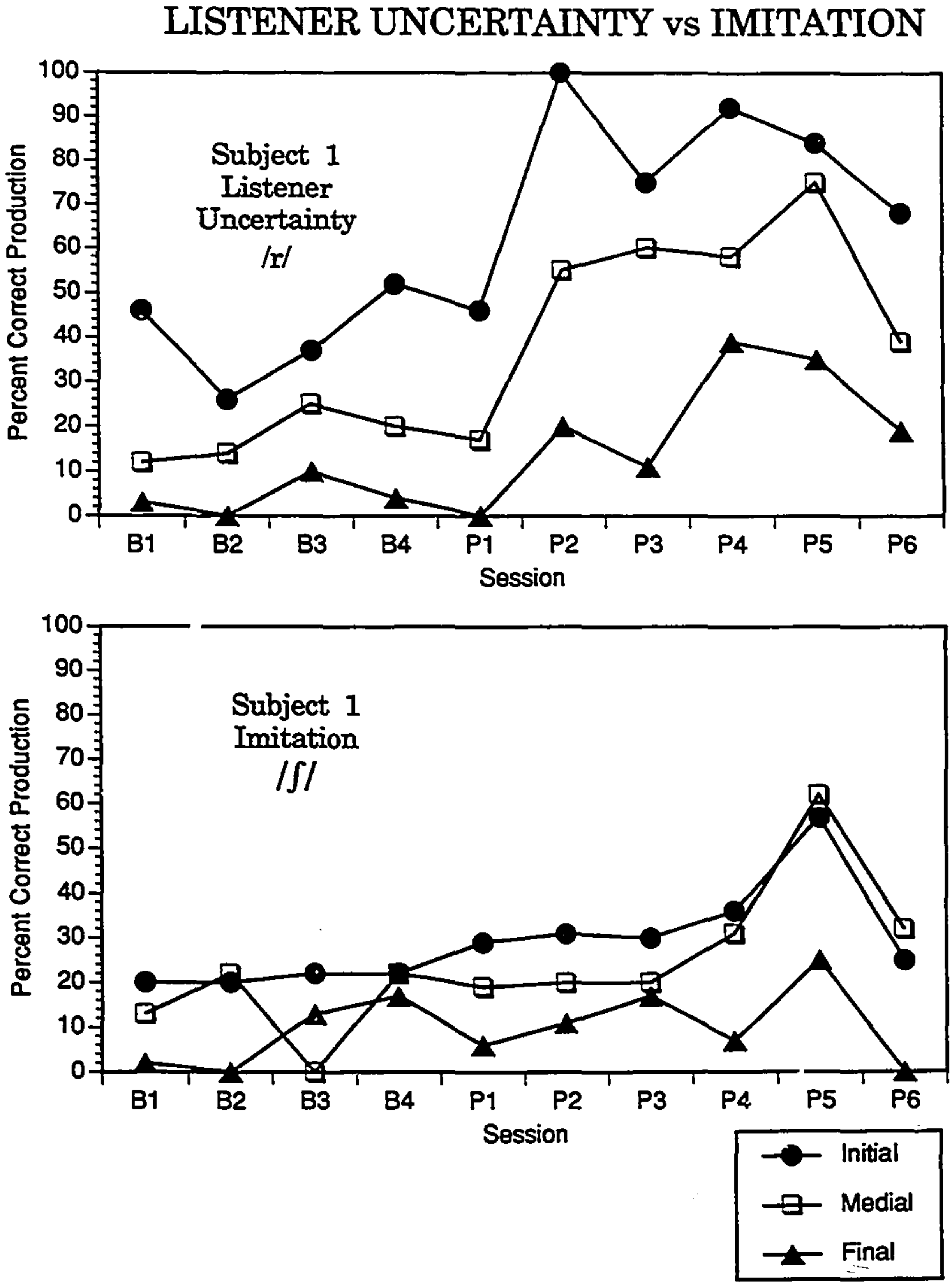

Figure 4.4 Percent correct production of treated phonemes in trained and untrained words for baseline (B) and probe (P) sessions in initial, medial and final positions for listener uncertainty and imitation conditions for Subject 1.

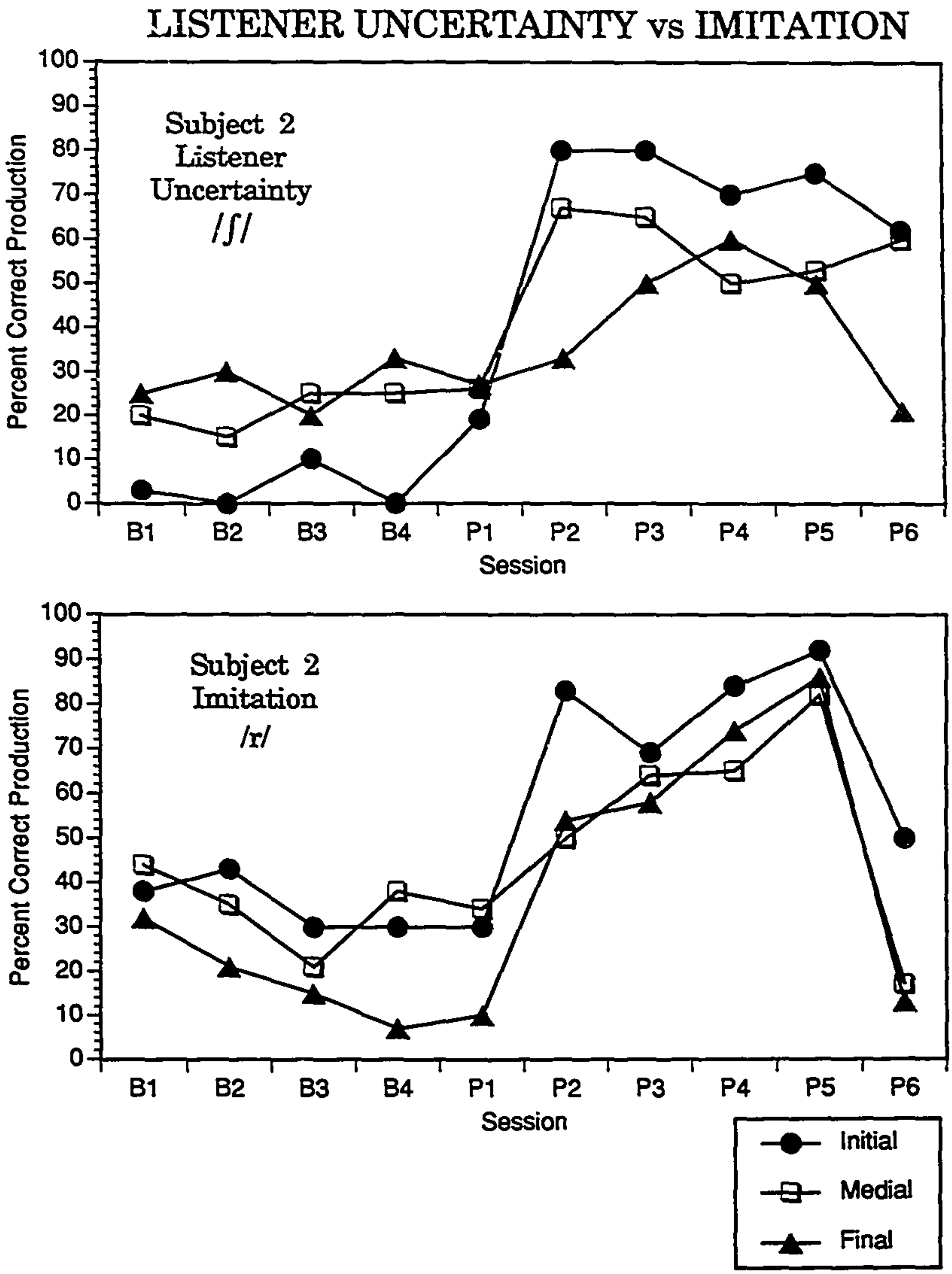

Figure 4.5 Percent correct production of treated phonemes in trained and untrained words for baseline (B) and probe (P) sessions in initial, medial and final positions for listener uncertainty and imitation conditions for Subject 2.

for the first three weeks of training, despite training on medial position, in Week 3 (P4). Scores did increase after the week of training in the medial abutting position for one week, before decreasing on the final probe. Scores for final position showed some improvement after the final two weeks of training, when medial position had been trained, before declining after the four-month break in training.

Since there was little improvement in the probes for /ʃ/ with Imitation training, possible position effects were very restricted. Once again, scores tended to be highest on the initial position and lowest in the final position before and during training. At the conclusion of training, scores in initial and medial positions had improved to about 60%, with final position scores much lower. Reduction of scores from post-training (P5) to the retention score (P6) were roughly parallel for all three positions.

<u>Subject 2</u>

In the Listener Uncertainty condition, Subject 2 showed his best production of /ʃ/ during baseline measures in the final position, but production in the final position tended not to improve as much as in the initial and medial positions. In fact, scores for initial and medial position showed much greater improvement than scores for the final position after training in final position during Week 1, and final position scores returned to baseline levels by Probe 6. Production of /ʃ/ was lower in medial position and lowest in initial position before training, but this reversed after training, with words in initial position scoring higher than those in medial position. After the break in training, the scores for initial position decreased slightly.

In the Imitation condition, Subject 2 performed better on /r/ in the initial and medial positions than in the final position before training. Probe scores obtained during the course of training were very similar, with the same general trend for continuing improvement for all three positions, and large decreases after the break in training. Scores for initial position production did not decrease as severely after the break as those for medial and final position.

Discussion

Separate Evaluation of the Two Methods

Listener Uncertainty

For the Listener Uncertainty condition, both subjects had similar patterns of performance for baseline and probe measures (See Figure 4.1). For the training sessions, both subjects had immediate improvement during the training sessions on those words being trained. This performance was fairly consistent for the final, initial, medial and medial abutting words trained, with the exception of the fourth week of training in which Subject 2 had reduced scores on the target sounds in the medial abutting position.

Probe One, taken before training, was consistent with baseline scores for both of the subjects. There were immediate improvements in probe scores after the first week of training for both subjects. The probe scores were generally lower than the scores received during the training sessions except for Probe 2 for Subject 2 and Probe 5 for Subject 2 which were at the same level as the training score.

Most important perhaps, is the retention score at Probe 6. Although it shows a decline in probe performance for both subjects, after the four-month break in training, the scores were higher than those obtained before training.

The spontaneous speech results for both subjects for the sounds learned in the Listener Uncertainty condition, are slightly different. Subject 1 started with slightly higher percent correct production before training and did show slight increases after training in the Listener Uncertainty condition. Subject 2 had lower pre-training scores and showed a greater improvement over time on the spontaneous speech scores and, in fact, did continue to increase his percent of correct production even after a break in training.

Imitation

For the Imitation condition, the two subjects showed differing patterns of performance (See Figure 4.1). Their baseline scores were fairly stable and there was some improvement in the scores during training. However, Subject 1 showed higher training session scores for the phoneme trained in the Imitation condition than did Subject 2. Scores during training for Subject 1 did reach levels equal to scores achieved using the Listener Uncertainty approach for some of the training sessions.

Subject 2 had training scores that were similar to Listener Uncertainty scores for weeks one and four of training and were consistently lower for Imitation than for Listener Uncertainty for Weeks 2 and 3.

The greatest difference is that Subject 1 had probe scores during training which were substantially lower than the scores achieved for the training sessions. Probe 1 was consistent with the baseline measure but Probes 2, 3 and 4 show very little increase from the pre-training scores. It was only after the completion of the study, Probe 5, that Subject 1 showed any increase in the percent of correct production of phonemes taught using the Imitation approach. At Probe 6, after the break in training, these probe scores returned to pre-training levels.

Subject 2 showed a quite different pattern of performance. Scores for probe sessions were higher than those for training sessions. This is inconsistent with scores achieved by Subject 1 and the scores achieved by both subjects using the Listener Uncertainty technique. However, the results for the follow up probe at Probe 6 show that, again, the scores returned to pre-training levels.

Using the Imitation technique, the spontaneous speech scores are fairly similar for both subjects. They started out fairly low and they stayed low throughout the course of the study. For training in the Imitation condition, Subject 1 started at only 5% correct usage of /ʃ/; improved slightly to about 9% but then returned again to about 5%. For Subject 2, in Imitation training, spontaneous speech scores before training started out low, at about 15%; increased to about 18%, and stayed at 19% after the four-month break in training.

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sentences were fairly easy, with the target word located in a stressed position at the end of the sentence.

"This is a _______."

Comparisons of scores for the two training methods show higher performance at Probe 6 for both subjects for the Listener Uncertainty condition for words and sentences, but scores for creative sentences were about the same pre- and post-training (See Figures 4.2 and 4.3). In the Imitation condition, creative sentences reflected scores in words and simple sentences. The students' creative sentences were fairly simple. Differences might have been more apparent if more complex language had been demanded in the task. This was reflected in the consistently lower scores in spontaneous spoken language data for both subjects.

Position

The effects of training on the position of the target phoneme in the word, were examined. Although there were differences between medial and medial abutting training scores, the scores were similar for probes and therefore combined. For both training conditions, and for both types of targets, /r/ and /ʃ/, production of the phoneme in the initial position was superior or equal to the other positions, except for the Imitation condition at Probe 6 for Subject 1 (See Figures 4.4 and 4.5). Regardless of the position trained, initial position production was usually better.

In comparing the two training methods, the benefits of Listener Uncertainty condition are most apparent for words with the target phoneme in the initial position at the end of training (P5) for both subjects. After the four-month break in training, (P6) differences are most marked for initial position production for Subject 1 and for both initial and medial productions for Subject 2. Production of the target phoneme in the final position increased only slightly for Subject 1 and returned to pre-baseline levels for Subject 2. The Listener Uncertainty technique therefore, appears more effective for production of phonemes in the initial and medial positions.

The Imitation condition was less effective for Subject 1 than the Listener Uncertainty condition, with P5 the only probe showing an improvement for initial and medial production (See Figure 4.4). The lack of retention at P6 for the Imitation condition for Subject 1 was apparent for all three positions.

Imitation training was an effective training technique for Subject 2 only as long as daily training was maintained (See Figure 4.5). After the treatment was terminated, scores for speech production in final and medial positions returned to pre-training levels.

A comparison of results for this subject with regard to phoneme position in the word, indicates that neither approach appears to been effective for target sounds produced in the final position. There were also little or no specific effects of training at a particular position for either subject.

Conclusions

The results indicated that both strategies lead to improvement in phonologic level speech skills for profoundly hearing-impaired children, but individual differences were found for generalization of speech skills to untrained words and for retention of learned speech behaviors. The Listener Uncertainty condition worked well for both subjects with reasonable retention for the probe scores but little generalization to spontaneous speech for Subject 2. The Imitation condition had inconsistent results, with improvement on training scores but not probes for Subject 1 and improvement on probes, but not training scores for Subject 2. There was no retention of probe scores for either subject and no generalization to spontaneous speech using the Imitation approach.

Both subjects showed some generalization from training on words to untrained simple sentences and to creative sentences for probes during training. In the Imitation condition there was no retention for any context, but the Listener Uncertainty condition showed some retention for improved scores in the word and simple sentence contexts.

There were no outstanding position effects, except a tendency toward a better production in the initial position. It is questionable whether either of these training methods was particularly helpful in improving final position production as only one of the subjects (Subject 1) showed any improvement in final position production, even with the Listener Uncertainty condition.

The greatest limitation of a study of this kind is the inability to generalize findings from work with two subjects to the larger population of profoundly hearing-impaired children of different ages. With this in mind, a group study was designed to see if the trend for better retention using the Listener Uncertainty technique would hold true for other hearing-impaired children. Since the group study was a matched group design model with repeated measures, students were not able to serve as their own controls in the same way as in the single-subject design study. It was therefore necessary to make some changes in design which would provide greater control and ensure greater reliability of the findings.

1. Since the children would not be acting as their own controls, it was necessary to select a control group of children who would receive no training.

2. Training would be fifteen minutes per day as only one phoneme would receive treatment. This would also allow for the greatest possible number of children to be trained each day. Phonemes selected for training would all be of a similar type — voiceless fricatives. A control phoneme (plosive) would be selected for each student on which he/she would receive no training. An additional control would be untrained fricatives.

3. The number of untrained probe words would be equal to the number of trained probe words. Trained and untrained words would be separated in calculation of probe data to provide scores for trained words and generalization (untrained) words.

4. Training would not be restricted to words, as in Experiment One, but would include words, phrases, sentences and creative sentences. Words would be probed after every fifth day of training. Probe words would be tested in words, phrases and sentences, eliminating the creative sentences from testing. Measures of carry-over to spontaneous speech would continue to be used.

5. Training would be conducted in initial, medial and final positions with an equal number of words trained in each of the three positions.

In the next two chapters the methods and results of the group study will be presented.

Chapter 5

METHOD - EXPERIMENT TWO

The results of Experiment One left the main research questions unanswered. With only two subjects, it was impossible to generalize to the larger population of hearing-impaired students. A group study was, therefore, devised to examine the primary and secondary hypotheses listed at the end of Chapter Two.

Research Design

Group Study

Thirty-three profoundly hearing-impaired children were matched as closely as possible on relevant variables and then randomly assigned to three groups of eleven subjects each. Two groups were treatment groups and the remaining group was a control group. In the first treatment group, subjects received daily speech training at the phonologic level using a listener uncertainty approach. In the second treatment group, subjects received daily speech training at the phonologic level using an imitation approach. The control group received no additional individualized speech training during the course of the study.

<u>Groups:</u>

1: Listener Uncertainty Group

2: Imitation Group

3: Control Group

Comparisons among groups were made over three testing periods for phonemes in probe words presented in three different contexts; words, phrases and sentences, in three different positions; initial, medial and final in the probe words.

<u>Time of Testing:</u>

1. before the onset of training
2. after 20 sessions of training
3. after a four-week break in training

<u>Context:</u>

1. Word
2. Phrase
3. Sentence

<u>Position:</u>

1. Initial
2. Medial
3. Final

This resulted in a four-way mixed design model with subjects nested within treatment group and crossed with Time (testing session), Context and Position. Group was the between-subjects factor and Time, Context and Position were the within-subjects factors. There were three levels of each factor.

Table 5.1 illustrates the research design.

Table 5.1 Summary of research design showing subjects nested within Group (1, 2, 3) and crossed with Time (1,2,3), Context (word, phrase, sentence) and Position (initial, medial, final).

		Time (Testing Session)								
		1			2			3		
	Context	W 1	P 2	S 3	W 1	P 2	S 3	W 1	P 2	S 3
	Position	imf 123	imf 123	imf 123	imf 123	imf 123	imf 123	imf 123	imf 123	imf 123
Group	**Subjects** *									
Treatment Group 1 Listener Uncertainty	11									
	21									
	31									
	41									
	51									
	61									
	71									
	81									
	91									
	101									
	111									
Treatment Group 2 Imitation	12									
	22									
	32									
	42									
	52									
	62									
	72									
	82									
	92									
	102									
	112									
Control Group	13									
	23									
	33									
	43									
	53									
	63									
	73									
	83									
	93									
	103									
	113									

* subject 11 = 1st subject, group 1
subject 12 = 1st subject, group 2
subject 13 = 1st subject, group 3

The data obtained with these results were correct phoneme productions for target phonemes in trained words and untrained generalization words, and for control words containing non-target phonemes.

Training words: words used in training that contained the target fricatives;
Generalization words: untrained words that contained the same target fricative as the trained words;
Control words (plosives): untrained words that contained untrained plosives; and,
Control words (other fricatives): untrained words that contained untrained fricatives.

Another level of context, spontaneous speech, was examined to test for generalization of speech skills to spontaneous spoken language. These data were analyzed separately, as the number of attempts to produce each target phoneme could not be controlled across subjects. Spontaneous speech was studied using a one-way, one repeated measure design with subjects nested within treatment group and crossed with Time. This resulted in a two-way mixed design model with Group as the between-subjects factor and Time as the within-subjects factor. The data obtained were the correct productions of trained phonemes and control phonemes.

Individual Performance

Baseline, probe and training scores were obtained over a three month period, in order to document individual progress before, during, and after training. Baseline and probe measures were taken prior to training (Baseline 1, 2, and 3 and Probe 1). Training was then implemented for the two treatment groups. Probes for acquisition and generalization were administered after every fifth training session.

The following is a summary of the testing and training schedule for the two treatment groups, where:

B	=	Baseline measure for trained phonemes
T	=	Training session
P	=	Probes of training words, generalization words and control words
S	=	Spontaneous speech sample (generalization score of trained phonemes in untrained, spontaneous words).

B1	B2	B3			P1	S1
T1	T2	T3	T4	T5	P2	
T6	T7	T8	T9	T10	P3	
T11	T12	T13	T14	T15	P4	
T16	T17	T18	T19	T20	P5	S2
no training for four weeks					P6	S3

Probe 1 was the Time 1 measure administered prior to training. Probe 5 was the Time 2 measure administered at the end of training. Probe 6, the Time 3 measure, was administered four weeks later to test for retention of learned speech skills. The break in training was scheduled to coincide with the four-week period including the week before Christmas vacation, Christmas break itself (during which the students went home) and the beginning of January when the students were taking achievement tests and not receiving regular instruction.

Subjects

Subjects were thirty-three students from a large oral school for the deaf, who were being trained using a visual-oral approach. All were prelinguistically hearing-impaired with profound, bilateral, sensorineural hearing losses. All had unaided pure tone averages (PTA) of the frequencies 500 Hz, 1000 Hz, and 2000 Hz of 90 dBHL (re ANSI 1969) or greater in the better ear. Subjects ranged in age from 7.8 to 15.11 years. The students were judged by school personnel to have no other major handicapping conditions. All were of average to above average intelligence, with Performance I.Q. scores ranging between 92 and 133 as measured by the Wechsler Intelligence Scale for Children-Revised (Wechsler, 1974). All used speechreading to supplement hearing levels. They scored between 45 and 86.7% on perception of isophonemic words, presented out of context, with auditory and visual cues, on the Auditory-Verbal Test (Boothroyd, 1968). They scored between 60% and 100% on Clarke School's Speech Intelligibility Test for Deaf Children (Magner, 1972), and were rated between (2) and (5-) on speech intelligibility of their spontaneous speech, using Speech and Voice Characteristics of the Deaf (Subtelny et al., 1981). Their phoneme production on the Phonetic Level Speech Evaluation (Ling, 1976) ranged from 90.0 to 201.5 for overall score and from 41.0 to 136.5 for consonant production. (See the section on Testing for additional information on pre-tests.)

Triads, (sets of three subjects), were matched as closely as possible on age, gender, hearing loss, speech measures and errors made on the pre-test probes. Matching was done in triads because the members of a triad would receive training on the same target sounds. (See Table 5.5). Subjects from each triad were then randomly assigned to one of the two treatment groups or to the control group, creating three groups with eleven subjects in each group. Table 5.2 lists the matching variables and Table 5.3 lists a number of other subject variables of interest, including etiology, age at onset, Auditory-Verbal Test (Boothroyd, 1968), WISC-R Performance I.Q. (Weschler, 1974), language level, reading level and status (day/residential).

There were 15 girls and 18 boys in the study, of whom 21 were residential students and 12 were day students. Seven students from each group were residential students. The students were selected from several classes in the school. Parents and teachers knew that the students were selected for a speech study, but were unaware of the type of training that the children were to receive.

Group means for age, hearing loss, speech measures, the Auditory-Verbal Test, WISC-R Performance IQ. scores, language level, and reading level are presented in Table 5.4.

Table 5.2

Subject variables for subjects in matched triads.
Group 1 = Listener Uncertainty. Group 2 = Imitation.
Group 3 = Control.

Subject-Group	Gender	Age	PTA (HL)	Speech Intellig. (%)	Intellig. Rating	PLE Total	PLE Conson.
11 *	F	8.4	105.0	93	3 +	126.0	78.5
12 **	F	9.0	113.3	67	2 +	100.5	75.5
13 ***	F	10.10	93.3	100	4 +	128.5	76.0
21	F	12.10	105.0	65	2 +	116.0	63.0
22	F	11.5	95.0	64	2	114.0	91.0
23	F	13.2	113.0	60	2 +	105.5	50.0
31	F	11.3	90.0	98	5 –	194.5	132.5
32	F	15.5	93.0	99	4 +	201.5	136.5
33	F	12.10	96.6	95	3 +	167.5	108.0
41	F	13.10	93.3	95	3	194.0	133.0
42	F	15.2	105.0	96	4	178.0	114.5
43	F	14.0	90.0	95	4	180.0	122.5
51	F	15.6	103.3	95	3	152.0	99.5
52	F	15.2	106.6	95	3	134.5	80.5
53	F	15.11	103.0	78	3 +	153.0	97.0
61	M	7.8	95.0	61	3 –	90.0	52.5
62	M	9.6	106.6	77	3	92.5	41.0
63	M	8.6	98.3	83	3	77.5	56.0
71	M	9.5	98.3	92	4 –	97.5	61.0
72	M	9.2	101.6	89	3 +	103.0	59.0
73	M	10.1	101.6	87	4 –	115.5	60.5
81	M	11.11	108.0	65	3 –	117.5	63.5
82	M	11.8	116.6	54	2 +	103.5	59.5
83	M	12.3	90.0	82	2 +	156.0	87.5
91	M	11.4	95.0	100	3 +	140.0	80.5
92	M	12.3	95.0	94	3 +	150.5	91.5
93	M	12.3	103.3	100	4	166.0	109.5
101	M	12.7	100.0	90	3	132.5	86.5
102	M	11.9	100.0	89	3	161.5	103.5
103	M	12.8	110.0	81	2 +	144.5	86.0
111	M	15.0	101.6	91	3	149.5	89.5
112	M	14.4	96.6	92	3	188.0	133.5
113	M	14.3	93.3	93	3 +	146.0	88.0

* 1st subject Group 1
** 1st subject Group 2
*** 1st subject Group 3

Table 5.3

Subject variables for subjects in matched triads.
Group 1 = Listener Uncertainty. Group 2 = Imitation.
Group 3 = Control.

Subject-Group	Etiology	Age at Onset	Auditory Verbal Test (%)	WISC-R Perf.I.Q.	Language (in grade level)	Reading (in grade level)	Day/ Resid-ential
11	unknown	0	83	92	1.0	DNT	H
12	unknown	0	54	98	<1.0	2.0	R
13	unknown	0	85	114	1.10	4.2	H
21	ototox drugs	0	76	95	1.0	1.9	R
22	unknown	0	58	117	2.0	2.3	H
23	meningitis	1.9	54	128	2.0	3.9	R
31	unknown	0	86.7	111	6.5	5.3	R
32	unknown	0	76	128	13.0	13.0	R
33	unknown	0	83	129	6.8	4.1	R
41	unknown	0	70	105	5.2	2.6	R
42	unknown	0	48	109	3.8	5.6	H
43	genetic	0	83	98	3.6	2.8	H
51	viral enceph.	0.7	70	105	7.0	3.6	R
52	meningitis	0.1	58	111	6.5	12.3	R
53	genetic	0	70	112	9.0	4.5	H
61	unknown	0	45	118	<1.0	DNT	H
62	unknown	0	54	133	<1.0	DNT	R
63	unknown	0	60	130	<1.0	1.7	H
71	genetic	0	76	109	1.0	3.0	H
72	ototox drugs	0.1	70	130	1.0	2.0	H
73	genetic	0	76	129	1.0	DNT	R
81	cytomeg vir.	0	60	95	1.5	2.1	R
82	unknown	0	54	118	2.0	3.1	R
83	viral enceph.	0	67	132	DNT	2.9	R
91	genetic	0	60	115	2.0	4.7	H
92	unknown	0	74	108	1.0	3.5	H
93	unknown	0	76	105	6.0	11.0	R
101	meningitis	1.2	70	105	2.0	5.0	R
102	unknown	0	63.3	114	1.0	2.9	R
103	unknown	0	60	138	2.0	6.9	R
111	unknown	0	58	111	4.0	2.9	R
112	genetic	0	76	121	6.5	5.9	R
113	anoxia birth	0	70	98	1.0	2.7	R

DNT - did not test/test score unavailable

Table 5.4

Group means for subject variables
for the three matched groups.
Group 1 = Listener Uncertainty. Group 2 = Imitation.
Group 3 = Control.

	Group 1 Listener Uncertainty	Group 2 Imitation	Group 3 Control
Age	11.8	12.11	12.9
PTA (HL)	99.5	102.6	99.3
Speech Intelligibility (%)	85.9	83.3	86.7
Intelligibility Rating	3	3+	3+
PLE Total	137.2	138.9	140
PLE Consonants	85.5	89.6	85.6
Auditory-Verbal Test (%)	68.6	62.3	71.3
WISC-R Performance IQ.	105.5	117	119
Language (in grade level)	2.10	3.4	3.4
Reading (in grade level)	3.4	5.2	4.2

Equipment

All test probe and spontaneous speech data were recorded on portable Beta video cassette recorders with external, omni-directional, electret condenser microphones with a frequency range from 50 to 15,000 Hertz. Subjects were simultaneously audiotaped using a Bell & Howell audio cassette recorder and an external lapel microphone similar to the one used with the video equipment. The Phonetic Level Speech Evaluations, pre-tests and all training sessions were audiotaped using the above equipment. The training sessions were periodically video taped to check for uniformity in presentation of training.

Students were all binaurally aided and wore FM hearing aids that were individually fitted by the school audiologist. The FM hearing aids were maintained by a technician at the school. Students in lower and middle school wore Phonic Ear FM receivers PE 461 in conjunction with a Phonic Ear FM microphone transmitter 421T. Students in upper school used System 4 Phonic Ear FM receivers PE 475R in conjunction with Phonic Ear FM microphone transmitter 421T. Additional FM systems were available if any hearing aid problems were detected. See Appendix E for a list of equipment.

Pre-testing was administered in a quiet room provided by the school. For the probes and spontaneous spoken language samples, the school provided a television studio with appropriate lighting and a small stage. This had originally been used for school broadcasts of student produced television newscasts. The location and acoustics were ideal for audio and video taping. Training was done in a quiet room adjacent to the television studio.

Materials

For testing and training, probe words were illustrated by a set of color drawings, with no text, mounted on 7cm by 10.8 cm white cards, similar to those used in the first experiment. Nine word cards were used for each training, generalization or control phoneme; three for initial position, three for medial position, and three for final position production of the target sound. Probe words were of simple vocabulary and were selected to provide a variety of vowel contexts for each consonant phoneme tested. Words containing blends or difficult phonemes, such as affricates, were avoided as much as possible. A list of probe words for each phoneme used in the test probes and for training is presented in Appendix F.

For elicitation of the spontaneous spoken language samples, books, toys and food were used. These were selected to elicit as many of the target fricative sounds as possible, such as the story "Cinderella" for /s/. See Appendix G for a complete list of elicitation materials used in collection of the language samples.

Testing

Pre-tests

Forty-three children at the school met the criteria for age, hearing loss, and no additional handicapping conditions, and had enough language to master the vocabulary of the words used in this study. They were all pre-tested and the thirty-three students who could best be matched were selected for the study.

Speech Production Tests

The subjects were evaluated in a quiet, distraction-free room. They were pre-tested, using the Phonetic Level Speech Evaluation (Ling, 1976) and a screening list of pre-test words prepared by the experimenter (see Appendix D). Performance on the Phonetic Level Speech Evaluation (PLE) and the screening test determined the speech targets and hence the list of test probes to be administered for the baseline and Probe 1 measures.

Phonetic Level Speech Evaluation. The PLE was administered by a graduate student who had been trained in administration and scoring. In order to test production of consonants to be used in this study, the test was administered to all subjects until the end of "Step 3 Consonants", including all fricatives to be used in the test probes. If the student completed "Step 3 Consonants" successfully, the test was administered until at least six errors were made.

Scoring of the Phonetic Level Speech Evaluation followed the criteria established by Perigoe and Ling (1986). Target sounds correctly produced consistently (√) were given one point; sounds produced inconsistently (+) were given a score of .5; and, sounds produced incorrectly or not at all (-) received no score. An overall score was calculated for each student (PLE Total), which included performance on suprasegmentals, vowels and consonants. A second score for consonants only (PLE Consonants) was calculated, since this study involved the training of consonant sounds.

The PLEs were later scored by a trained teacher of the hearing-impaired who had several years of experience in both administration and scoring the test procedure. The interjudge agreement between the live scoring and the audiotaped score was 86% for the PLE Total and 94% for the PLE Consonants. The difference here may be due to the greater difficulty in scoring suprasegmentals and vowels, particularly from a tape recording. Live scores are reported in Table 5.2.

Screening Test. The screening test consisted of a variety of the probe words. Forty-three picture cards were randomly presented to test fricative and plosive production in initial, medial and final position in words. The experimenter showed the card to the student, who then named the picture shown. No reinforcement was given until the end of the pre-test. Responses were scored live as correct or incorrect, with respect to the particular phoneme being tested. All responses were audio taped for scoring and a graduate student scored the recorded responses. Interjudge agreement between the experimenter and graduate student (live and recorded scores) was 96%. Errors made on the screening test were used for selection of the phonemes and hence the probe words to be used in the baseline measures.

Selection of Targets

Speech targets were selected on the basis of pre-testing. Subjects were required to be able to produce the speech sound at the phonetic level as assessed by phonetic level mastery on the Phonetic Level Speech Evaluation (Ling, 1976), but have inadequate control over correct production at the phonologic level, as tested in the pre-test screening words (Appendix D) and in the baseline probe words (Appendix F).

Voiceless fricatives were chosen as speech targets, since they were difficult for the children in this study to produce with accuracy at the phonologic level before the onset of the training. Profoundly hearing-impaired students often have difficulty producing fricatives correctly (Levitt & Stromberg, 1983). Fricatives are not acoustically available to hearing-impaired children with profound hearing losses, because they are mostly high in frequency and low in intensity (Ling & Ling, 1978).

Plosives were chosen as control phonemes for several reasons:

1. They could be produced adequately at the phonetic level. They were produced more accurately than fricatives at the phonologic level, but still had some room for improvement.
2. It was hypothesized that training on fricatives would have little effect on the production of plosive sounds.
3. It was preferable to have a class of sounds which, like the fricatives selected, had different places of articulation and correspondingly increasing levels of difficulty (Ling, 1976).
4. It was also necessary that the class of phonemes chosen had production in words in all positions - initial, medial, and final. This excluded the nasals since /ŋ/, does not appear in the initial position in English.

Matching of Targets

Training, generalization and control phonemes were matched across triads of subjects. For example, Subjects 11, 12, and 13 were trained on /f/, tested for generalization to other /f/ words, tested on /b/ words for a plosive control and tested on other fricatives as additional control words. Children who had already mastered use of earlier developing sounds, such as /f/, had other voiceless fricatives as targets, e.g. /θ/, /s/, or /ʃ/.

In this way, target phonemes were selected for training words, generalization words, control words (plosives), and control words (fricatives). A list of the phonemes used for each triplet of subjects is presented in Table 5.5.

Baseline and Probes

The words used in baseline and probe testing contained phonemes selected for each triad of subjects. Word cards were used to elicit the baseline and probe measures, which were administered by a graduate student who had been trained in administration and scoring.

The baseline and probe words were elicited in the following contexts:

words — single word only

phrase — "on the ________"

sentence — "I have the ___________."

Table 5.5

Training, generalization, control (plosive) and control (fricative) phonemes for each group of subjects.

Subjects	Training and Generalization	Control (plosive)	Control (fricative)
11,12,13	ʃ	g	s , z , ʒ
21, 22, 23	f	d	θ , ʃ, s , v
31, 32, 33	ʃ	g	s , z , ʒ
41, 42, 43	s	g	ʃ, ʒ , z
51, 52, 53	s	g	ʃ, ʒ , z
61, 62, 63	f	b	θ , ʃ, s , v
71, 72, 73	f	d	θ , ʃ, s ,v
81, 82, 83	f	d	θ , ʃ, s ,v
91, 92, 93	θ	d	s , ʃ, ð
101, 102, 103	s	g	ʃ, ʒ ,z
111, 112, 113	θ	d	s , ʃ, ð

The order of presentation of stimuli to elicit baseline and probe measures was randomized for each student within each context for each testing session.

Baseline and test probes were scored live as correct (√) or incorrect (-). No reinforcement or feedback for correct or incorrect speech production was provided during the test procedure. Baseline and probe word productions were also scored independently from the videotapes by two former teachers. Percentages of agreement between judge A (live), judge B (tape) and judge C (tape) were computed from a random sample of the responses for each subject. The mean percentage of agreement between judge A (live) and judge B (tape) was 91.4%. Interjudge agreement between judge A (live) and judge C (tape) was 91.1% . Agreement between the two taped scores, judges B and C was 89.1%.

Sample Score sheets for baseline and probe sessions are presented in Appendix H.

Spontaneous Speech

The spontaneous speech samples were collected as outlined by Ling (1981b). Samples were collected on three occasions: before training (Time 1); after training (Time 2); and, after a four-week break in training (Time 3). The samples were gathered by a retired teacher from the school with many years of experience in working with profoundly hearing-impaired students. She is also the parent of an orally-trained hearing-impaired young adult who is a graduate of the school. She is very familiar with the speech of profoundly hearing-impaired students and was able to stimulate the children to speak.

A list of materials used to elicit the spoken language samples is presented in Appendix G.

The language samples were orthographically transcribed from the videotapes by former teachers. The orthographic transcriptions were then given to two phonetic transcribers. The phonetic transcribers were a doctoral student who was a trained teacher of the hearing-impaired and a graduate student in applied linguistics. Both had many hours of transcription time transcribing errors in deaf speech. Both had also received training in characteristics of deaf speech using the audiotape training program Speech and Voice Characteristics of the Deaf (Subtelny et al.1981). For the phonetic transcriptions, narrow transcription using the guidelines provided by Shriberg and Kent (1982) was used. Words containing target phonemes were transcribed with particular attention to the phonemes chosen for study. Interjudge agreement for correct vs. incorrect phoneme production was high - 96%. Interjudge agreement on the type or severity of the error was not as high, but correct vs. incorrect judgments were used in this study. Any co-articulation effects which would be considered acceptable allophonic variations of the target phoneme were not considered errors. Essentially similar transcriptions such as /s/ and unvoiced /z/were judged equivalent and for the purposes of this study were both considered acceptable productions of /s/. Distortions such as a lateral /s/ or retroflexed /s/ were both considered errors.

For the analysis of the errors, both the orthographic and phonetic transcriptions were entered on IBM PS2 using the Programs to Examine Phonetic and Phonologic Evaluation Records (PEPPER) computer program, (Shriberg, 1986). This analysis calculated the percentage of correct productions out of the number of attempted productions for each phoneme. The percent correct production for each of the phonemes selected for each subject in the test probes was used for analysis.

Training

One child from each of the eleven triads was randomly assigned to the Listener Uncertainty Group, one to the Imitation Group, and one to the Control Group. The children in the Control Group received regular instruction from classroom teachers, but no additional speech instruction from the experimenter or members of the speech staff at the school. Concentrated, individualized speech work was scheduled on a rotating basis. Therefore, the students in the Control Group could be scheduled for speech instruction later in the school year, after the completion of the study.

Subjects in the two treatment groups received daily speech training, five days a week for a total of twenty training sessions. Training was carried out by the experimenter at the phonologic level in words, phrases, sentences and "creative" sentences. Individual sessions were fifteen minutes in length and scheduled between 8:00 A.M. and 4:00 P.M. Any sessions missed due to illness were made up so that the correct number of sessions was completed before each probe. All children in the two treatment groups completed the twenty training sessions.

Prior to each training session, the subject's hearing aid was checked. The Five Sound Test (Ling & Ling, 1978) was administered and the subject's responses recorded, so that any changes over time which might affect speech detection were noted.

Training was conducted in a quiet room adjacent to the television studio. The student and experimenter sat at two adjoining sides of a small table at approximately a 90 degree angle. This was to encourage listening, but not discourage speechreading when it was required.

The experimenter kept a written record of correct and incorrect responses during each session. Responses during training were also recorded on audio cassette. Training stimuli (word cards) were the same as those used for the test probes. Sample score sheets for recording responses on training words are presented in Appendix I.

Training Contexts

During training, subjects were required to produce the target fricative in words, phrases, sentences and creative sentences. The purpose of these levels of contexts was that they be analogous to the levels of testing in the probes: words, phrases, sentences, and spontaneous speech.

words — single word only

phrase — "on the ________"

sentence — "I have the ___________."

creative sentence - invented by the student

The order of presentation in each of these contexts was randomly assigned for each student at each training session. Phonemes were elicited in initial, medial and final position within each of the above contexts. The order of presentation of the position in the word was also randomly assigned for each session and for each context presented.

Training Conditions

Imitation Training Condition

Imitation training consisted of presenting the picture card to the subject and he/she would respond in the context chosen (word, phrase, sentence or creative sentence).

If the subject's production was incorrect, the experimenter provided a model for the child to imitate. For a complete description of the procedure, refer to Experiment One.

After all the word cards were presented, the cards were randomized and presented again, until all four contexts were presented twice.

Listener Uncertainty Condition

In the Listener Uncertainty condition the word card was presented to the subject, who responded in the context chosen (word, phrase, sentence or creative sentence).

If the subject's production was incorrect, the experimenter said "What?" or "I don't understand." and the subject was required to self-correct. For a detailed description of the procedure, refer to Experiment One.

As with the Imitation Group, after all the word cards were presented, the cards were randomized and presented again, until all four contexts were presented twice.

Scoring

On each production, subjects were scored as correct (√) or incorrect (-). Each word was presented twice in each context. If each target was produced successfully the first time (100%), then the student had 72 opportunities to produce the phoneme in each session in a variety of contexts and positions:

9 words	Words	Phrases	Sentences	Creative Sentences
3 initial	2x	2x	2x	2x
3 medial	2x	2x	2x	2x
3 final	2x	2x	2x	2x

If there were inaccuracies, the child could be producing up to 144 productions of the target. Subjects were scored only on the correct or incorrect production of the target phoneme and not on other sounds within the word which may have been in error.

Live scores were randomly checked against the audio cassette recordings. There was a 97% agreement between the live and recorded scores. Live scores were used to graph results. (See Figures 6.8 to 6.16.)

Reinforcement

During training, correct productions were socially reinforced with phrases such as "Good," or "That's right." for the Imitation Group, and by showing understanding for the Listener Uncertainty Group. Students were also given stickers to place on a 21.5 cm by 28 cm page to show progress and completed sessions. The younger students were responsive to small tangible reinforcers, such as candy, gum, pennies and small toys. At the end of the study, a pizza party was held for the older students.

Analysis

Group Results

Probes

For the test probes, separate analyses of variance were performed to analyze performance on target phonemes in four classes of words that contained either a target phoneme or a control phoneme:

Training words: words used in training that contained the target fricatives;

Generalization words: untrained words that contained the same target fricative as the trained words;

Control words (plosives): untrained words that contained untrained plosives; and,

Control words (other fricatives): untrained words that contained untrained fricatives.

Conservative degrees of freedom (the Greenhouse Geisser Correction) were used in the analyses of variance to correct for Type I errors caused by heterogeneous covariance due to repeated measures (Olson, 1988, pp.700-701). Where results using the Greenhouse Geisser corrected degrees of freedom differ from those found when using the full degrees of freedom, it will be reported. Tables presented in the Results report the full degrees of freedom. Satterthwaite's approximate degrees of freedom and a pooled error term were used in the post hoc analysis of interactions (Winer, 1971). Tests of simple effects (Winer, 1971; Olson, 1988, p.726) were performed to further assess the significance of any interactions that were found. Where there were significant main effects for groups, testing periods (time), context or position, the Tukey test (Ferguson, 1976; Olson, 1988) was used to further assess the significance of these differences. Tukey tables of differences between means are presented in Appendix J.

Only the highest order interactions involving group and time will be interpreted, as the purpose of the study was to compare training effects.

Spontaneous Speech

Samples of spontaneous speech were analyzed to see whether training on fricative sounds in words, phrases and sentences would generalize to words hearing-impaired students used in spontaneous spoken language. This analysis provided data on a fourth level of context — spoken language. The data were analyzed separately because the type and frequency of words used by the students in their spontaneous speech could not be controlled. Percentage correct scores were used.

Separate analyses of variance were performed to analyze speech production scores for spoken language on three classifications of sounds within words:

Trained phonemes: the target fricatives contained in the trained words in the probes;

Control phonemes (plosives): the untrained plosives contained in the probe words; and,

Control phonemes (other fricatives): the untrained fricatives contained in the probe words.

As with the probe words, comparisons among groups were made for production of these phonemes over the three testing periods. Articulatory performance on production of selected phonemes in spontaneous speech was, therefore, evaluated for differences with respect to the interaction of group and time.

Individual Performance

For the evaluation of individual performance of subjects in the two training groups, percentages of correctly produced phonemes within training, generalization, and control (plosives) words were calculated for the following periods, where the results for different contexts and different positions had been pooled:

Baseline 1, 2, and 3 — prior to training;
Probe 1 — prior to training;
Probe 2 — after 5 training sessions;
Probe 3 — after 10 training sessions;
Probe 4 — after 15 training sessions;
Probe 5 — after 20 training sessions (the conclusion of training); and,
Probe 6 — after a four-week break in training.

For subjects in the two treatment groups, percentage correct scores were also calculated for the training words for every training session. Since there were no interesting effects of control words (fricatives), scores were not individually plotted.

The students in the Control Group received three test probes: Probes 1, 5 and 6. Percentages of productions of training, generalization, and control words (plosives) were calculated for these periods.

Baseline (B), probe (P) and training (T) scores were graphed for each subject in the two treatment groups. Probes 1, 5 and 6 were graphed for students in the Control group. In this way, the individual results that contributed to group differences could be illustrated.

Chapter 6

RESULTS - EXPERIMENT TWO

Group and individual results were analyzed to examine the amount of improvement over time and relative effectiveness of the different treatments. Group results for the probes will be presented first, followed by group results for generalization to spontaneous speech. Then results for individual subjects will be presented.

Group Results: Probes

Training Words

Subjects were scored on the number of correct productions of the target fricative phoneme in the words that were trained. Group means for percentage correct scores obtained in each of three positions and each of three contexts, over the three time periods, are presented in Table 6.1. The results of the analyses of variance are summarized in Table 6.2. The following results were significant:

1. A main effect for group ($p<.01$).
2. A main effect for time ($p<.01$).
3. A main effect for context ($p<.01$).
4. An interaction between group and time ($p<.01$).
5. An interaction between time and position ($p<.01$).

There were no significant three-or four-way interactions. The four-way interaction proved non-significant after application of the Greenhouse Geisser Correction used to adjust the degrees of freedom. Only the group by time interaction will be interpreted.

Table 6.1

TRAINING WORDS - MEANS

Group means (% correct) for Group 1 (Listener Uncertainty), Group 2 (Imitation) and Group 3 (Control), for trained words containing target fricatives for words, phrases and sentences; in initial, medial and final positions; over three time periods (1-before training, 2-after training and 3-four weeks post-training).

		TIME 1			TIME 2			TIME 3		
GROUP		1	2	3	1	2	3	1	2	3
	Initial	36.3	33.3	63.6	100	91.0	60.6	91.0	72.6	63.6
Word	Medial	30.3	27.3	48.6	100	87.9	42.3	94.0	75.3	57.6
	Final	24.3	27.3	42.3	100	97.3	66.7	94.0	91.0	66.7
	Initial	33.3	30.3	60.6	91.0	91.0	54.6	91.0	66.7	63.6
Phrase	Medial	33.3	33.3	15.3	91.0	85.0	36.3	85.0	66.7	54.6
	Final	18.3	27.3	33.3	97.3	91.0	48.6	94.0	91.0	51.6
	Initial	27.3	27.3	42.3	97.3	78.7	51.6	87.9	69.6	57.6
Sentence	Medial	27.3	15.3	36.3	100	78.7	42.3	94.0	66.7	51.6
	Final	15.3	18.3	33.3	100	91.0	42.3	91.0	82.0	51.6

Table 6.2 Analysis of variance summary table for training words.

Source of Variation	Sum of Squares	df	Mean Square	Mean Square Error	F	p
Group	66.47	2,30	33.24	5.89	5.64	.008**
Time	364.26	2,60	182.13	2.06	88.39	.000**
Context	9.10	2,60	4.55	.44	10.28	.000**
Position	5.09	2,60	2.55	1.00	2.53	.088
Group by Time	112.70	4,60	28.18	2.06	13.67	.000**
Group by Context	2.27	4,60	.57	.44	1.28	.287
Group by Position	8.13	4,60	2.03	1.00	2.03	.102
Time by Context	.74	4,120	.19	.29	.64	.634
Time by Position	9.29	4,120	2.32	.54	4.34	.003**
Context by Position	.84	4,120	.21	.27	.78	.540
Group by Time by Context	1.57	8,120	.20	.29	.68	.709
Group by Time by Position	2.49	8,120	.31	.54	.58	.792
Group by Context by Position	2.24	8,120	.28	.27	1.04	.412
Time by Context by Position	.63	8,240	.08	.21	.37	.933
Group by Time by Context by Position	5.70	16,240	.36	.21	1.69	.050

**p < .01

Group by Time Interaction

Group Comparisons over Time. Analysis of the group by time interaction for training words in terms of differences between groups for each time period, revealed significant differences between the following groups for each time period:

Time 1:

The Listener Uncertainty Group and the Control Group ($p<.01$).

The Imitation Group and the Control Group ($p<.01$).

Time 2:

The Listener Uncertainty Group and the Imitation Group ($p<.01$) .

The Listener Uncertainty Group and the Control Group ($p<.01$).

The Imitation Group and the Control Group ($p<.01$).

Time 3:

The Listener Uncertainty Group and the Imitation Group ($p<.01$).

The Listener Uncertainty Group and the Control Group ($p<.01$).

The Imitation Group and the Control Group ($p<.01$).

Figure 6.1 illustrates the differences between means for the three groups at the three time periods. At Time 1, the Control Group was significantly better in performance than the other two groups before training. There were significant differences between all three groups at Time 2 (after training) with the Listener Uncertainty Group performing better than the Imitation and Control Groups, and the Imitation Group performing better than the Control Group. At Time 3 (after the four week break in training), there were still significant differences between groups, with the Listener Uncertainty Group performing best, the Imitation Group second, and the Control Group third. See Appendix J for Tukey tables.

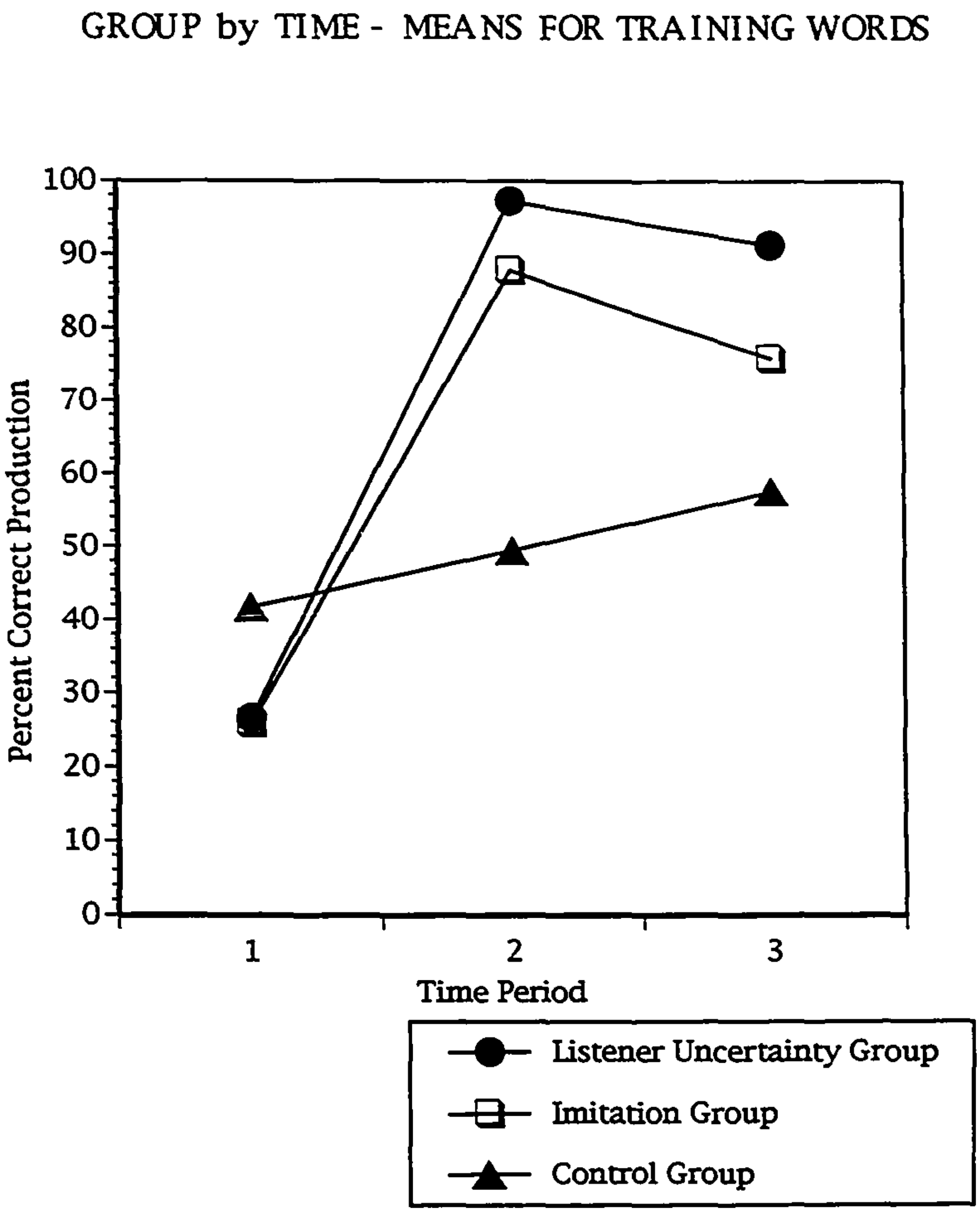

Figure 6.1. Means for the three groups at the three time periods for training words. Time 1 - before training; Time 2 - after twenty sessions of training; Time 3 - after a four-week break in training.

It should be noted that differences between the trained groups and the control group at Times 2 and 3 would have been more significant if the groups had been statistically equated by analysis of co-variance at Time 1.

<u>Time Comparisons over Group.</u> Further analysis of the group by time interaction in terms of differences between time periods for each group, revealed significant differences ($p < .01$) between all three time periods for all three groups. The two treatment groups improved dramatically with training, and then displayed a significant decline in performance after the break in training. Figure 6.1 illustrates the marked rise in performance between Time 1 and Time 2 (after training) and the decrease in scores between Time 2 and Time 3 (after the break in training) by both trained groups. It should be noted, however, that the difference in scores between Time 1 and Time 3 was still significant for both training groups. The Control Group exhibited a steady growth in performance over all time periods, but their scores never reached those of the two trained groups at Time 2 or Time 3.

Generalization Words

Subjects were scored on the number of correct productions of the target fricative phoneme in words which were not used in training. Group means for scores obtained in each of three positions and each of three contexts over the three time periods are presented in Table 6.3.

Analysis of variance (Table 6.4) showed the following results to be significant:

1. A main effect for time ($p<.01$).
2. An interaction between group and time ($p<.01$).
3. An interaction between time and position ($p<.01$).
4. An interaction between group, time and context ($p<.05$).

There was no significant four-way interaction. Only the three-way interaction between group, time and context will be interpreted.

Tukey test results of three way comparisons are presented in Appendix J.

Table 6.3

GENERALIZATION WORDS - MEANS

Group means (% correct) for Group 1 (Listener Uncertainty), Group 2 (Imitation) and Group 3 (Control), for generalization words containing target fricatives for words, phrases and sentences; in initial, medial and final positions; over three time periods (1-before training, 2-after training and 3-four weeks post-training).

		TIME 1			TIME 2			TIME 3		
GROUP		1	2	3	1	2	3	1	2	3
Word	Initial	42.3	27.3	66.7	94.0	82.0	45.3	85.0	72.6	60.6
	Medial	24.3	12.0	42.3	82.0	75.3	48.6	69.6	60.6	51.6
	Final	30.3	27.3	36.3	100	87.6	39.4	85.0	85.0	45.3
Phrase	Initial	30.3	30.3	51.6	85.0	78.7	54.6	87.9	54.6	63.6
	Medial	27.3	27.3	51.6	82.0	78.7	39.4	75.3	54.6	48.6
	Final	30.3	15.3	36.3	97.3	82.0	45.3	87.9	75.3	42.3
Sentence	Initial	24.3	36.3	42.3	91.0	75.3	63.6	66.7	48.6	66.7
	Medial	27.3	30.3	36.3	75.3	82.0	36.3	75.3	57.6	45.3
	Final	12.0	18.3	33.3	91.0	87.9	39.4	87.9	78.7	45.3

Table 6.4 Analysis of variance summary table for generalization words.

Source of Variation	Sum of Squares	df	Mean Square	Mean Square Error	F	p
Group	42.57	2,30	21.29	8.59	2.48	.101
Time	247.17	2,60	123.59	1.88	65.91	.000**
Context	1.69	2,60	.84	.49	1.72	.187
Position	8.50	2,60	4.25	1.51	2.81	.068
Group by Time	104.40	4,60	26.10	1.88	13.92	.000**
Group by Context	1.92	4,60	.48	.49	.98	.424
Group by Position	12.36	4,60	3.09	1.51	2.04	.100
Time by Context	.94	4,120	.25	.30	.79	.536
Time by Position	7.76	4,120	1.94	.47	4.12	.004**
Context by Position	1.17	4,120	.29	.31	.95	.437
Group by Time by Context	5.31	8,120	.66	.30	2.22	.031*
Group by Time by Position	5.90	8,120	.74	.47	1.57	.142
Group by Context by Position	2.51	8,120	.31	.31	1.02	.424
Time by Context by Position	3.50	8,240	.44	.31	1.43	.185
Group by Time by Context by Position	5.32	16,240	.33	.31	1.09	.368

*p < .05
**p < .01

Group by Time by Context Interaction

Group Comparisons Over Time at Each Level of Context.

The group comparisons for the three levels of context for each of the time periods are as follows (See Figure 6.2):

Group Comparisons Over Time at the Word Level

Time 1: There were no significant differences between groups.

Time 2: There was a significant difference ($p<.01$) between the Listener Uncertainty Group and the Control Group.
There was a significant difference ($p<.05$) between the Imitation Group and the Control Group.

Time 3: There were no significant differences between groups.

Group Comparisons Over Time at the Phrase Level

Time 1: There were no significant differences between groups.

Time 2: There was a significant difference ($p<.01$) between the Listener Uncertainty Group and the Control Group.
There was a significant difference ($p<.05$) between the Imitation Group and the Control Group.

Time 3: There was a significant difference ($p<.05$) between the Listener Uncertainty Group and the Control Group.

Group Comparisons Over Time at the Sentence Level

Time 1: There were no significant differences between groups.

Time 2: There was a significant difference ($p<.01$) between the Listener Uncertainty Group and the Control Group.
There was a significant difference ($p<.05$) between the Imitation Group and the Control Group.

Time 3: There were no significant differences between groups.

GROUP by TIME by CONTEXT
MEANS FOR GENERALIZATION WORDS
Word, Phrase and Sentence Levels

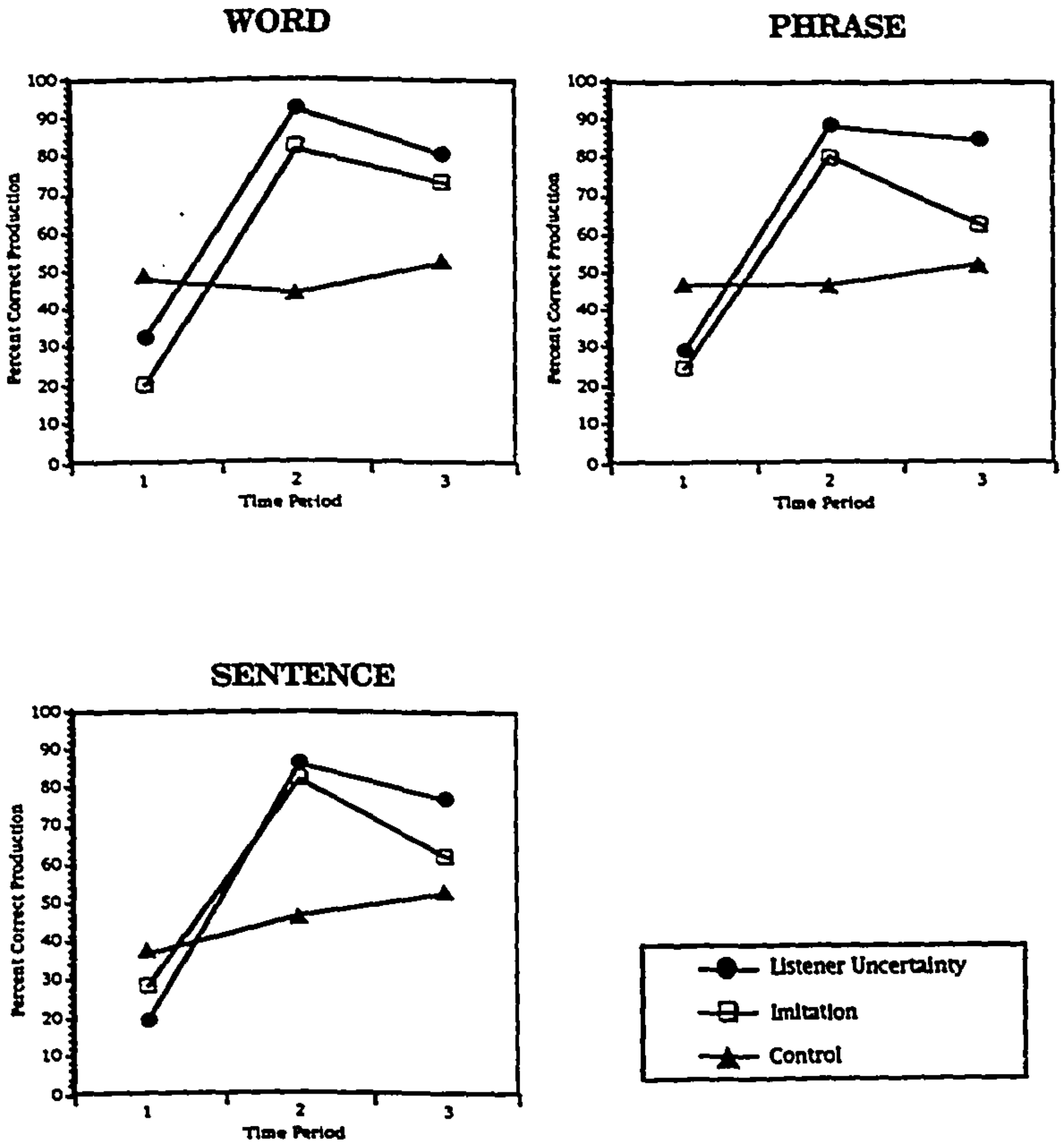

Figure 6.2. Means for the three groups at the three time periods, at three levels of context, for generalization words. Time 1 - before training; Time 2 - after twenty sessions of training; Time 3 - after a four week break in training.

The same results were obtained for all three contexts at Times 1 and 2. There was no significant difference between groups at Time 1; and at Time 2 both groups were significantly superior to the Control Group, but did not differ significantly from each other. The differential effects of context on the group by time interactions occurred for Time 3, where there was no significant difference between groups at the word and sentence levels, but the Listener Uncertainty Group was significantly superior to the Control Group at the phrase level.

Time Comparisons Over Group at Each Level of Context.

Time comparisons for each group also show the differential effect of context, but in a somewhat different way. There were no significant differences over time for the Control Group at any of the levels of context. There were significant differences over time for the trained groups at each level of context, as follows:

Time Comparisons Over Group at the Word and Sentence Levels

For both the Listener Uncertainty Group and the Imitation Group, correct productions of words at Time 2 and Time 3 were significantly higher ($p<.01$) than those at Time 1. The decrease in scores for both training groups between Time 2 and Time 3 was not significant.

Time Comparisons Over Group at the Phrase Level

For both the Listener Uncertainty Group and the Imitation Group, scores obtained at Time 2 and Time 3 were significantly higher ($p<.01$) than those at Time 1. For the Imitation Group, there was a significant difference ($p<.05$) between scores at Time 2 and Time 3, but there was no significant difference between scores at Time 2 and Time 3 for the Listener Uncertainty Group.

Context Effects

Examination of differences between the three types of contexts for each training method at each time period (Figure 6.2) reveals that for the Imitation Group, word accuracy was maintained at a higher level than phrase or sentence level production for the follow-up scores at Time 3. For the Listener Uncertainty Group, accuracy with respect to different contexts at each time period was about the same, with only slightly higher scores in word and phrase contexts than in sentences at Time 1. For the Control Group there was little difference between word, phrase and sentence level scores at each time period.

Comparison of Training and Generalization Words

Another way of viewing the data for generalization words, combining the different levels of linguistic context, allows us to look at the group by time interaction. Though not generally done after finding a three-way interaction, this aids in visually comparing the results of the group by time interaction for untrained, generalization words with the results previously reported in the group by time interaction for trained words.

Though any interpretation should be made with caution, a comparison of the two graphs (Figures 6.1 and 6.3) reveals very similar trends. The patterns of performance for the two trained groups for scores on training and generalization words are similar, but the levels of performance of both of the training groups is

GROUP by TIME - MEANS FOR GENERALIZATION WORDS

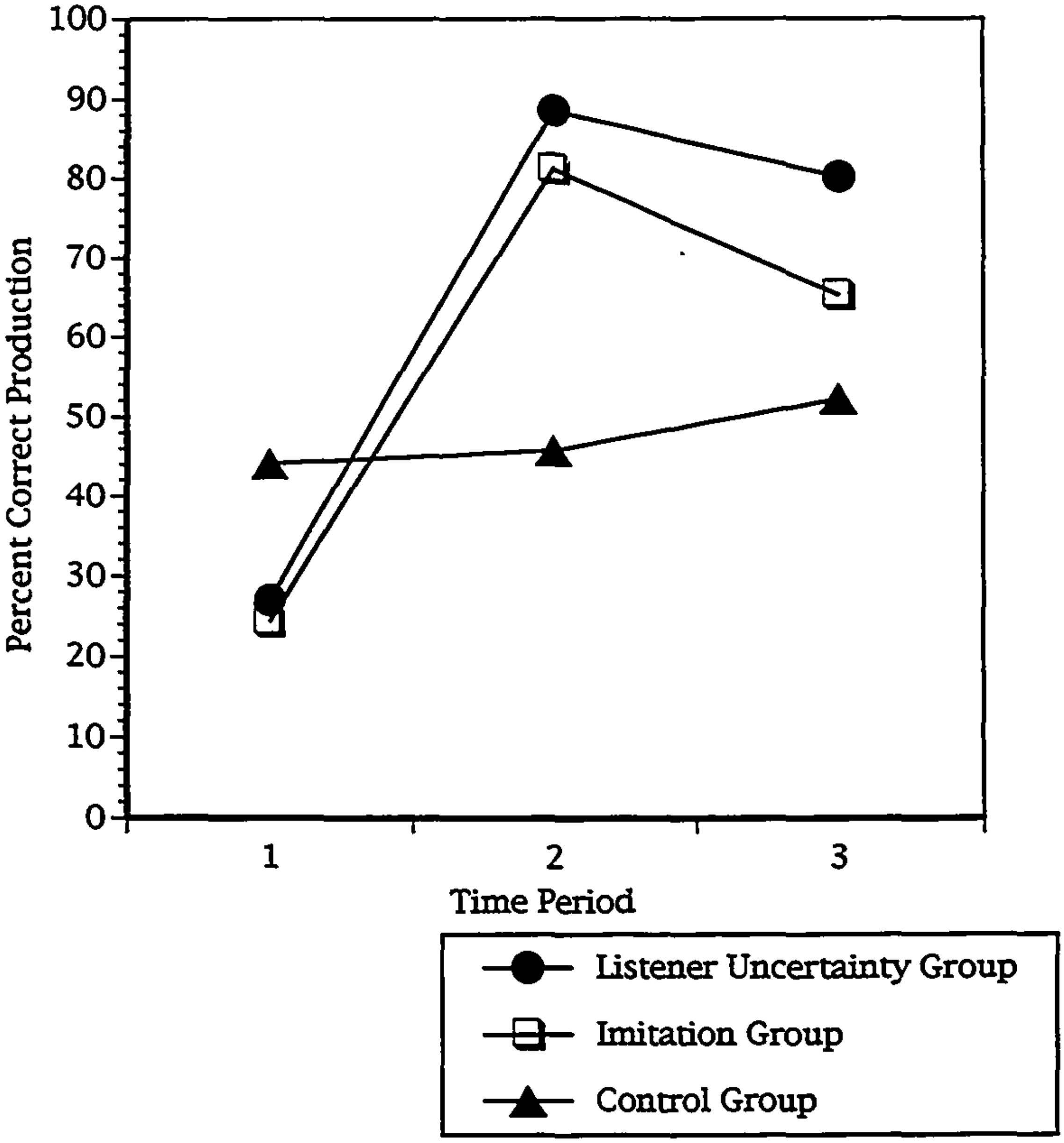

Figure 6.3. Means for the three groups at the three time periods for generalization words. Time 1 - before training; Time 2 - after twenty sessions of training; Time 3 - after a four-week break in training.

slightly lower on generalization words than on trained words. There was slightly better performance by the Listener Uncertainty Group for both trained and untrained, generalization words. The Control Group exhibited almost identical results for accuracy of phoneme production in both training and generalization words.

Control Words Containing Plosives

Subjects were scored on the number of correct productions of plosive phonemes in words which were not used in training. Group means for scores obtained in each of three positions and each of three contexts, over the three time periods are presented in Table 6.5.

Analysis of variance (Table 6.6) showed the following results as significant:

1. A main effect for group ($p<.01$).
2. A main effect for time ($p<.01$).
3. A main effect for context ($p<.01$).
4. A main effect for position ($p<.01$).
5. An interaction between time and position ($p<.01$)

There were no significant three- or four-way interactions. The significant effects will not be interpreted, as they did not involve the interaction of group and time. Patterns of performance for groups over time, as illustrated in Figure 6.4, were similar to the patterns displayed by the Control Group for training and generalization words.

Table 6.5

CONTROL WORDS (PLOSIVES) - MEANS

Group means (% correct) for Group 1 (Listener Uncertainty), Group 2 (Imitation) and Group 3 (Control), for control words containing plosives for words, phrases and sentences; in initial, medial and final positions; over three time periods (1-before training, 2-after training and 3-four weeks post-training).

		TIME 1			TIME 2			TIME 3		
GROUP		1	2	3	1	2	3	1	2	3
Words	Initial	97.3	69.6	87.9	97.3	66.7	85.0	100	75.3	87.9
	Medial	57.6	39.4	48.6	57.6	36.3	54.6	69.6	45.3	66.7
	Final	36.3	9.0	27.3	42.3	12.0	18.3	45.3	18.3	33.3
Phrases	Initial	94.0	66.7	72.6	100	69.6	82.0	100	63.6	82.0
	Medial	42.3	30.3	51.6	69.6	33.3	54.6	60.6	48.6	72.6
	Final	36.3	18.3	18.3	39.4	15.3	24.3	42.3	15.3	27.3
Sentences	Initial	94.0	69.6	72.6	94.0	66.7	75.3	97.3	69.6	82.0
	Medial	51.6	15.3	48.6	51.6	42.3	60.6	69.6	42.3	66.7
	Final	36.3	12.0	30.3	33.3	12.0	18.3	36.3	12.0	18.3

Table 6.6 Analysis of variance summary table for control words containing plosives.

Source of Variation	Sum of Squares	df	Mean Square	Mean Square Error	F	p
Group	84.13	2,30	42.06	11.10	3.79	.034*
Time	8.61	2,60	4.31	.33	12.95	.000**
Context	1.84	2,60	.92	.27	3.36	.042*
Position	437.02	2,60	218.51	4.95	44.16	.000**
Group by Time	.25	4,60	.06	.33	.19	.944
Group by Context	.09	4,60	.02	.27	.09	.986
Group by Position	7.82	4,60	1.96	4.95	.40	.811
Time by Context	1.14	4,120	.29	.22	1.28	.282
Time by Position	6.17	4,120	1.54	.30	5.15	.001**
Context by Position	.30	4,120	.07	.20	.36	.836
Group by Time by Context	1.87	8,120	.23	.22	1.05	.405
Group by Time by Position	.42	8,120	.05	.30	.18	.994
Group by Context by Position	2.07	8,120	.26	.20	1.27	.268
Time by Context by Position	2.56	8,240	.32	.20	1.62	.120
Group by Time by Context by Position	4.79	16,240	.30	.20	1.51	.096

*p < .05
**p < .01

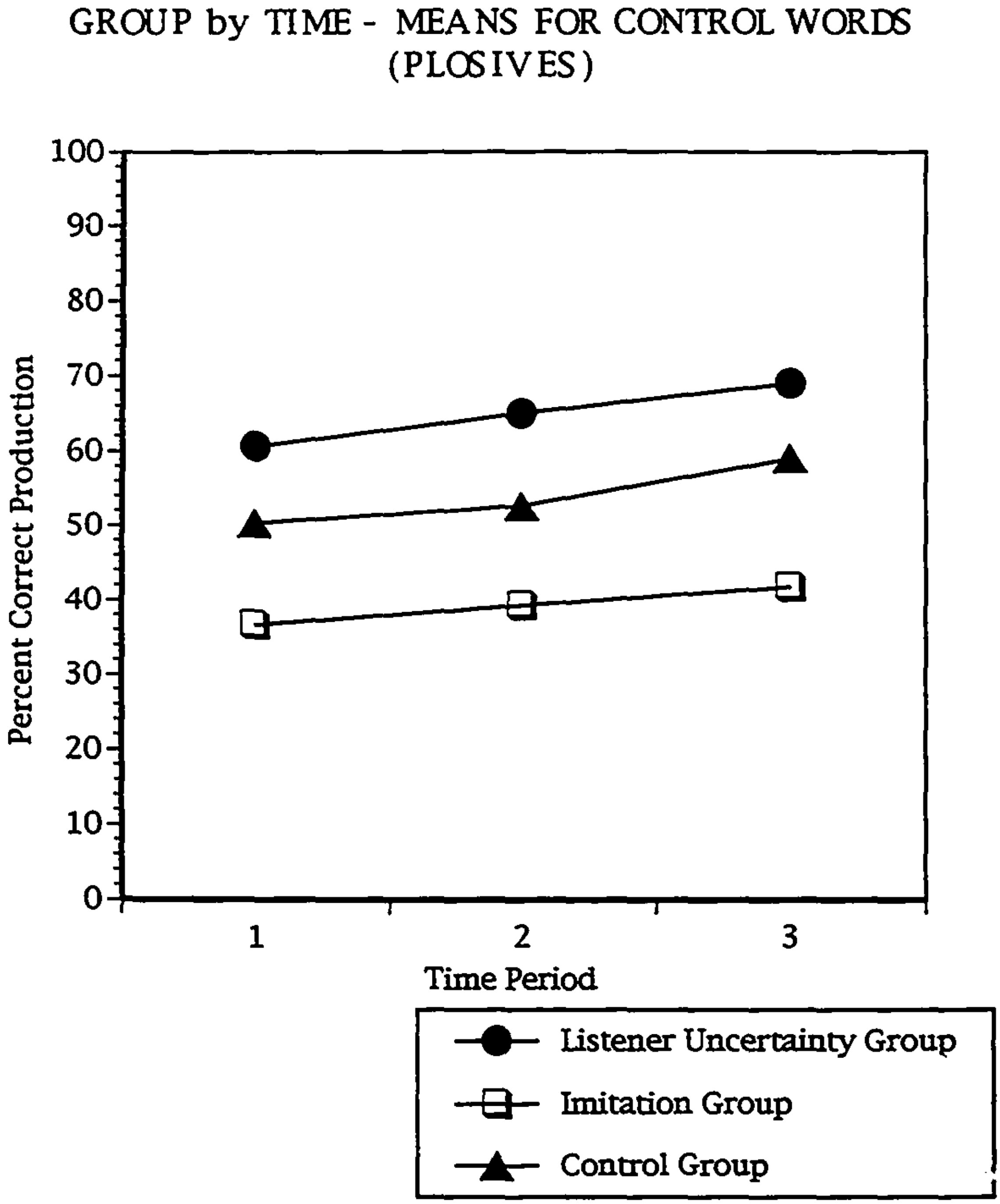

Figure 6.4. Means for the three groups at the three time periods for control words (plosives). Time 1 - before training; Time 2 - after twenty sessions of training; Time 3 - after a four-week break in training.

Control Words Containing Other Fricatives

Subjects were scored on the number of correct productions of untrained fricative phonemes in words which were not used in training. This part of the study was undertaken to see if there was any generalization from the trained fricatives to untrained fricatives. Because some fricative sounds do not appear in all positions (e.g. /ʒ/ does not appear in English in the initial position), other fricative sounds were not analyzed for position in the word. Group means for scores obtained over the three time periods in the three contexts are presented in Table 6.7.

The only significant results in the analysis of variance (Table 6.8) were main effects for time and context ($p<.01$). There were no significant interactions. As shown in Figure 6.5, the two trained groups showed about the same improvement over time as the control group.

Table 6.7

CONTROL WORDS (OTHER FRICATIVES) - MEANS

Group means (% correct) for Group 1 (Listener Uncertainty), Group 2 (Imitation) and Group 3 (Control), for control words containing fricatives for words, phrases and sentences; over three time periods (1-before training, 2-after training and 3-four weeks post-training).

	TIME 1			TIME 2			TIME 3		
GROUP	1	2	3	1	2	3	1	2	3
Word	28.0	22.5	24.0	47.7	39.6	34.0	49.0	42.7	43.8
Phrase	28.1	18.7	21.7	47.2	36.3	29.1	47.3	40.7	35.6
Sentence	29.0	17.2	21.0	45.1	36.1	28.2	48.4	38.9	38.4

Table 6.8 Analysis of variance summary table for control words containing other fricatives.

Source of Variation	Sum of Squares	df	Mean Square	Mean Square Error	F	p
Group	49.91	2,30	24.96	28.55	.87	.428
Time	164.35	2,60	82.17	2.24	36.70	.000**
Context	5.07	2,60	2.53	.31	8.15	.001**
Group by Time	9.14	4,60	2.28	2.24	1.02	.404
Group by Context	1.87	4,60	.47	.31	1.50	.214
Time by Context	.41	4,120	.10	.25	.41	.803
Group by Time by Context	1.05	8,120	.13	.25	.53	.834

**p < .01

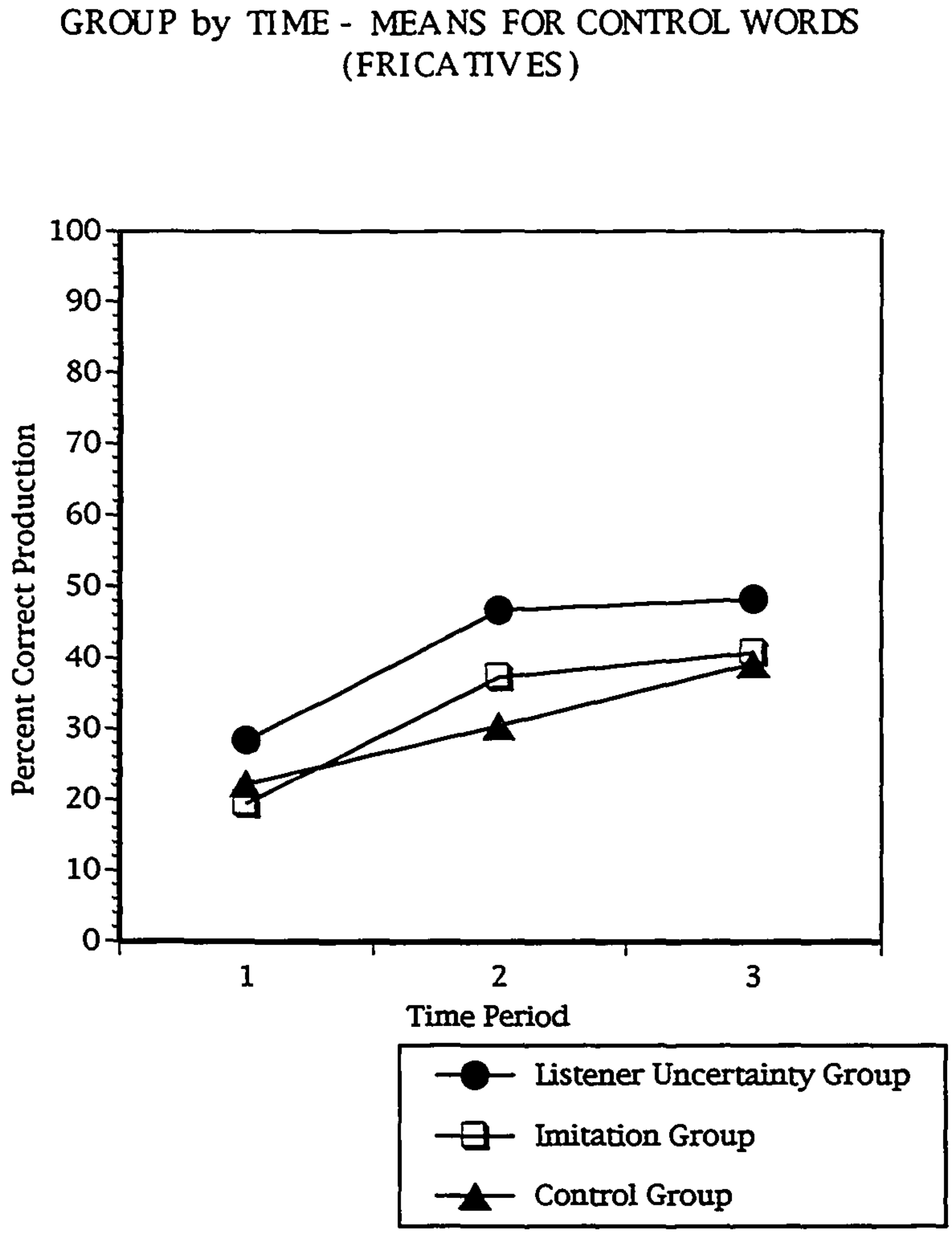

Figure 6.5. Means for the three groups at the three time periods for control words (fricatives). Time 1 - before training; Time 2 - after twenty sessions of training; Time 3 - after a four-week break in training.

Group Results: Spontaneous Speech

Samples of spontaneous speech were obtained at each time period and analyzed to see whether training on fricative sounds in words, phrases and sentences would generalize to words the hearing-impaired students used in their spontaneous speech.

Means are presented in Table 6.9 and the analyses of variance are summarized in Table 6.10. Results of the three groups for the three time periods are shown in Figure 6.6. There is no indication of a training effect for any of the phonemes.

Trained Phonemes: Fricatives

There was no main effect for group and there were no interactions. The only significant result was a main effect for time ($p<.01$).

Control Phonemes: Plosives

An analysis of plosive sounds revealed no significant effects.

Control Phonemes: Other Fricatives

An analysis of other fricatives showed no main effect for group and no interactions. The only significant result was a main effect for time ($p<.05$).

Table 6.9
SPONTANEOUS SPEECH

TRAINED FRICATIVES - MEANS

Group means (% correct) for Group 1 (Listener Uncertainty), Group 2 (Imitation) and Group 3 (Control), for words in spontaneous speech containing trained fricatives over the three time periods. (1-before training, 2-after training, and 3-four weeks post-training).

GROUP	TIME 1	TIME2	TIME 3
1	18.7	36.4	33.7
2	18.8	29.2	33.9
3	22.5	53.9	38.6

CONTROL PHONEMES (PLOSIVES) - MEANS

Group means (% correct) for Group 1 (Listener Uncertainty), Group 2 (Imitation) and Group 3 (Control), for words in spontaneous speech containing untrained plosives over the three time periods. (1-before training, 2-after training, and 3-four weeks post-training).

GROUP	TIME 1	TIME2	TIME 3
1	52.1	48.1	52.3
2	39.6	38.9	42.6
3	49.4	50.5	51.4

CONTROL PHONEMES (OTHER FRICATIVES) - MEANS

Group means (% correct) for Group 1 (Listener Uncertainty), Group 2 (Imitation) and Group 3 (Control), for words in spontaneous speech containing untrained fricatives over the three time periods. (1-before training, 2-after training, and 3-four weeks post-training).

GROUP	TIME 1	TIME2	TIME 3
1	14.1	12.0	14.5
2	14.6	9.1	10.9
3	16.7	13.9	10.2

Table 6.10 Analysis of variance summary table for spontaneous use of trained phonemes and control phonemes.

Trained Fricatives

Source of Variation	Sum of Squares	df	Mean Square	Mean Square Error	F	p
Group	2221.65	2,30	1110.82	2210.08	.50	.610
Time	7168.86	2,60	3584.43	319.35	11.22	.000**
Group by Time	1581.27	4,60	395.32	319.35	1.24	.305

Control - untrained plosives.

Source of Variation	Sum of Squares	df	Mean Square	Mean Square Error	F	p
Group	2319.86	2,30	1159.93	1370.85	.85	.439
Time	140.75	2,60	70.38	245.93	.29	.752
Group by Time	86.69	4,60	21.67	245.93	.09	.986

Control - untrained fricatives.

Source of Variation	Sum of Squares	df	Mean Square	Mean Square Error	F	p
Group	89.06	2,30	44.53	304.69	.15	.865
Time	252.99	2,60	126.50	29.37	4.31	.018*
Group by Time	190.44	4,60	47.61	29.37	1.62	.181

*p < .05
**p < .01

SPONTANEOUS SPEECH - GROUP by TIME - MEANS

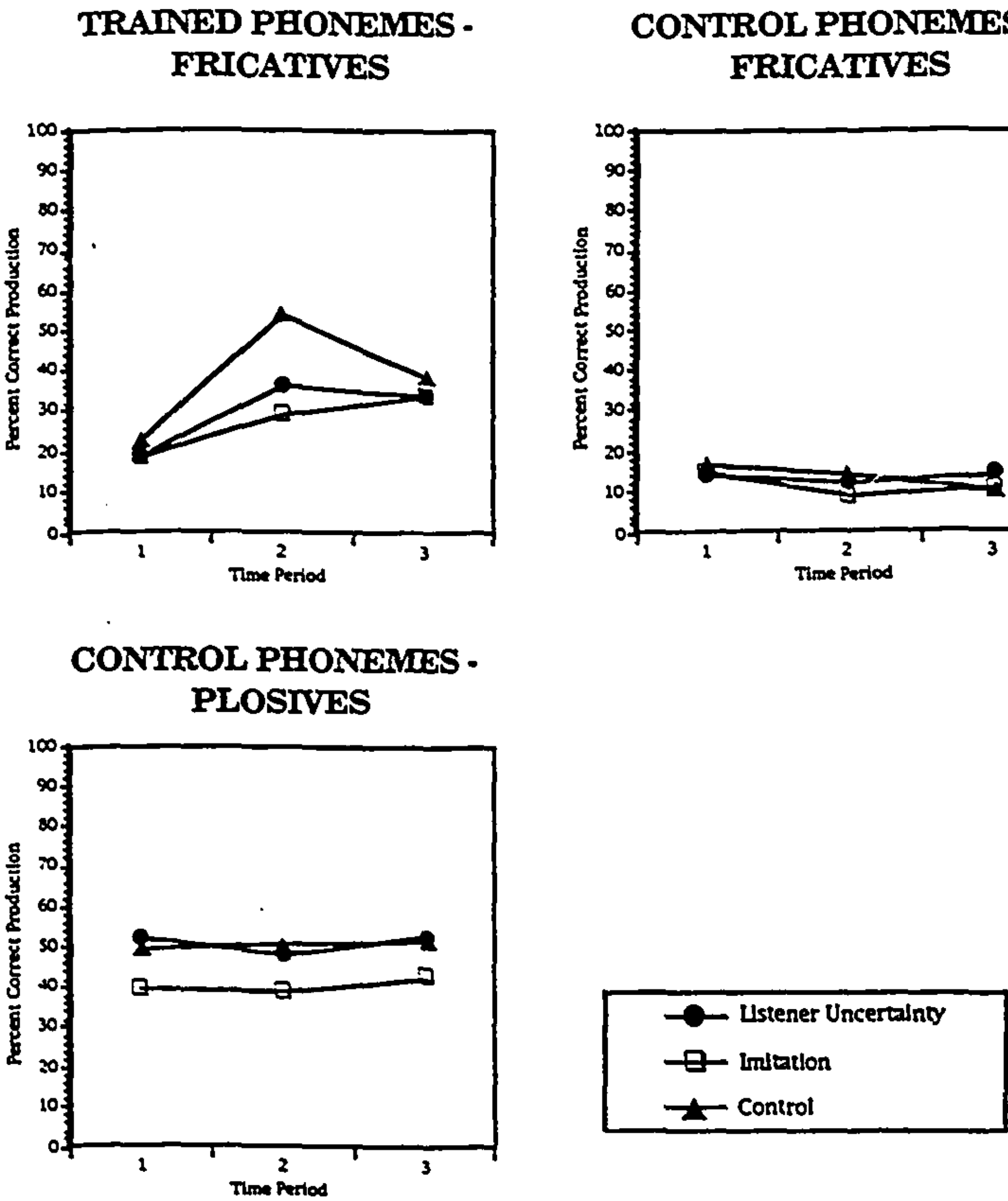

Figure 6.6. Means for the three groups at the three time periods for trained phonemes (fricatives), control phonemes (plosives) and control phonemes (other fricatives) in spontaneous speech. Time 1 - before training; Time 2 - after twenty sessions of training; Time 3 -after a four-week break in training.

Individual Performance

Trained Subjects

The following figures show the results for each subject in the training groups for the training words, generalization words and for control plosives. Context and position scores have been pooled for one overall score for each speech target. Baseline (B), probe (P) and training (T) scores are given for each subject in the two treatment groups.

Results for the 11 subjects in the Listener Uncertainty Group are shown in Figures 6.7, 6.8 and 6.9. Results for the 11 subjects in the Imitation Group are shown in Figures 6.10, 6.11, and 6.12.

Results for training words will be described first, followed by the results for generalization and control words.

Training Words

Listener Uncertainty Subjects.

For subjects in the Listener Uncertainty Group, training was successful for all but one subject (61). Seven subjects (21, 31, 41, 51, 71, 91, and 111) achieved near-perfect scores on training and probe words, including the follow-up retention score. Three subjects (11, 81, and 101) were less consistent, but their scores were nearly perfect by the end of training, including follow-up. The remaining subject (61) was near-perfect by end of training, but his scores decreased to slightly below baseline levels on the follow-up assessment.

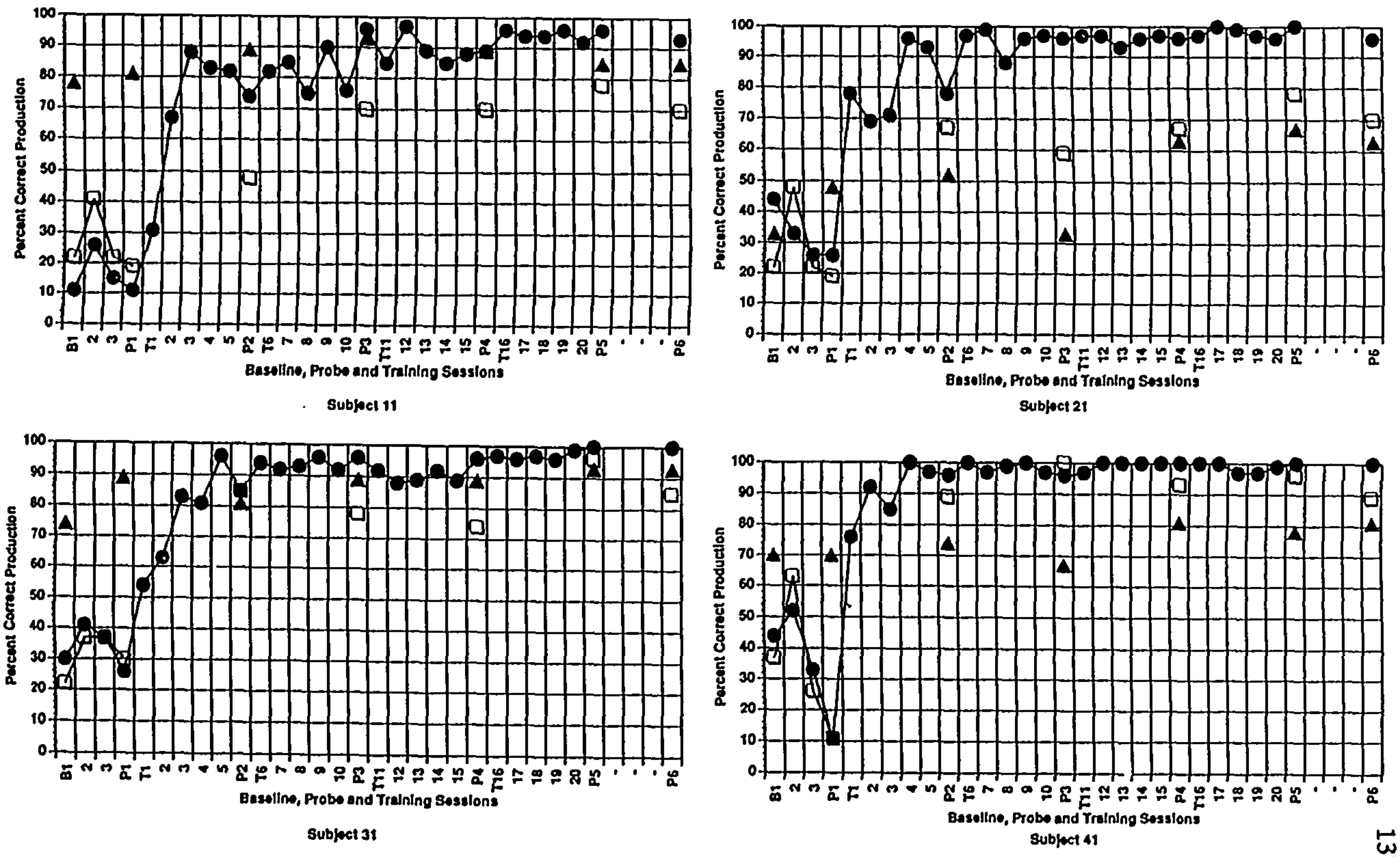

Figure 6.7. Percent of correct production of trained phonemes (fricatives) in training words (●) and generalization words (□), and of untrained phonemes (plosives) in control words (▲) for baseline, probe and training sessions for Subjects 11, 21, 31, and 41 of the Listener Uncertainty Group.

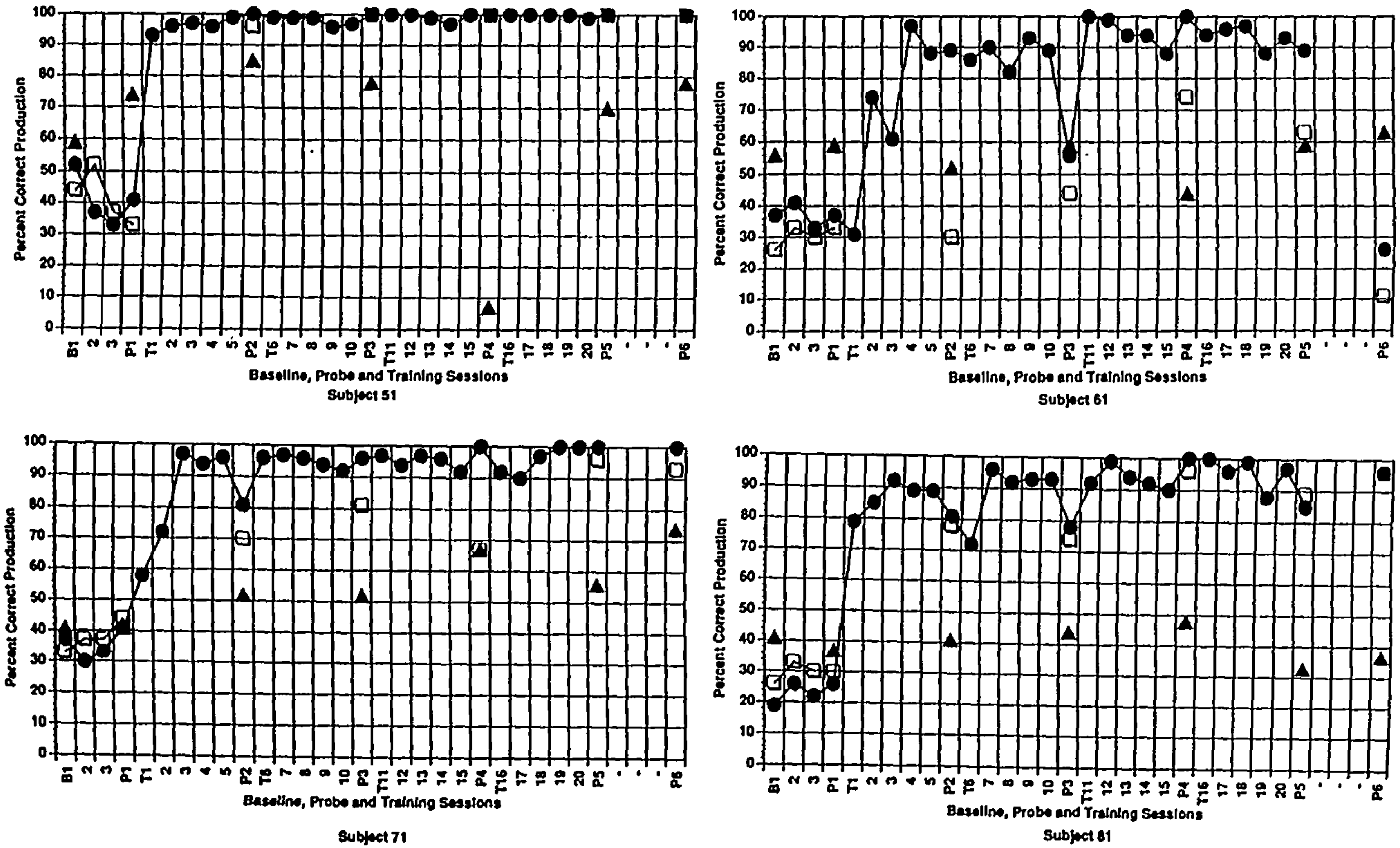

Figure 6.8 Percent of correct production of trained phonemes (fricatives) in training words (●) and generalization words (□), and of untrained phonemes (plosives) in control words (▲) for baseline, probe and training sessions for Subjects 51, 61, 71, and 81 of the Listener Uncertainty Group.

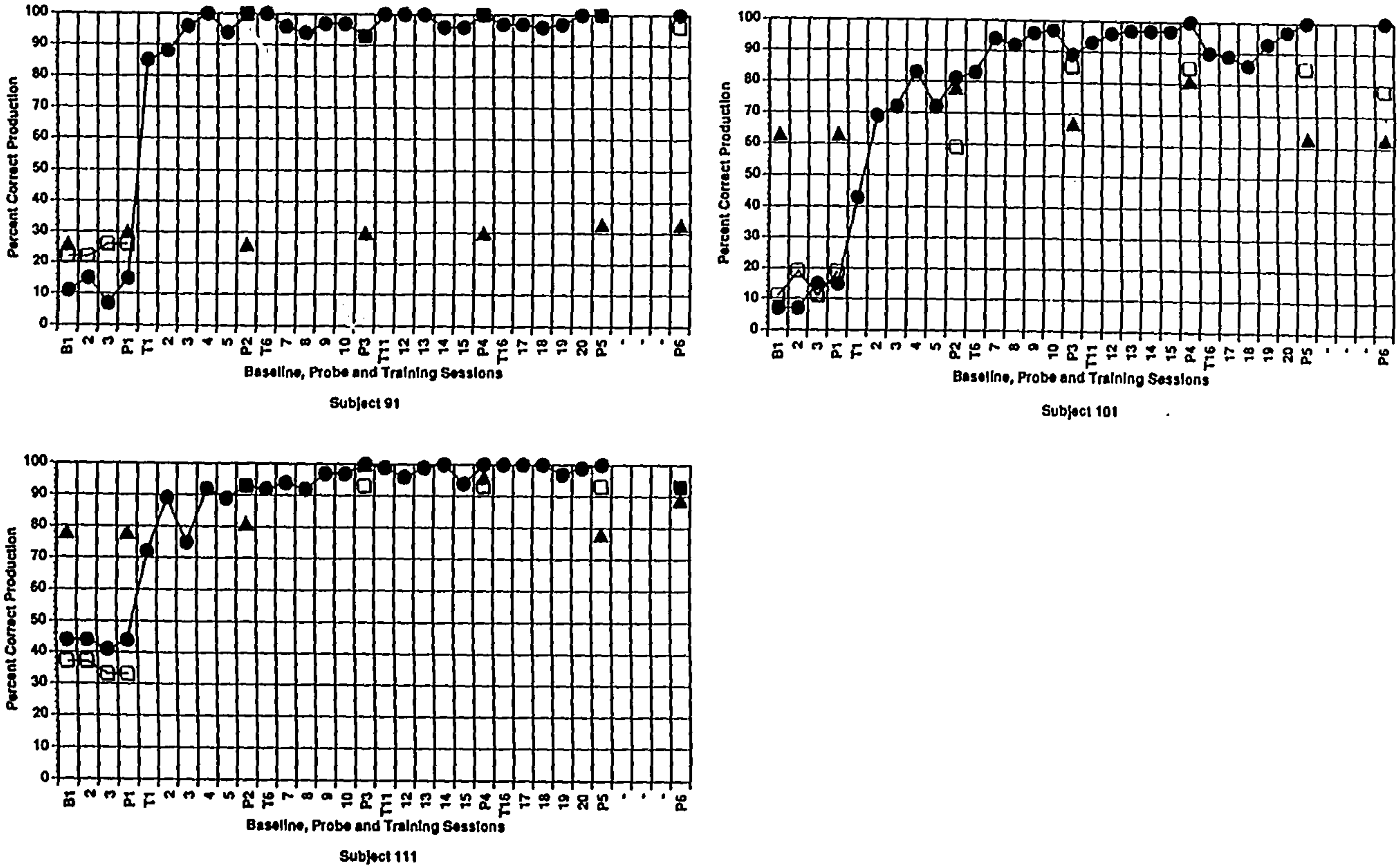

Figure 6.9 Percent of correct production of trained phonemes (fricatives) in training words (●) and generalization words (□), and of untrained phonemes (plosives) in control words (▲) for baseline, probe and training sessions for Subjects 91, 101, and 111 of the Listener Uncertainty Group.

Imitation Subjects.

For subjects in the Imitation Group, training was less successful than for those in the Listener Uncertainty Group, but many subjects improved. Three subjects (52, 92, 112) improved dramatically with the onset of the imitation training and maintained high levels of performance on target phonemes throughout the study, including scores on follow-up retention probes. Three subjects (32, 42, 72) were less consistent, but achieved near-perfect performance by the end of the study, including follow-up scores. Two subjects (82, 102) had more variable scores, approached perfect scores by the end of training and then decreased on the follow-up, but not to baseline levels. One subject (22) achieved near perfect scores during the training, but her scores decreased for the last probe and continued to deteriorate for the follow-up probe - almost to baseline. One subject (62) reached near-perfect scores by the end of training, but his scores decreased on the final probe, and continued to decrease to baseline levels on the follow-up. The remaining subject (12) had very variable scores. Improvement was inconsistent and scores decreased on the follow-up, but not to baseline.

The majority of trained words were produced with the same level of accuracy in probes (P) as they were during training (T) for most subjects in both groups.

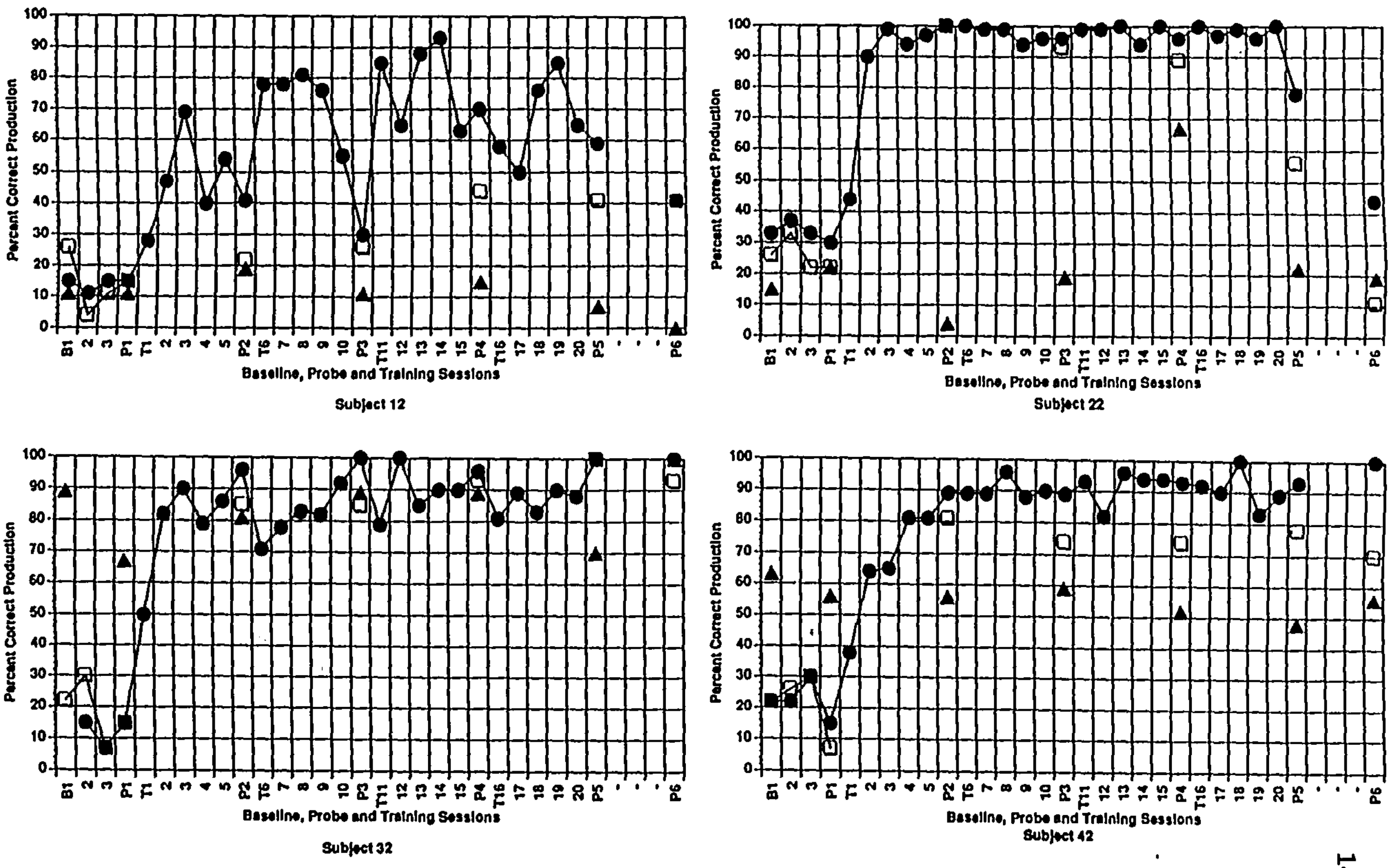

Figure 6.10. Percent of correct production of trained phonemes (fricatives) in training words (●) and generalization words (□), and of untrained phonemes (plosives) in control words (▲) for baseline, probe and training sessions for Subjects 12, 22, 32 and 42 of the Imitation Group.

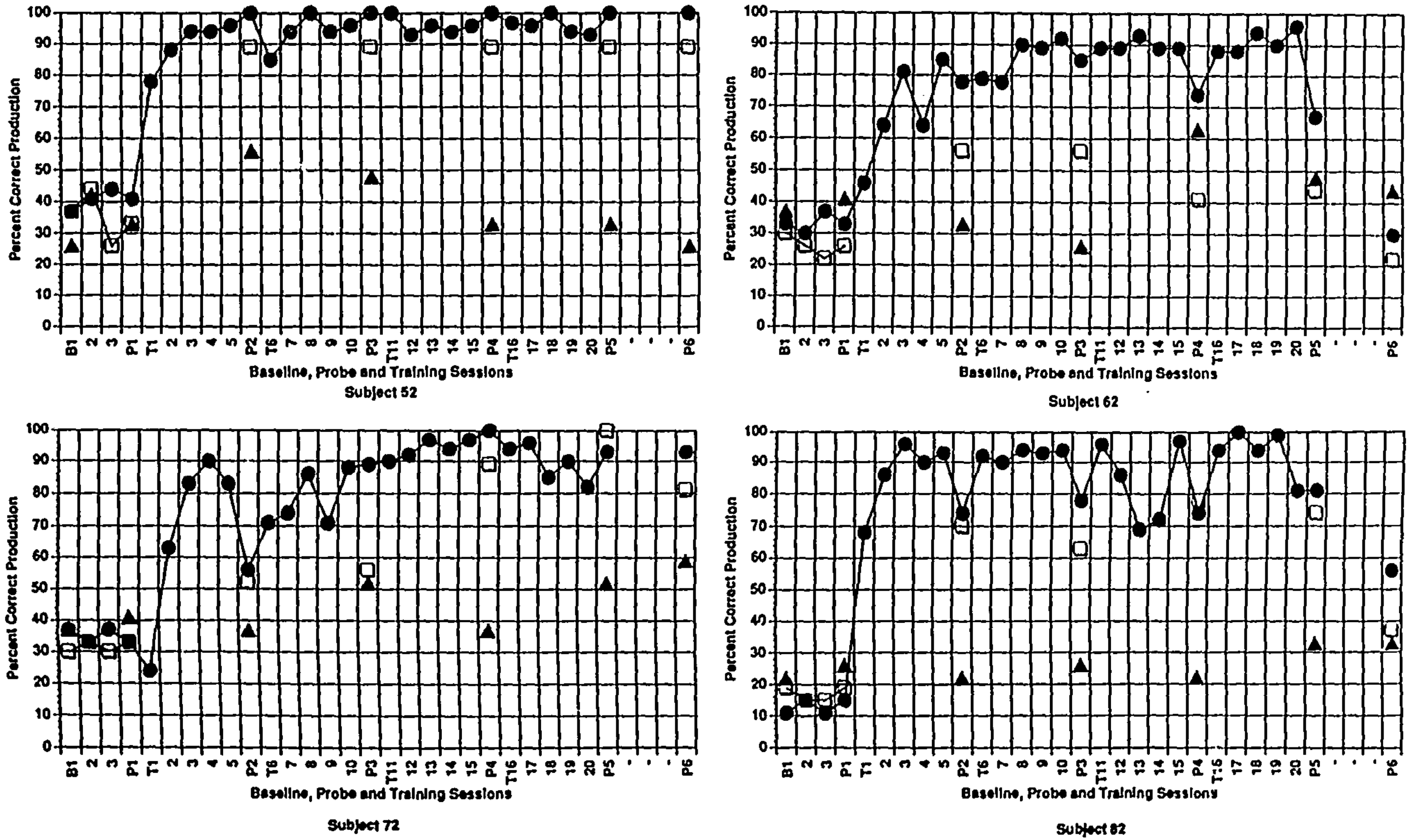

Figure 6.11. Percent of correct production of trained phonemes (fricatives) in training words (●) and generalization words (□), and of untrained phonemes (plosives) in control words (▲) for baseline, probe and training sessions for Subjects 52, 62, 72 and 82 of the Imitation Group.

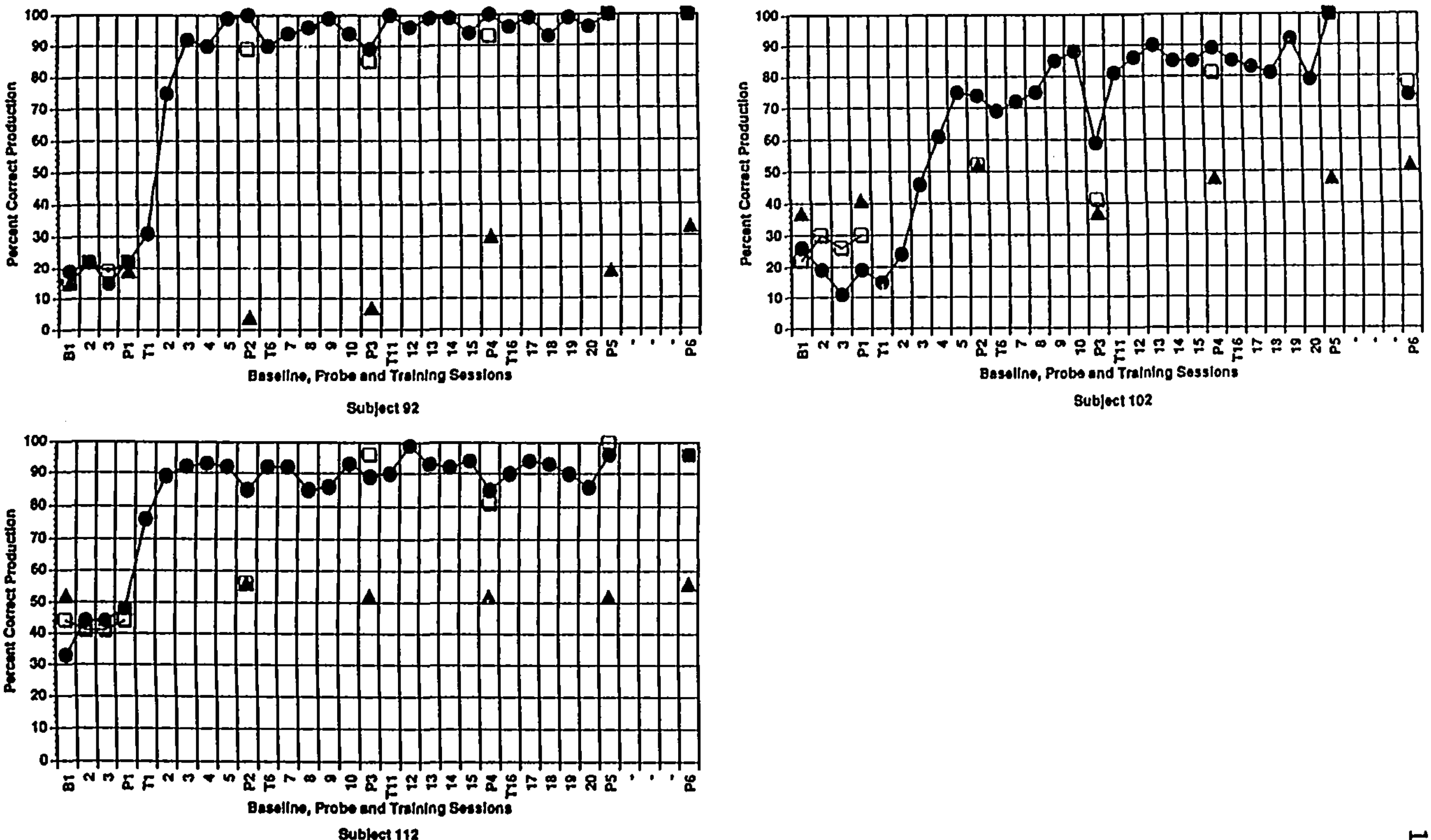

Figure 6.12. Percent of correct production of trained phonemes (fricatives) in training words (●) and generalization words (□), and of untrained phonemes (plosives) in control words (▲) for baseline, probe and training sessions for Subjects 92, 102, and 112 of the Imitation Group.

Generalization Words

Listener Uncertainty Subjects.

In the Listener Uncertainty Group, 10 of the 11 subjects improved production of the target phoneme in untrained generalization words with training and maintained their scores on the follow-up probe. Six subjects (41, 51, 71, 81, 91, and 111) performed at about the same level on probes of target phonemes in generalization words as on probes of training words. For four subjects (11, 21, 31, and 101), probes of untrained generalization words improved to about 20% below the probes of trained words. For subject 61, generalization probes were lower than training probes throughout, and were below baseline at follow-up.

Imitation Subjects.

In the group trained using the imitation strategy, eight of 11 subjects improved production of target phonemes in probes of untrained, generalization words with training and maintained this level of performance at follow-up. Six subjects (32, 52, 72, 92, 102, 112) performed at about the same level for generalization probes as for training probes. Two subjects (12, 42) improved, but were about 20% lower on most generalization probes than they were on the training probes. Two subjects (22, 82) improved on generalization probes with scores close to those of the training probes, but decreased to about baseline levels on the follow-up.

Control Words

For control words containing plosives, there was no more improvement over time for subjects in either training group than there was for subjects in the Control Group. In the Listener Uncertainty Group, seven subjects showed no improvement on accuracy of plosive production and the remainder of the subjects had very slight increases in scores. In the Imitation Group, two subjects showed no improvement and the remainder showed very slight increases.

Control Subjects

Though the Control Group did not receive any training, it is useful to show the individual differences within the group, for each type of word tested over the three time periods.

Results shown in Figures 6.13, 6.14, and 6.15, show that some of the subjects, (e.g., 43, 53, 63, 83 and 93) were fairly consistent over time, showing similar levels of performance at each of the three testing periods. Others had more variable scores, with some showing an improvement over time for some types of words. These results are very similar to those for the control words for subjects in the two trained groups.

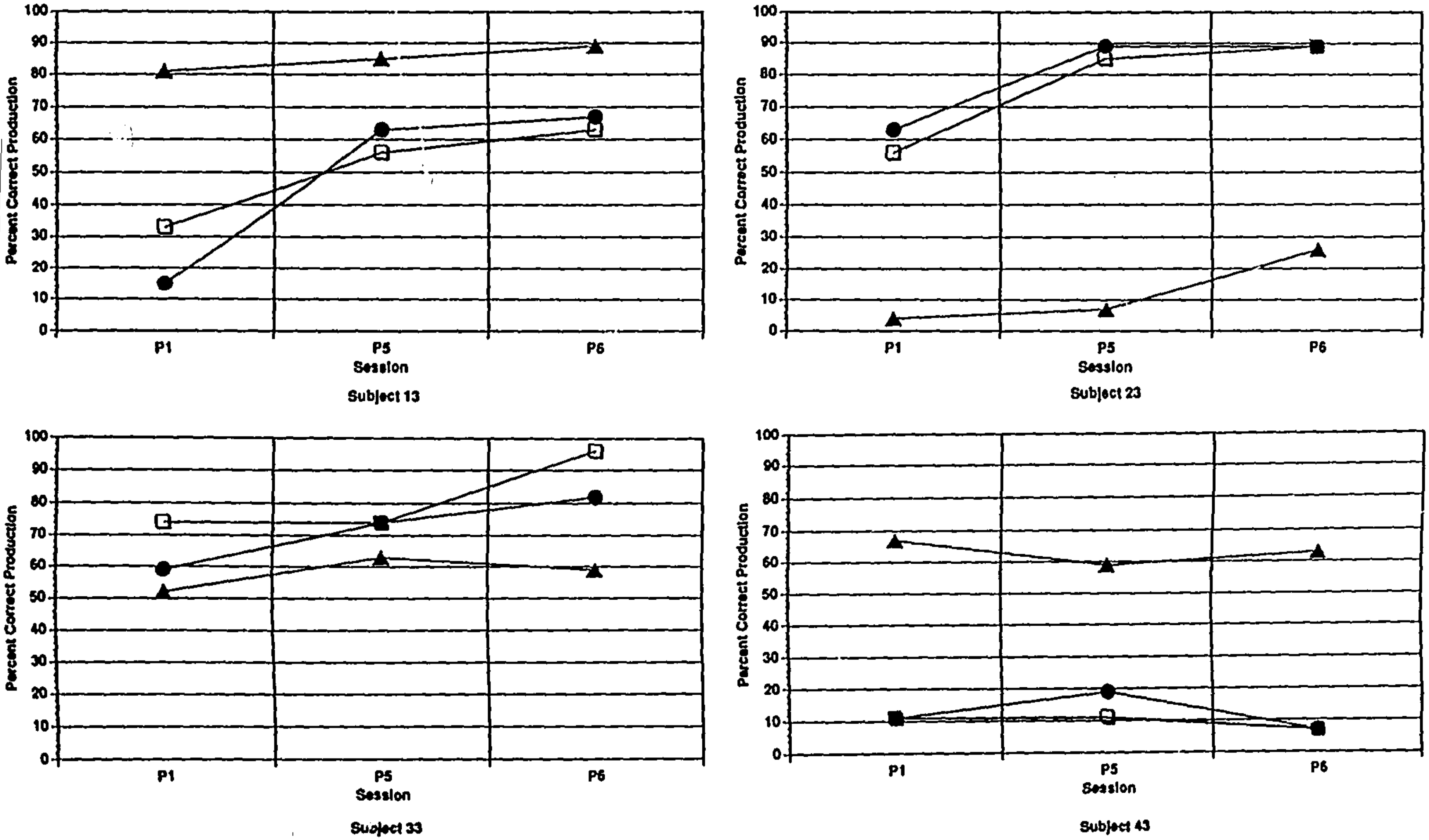

Figure 6.13 Percent of correct production of trained phonemes (fricatives) in training words (●) and generalization words (□), and of untrained phonemes (plosives) in control words (▲) for baseline, probe and training sessions for Subjects 13, 23, 33 and 43 of the Control Group.

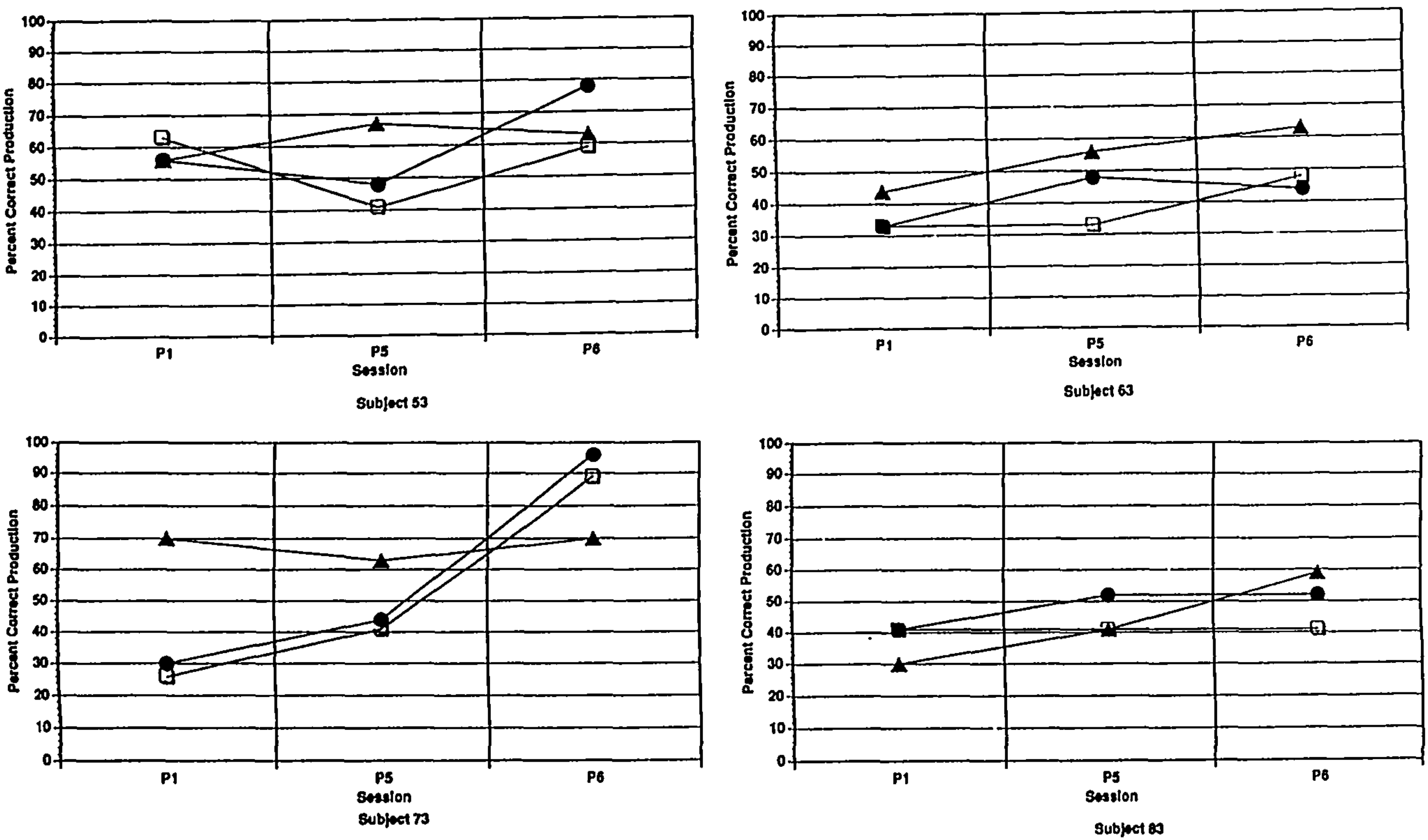

Figure 6.14 Percent of correct production of trained phonemes (fricatives) in training words (●) and generalization words (❑), and of untrained phonemes (plosives) in control words (▲) for baseline, probe and training sessions for Subjects 53, 63, 73 and 83 of the Control Group.

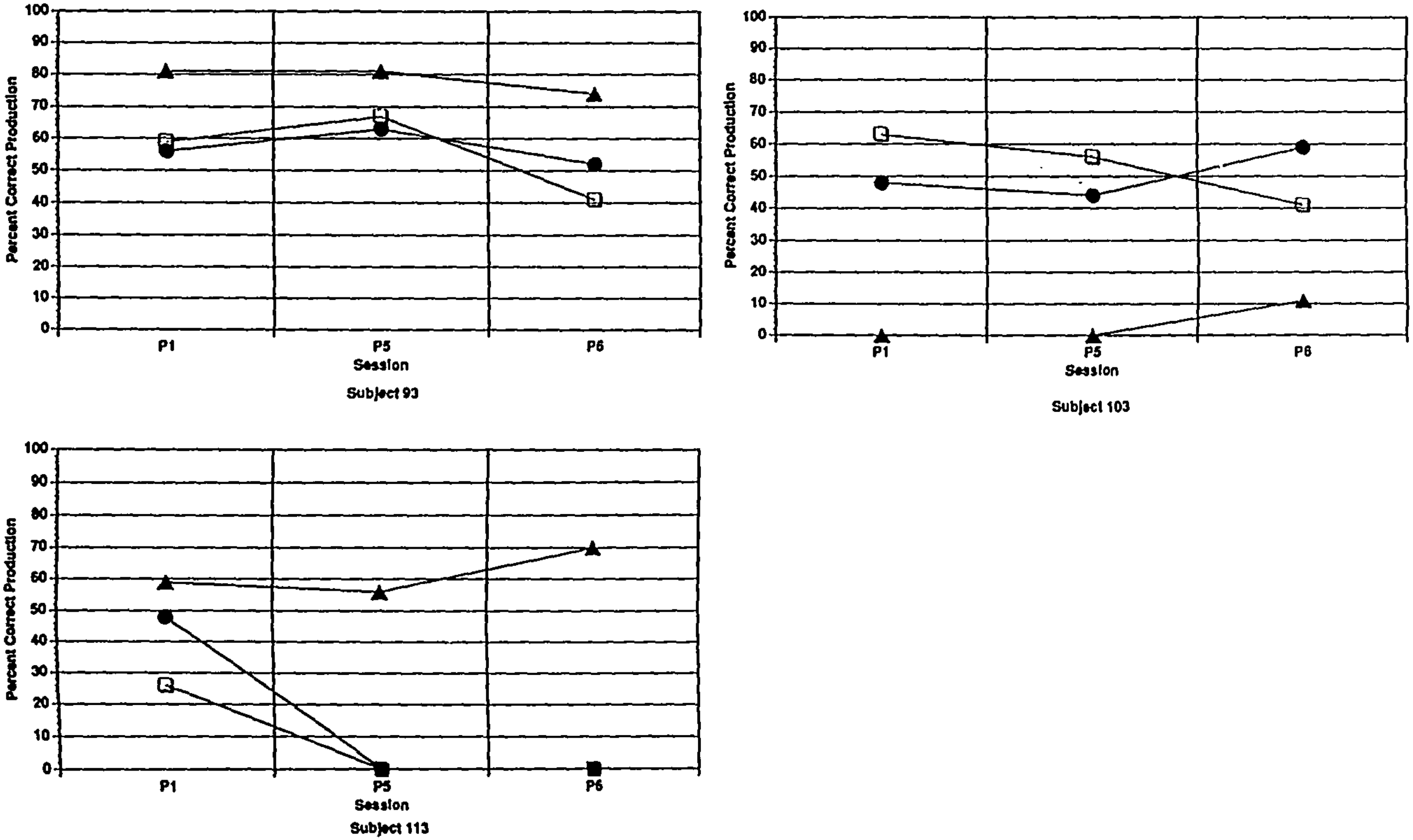

Figure 6.15 Percent of correct production of trained phonemes (fricatives) in training words (●) and generalization words (❑), and of untrained phonemes (plosives) in control words (▲) for baseline, probe and training sessions for Subjects 93, 103, and 113 of the Control Group.

Chapter 7

DISCUSSION and CONCLUSIONS
EXPERIMENT TWO

Few researchers have taken up the challenge of examining phonologic level speech teaching strategies and their effectiveness for profoundly hearing-impaired children. Various techniques based on clinical observation have been proposed (Moog, 1985; Ling 1989), but have not been systematically studied.

The primary aim of the present investigation was to determine the effectiveness of two techniques used in speech correction with profoundly hearing-impaired children: Listener Uncertainty and Imitation. Another purpose was to compare the relative effectiveness of these two approaches with this population.

The results of the present study will first be considered with respect to the hypotheses formulated at the end of Chapter Two, followed by a discussion of the major findings in relation to previous research and clinical practice. Theoretical and clinical implications of the findings will be considered; limitations of the findings and suggestions for future research in this area will be presented; and, the appropriateness of the research designs will be addressed. Finally, conclusions will be drawn regarding the contributions to knowledge of the findings of this research.

Relationship of Findings to the Research Hypotheses

The results of Experiment One showed short term benefits for both treatments, but better retention and better generalization to spontaneous speech for the Listener Uncertainty approach. This prompted further investigation, to see whether the slightly better performance using Listener Uncertainty, particularly with regard to the generalization of speech skills to spontaneous speech, would apply to a larger group of subjects over a wider age range.

Each of the primary and secondary hypotheses proposed will be addressed. There were five primary hypotheses.

The results of the group study in Experiment Two confirmed the initial hypothesis that both strategies improved speech production of target phonemes, especially on trained phonemes in trained words. Both conditions also led to improvement in phonologic speech production of target phonemes in untrained, generalization words but to a slightly lesser degree.

The second hypothesis, that trained phonemes would improve more than control phonemes, was also confirmed. The patterns of performance for the two treatment groups and the control group with respect to control phonemes were similar, showing slight but steady improvement over the course of the study. By contrast, both treatment groups improved dramatically on the trained phonemes with training.

The third hypothesis, that the Imitation strategy would produce more correct productions on trained words, was not supported. Scores for the Listener Uncertainty Group were, in fact, significantly higher on trained words than scores for the Imitation Group.

The fourth hypothesis was that the Listener Uncertainty strategy would produce greater generalization to untrained words, phrases, sentences and use of the target sound in spontaneous speech. The individual results indicated more correct productions on probe words for the Listener Uncertainty approach, but the differences between treatment groups was not statistically significant. It also did not confirm the hypothesis that the Listener Uncertainty treatment would be more effective with respect to generalization to spontaneous speech. In fact, if we were to use the spontaneous speech data as the criteria for effectiveness, we would have to conclude that the effectiveness of both of these strategies for use with profoundly hearing-impaired children is left in doubt. Neither approach appears effective enough to produce changes at the level of spontaneous spoken language. This is an important finding. With no generalization to spontaneous speech for either approach, it would be premature to state a definite preference for a particular method with regard to treatment effectiveness.

The fifth hypothesis, that Listener Uncertainty would lead to greater retention of speech skills, was confirmed, but primarily for production of target phonemes in trained words. Production of target phonemes in generalization words was not significantly better than for the Imitation Group at the follow-up.

There were three secondary hypotheses which addressed the issues of phoneme position, linguistic context and generalization to other fricatives.

It was hypothesized that differences would exist in the accuracy of target phonemes in different positions in the word (initial, medial or final), depending on the type of treatment. This was not supported, as there were no Group by Position interactions.

It was also hypothesized that differences would exist in production of target phonemes in different linguistic contexts (words, phrases, and sentences) depending on the type of treatment. This hypothesis was not confirmed, but there was a significant difference between Times 2 and 3 at the phrase level for the Imitation Group and not the Listener Uncertainty Group.

The final hypothesis was that training on target fricatives would generalize to improved production of other fricative sounds. This was not proven, as carry-over to control words of similar type (fricatives) was not facilitated by either treatment.

Relationship of the Major Findings of This Study to Previous Research and Clinical Practice

Most studies with hearing-impaired children have focused on speech errors rather than on training. Results of previous training studies with hearing impaired students indicate that either of the strategies chosen for the present study might be effective (Abraham & Weiner, 1985; Bennett, 1974, 1978; Loeding, 1979; McReynolds & Jetzke, 1986; Novelli-Olmstead & Ling, 1984; Perigoe & Ling, 1986, Solomon, 1981). With the exception of the one Listener Uncertainty study by Loeding (1989), all these studies used Imitation as the treatment strategy.

Results of treatment on trained and generalization words will be presented first, followed by results of generalization to other phonemes. Effects of context (words, phrases, and sentences) and position effects (initial, medial, and final) will be addressed. Finally, the spontaneous speech results and possible explanations of the lack of carry-over will be discussed.

Trained and Generalization Words

Studies of imitation training with hearing-impaired children have shown positive effects of training on trained words (Bennett, 1974, 1978) and generalization to untrained words (Bennett, 1974, 1978). The results of this study support these findings. The present study also extends to hearing-impaired children the findings of Weiner and Ostrowski (1979) who found that Listener Uncertainty training increased the accuracy of articulation in hearing children.

The results of training on amount of carry-over to generalization words are similar for the two treatments. This may be attributed to the effect of feedback and reinforcement on speech production, rather than the effects of any particular treatment. Another interpretation of the results, then, is that any reasonable treatment strategy which uses reinforcement of correct productions may lead to increased accuracy in verbal performance on training and generalization words.

Generalization to Other Phonemes

Generalization of training on voiceless fricatives to performance on plosives was not expected, nor was it observed.

There was also no generalization of speech skills to control words containing other fricatives. These results support earlier findings which showed that hearing-impaired children could generalize from training on plosives/stops to production of other plosives/stops (Bennett, 1978; McReynolds & Jetzke, 1986), but that they could not generalize training on fricatives to other fricatives (Bennett, 1974; Metz et al., 1980). Hearing-impaired children have reduced sensitivity to and discrimination of high frequency sounds such as fricatives (Boothroyd, 1985; Boothroyd & Huber, 1977; Ling & Ling, 1978). This would make not only speech perception for fricatives, but self-monitoring of fricative production more difficult than for other sounds, such as plosives.

It is also possible that this lack of carry-over of skill to other fricatives was due to inadequate mastery of other fricatives at the phonetic level. Speech skills on specific target sounds may not generalize to other similar phonemes if the child does not have prerequisite underlying speech behaviors. Ling (1976) has cautioned against expecting phonologic level mastery before phonetic level skills have been attained.

Context Effects

As was found in Experiment One, differences between contexts were fairly limited, perhaps due to the simplicity of the phrase and sentence level tasks. Greater differences might have been evident had the linguistic complexity of sentences been greater, as was reflected in the spontaneous speech scores. The only significant differences in level of context in Experiment Two were in generalization words. There were significant differences between the Treatment Groups and the Control Group for all contexts after the completion of training. Differences between the Listener Uncertainty Group and the Control Group at the phrase level after the break in training were also significant. This suggests that the greater retention of generalization words for the subjects in the Listener Uncertainty Group was due to scores on the phrase level task. There is no reasonable explanation for this, since it would be more likely to assume that the word level scores would have been higher than the phrase level scores (Solomon, 1981).

Position Effects

The group study confirmed the finding of Experiment One that there were no differences between treatments with regard to phoneme position in the word - initial, medial or final. This was true for trained words, generalization words and both types of control words. Differences may have occurred in this study for initial, medial, and final production within each of the treatment groups, but as no significant differences were found between groups, position effects were not investigated further. There were also no significant position effects in spontaneous speech.

Studies of the speech of hearing-impaired children which have investigated position effects have shown more accurate production of speech targets in the initial position (Solomon, 1981) and least accurate phoneme production in the final position (Abraham, 1989).

The effects of position with respect to type of phoneme merits further examination, before position effects with respect to treatment strategies can be adequately researched.

Generalization to Spontaneous Speech

Previous studies of phonologic level training of hearing-impaired children have found carry-over to spontaneous spoken language as measured by Ling's Phonologic Level Speech Evaluation after training using an Imitation approach (Novelli-Olmstead & Ling, 1984; Perigoe & Ling, 1986).

In the only study on the effects of Listener Uncertainty on the spontaneous speech of a hearing-impaired student, Loeding (1989) found improvement in speech intelligibility. Her subject was a young adult male who relied primarily on sign language and did not utilize hearing aids, which could present problems for carry-over and self-monitoring of speech skills. Trained and generalization words were not used, but improvement in overall articulation was reported. The present study was more carefully controlled with respect to trained and generalization words. Also, consistent use of hearing aids by the subjects was an integral part of the training and self-monitoring process of speech.

The lack of generalization to spontaneous speech, particularly after the levels of speech skill attained on trained and generalization words, is a major, but discouraging, finding of this study. There may be several possible reasons for lack of generalization to spontaneous speech.

The amount of time spent daily or in total on speech training may have been insufficient to see changes in spontaneous speech. Use of particular speech skills during a 15 minute segment daily, without incorporation of these same speech elements into content areas throughout the school day, may not give the student enough practice with the required skills. It is also possible that the involvement of classroom teachers, dorm supervisors and parents is needed to reinforce correct production of spontaneous speech outside the clinic.

Another explanation may be that this study focused on one target sound. Novelli-Olmstead and Ling, (1984) and Perigoe and Ling, (1986) found generalization to phonology when multiple targets were used in training.

An additional factor is that there was greater linguistic complexity in spontaneous speech than for sentences used in the probes. Abraham and Weiner (1987) found an inverse relationship between semantic and grammatical complexity and articulation in hearing-impaired students. Studies of normally hearing children have also noted this effect (Camarata & Leonard, 1986; Camarata & Schwartz, 1985; Panagos et al.,1979).

Lack of carry-over to spontaneous speech may also be an outcome of limited use of spoken language by this population. Guess, Keogh & Sailor (1978) have hypothesized that linguistically impoverished children may have less opportunity to express experiences because they lack the vocabulary and structures to do so. This factor may have also been operating with some of the profoundly hearing-impaired children in this study. Fewer occasions to practice newly acquired sounds may have affected carry-over.

Still another explanation of the spontaneous speech results is that the use of correct versus incorrect scorings may not have been sensitive enough to detect changes toward improved speech productions. For this reason, future research studies may wish to utilize a scaling technique to evaluate incremental changes toward more acceptable productions of the target sound. For example, the substitution of /θ/ for /s/ would not be considered as significant an error as the use of a glottal stop. Criteria for shaping correct productions and evaluating closer approximations to the target sound would need to be established for such an undertaking. It is important to keep in mind, however, that the goal is improved speech intelligibility, so listeners must be able to perceive a difference between sounds for articulation changes to be meaningful.

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Theoretical and Clinical Implications

The results of both experiments lead to further questions about the different theoretical frameworks on which the two teaching techniques are based - a language-based framework (Listener Uncertainty), versus a motor-based viewpoint (Imitation). One hypothesis is that the higher scores obtained with the Listener Uncertainty approach, which required self-correction, could be due to the use of higher level skills. This might also account for the greater retention and generalization with the subjects in Experiment One.

The differences between actual use of strategies are not so clearly defined in practice. Teachers/clinicians often combine approaches. They may use a motor-speech based approach, but also look for ways to integrate speech and language. Those using language-based approaches may still need to do some phonetic level practice as profoundly hearing-impaired children often need specific strategies for the elicitation and establishment of certain phonemes (Ling, 1976).

Both of these strategies can be employed by non-professionals such as parents, provided they can detect speech errors. Any competent speaker can provide either a Listener Uncertainty response or a model to imitate, unlike some of the other strategies proposed by Moog (1985) which require greater expertise.

An added advantage of the Listener Uncertainty technique is that it is pragmatically based and can be easily utilized throughout the child's day by non-professionals. It is less invasive than providing a model to imitate, and is apt to be used naturally in conversations by untrained listeners, who have difficulty understanding the speech of the hearing-impaired child. The response "What?" is something that the hearing-impaired child encounters in normal daily life and must learn to respond to by improving or changing his spoken behavior in some way. It is possible hearing-impaired children can benefit from learning specific repair strategies to use when communication breaks down.

Listener Uncertainty was a successful phonologic level speech correction strategy for all but one subject for the trained word probes and for six of 11 subjects for the generalization word probes. Imitation was successful with six of 11 subjects on the probes of trained words and for six subjects on probes of generalization words. Probe scores at the end of training were almost as high for subjects trained using the Imitation approach as for students trained using the Listener Uncertainty technique, but they appeared to decline to a greater degree at the follow-up probe measure. So, although this study found that each of these techniques was effective, neither was effective for all subjects. This can be said for every type of strategy - no one strategy will be best for all students. A combination of strategies, suited to the student and the circumstances, will need to be employed by the clinician. Children have different learning styles and respond differently to the various strategies employed by the clinician. The more strategies the clinician knows, and the more adept that clinician is at switching between strategies, the more likely it will be that he/she will be able to find a strategy or combination of strategies suited to a particular child in a particular situation.

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Limitations of Findings and Suggestions for Further Research

This is the first study to examine differences between two different phonologic level speech correction strategies for use with profoundly hearing-impaired children. Inferences based on the findings should, therefore, be conservative. The limitations of the present study will be presented and suggestions made for further research.

Subjects

The second experiment of the present investigations was conducted with profoundly hearing-impaired children in an oral school for the deaf. Generalization of the findings to other populations of deaf students in total communication, manual or mainstream settings is not possible. Further research of these training approaches with diverse populations is required. In addition, it is not known whether results with younger children and with adults would be similar. Examination of the individual performance of the two youngest boys in the study (Subjects 61 and 62, ages 7.8 and 9.6) showed problems with retention of speech skills. The youngest girl in the Imitation Group (Subject 12, age 9.0) also showed the greatest variability of scores during training. Careful selection of vocabulary for younger children would be a primary consideration in any future study of younger students. It should also be kept in mind that younger children, with fewer habituated speech errors, might improve over time as a function of maturation, regardless of treatment group.

Students with different personalities or learning styles might respond differently to various treatments. We may need to identify particular learning styles and attempt to fit the type of training to each child on an individual basis.

Training

Studies of the speech of hearing-impaired children by Novelli-Olmstead and Ling (1984) and by Perigoe and Ling (1986) found gains in speech production skills after thirty and forty training sessions respectively. Total training time was seven and a half hours (Novelli-Olmstead & Ling,1984) and ten hours (Perigoe & Ling, 1986). Training for the present investigation (Experiment Two), which totaled five hours of training, did not find the same degree of improvement at the phonologic level as these previous studies. Future research should examine whether longer periods of treatment would yield similar results or make differences between the treatments more apparent.

In examining the individual graphs for patterns of improvement, it is clear that most students made the greatest gains after the first week of training. Future research should investigate the amount of training required to effect changes. The variation in the amount of time between sessions (spaced practice) might also be investigated.

Further research is also needed to examine the techniques and responses children use when confronted with a request to self-correct. Here are some examples from the videotaped sessions of children in the Listener Uncertainty Group:

(1) Some subjects asked for a model to imitate.

(2) Some subjects did not know what was wrong with the speech production. They mispronounced another part of the word.

(3) Some subjects rehearsed the word before saying it aloud (subvocalized). This was especially true in probes for the sentence level task.

(4) Most subjects seemed pleased at being understood in the communication.

The effect of Listener Uncertainty on articulation of hearing-impaired children in natural settings, with parents, peers, etc. is a topic that needs closer examination.

In addition, the prevalence of various treatment strategies currently in use with hearing-impaired children should be assessed. Comparisons between the use of single and multiple strategies might also prove useful for practical application.

In the present study, Listener Uncertainty and Imitation were trained separately. Future researchers may wish to examine whether the combination of these, or other, approaches is more effective than the use of a single approach. Combined approaches might also more accurately reflect typical interactions between students and teachers.

Understanding in real-life situations relies not only on correct production by the speaker, but on context clues - familiarity of the topic, word predictability, accompanying prosodic features (such as proper intonation and stress) and even gestural cues. The specification of these variables in future research will be important in judging their relative importance in the communication process.

There are many possible avenues for future research. There is a pressing need for research to compare a wide variety of methods currently in use and to evaluate new methods. Longitudinal studies of the impact of various treatments is also required. At a time when the debate continues between oral and manual methods of communication for deaf individuals, proponents of either approach must prove the effectiveness of their methods with conclusive studies and not rhetoric. The emergence of new technologies such as digital hearing aids, tactile aids and cochlear implants means that the use of various speech teaching techniques with these new devices will need to be evaluated.

Error Analysis

The present investigation used correct versus incorrect judgments of the target sound. Future studies may want to focus on the type and severity of errors. If subjects are given partial scores for errors closer to the target sound, smaller changes towards the correct production may be noted. In addition, a child who has one consistent substitution for a target sound, e.g. /t/ for /s/, is very different from the kind of child who has a variety of substitutions, distortions and omissions for that same sound. Are children whose errors are more consistent easier to remediate, or are their errors too habitual? Are children with many types of errors for the same sound more difficult to train because they haven't any idea how that sound is produced; or are they easier to train because they have developed no set pattern? Would the answers to these questions be different depending on the child's age or degree of the hearing loss? These kinds of questions have never been addressed with profoundly hearing-impaired children.

Evaluation of the Research Designs

In any study, the amount of improvement during testing and training may differ for individual subjects. These individual differences are not apparent in the group results. It is for this reason that the individual results were graphed for analysis. It is hoped that this combination of small group and single-subject design might serve as a model for future applied research.

This study attempted to combine research methods appropriate for a small group study with an analysis of individual performance data. The advantages of this approach are that:

1. the small group study allows for greater generalization to the larger population of orally-trained hearing-impaired students than the earlier single-subject design study (Experiment One);
2. individual performance scores were useful in analyzing to what extent each of the subjects contributed to the group scores;
3. the individual graphs allow for comparisons between matched subjects; and,
4. the individual graphs are a reminder that treatment strategies need to be effectively employed on an individual basis.

For example, if we compare the individual graphs to the group results we see that all but one of the subjects in the Listener Uncertainty Group were able to maintain their speech performance on the training words after the four week break in training. The exception was Subject 61, whose scores returned to below baseline levels. This may be a student for whom daily speech correction is necessary to maintain speech skills. He was perhaps well matched with Subject 62 of the Imitation Group, who also scored low after a break in the training. These were two of the youngest boys in the study. They had low average language and reading scores as well, so it is possible that their language and phonological systems were not as sophisticated as those of older students. Subjects 61 and 62 were well matched, not only on levels of speech performance, but on learning and retention as well.

The use of a probe score after a period of no treatment was a useful test of retention. This was important for detecting differences between the two treatments in maintenance of speech skills after termination of training. The addition of a second retention score would be a confirmation of post-treatment scores and would further ensure the level of consistency of the findings.

One of the major limitations of this type of training study is the inability to provide a control group due to the ethical considerations of withholding therapy (cf. Rubenstein & Boothroyd, 1987). The present study was able to provide a no-treatment control group because it took advantage of rotating schedules for individualized speech instruction. An additional control was the use of control words which received no treatment. These could be employed in circumstances where a control group of untrained students is inadvisable.

Experiment Two of the present investigations was also able to circumvent the problem of withholding therapy until the retention score was obtained by using a natural break in the school year. Similar studies could be timed to utilize vacation breaks.

The alternating treatment design utilized in Experiment One is a useful alternative to the small group design, when numbers of subjects are limited or when clinicians are interested in evaluating treatment suitability for specific clients. It is also an appropriate design to use when withdrawal or reversal of treatment is to be avoided for ethical reasons.

CONCLUSIONS

These two experiments were the first to investigate the use of Listener Uncertainty and Imitation with profoundly hearing-impaired students and to compare their relative effectiveness. The following contributions to knowledge, therefore, require confirmation with additional study of these speech teaching techniques.

1. As expected, both treatment conditions led to increased ability to produce target phonemes correctly in trained and, to a lesser extent, in generalization words.
2. Listener Uncertainty led to greater gains than did Imitation with more correct productions of the target phoneme in trained words than in generalization words.
3. There was no carry-over to production of similarly produced phonemes with either approach.

4. Differences with respect to treatment approach and linguistic context were very limited.
5. There were no significant position effects with respect to type of treatment.
6. Contrary to expectations, there was little generalization to spontaneous speech in Experiment One and no generalization to spontaneous speech in Experiment Two.

The clinical implications of the lack of generalization of learned speech skills to spontaneous speech provide a discouraging picture for practitioners. The analysis of spontaneous speech, however painstaking, is necessary to evaluate carry-over and, hence, treatment effectiveness.

Both experimental designs were appropriate for use with this population and demonstrate the effective use of single-subject studies as a basis for small group research. The combined analysis of individual performance scores with the results group is a practical model for use with hearing-impaired students.

Further investigation of subject variables and treatment variables which may determine the effectiveness of various speech teaching techniques is required. Continued research of both short and long-term effects to determine maintenance of speech behaviors is necessary to evaluate continued effectiveness of various treatments.

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APPENDIX A

EQUIPMENT : EXPERIMENT ONE

EQUIPMENT - EXPERIMENT ONE

Recording Equipment

1 Sony portable video cassette recorder TT-2000, SL-2000
1 JVC GX-N5 ultra-low-light video camera
1 Velbon tripod
1 Bell & Howell audio cassette recorder 3179C
2 Realistic, lapel, omni-directional, electret condenser microphones
(frequency response 50 - 15,000 Hz, sensitivity -72 dB $\pm$4 dB)
Sony Beta videotapes
Realistic XR-60 supertape extended range audiotape (30 - 20,000 Hz)

Hearing Aid-FM Equipment

Phonic Ear FM microphone transmitter - 441 T
Phonic Ear FM receiver - 445 R
Phonic Ear FM stereo charger

APPENDIX B

MATERIALS: EXPERIMENT ONE

Word Lists for Trained and
Untrained (Generalization) Words
Sources for Picture Cards
Sample Score Sheets

Word Lists for Trained and Untrained (Generalization) Words

WORD LIST FOR /ʃ/ -"sh"- EXPERIMENT 1

TRAINED WORDS - /ʃ/ - "sh"

FINAL	INITIAL	MEDIAL	MEDIAL ABUTTING
brush	shamrock	dishes	flashlight
fish	shelf	eyelashes	horseshoe
leash	shield	pin cushion	marshmallow
sash	shin	sewing machine	pencil sharpener
squash	shoehorn	showshoes	wishbone

UNTRAINED (GENERALIZATION) WORDS - /ʃ/ -"sh"

FINAL	INITIAL	MEDIAL	MEDIAL ABUTTING
bush	shadow	fishing rod	bookshelf
dog dish	shade	magician	fishbowl
licorice	shampoo	ocean	
mustache	shark	parachute	
(shoe) polish	shawl	station wagon	
radish	sheep	washing machine	
	shell		
	ship		
	shirt		
	shoe		
	shoulder		
	shower		
	shutter		
	sugar		

Word Lists for Trained and Untrained (Generalization) Words

WORD LIST FOR /r/ - EXPERIMENT 1

TRAINED WORDS - /r/

FINAL	INITIAL	MEDIAL	MEDIAL ABUTTING
car	racoon	arrow	harmonica
bear	radio	carrot	jumprope
ear	red	fairy	marbles
fire	rope	gorilla	organ
oar	ruler	kangaroo	tennis racket

UNTRAINED (GENERALIZATION) WORDS /r/

FINAL	INITIAL	MEDIAL	MEDIAL ABUTTING
door	rabbit	carriage	firechief
four	radish	cherrios	fireman
hair	raft	cherries	garbage
pear	rain	garage	
refrigerator	rake	giraffe	
rooster	rat	orange	
spider	rattle	parrot	
tire	ribbon		
star	ring		
	robin		
	robot		
	rocket		
	roll		
	rolling pin		
	rooster		
	rose		
	rug		

Materials:
Sources for Picture Cards used in Testing and Training

Word Making Cards
Word Making Productions
P.O. Box 15038
Salt Lake City, Utah
84115

Artic Sticks (#620, 621, and 622)
PRO-ED
8700 Shaol Creek Boulevard
Austin, Texas
78758-6897

Sample Score Sheet — Training — Experiment 1

Summary Sheet - Percent Correct Production

SUBJECT ____________ Date ______ Session _____

PHONEME ____________

	WORDS	SIMPLE SENTENCES "This is a ___"	CREATIVE SENTENCES	TOTAL
INITIAL				
MEDIAL				
MEDIAL ABUTTING				
FINAL				
Totals				

Sample Probe Tally Sheet — Experiment 1

Words _______
Simple Sentences _______
Creative Sentences ______

SUBJECT _________ Date ______ Session _____

PHONEME _________

	CORRECT	INCORRECT	TOTAL	%
INITIAL				
MEDIAL				
FINAL				
Totals				

APPENDIX C

MATERIALS: EXPERIMENT ONE

Elicitation of Spontaneous Spoken Language Samples

Materials for Elicitation of Spontaneous Spoken Language Samples - Experiment One

LANGUAGE AREAS SAMPLED (Ling, 1981b)

1. **CONVERSATION** (interaction)

   Possible topics:
   family, friends, school, summer vacation, Halloween, weekend activities, Christmas vacation, toys and games, animals

2. **NARRATION** (sequencing ideas)

   Picture books:
   The Three Bears, Seven in One Blow,
   Jack in the Beanstalk, Little Red Riding Hood.

3. **EXPLANATION** (temporal relationships, commands)

   How to fish,
   How to play hockey,
   How to play a video game.

4. **DESCRIPTION** (spatial relationships, prepositions)

   Describe a room.

5. **QUESTION FORMATION** (open/closed questions, WH-questions, inverted questions e.g. "Is it...?, Does it...?")

   (A) Treasure Box:
   blue balloon, small read ball, chocolate candy
   (B) Asking questions about the teacher

APPENDIX D

SPEECH ASSESSMENT MEASURES:

Phonetic Analysis of Imitated Speech (Experiment One)
Screening Test (Experiment Two)

PHONETIC ANALYSIS OF IMITATED SPEECH
(PAIS)

CHILD'S NAME ______________________ DOB ______ AGE ______

EXAMINER ______________________ DATE ______________________

SCHOOL ______________________ GRADE ______________________

Target only: #correct ___ #incorrect ___ %correct ______

Environment: #correct ___ #incorrect ___ %correct ______

STEP 1 - SIMPLE CONSONANTS:

TARGET	FUNCTION	STIMULUS	RESPONSE	
/b/	VR	I see a cabin.	æbɪ	
		I see the baby.	əbeɪ	
	AR	The mean bear growled.	inbɛ	
		Give me the big ball.	ɪgbɔ	
	AA	That job can be hard.	ɑbkɚ	
		Tubs are fun to play in.	ʌbzə	
/p/	VR	The apple is good.	æpə	
		See the pony run.	əpo	
	AR	His pack is heavy.	ɪzpæ	
		His picture is good.	ɪzpɪ	
	AA	I can mop the floor	ɑpðə	
		Hop some more for me.	ɑpsə	
/w/	VR	Go away from here.	əweɪ	
		My wallet is full.	aɪwɑ	
	AR	The bad witch flies.	ædwɪ	
		The girl went home.	ɝlwɛ	
/f/	VR	He is a funny clown.	ʌfə	
		Sit on the sofa.	ofə	
	AR	The game is fun.	ɪzfə	
		The duck found a bug.	ʌkfaʊ	
	AA	Go off to school.	ɔftu	
		A leaf can grow.	ifkæ	
/v/	VR	Give it to me now.	ɪvɪ	
		I have a cat at home.	ævə	

	AR	His voice is loud.	ɪzvɔɪ
		I like very hot soup.	aɪkvɛ
	AA	He gave me a cookie.	eɪvmi
		They live down the street.	ɪvdaʊ
/θ/	VR	His mouth is open.	aʊθɪ
		What do you think?	uθɪ
	AR	I was thinking about you.	ʌzθɪ
		Tom thought about it.	ɑmθɔ
	AA	Both cats are black.	oθkæ
		Go with her.	ɪθhɝ
/ð/	VR	I see the clowns.	iðə
		My mother is here.	ʌðɚ
	AR	Take these with you.	eɪkði
		Can you guess the name?	ɛsðə
	AA	I can bathe two dolls.	eɪðtu
		Feel his smoothe coat.	uðko
/h/	VR	I help mama.	aɪhɛ
		Be a happy girl/boy.	əhæ
	AR	Make a big hole.	ɪgho
		His horse is tall.	ɪzhɔ
/m/	VR	Put it in her mouth.	ɝmaʊ
		The man is happy.	əmæ
	AR	I need more juice.	idmɔ
		Let me go with you	ɛtmi
	AA	I ate ham for lunch.	æmfɔ
		We have the same pants.	eɪmpæ

STEP 2 – SIMPLE CONSONANTS:

/d/	VR	Will you do it?	udu
		The bird is red.	ɝdɪ
	AR	What time do we eat?	aɪmdu
		The big doll is mine.	ɪgdɔ
	AA	I had coke to drink.	ædko
		He did some work.	ɪdsʌ
/t/	VR	My tooth is white.	aɪtu
		You take a turn.	uteɪ

	AR	Give the clothes to me.	oðtu
		Make time to read.	eɪktaɪ
	AA	I cut my hand.	ʌtmaɪ
		You may go out first.	aʊtfɝ
/ʃ/	VR	The ship is big.	əʃɪ
		The shape is round.	əʃeɪ
	AR	See the bookshelf.	ʊkʃɛ
		Dad shut the door.	ædʃʌ
	AA	You have a fish like mine.	ɪʃlaɪ
		You push me over.	ʊʃmi
/zh/	VR	Let me measure you.	ɛʒɚ
		It is a pleasure.	ɛʒɚ
	AA	I have a beige coat.	eɪʒko
		The rouge was red.	uʒwə
/s/	VR	You listen to me.	ɪsə
		The soup is hot.	əsu
	AR	My doll sat on the bed.	ɔlsæ
		I gave some candy to him.	eɪvsʌ
	AA	The ice made me cold.	aɪsmeɪ
		This boy can go.	ɪsbɔɪ
/z/	VR	Will you visit me?	ɪzɪ
		She is a good girl.	ɪzə
	AR	Go to the big zoo.	ɪgzu
		Our beds are soft.	ɛdzɑ
	AA	Candy is good to eat.	ɪzgʊ
		She has dogs at home.	æzdɔ
/n/	VR	What a nice gift.	ənaɪ
		You may go now.	onaʊ
	AR	John has no shoes.	æzno
		I have nine cats.	ævnaɪ
	AA	I want mine back.	aɪnbæ
		His van was old.	ænwʌ
/j/	VR	Say yes for me.	eɪjɛ
		Do you want one?	uju
	AR	What year is this?	ʌtjɪ
		When will you go?	ɪlju

/l/	VR	You say hello.	ɛlo
		Go along with her.	əlɔ
	AR	The pig looks mean.	ɪglʊ
		The boss let me work.	ɔslɛ
	AA	I can pull two wagons.	ʊltu
		Call me on the phone.	ɔlmi

STEP 3 - SIMPLE CONSONANTS:

/g/	VR	I go to bed.	aɪgo
		The girl likes candy.	əgɝ
	AR	I like to eat good food.	itgʊ
		Don't go with him.	ontgo
	AA	He is a big boy.	ɪgbɔɪ
		The bugs are eating.	ʌgzə
/k/	VR	Daddy drives the car.	əka
		I saw a cat.	əkæ
	AR	Tom called me to come.	amkɔ
		The trash can is full.	æʃkæ
	AA	You take two marbles.	eɪktu
		Did you pack my lunch?	ækmaɪ
/tʃ/	VR	Don't scratch it now.	ætʃɪ
		The witch is bad.	ɪtʃɪ
	AR	I like chicken.	aɪktʃɪ
		Daddy will chop wood.	ɪltʃa
	AA	Watch the T.V.	atʃðə
		You catch the ball.	ætʃðə
/dʒ/	VR	The juice is good.	ədʒu
		I like jelly.	aɪdʒɛ
	AR	I can jump high.	ændʒʌ
		I like jelly.	aɪkdʒɛ
	AA	The bridge fell down.	ɪdʒfɛ
		The bird cage will lock.	eɪdʒwɪ
/r/	VR	Go around the tree.	əraʊ
		I run very fast.	aɪrʌ
	AR	The white rabbit is mine.	aɪtræ
		He can run fast.	ænrʌ

SCREENING TEST - EXPERIMENT TWO

SUBJECT ____________ DATE ___________

INITIAL	MEDIAL	FINAL
feet	coffee	knife
volcano	seven	five
thumb	bathtub	teeth
	feather	
soap	bicycle	mouse
zipper	scissors	nose
shoe	washing machine	dish
	television	garage
chair	kitchen	witch
giraffe	pajamas	garbage
pen	zipper (2)	cup
banana	baby	bathtub (2)
teeth (2)	skeleton	feet (2)
dog	ladder	bed
kitchen (2)	bacon	snake
goat	wagon	dog (2)
mouse (2)	hammer	thumb (2)
nose (2)	banana (2)	balloon
lion	balloon (2)	bell

APPENDIX E

EQUIPMENT : EXPERIMENT TWO

EQUIPMENT - EXPERIMENT TWO

Recording Equipment

2 Sony portable video cassette recorders TT-2000, SL-2000
1 Sony video camera
1 JVC GX-N5 ultra-low-light video camera
2 Velbon tripods
1 Bell & Howell audio cassette recorder 3179C
3 Realistic, lapel, omni-directional, electret condenser microphones
(frequency response 50 - 15,000 Hz, sensitivity -72 dB $^{+}$4 dB)
Sony Beta videotapes
Realistic XR-60 supertape extended range audiotape (30 - 20,000 Hz)

Hearing Aid-FM Equipment-Lower and Middle School students

Phonic Ear FM microphone transmitter - 421 T (general frequency)
Phonic Ear FM receiver - 461 R
Phonic Ear FM stereo charger

Hearing Aid-FM Equipment-Upper School students

Phonic Ear FM microphone transmitter - 421 T (general frequency)
Phonic Ear FM receiver - System 4 PE 475 R
System 4 RO - General frequency (green/pink)
Phonic Ear FM stereo charger

APPENDIX F

MATERIALS: EXPERIMENT TWO

Word Lists for Training Words, Untrained (Generalization) Words, Control Words (Plosives) and Control Words (Fricatives)

WORD LISTS- EXPERIMENT 2

TRAINING WORDS

/f/

INITIAL	MEDIAL	FINAL
fish	muffins	knife
fight	coffee	hoof
foot	elephant	cough

/θ/ - "th"

INITIAL	MEDIAL	FINAL
thermos	bathtub	path
thorn	toothpaste	tooth
thumb	mouthwash	mouth

/ʃ/ - "sh"

INITIAL	MEDIAL	FINAL
sheep	ocean	fish
shower	fishing rod	radish
shoe	sewing machine	mustache

/s/

INITIAL	MEDIAL	FINAL
saw	bicycle	moose
soap	dinosaur	house
seed	muscle	dice

WORD LISTS- EXPERIMENT 2

UNTRAINED (GENERALIZATION) WORDS

/f/

INITIAL	MEDIAL	FINAL
finger	telephone	calf
fan	sofa	safe
feet	laughing	leaf

/θ/ - "th"

INITIAL	MEDIAL	FINAL
thermometer	bathrobe	bath
thirteen	toothbrush	teeth
thigh	toothpick	cloth

/ʃ/ - "sh"

INITIAL	MEDIAL	FINAL
ship	dishes	dish
shampoo	parachute	paintbrush
shoulder	washing (machine) (washer)	bush

/s/

INITIAL	MEDIAL	FINAL
salt	tricycle	goose
sock	faucet	mouse
seal	castle	ice

WORD LISTS- EXPERIMENT 2

CONTROL WORDS - PLOSIVES

/b/

INITIAL	MEDIAL	FINAL
bee	elbow	doorknob
boy	bubbles	web
banana	cabin	bathtub

/d/

INITIAL	MEDIAL	FINAL
duck	ladder	bed
deer	spider	lemonade
door	soda	seed

/g/

INITIAL	MEDIAL	FINAL
gun	tiger	pig
gas	alligator	bug
game	magazine	dog

WORD LISTS- EXPERIMENT 2

CONTROL WORDS - FRICATIVES

/v/

INITIAL	MEDIAL	FINAL
vacuum	movie	five
van	devil	glove
vest	elevator	cave

/ð/ - "TH"

INITIAL	MEDIAL	FINAL
	mother	
	father	
	feather	

/ʒ/ - "zh"

INITIAL	MEDIAL	FINAL
	measure	garage
	treasure	
	division	

/z/

INITIAL	MEDIAL	FINAL
zebra	razor	cheese
zoo	music	nose
zipper	magazine	Santa Claus

APPENDIX G

MATERIALS: EXPERIMENT TWO

Elicitation of Spontaneous Spoken Language Samples

Materials for Elicitation of Spontaneous Spoken Language Samples - Experiment Two

LANGUAGE AREAS SAMPLED (Ling, 1981b)

1. **CONVERSATION** (interaction)
   Possible topics: family, friends, school, summer vacation, weekend activities, Christmas vacation, favorite things

2. **NARRATION** (sequencing ideas)
   Picture books:
   Cinderella, The Gingerbread Man, The Three Bears, The Three Little Pigs, Jack in the Beanstalk, Little Red Riding Hood.

3. **EXPLANATION** (temporal relationships, commands)
   How to make a peanut butter sandwich: peanut butter, bread (in plastic bag), knife, plate
   How to make lemonade: lemonade mix, water, sugar, pitcher, spoon, glasses
   How to make a paper bag puppet: small paper bag, stickers of different shapes and sizes

4. **DESCRIPTION** (spatial relationships, prepositions)
   Describe with visual support, rooms in doll house
   Fisher-Price doll house (or their own bedroom)
   Furniture: table, three chairs, highchair, sofa, desk, end table, crib, single bed, double bed, television, sink, bathtub
   People and Animals: man (father), lady (mother), lady (grandmother), girl, boy, baby, dog, cat
   Vehicles: car, bus, garbage truck, toy horse with wheels
   Miscellaneous: garbage can, ball , blanket, bowl, spoon, fork, knife, cereal, cup and saucer, pot, plate (with sandwich, carrots, cucumber, potatoes/chips, bowl of fruit (with banana, apple, orange)

5. **QUESTION FORMATION** (open/closed questions, WH-questions, inverted questions e.g. "Is it...?, Does it...?")
   (A) Treasure Box (small)
   orange car, silver airplane
   large yellow balloon. small red balloon
   small yellow ball
   (B) Asking questions about the teacher

APPENDIX H

MATERIALS: EXPERIMENT TWO

Sample Score Sheets for Baseline and Probe Words

Sample Score Sheet - Baseline / Probe Words - Experiment 2

Subject__________ Date ______ Session ____ Baseline ____ Probe ____

Training Words

/ s /	SINGLE WORDS	PHRASES "on the ___"	SENTENCES "I have the ___
INITIAL			
saw			
soap			
seed			
MEDIAL			
bicycle			
dinosaur			
muscle			
FINAL			
moose			
house			
dice			
Totals			

Sample Score Sheet - Baseline / Probe Words - Experiment 2

Subject __________ Date ______ Session ____ Baseline ____ Probe ____

Untrained (Generalization) Words

/s/	SINGLE WORDS	PHRASES "on the ___"	SENTENCES "I have the ___
INITIAL			
salt			
sock			
seal			
MEDIAL			
tricycle			
faucet			
castle			
FINAL			
goose			
mouse			
ice			
Totals			

Sample Score Sheet — Baseline / Probes - Experiment 2

Subject___________ Date ______ Session ____ Baseline ____ Probe ____

Control Words - Plosives

/d/	SINGLE WORDS	PHRASES "on the ___"	SENTENCES "I have the ___"
INITIAL			
duck			
deer			
door			
MEDIAL			
ladder			
spider			
soda			
FINAL			
bed			
lemonade			
seed			
Totals			

Sample Score Sheet — Baseline / Probes - Experiment 2

Subject__________ Date ______ Session ____ Baseline ____ Probe ____

Control Words - Fricatives

/z/	SINGLE WORDS	PHRASES "on the ___"	SENTENCES "I have the ___
INITIAL			
zebra			
zoo			
zipper			
MEDIAL			
razor			
music			
magazine			
FINAL			
cheese			
nose			
Santa Claus			
Totals			

APPENDIX I

MATERIALS: EXPERIMENT TWO

Sample Score Sheets for Training Words

Sample Score Sheet — Training Words — Experiment 2

Subject ______________ Date ________ Training Session _______

Training Words

/f/	SINGLE WORDS	PHRASES "on the ___"	SENTENCES I have the ___"	CREATIVE SENTENCES
INITIAL				
fish				
fight				
foot				
MEDIAL				
muffins				
coffee				
elephant				
FINAL				
knife				
hoof				
cough				
Totals				

Sample Score Sheet — Training Words — Experiment 2

Subject_______________ Date __________ Training Session _______

Training Words

/θ/ "th"	SINGLE WORDS	PHRASES "on the ___"	SENTENCES "I have the ___"	CREATIVE SENTENCES
INITIAL				
thermos				
thorn				
thumb				
MEDIAL				
bathtub				
toothpaste				
mouthwash				
FINAL				
path				
tooth				
mouth				
Totals				

Sample Score Sheet — Training Words — Experiment 2

Subject ______________ Date ________ Training Session ________

Training Words

/ʃ/ "sh" SINGLE WORDS	PHRASES "on the ___"	SENTENCES "I have the ___"	CREATIVE SENTENCES
INITIAL			
sheep			
shower			
shoe			
MEDIAL			
ocean			
fishing rod			
sewing machine			
FINAL			
fish			
radish			
mustache			
Totals			

Sample Score Sheet — Training Words — Experiment 2

Subject ________________ Date _________ Training Session ________

Training Words

/s/	SINGLE WORDS	PHRASES "on the ___"	SENTENCES "I have the ___"	CREATIVE SENTENCES
INITIAL				
saw				
soap				
seed				
MEDIAL				
bicycle				
dinosaur				
muscle				
FINAL				
moose				
house				
dice				
Totals				

APPENDIX J

TUKEY TABLES

TABLE J.1

Tukey Tests of Pairwise Comparisons for Training Words Group Comparisons over Time

TIME 1

	Group 1 Listener Uncert.	Group 2 Imitation	Group3 Control
Group 1		0.9804	22.2773**
Group 2			23.2577**

TIME 2

	Group 1 Listener Uncert.	Group 2 Imitation	Group3 Control
Group 1		13.8349**	70.3179**
Group 2			56.4830**

TIME 3

	Group 1 Listener Uncert.	Group 2 Imitation	Group3 Control
Group 1		22.7675**	49.5112**
Group 2			26.7437**

*p<0.05 **p<0.01

TABLE J.2

Tukey Tests of Pairwise Comparisons for Training Words Time Comparisons over Group

	Time 1	Time 2	Time3
GROUP 1 - LISTENER UNCERTAINTY			
Time 1		132.3396**	121.0398**
Time 2			11.2999**
GROUP 2 - IMITATION			
Time 1		115.9791**	93.3102**
Time 2			22.6689**
GROUP 3 - CONTROL			
Time 1		14.4887**	29.6707**
Time 2			15.1820**

* $p<0.05$ **$p<0.01$

TABLE J.3

Tukey Tests of Pairwise Comparisons for Generalization Words Group Comparisons over Time for Word Context

TIME 1

	Group 1 Listener Uncert.	Group 2 Imitation	Group3 Control
Group 1		1.4783	1.9711
Group 2			3.4494

TIME 2

	Group 1 Listener Uncert.	Group 2 Imitation	Group3 Control
Group 1		1.6413	5.8677**
Group 2			4.2264*

TIME 3

	Group 1 Listener Uncert.	Group 2 Imitation	Group3 Control
Group 1		0.8617	3.3236
Group 2			2.4620

*$p<0.05$ **$p<0.01$

TABLE J.4

Tukey Tests of Pairwise Comparisons for Generalization Words Group Comparisons over Time for Phrase Context

	Group 1 Listener Uncert.	Group 2 Imitation	Group3 Control
TIME 1			
Group 1		0.6155	2.0927
Group 2			2.7082
TIME 2			
Group 1		1.0258	5.1291**
Group 2			4.1033*
TIME 3			
Group 1		2.7902	3.9802*
Group 2			1.1899

*p<0.05 **p<0.01

TABLE J.5

Tukey Tests of Pairwise Comparisons for Generalization Words Group Comparisons over Time for Sentence Context

TIME 1

	Group 1 Listener Uncert.	Group 2 Imitation	Group3 Control
Group 1		1.1079	2.2158
Group 2			1.1079

TIME 2

	Group 1 Listener Uncert.	Group 2 Imitation	Group3 Control
Group 1		0.9027	4.8829**
Group 2			3.9802*

TIME 3

	Group 1 Listener Uncert.	Group 2 Imitation	Group3 Control
Group 1		1.8465	2.9543
Group 2			1.1079

*p<0.05 **p<0.01

TABLE J.6

Tukey Tests of Pairwise Comparisons for Generalization Words Time Comparisons over Group for Word Context

GROUP 1 - LISTENER UNCERTAINTY

	Time 1	Time 2	Time3
Time 1		11.3554**	9.0082**
Time 2			2.3472

GROUP 2 - IMITATION

	Time 1	Time 2	Time3
Time 1		11.1017**	9.9598**
Time 2			1.1419

GROUP 3 - CONTROL

	Time 1	Time 2	Time3
Time 1		0.7613	0.8247
Time 2			1.5860

* $p<0.05$ ** $p<0.01$

TABLE J.7

Tukey Tests of Pairwise Comparisons for Generalization Words
Time Comparisons over Group for Phrase Context

GROUP 1 - LISTENER UNCERTAINTY

	Time 1	Time 2	Time3
Time 1		11.1651**	10.4039**
Time 2			0.7613

GROUP 2 - IMITATION

	Time 1	Time 2	Time3
Time 1		10.5307**	7.1051**
Time 2			3.4257*

GROUP 3 - CONTROL

	Time 1	Time 2	Time3
Time 1		0.0000	1.0150
Time 2			1.0150

* $p<0.05$ ** $p<0.01$

TABLE J.8

Tukey Tests of Pairwise Comparisons for Generalization Words Time Comparisons over Group for Sentence Context

GROUP 1 - LISTENER UNCERTAINTY

	Time 1	Time 2	Time3
Time 1		12.6876**	10.9113**
Time 2			1.7763

GROUP 2 - IMITATION

	Time 1	Time 2	Time3
Time 1		9.5791**	6.3438**
Time 2			3.2353

GROUP 3 - CONTROL

	Time 1	Time 2	Time3
Time 1		1.7128	2.9182
Time 2			1.2053

* $p<0.05$ **$p<0.01$