CUED SPEECH AND THE RECEPTION OF SPOKEN LANGUAGE

by

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ABSTRACT

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This study was designed to investigate the effect of Cued Speech on profoundly hearing-impaired childrens' speech reception abilities under seven conditions of presentation: audition; lipreading; audition and lipreading; cues; audition and cues; lipreading and cues; and audition, lipreading and cues. The 18 subjects had been taught through the use of Cued Speech for at least four years. They were presented with specially designed speech tests (syllables and key words in sentences) which had been recorded on color videotape, and they responded in writing. Speech reception scores of over 95% with the key word in sentence materials and over 80% with the syllables were obtained with lipreading plus cues, and audition, lipreading plus cues. Equally high levels of accuracy in speech reception by such children have not previously been reported. The subjects also demonstrated the ability to use audition with the sentence materials, both in combination with lipreading and with cues, though there were large individual differences under these conditions. Speech reception abilities in the lipreading-plus-audition condition were highly correlated with scores for speech production; while language attainments were correlated with reception through Cued Speech. The implications of these findings to the field of aural rehabilitation are discussed.

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Ce projet a été préparé dans le but d'examiner l'effet du "Cued Speech" sur les capacités de réception du langage des enfants déficients auditifs sous sept conditions de présentation: audition; lecture labiale; audition et lecture labiale; "cues"; audition et "cues"; lecture labiale et "cues"; et, audition lecture labiale et "cues". Les 18 sujets furent entraînés par l'utilisation du "Cued Speech" pendant au moins quatre ans. On leur a présenté des tests de langage spécialement conçus (syllabes et mots-clés dans une phrase) qui avaient été enregistrés sur bandes magnétoscopiques de couleur. Leurs réponses furent par écrit . Pour ce qui est de la réception du langage, des moyennes de plus de 95% furent obtenues pour les mots-clés dans les phrases, et des moyennes de plus de 80% furent obtenues pour la lecture labiale avec "cues" et l'audition, lecture labiale et les "cues". Ce niveau de précision dans la réception du langage chez les enfants profondément sourds n'a pas été rapporté antérieurement. Les sujets ont de plus démontré l'habileté d'utiliser l'audition dans les phrases tant avec la lecture labiale qu'avec les "cues" quoiqu'il y eu de grandes différences individuelles sous ces conditions. La capacité de réception du langage dans le cas de la lecture labiale avec

l'audition correspondirent hautement avec les points obtenus pour la production de la parole cependant que l'obtention du langage fut en corrélation avec la réception à travers le "Cued Speech". Les applications potentielles de ces données dans le domaine de la réadaption auditive sont examinées.

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INTRODUCTION

Profound and total hearing impairment is an immense barrier to effective verbal communication. This is particularly true when such impairment is present from early infancy, the period in which linguistic skills are normally acquired. The profoundly hearing-impaired child may have average intelligence and the social needs common to his peers, yet be deprived of normal intellectual, social and educational opportunities simply because he can not adequately receive the spoken word or use speech.

Many different approaches to helping hearing-impaired children overcome their handicap have been suggested and attempted. It is now common for hearing-impaired children to be taught principally through sign language. This approach may be successful in some respects but has the disadvantage of limiting the child's communication to others who sign. Relatively few people are fluent signers. Other such children may be taught orally, that is, in a system which stresses the importance of speech, the use of residual hearing and lipreading. This approach is not however, appropriate for those children who find the auditory signal too degraded and the visual signal too ambiguous to decode.

Because communication through speech reception and speech production permits hearing-impaired children to function independently in society, much effort has been expended in providing them with devices that can either supplement the impoverished acoustic signal, such as

hearing aids, or offer alternatives to it, e.g. visual or tactile displays. An approach suggested by Cornett (1967), known as Cued Speech employs a set of manual (hand) cues rather than a device. Eight hand configurations and four hand positions (to be described in more detail later) are used to disambiguate the patterns of speech that can be seen on the lips of a speaker. This system has neither been extensively employed nor intensively studied. Its potential importance as a tool in teaching hearing-impaired children led the writer to design and carry out the present study.

Eighteen children who had been taught by means of Cued Speech for four years or more in a school in Australia served as subjects. Their performance under various conditions of speech stimulus presentation was measured by means of tests especially constructed for the purpose. The scores on these tests, and their relationship to the various characteristics of the subjects provide the data which will be presented and discussed in the following pages.

Chapter 2.

REVIEW OF THE LITERATURE

This study is concerned with various aspects of speech reception by profoundly hearing-impaired children. It was designed to investigate lipreading ability, the use of residual audition, the effects of combining audition and lipreading, and the contribution of Cued Speech. The following review therefore focusses upon each of these areas, particularly as it relates to work with profoundly hearing-impaired subjects and their ability to process spoken language.

Lipreading

Lipreading is the art of understanding speech through interpretation of the visible articulatory movements of a speaker (Nitchie, 1913). Because movements of the face, tongue, jaw and throat play a part in visual speech reception, and language offers contextual information, some writers (e.g. Berger, 1972), consider the term "speechreading" to be a more appropriate label for the task. The term lipreading is used throughout this report as it also remains in common use (Schow and Nerbonne, 1979).

Those who have limited hearing generally have to rely upon lipreading to compensate as far as possible for their auditory deficits. Totally, or near totally deaf persons may find themselves completely dependent upon it. Current knowledge relating to the lipreading of consonants, of vowels and of running speech under various conditions is briefly reviewed.

Consonant Reception

Numerous studies have investigated the adequacy of the visual modality for the reception of speech (see Berger, 1972, for a detailed review). Many consonants that are acoustically distinct (e.g. /p/ and /b/), can not be differentiated visually as they are formed with the same articulatory movements. Other sounds are produced too far back in the oral cavity to be clearly visible (e.g. /k/ and /g/). The influence of different vowel and consonant environments in coarticulation further reduces the accuracy of consonant reception. Blends, or consonant clusters, are frequently interpreted as single phonemes (Franks and Kimble, 1972) and the open-vowel /a/, affords higher levels of intelligibility than either the front or back vowels, /u/ and /i/ (Erber, 1971a; Pesonen, 1968). These factors result in a filtering of speech so that fewer consonants are available in lipreading than can normally be heard.

Woodward and Barber's (1960) classic study first established the phonemes that can be clearly differentiated visually in syllables with /a/. They found four groups of homophenous consonants; that is, consonants that look alike. These were:

1. p, b, m.
2. f, v.
3. w, r.
4. t, d, n, l, θ, ð, s, z, ʃ, ʒ, tʃ, dʒ, j, k, g, h.

These four groups correspond to the articulatory classifications bilabial, rounded labial, labio-dental and non labial.

Some workers have challenged Woodward and Barber's original classification in subsequent research. Various studies have shown that the number of visually contrastive groups, termed visemes by Fisher (1968), may range from four to twelve (Berger, 1972, pp. 96-97; Binnie, Montgomery and Jackson, 1974; Binnie, Jackson and Montgomery, 1976; Fisher, 1968; Walden, Prosek and Worthington, 1974). Most studies conducted under everyday viewing conditions indicate that relatively few viseme groups are available to the lipreader. Fisher (1968), who presented consonants in both initial and final position, found five viseme groups. A fifth group, one additional to those described by Woodward and Barber (1960), was formed by either /k/ and /g/ in the initial position, or /s, t, dʒ, ʒ/ in the final position. Five viseme groups with initial consonants were also found by Binnie et al (1974). These were:

1. p, b, m.
2. f, v.
3. θ, ð.
4. ʃ, dʒ.
5. s, z, t, d, n, k, g.

However, the basic consistency of Woodward and Barber's original classification was confirmed by Walden et al (1974). Virtually all of their subjects obtained a high degree of homogeneity of performance in the visual reception of consonants, with responses falling into the original four groupings. Only a few could distinguish a greater number.

Under exceptional viewing conditions, ability to lipread consonants can be substantially improved. Binnie et al (1976), conducted an experiment with flood lighting arranged at an angle of 45 degrees,

three feet from the speaker's lips. The improved visibility of tongue movements allowed the subjects to differentiate 9 viseme groups. The groupings yielded under these conditions were as follows:

1. p, b, m.
2. f, v.
3. w.
4. r.
5. θ, ð.
6. l, n.
7. ʃ, ʒ.
8. t, d, s, z.
9. k, g.

These researchers considered that testing under optimal lighting conditions was a useful means of identifying individuals who experience difficulty in discriminating place of articulation, and who could benefit from training in the visual discrimination of consonants in nonsense syllables. In several research studies, live presentation of the stimulus materials has yielded better results for lipreading than those obtained for the same materials when they have been video-taped or filmed. Such differences in lipreading performance have been attributed mainly to the added difficulty caused by presenting a two- rather than a three-dimensional image of the speaker's face (Berger, 1972, pp. 69-175).

The effects of training on consonant recognition were studied in an experiment by Walden, Prosek, Montgomery, Scherr and Jones (1977). Their purpose was to determine whether subjects could learn to discriminate consonants that fall within each viseme group. They utilised programmed instruction techniques with immediate feedback to provide knowledge of correctness. Their stimuli were pairs of "same" or "different" syllables. The training resulted in an overall increase of 24% in lipreading performance over a two week training period. On pre-training tests,

the subjects could distinguish five viseme groups, whereas they could differentiate nine following the 14 hours of instruction given. There is no evidence that analytic training of the type employed in this study results in improved lipreading performance with sentence or discourse materials. However, the authors suggested that higher levels of consonant recognition could be beneficial in reducing the ambiguities in sentence contexts.

Among the few studies on the lipreading of consonants that have employed children as subjects, those of Erber (1971a, 1972a), Heider and Heider (1940) and Pesonen (1968) are the most important. Performance in the first two of these studies was shown to vary little with chronological age over several grades or length of time in school programs in which lipreading was emphasised. Erber's (1971a, 1972a) studies indicated that children's scores were optimal at a distance of 5 feet from the speaker and better in the context of the vowel /a/ than in the contexts of either /i/ or /u/: also, that both normally hearing and hearing-impaired children were able reliably to discriminate the place, but not the manner of voicing characteristics of consonants through vision. In summary, these studies show that the speechreading of consonants among children is similar to that among adults. Scores average about 30 percent under everyday lighting conditions and confusions of consonants are made principally within the four viseme groupings described by Woodward and Barber (1960).

Vowel Visemes

The visual reception of vowels has received less attention than the lipreading of consonants. Nitchie (1950, p. 47) considered that most vowels are visually distinct. However, Heider and Heider (1940) and Berger (1970), among others, have shown that this is not the case. Vowels tend to be confused with their adjacent tense or lax counterparts, more so in running speech than in isolation (Berger, 1972, p. 79).

Heider and Heider (1940) found that vowel recognition is more closely related to everyday lipreading performance than is consonant recognition. They also found that improvement in vowel recognition could be achieved through training. Whereas, with training, finer and finer distinctions could be made among vowels, consonant reception tended to remain categorical within viseme groupings. Berger (1970) reported that there were relatively few visual confusions among back and front vowels, and high and low vowels. He concluded that about 9 vowel viseme groupings can be differentiated. This was not confirmed by Jeffers and Barley (1971), who found that their subjects could distinguish 4 vowel viseme groupings under normal viewing conditions (namely spoken in connected speech, at an average rate and with normal articulation), and 7 vowel groupings with slow speech rate and accentuated lip movements.

The most recent approach to the study of vowel reception has been to define the visual distinctive features underlying the lipreading of vowels and diphthongs. To this end, Jackson, Montgomery and Binnie (1976), used a multi-dimensional scaling technique. They found that the

resulting perceptual dimensions correlated closely with physical measures of lip shape and position. The lip separation and size of mouth opening were the mostsalient characteristics used for vowel identification. The vertical movement together with the size of the mouth opening for the second vowel nucleus were used to identify the diphthongs.

In speech, consonants and vowels are coarticulated. It is not, therefore, surprising that Pesonen (1968) and Erber (1971a) found that vowel context affects consonant reception. They noted that alveolar and velar consonants tend to be masked by the teeth and the lips to a greater extent in the context of the vowels /u/ and /i/ than in the context of /a/. This point is emphasised, since it is relevant to the design and results of the present study.

Linguistic Context

The reception of phonemes in syllables bears only a limited relationship to their reception in meaningful linguistic contexts. Even with an intact auditory system, it is apparent that we do not receive completely unambiguous cues on all the phonemes in the speech stream (Foss and Hakes, 1978, p. 93). Analysis-by-synthesis models of auditory speech perception (e.g. that of Stevens and House, 1972) state that the context of the speech utterance serves to clarify the missing or ambiguous elements. The same could be true of speech reception through lipreading. The information stored in long term memory on the phonological, lexical, semantic and syntactic systems of language interacts with the incoming speech signals in the listener's active search for meaning (Miller, Heise,

and Lichten, 1951; Ling, 1978). This process enables one to perceive speech, not as a series of distinct phonemic units, but as units of meaning conveying information on the speaker's intent. Furthermore, the listener, while attending to the acoustic signal actually tries to predict in advance what parts are likely to be the most informative (Foss and Hakes, 1978, pp. 96-97).

Liberman (1974) has cast doubts on the possibility that the eye, or the skin, could be a completely adequate substitute for the ear as a pathway for the reception of speech. Thus, according to Liberman, the speech decoding mechanism described in the previous paragraph is primarily adapted for analysing acoustic signals, and the non-auditory modalties of vision and touch may not have access to it. He considered lipreading to be an exception, as there is at least partial phonemic information conveyed in the visible articulatory movements.

Research studies investigating the visual reception of speech in meaningful contexts with normal listeners as subjects show that the processes of speech perception are hampered by the paucity of visible information. Performance of subjects with sentence materials from the Utley Test of Lipreading (Utley, 1946) is generally around 30% (Clouser, 1977; Bode, Nerbonne and Sahlstrom, 1970; Hardick, Oyer and Irion, 1970). The reception of discourse materials is much more impoverished. For example, Hardick, et al (1970), using the Utley (1946) story test, found that their normally hearing subjects were able to perceive only 4.49% of the material accurately. Similarly, Binnie (1974) found that 6.8% of discourse material could be identified by normally hearing subjects. No studies of discourse reception through lipreading by skilled

lipreaders have yet been reported. New strategies for measurement of discourse such as the tracking technique utilised by Sparks, Ardell, Bourgeois, Wiedmar and Kuhl (1979) may stimulate such research.

The variables that influence the synthesis of information in visual speech reception have received considerable attention. The visibility of words and the interaction of higher order language processes was the subject of research by Albright, Hipskind and Schuckers (1973). They measured the reception of matched pairs of English and "Slurvian" sentences: for example, "Always be polite" - "Ah waits beep a light". The pairs were "phonemically similar, and therefore of approximately the same visibility value, yet different in linguistic form". The authors concluded that the superior performance for the English sentences was due to linguistic processing, rather than the visibility levels of the words. The lack of linguistic constraints in the Slurvian counterparts necessitated word level perception, and thus restricted predictability of the other units.

Such variables as sentence length, complexity and familiarity have also been the subject of investigation. Results from one study showed that short 3 word sentences were easier to lipread than longer ones of 6 or 9 words, (Clouser, 1977). Simple kernel sentences have been found to present less difficulty to the lipreader than sentences containing either single or double-based transformations (Fehr and Trotter, 1975; Hannah, 1974), and there is a significant correlation between sentence familiarity and relative lipreading ease (Lloyd and Price, 1971). The implications of results from these and previously mentioned studies indicate that, for lipreaders with normal language

abilities, linguistic context can provide at least some information on the missing or ambiguous elements in running speech.

Erber (1976) suggests that, in contrast to adults with normal language, children in the process of acquiring language do not have "sufficient knowledge of typical language patterns to make use of contextual information." They are more dependent upon the reception of the acoustic-optical signal itself. To investigate the effects of linguistic context on the responses of 15 profoundly hearing-impaired children aged 13-16 years, Erber (1976) presented both key words in sentences and those same words in isolation. The intelligibility of the words in isolation was higher (80%) than the words in sentences (46%). Erber's results suggest both that lipreading is an ineffective means of acquiring language and that relatively high levels of linguistic skill may be essential before linguistic context can aid the lipreader. "The general question of how profoundly hearing-impaired children can acquire language most efficiently through lipreading aided by other sensory input therefore remains the crucial issue" (Erber, 1974, p. 107).

Audition

There are relatively few totally deaf children (Boothroyd, 1970; Elliott, 1967; Ling, 1964a), the majority have some useful residual hearing. Technological advances in hearing aids over the past few decades have made it possible for profoundly hearing-impaired children (those with hearing levels greater than 90 dB), to receive at least some aspects of speech through audition. Although such children's

audition alone is rarely adequate for everyday communication, the utilisation of residual hearing is widely recognised as a vitally important component in their acquisition of communication skills (Ross and Giolas, 1978).

Research on profoundly hearing-impaired children's auditory capabilities is limited (see Stark (1974) for a detailed review). Most work on auditory speech reception by hearing-impaired listeners has been carried out with adults who have had moderate or severe hearing loss (for details see Pickett, Martin, Johnson, Smith, Daniel, Willis and Otis, 1972). In general, studies have shown that the configuration of subjects' audiograms can be used to predict the type of errors that are likely to be made in speech reception. The quantity of such errors, however, tends to be idiosyncratic, although error rates increase in direct proportion to hearing levels (Bilger and Wang, 1976). One may, therefore, within certain limits, consider hearing impairment as being akin to an acoustic filter. For example, if the "filter" attenuates or excludes high frequency sounds, then they will not be audible and errors on fricatives and unvoiced stops will be likely to occur. Whether sounds passed by the "filter" will be discriminable will depend upon other factors such as the integrity of the subjects' residual audition and central nervous system (Ling, 1978).

In the absence of definitive studies, profoundly deaf childrens' potential for auditory speech reception remains a speculative matter. Some writers, such as Boothroyd (1978), Ling (1978), Sanders (1971) and Whetnall and Fry (1971), consider that many profoundly hearing-impaired children can, under good listening conditions and with appropriate

training, learn to receive speech much as normally hearing people receive it when it is low-pass filtered. They consider that, when properly fitted with hearing aids, profoundly deaf children should be able to detect, discriminate, identify and comprehend speech within the range of their audition, using some of the acoustic cues that have been specified as crucial in studies of speech synthesis (Stevens and House, 1972), acoustic phonetics (Ling and Ling, 1978), and auditory speech perception by normally hearing persons (Studdert-Kennedy, 1970; Foss and Hakes, 1978). The main acoustic cues for the reception of the different aspects of speech are briefly surveyed below.

The Acoustic Aspects of Speech

The suprasegmental aspects of speech, intonation, stress and rhythm, are conveyed by changes in frequency and intensity of the speech waveform over time. Children with no hearing beyond 500 Hz can hear the suprasegmentals as most of the information on voicing is present below 300 Hz (Ling, 1964b).

Hearing for time/intensity information by profoundly hearing-impaired children has been demonstrated by Erber (1972b). In an experiment using common nouns as stimuli, he modified the speech signal by eliminating the spectral information. The remaining wave-form envelope comprised only time/intensity information. When this signal was provided together with the visual pattern, a mean increase of 7% in speech reception scores over lipreading alone was achieved. Similar increases have been demonstrated when lipreading has been combined with tactile stimuli;

thus, Boothroyd and Cawkwell (1970), Erber (1974, p. 22) and Nober (1967) have considered that many profoundly deaf children's thresholds might be of tactile rather than auditory origin. Stressing this likelihood, Erber (1974, p. 48) suggested that profoundly deaf children have the ability to perceive time and intensity cues in speech but not to discriminate small differences in frequency or rapid frequency changes, i.e. the spectral changes which are characteristic of speech. Erber's results can not, however, be interpreted as evidence that all profoundly deaf children have only tactile thresholds or are unable to use frequency information. Risberg and Agelfors (1978), among many others (see Stoker (1977) for a detailed review), have shown that some profoundly deaf children have difference limens for frequency of as much as 40% but many for as little as 5-7%. Even a 40 percent difference limen for frequency should allow hearing impaired children to perceive broad intonation patterns, which often cover a range of over half an octave (Lieberman, 1967). Furthermore, hearing-impaired subjects who initially have poor frequency discrimination may substantially improve with training (Gengel, 1969; Risberg and Agelfors, 1978).

The vowel formants are the peaks of energy that occur when the harmonics of the fundamental frequency of the voice are filtered and resonated in the vocal tract during phonation. All vowels have a first formant resonance below 1,000 Hz and can therefore be detected by children with hearing under that frequency (Ling, 1976). Reception of both first and second formants, however, is essential for identification of the vowels by normal listeners (Delattre, Liberman, Cooper and Gerstman, 1952). Owens, Talbott and Schubert (1968) have also found that hearing-

impaired persons require hearing extending to 3 kHz, the upper limit of F2 for the vowels, if these sounds are to be consistently identified correctly.

The consonants are classified according to their voicing, place and manner of articulation. Acoustic cues for both voicing and manner are spread over a broad spectrum of frequencies, and are contained in the time/intensity patterns of speech (Boothroyd, 1978). Perceptual confusions among consonants made by normally hearing subjects under varying signal to noise ratios were studied by Miller and Nicely (1955). They found that the features of nasality, voicing and affrication could be differentiated on the basis of low frequency information below 1 kHz. Nasality and voicing were particularly resistant to distortions of the signal, and each feature could be distinguished on the basis of cues under 500 Hz.

Contrasting results have been obtained when profoundly hearing-impaired children were tested for discrimination of voicing and nasality cues. One experiment used consonants from each class of sounds in syllables with /a/ as stimuli (Erber, 1972a). The random nature of the responses when audition alone was used indicated that these children could not classify the sounds on the basis of low frequency cues available. Results from other experiments show that children with losses exceeding 90 dB can detect and discriminate these cues (Bennett and Ling, 1977; Boothroyd, 1976). Ling (1974, p. 52) suggested that Erber's subjects' failure to discriminate such distinctions might be due to their lack of adequate training, since Aston (1972) had found that training resulted in marked improvements in ability to discriminate nasality and

voicing features.

The importance of training has recently been demonstrated in two studies, one by Lieberth and Subtelny (1978), and the other by Novelli-Olmstead (1979). Both investigated Ling's (1976) hypothesis that training in speech production would lead to improvements in speech perception. This hypothesis was based upon the Motor Theory proposed by Liberman, Cooper, Shankweiler and Studdert-Kennedy (1968). According to this theory, speech is in part perceived through reference to the listener's knowledge of his own speech acts. Lieberth and Subtelny (1978) worked with 58 profoundly hearing-impaired young adults. In the course of learning speech over a 20 week period, their subjects made mean gains of 17 percent in auditory perception as measured by a test of phoneme identification. The control group, who were not taught speech, made no such gains. It is possible that these results were due to their use of hearing during training rather than their learning speech as such. This possibility was covered in the study carried out by Novelli-Olmstead (1979). She worked with 7 pairs of children. One member of each pair actively learned to speak. The other listened, and was not encouraged to talk. Training over a six week period led to significant gains in auditory discrimination only for the seven subjects taught speech. These studies suggest that speech production skills should, if possible, be investigated when the speech reception skills of hearing-impaired children are being studied.

Linguistic Context. As in the case of lipreading, the number of phonemes available to profoundly hearing-impaired children through audition alone, relative to the total number in the language is greatly reduced (see above). Even those phonemes that can be heard by such children may not be identified on the basis of the same, or the same number, of acoustic cues available to normally hearing listeners (Boothroyd, 1978). As speech is a highly redundant signal, several acoustic cues serve to specify the same phoneme (Liberman, 1970). For example, a given plosive may be identified through reference to either the variant energy (vowel-to-consonant transitions) or the invariant energy (the burst following a period of silence), or both (Ling, 1976). (This may not be the case in lipreading, where only one visible pattern has to define a given phoneme or group of phonemes.) According to Fry (1978), the profoundly hearing-impaired child searches for those auditory cues within his range of residual audition that most effectively help him to identify each audible sound pattern. There are, however, some sounds that have no energy within a profoundly hearing-impaired child's auditory range, e.g. /s, f and θ/. The child must then learn to predict the presence of inaudible sounds from his knowledge of morphology. Without such knowledge predictions of this type can not be made.

The detection and the categorical identification of many acoustic patterns is then, impossible for profoundly hearing impaired children. As with lipreading, there is not enough information in the acoustic signal available to such children to permit them to learn language through audition alone. How far spoken language can be received through hearing will vary according to the extent of a child's residual audition.

Similarly, the extent of a child's residual audition will largely determine how well he can use hearing to help him disambiguate the lipread form. In normal everyday communication, profoundly hearing-impaired children are rarely called upon to rely solely on residual audition. Audition and vision combined are the usual means by which they receive speech in such contexts.

Audition and Vision

Skill in audio-visual speech reception is of paramount importance to profoundly hearing-impaired children as it permits communication in society at large through the use of spoken language. It has long been recognised that the combined use of the modalities is of benefit in speech reception (Clarke, 1957; Ewing, 1940). The auditory-visual reception of consonants, words and sentences has consistently yielded better results than reception by either modality used separately (Binnie, 1974; Erber, 1971b and 1972a; Numbers and Hudgins, 1948; Ross, Kessler, Phillips and Lerman, 1972; Risberg and Agelfors, 1978; Walden, Prosek and Worthington, 1974).

In a review of studies concerned with determining the relative contributions of the two modalities in auditory-visual speech reception, Erber (1974, p. 19), showed that, among profoundly hearing-impaired children, the increase in scores resulting from the addition of audition to lipreading is typically from 1 to 15 percent. Erber concluded that such children's use of audition served merely as a supplement to lipreading.

Individual performances of persons with similar hearing levels and audiometric configurations however, can vary greatly (Risberg and Agelfors, 1978). Such variance is illustrated in an experiment by Seewald and Ross, (1978). They tested six profoundly hearing-impaired children's discrimination of words within closed sets of four items, through audition, vision and audition plus vision. Two children, both with pure tone averages of 100 dB over the frequencies 500 Hz, 1 kHz and 2 kHz, scored 12% and 48% on auditory reception, 76% and 60% on visual reception, and 60% and 80% on audiovisual reception respectively. Another child with similar average hearing levels (102 dB), scored 80% through audition, 72% through vision and 96% with audition and vision combined. Similarly divergent scores for the auditory-visual reception of consonants in syllables and of words have been found with hearing-impaired adults (Owens, 1978; Walden et al, 1974). These workers considered the variances to be due mainly to differences in the subjects' use of audition rather than lipreading.

A major issue concerning the use of sense modalities has persisted in the field of aural rehabilitation since hearing aids were first commonly used by children in the 1950's. Although most oral educators have considered the use of both modalities to be essential, there have been divergent opinions as to which one should receive primary emphasis and when. Whereas residual hearing has been regarded as a supplement to lipreading by some (Erber, 1972a; Risberg and Agelfors, 1978), lipreading has been regarded as a supplement to residual hearing by others (Pollack, 1970; Whetnall and Fry, 1971).

Traditionally, oral teaching methods have emphasised the development of profoundly hearing-impaired children's language and speech through the use of lipreading, supplemented by written material, natural gestures and situational context. Numbers and Hudgins (1948) reported, when hearing aids were first in widespread use, that some oral educators thought auditory training might interfere with the development of lipreading. Their own work, however, suggested that lipreading skills were not adversely affected by auditory training and that audition and lipreading yielded performances superior to that obtained by lipreading alone. Most modern workers, including Boothroyd, (1978); Ling, (1976); Ling and Ling (1978), Pollack, (1970); Wedenberg (1951) and Whetnall and Fry (1971), consider that the best results can be obtained by focussing upon the child's use of audition and allowing lipreading skill to develop spontaneously. Although these workers recognise that audition and vision are both essential for everyday communication, they stress audition as the primary avenue for the development of basic language skills, and maintain that such primacy can be preserved despite profound hearing loss.

The auditory approach is likely, as is any other single approach, to be suitable for some children, but not for others (Luterman, 1976). Several factors must be considered in order to select the most appropriate avenue for spoken language development including the age of detection, amount and utility of residual hearing, additional handicaps, parent participation and motivation, and the skill of the teacher/clinician in guiding speech and language development (Ling, Ling and Pflaster, 1977; Ling and Ling, 1978). At present, however, there are no generally accepted criteria for gauging progress. Nor are there tools for evaluating

if a child's speech reception abilities are adequate for the reception and development of spoken language (Erber, 1977). Erber suggests that diagnostic evaluations of speech reception ability should be both at the level of syllables or words, for accurate measures of phoneme reception, and also within the context of running speech using either sentence or discourse materials. In the absence of such diagnostic information, many children with inadequate speech reception abilities are identified late in their schooling as having failed to acquire sufficient language and reading skills to progress academically (Ivimey, 1977). Thus, by the time they are identified they have missed the vitally important years of infancy during which spoken language is normally developed through parent-child interaction (Ling and Ling, 1978).

Two main approaches to presenting additional information as a supplement to speech which can be employed from early infancy, are currently being explored. These are the use of tactile aids and Cued Speech. Work with the former is still in its infancy, and so far has yielded disappointing results (Sparks et al, 1979). Cued Speech has been adopted in some programs for hearing-impaired children, but the effects of its use have not been studied sufficiently. The evaluation of Cued Speech as a tool for supplementing spoken language information is the central concern of the present study.

Cued Speech

The System

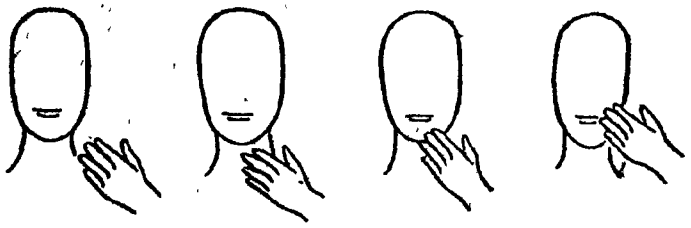
Cued Speech is an oral method of communication designed for use with the hearing-impaired (Cornett, 1967, 1972a). It employs a set of hand cues that, together with the lipread form, resolve the ambiguities among the phonemes in visual speech reception. The basic and unique principle of Cued Speech is that the hand cues merely supplement, and do not replace the information on the lips (Cornett, 1972b, p. 227).

The consonants are cued by 8 hand configurations. Each configuration represents a group of consonants that can be distinguished on the lips. For example, [l, w and ʃ] are visually contrastive consonants in lipreading and thus have the same cue. Conversely, the visually similar consonants [p, b and m] are identified by different hand cues. In this manner, all the consonants can be clearly differentiated by reference to both the lipread form and the accompanying hand cue.

The vowels are cued in 4 different positions; at the chin, the mouth, the throat and the side of the face. Each position contains a lip spread, a lip rounded and a lip open vowel which can be easily differentiated on the lips. For example, the hand position at the chin is the cue for [a, ɛ and u]. Diphthongs are cued by gliding from the position of the initial to the final vowel nucleus. The hand configurations and positions utilised in Cued Speech are shown in Figure 2.1.

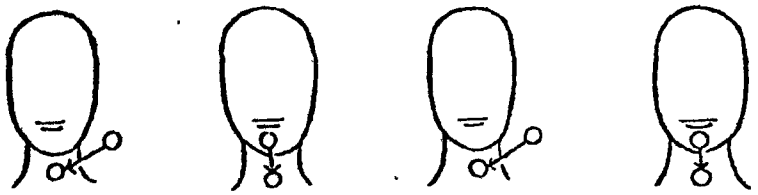
Cues for English Vowels

	Group I (base position)		Group II (larynx)		Group III (chin)		Group IV (mouth)	
open	[a:]	(fäther) (gŏt)	[a]	(thăt)	[o:]	(fôr) (ought)		
flattened-relaxed	[ʌ]	(but)	[i]	(ĭs)	[e]	(gĕt)	[i:]	(fēēt) (meat)
	[ə]	(the)						
rounded	[ou]	(nōte) (boat)	[u]	(gŏŏd) (put)	[u:]	(blue) (fōōd)	[ə:]	(ûrn) (hĕr)



Diphthongs

[ai] (might)	[ei] (pay)	[au] (cow)	[oi] (boy)
[a:] plus [i]	[e] plus [i]	[a:] plus [u]	[o:] plus [i]



Cues for English Consonants

T Group*	H Group	D Group	ng Group	L Group	K Group	N Group	G Group
t	h	d	(ng)	l	k	n	g
m	s	p	y (you)	sh	v	b	j
f	r	zh	ch	w	th (the)	hw**	th (thin)
					z		

*Note: The T group cue is also used with an isolated vowel—that is, an initial vowel not run in with a final consonant from the preceding syllable.

Figure 2.1. Hand configurations and hand positions used to cue the phonemes of English. (Reproduced from Cornett, 1967).

In running speech, the consonant-vowel hand cues are coarticulated in a one-to-one relationship with the syllables of the language. A sender is able to transmit the cues in real time synchronously with speech, thus conveying a visual analog of the syllabic-phonemic-rhythmic patterns of spoken language (Cornett, 1975).

The Purpose of Cued Speech

In designing Cued Speech, Cornett's main objective was to provide an accurate means of verbal communication for facilitating language development among hearing-impaired children (Cornett, 1972a, p. 213). He considered that if a child received verbal language patterns in a completely unambiguous form from his parents in early years, he would develop language in a manner similar to that of hearing children (Cornett, 1972b, pp. 228). In normal everyday situations, he would learn to associate meaning with the verbal patterns cued by his parents, and thus develop concepts in relation to his experience (Henegar and Cornett, 1971, p. 20; Lykos, 1971, p. 11).

Although the main purpose of Cued Speech is to develop language, Cornett (1967, 1972a,b) has claimed that it has several additional benefits. They include the notions that:

1. Cued Speech should, by focussing a child's attention on the lips, help to develop his or her lipreading ability without specific training in lipreading.
2. Children who have acquired language through the use of Cued Speech should be able to utilise linguistic/contextual

information to disambiguate the visual or audio-visual speech signal in the absence of cues.

3. The use of Cued Speech with a child should lead to the development of spoken language prior to any introduction of the written form.
4. Cued Speech should help the child to generalise speech production into spoken language as its use defines where specific patterns occur in speech.

Cornett (1975, p. 27) emphasizes, however, that Cued Speech cannot help a profoundly hearing-impaired child to actually produce sounds since it in no way reflects articulatory movements. He suggests that the production of speech sounds be taught in a parallel program. Cornett (p. 45) stresses also that, as Cued Speech is a visual system, the use of audition must be developed synchronously.

Since Cued Speech was first developed 12 years ago, Cornett has expressed the need for researchers to investigate the various claims he has made for its effectiveness (Cornett, 1972b, p. 229; 1975, p. 29). Only two studies specifically evaluating Cued Speech have been reported in that time, the first by Ling and Clarke (1975) and the second by Clarke and Ling (1976). In the first study, 12 children ranging in age from 7-11 years, served as subjects. All the children had been introduced to Cued Speech because they had failed to make adequate academic or linguistic progress with traditional oral teaching. Their speech reception of phrases and sentences was tested both with and without Cued Speech. The results indicated that the children were more proficient at receiving sentences with cues (12%), than without (5.8%), but their performance in

both modes was extremely limited. The second study was designed as a follow-up, one year later to evaluate progress. In this study, the subjects' mean score for the Cued sentence materials was 62%, an increase of 50% over the previous years' results. Furthermore their responses without Cues had increased to 19.4%. The substantial improvement in the children's speech reception ability demonstrated by these results provided compelling evidence for the effectiveness of Cued Speech as a tool for clarifying the spoken message. It also supported Cornett's claim that Cued Speech would enhance speechreading ability in the absence of cues (Cornett, 1975).

Concern was expressed, however, by Clarke and Ling (1976) over the finding that the subjects' scores with and without the use of audition were not significantly different. They suggested that the use of Cued Speech might have focussed attention exclusively on visual input and thus prevented the children's development of auditory skills. Further research was considered necessary to determine whether acoustic information could in fact be utilised as a supplement to lipreading by profoundly hearing-impaired children who had been taught through the used of Cued Speech.

The writer suggests that such research would have implications beyond the used of Cued Speech. Any supplementary aid (such as a tactile device) might also affect a profoundly hearing-impaired child's use of residual audition or vision in speech reception.

The Present Study

The present study was designed to compare and contrast the performance of profoundly hearing-impaired children under 7 conditions of speech reception. These were:

1. Audition (A).
2. Lipreading (L).
3. Audition and Lipreading (AL).
4. Cues (C).
5. Audition and Cues (AC).
6. Lipreading and Cues (LC).
7. Audition, Lipreading and Cues (ALC).

The specific questions investigated were as follows:

1. How well can children receive linguistic information by means of Cued Speech and what is the effect of the prolonged use of this system on their use of audition and lipreading abilities.
2. If we find that the simultaneous use of two modalities enhances phoneme reception in nonsense syllables or words, can we assume that similar enhancement will occur in running speech? (Ling, 1976).
3. What correlations exist between speech perception, speech production and linguistic skills?

In order to carry out this work, an original test of speech reception was designed and constructed. It included materials for testing phoneme reception in syllables and the perception of key words in high predictability and low predictability sentence contexts. These materials were videotaped and are available for use in further studies requiring measurements of speech reception skills.

Chapter 3

METHOD

Subjects

A group of 18 children, 12 boys and 6 girls served as subjects. They were drawn from St. Gabriel's School for Hearing Impaired Children, Sydney, Australia, where Cued Speech has been the principal means of communication since 1968. All children in the age range 9 to 16 years, who had been in this program for at least 4 years, were included in the study.

The children were profoundly deaf with pure tone averages in the better ear, over the frequencies 500 Hz, 1 kHz and 2 kHz ranging from 97 dB to 122 dB (I.S.O.). Data relating to each subject's hearing loss is specified in Table 3.1. This table shows that of the 18 subjects, 6 had no measurable hearing beyond 1 kHz.

Table 3.2 provides specific information on family history and educational background. The age when hearing aids were first worn varied from 3 months (Subject 6), to 5 years (Subjects 9 and 13). Five children, (Subjects 1, 9, 11, 12, and 13), had no pre-school training, but the rest had attended oral pre-school programs which offered guidance on a one hour per week basis. On reaching school age, 13 children began at St. Gabriel's or other oral programs, and 5 (Subjects 2, 5, 10, 12 and 17) attended a school where speech, finger-spelling and signs were used. These children joined the Cued Speech program at St.

Table 3.1 Hearing levels (ISO) of each subject in dB at the five frequencies 250, 500, 1000, 2000 and 4000 Hz. The pure tone average (P.T.A.) for each ear over the frequencies 500, 1000 and 2000 Hz is shown in the column at the right. For averaging, non response was calculated as 125 dB.

Subject	Ear	250	500	1000	2000	4000	P.T.A.
1	L	80	85	100	105	-	97
	R	80	85	95	-	-	101
2	L	80	90	100	105	110	98
	R	75	95	105	110	-	103
3	L	85	85	100	110	100	98
	R	85	85	100	110	110	98
4	L	90	85	105	105	105	98
	R	90	95	105	115	115	98
5	L	75	85	110	-	110	107
	R	80	85	105	110	-	100
6	L	75	85	105	110	-	100
	R	75	85	105	110	110	100
7	L	80	90	105	-	-	107
	R	80	85	100	-	-	103
8	L	90	100	110	115	110	108
	R	95	100	100	110	-	103
9	L	80	95	100	115	115	103
	R	80	100	105	115	115	107
10	L	85	85	110	-	-	107
	R	85	90	110	115	115	105
11	L	95	100	115	-	-	113
	R	80	90	100	-	120	105
12	L	85	95	110	-	110	110
	R	70	85	105	-	95	105
13	L	80	95	110	115	115	107
	R	85	100	110	115	-	108
14	L	70	85	-	-	-	112
	R	75	100	105	-	-	110
15	L	95	110	-	-	-	120
	R	90	105	120	-	-	117
16	L	80	105	-	-	-	118
	R	80	100	-	-	-	117
17	L	95	110	-	-	-	120
	R	-	-	-	-	-	-
18	L	90	115	-	-	-	122
	R	90	115	-	-	-	122

Table 3.2 Summary of Characteristics Relating to Each Child. An asterisk beside a subject indicates the presence of a learning disorder (see text for further details).

Subjects	Chron. Age at Testing	P.T.A. dB Better Ear	Cause of Hearing Loss	Age when hearing aids first worn	Type of Pre-School Program	Age when first began Cued Speech	No. of family members using Cued Speech	Teacher's Rating of Intelligence
1	10:4	97	Viral infection at 15 months	3:11	Nil	4:0	3	5
2	12:10	98	Pre-natal Haemorrhage	1:3	Oral parent/ infant	7:6	2	5
3	13:3	98	Rubella	1:2	Nil Boarded at 3 yrs. in oral program	8:10	0	5
4	13:10	98	Rubella	1:10	Oral parent/ infant	5:3	1	5*
5	14:6	100	Mumps at 10 mos.	2:0	Oral parent/ infant	8:1	2	2
6	13:1	100	Rubella	0:3	Oral parent/ infant	5:6	2	6*
7	13:3	103	Rubella	1:6	Oral parent/ infant	3:10	1	4*
8	15:2	103	Rubella	0:10	Oral parent/ infant	5:7	2	2
9	16:9	103	Influenza	5:0	Nil	6:4	0	7*
10	13:2	105	Rubella	1:5	Oral parent/ infant	8:7	2	3
11	14:6	105	Heroditary	2:0	Nil	5:1	0	3
12	13:3	105	Rubella	3:0	Nil	8:10	1	5
13	14:6	107	Hereditary	5:1	Nil	5:1	0	2
14	13:4	110	Rubella	2:0	Oral parent/ infant	7:11	1	3*
15	9:2	117	Rubella	2:00	Oral + Cued Speech	2:0	2	2
16	15:1	117	Meningitis at 14 months	1:10	Oral parent/ infant	5:0	0	4
17	14:2	120	Meningitis at 21 months	3:0	Oral parent/ infant	9:7	1	2
18	16:6	122	Hereditary	1:7	John Tracy Correspondence	7:11	5	3

Gabriel's between 6 and 9 years of age.

The earliest age at which Cued Speech was first used with a child was 2 years (Subject 15), the latest, 9 years (Subject 17). Table 3.2 also indicates the number of family members who communicated with each child using Cued Speech.

As no formal intelligence scores were available for all children, teachers rated the Subjects on a 9 point scale: 1 - 3 below average, 4 - 6 average and 7 - 9 above average. These ratings showed that all but one of the children were of average or above average intelligence. Five children were also judged by the teachers to have learning difficulties in addition to hearing impairment.

Materials and Apparatus

Syllables

Twenty-eight consonants were drawn from each class of sounds. These consonants were p, t, k, b, d, g, m, n, f, v, l, r, w, j, θ, ð, s, z, ʃ, h, tʃ, dʒ, p̄, t̄, k̄, b̄, d̄, ḡ and included released and unreleased stops. They were combined with the back, middle and front vowels [u], [a] and [i] in CV (consonant-vowel) or VC syllables. These syllables were repeated, for example [pa/pa], [it̄/it̄], to ensure that the transitions between consonants and vowels were optimally salient. Three consonants [ʒ], [ŋ], and [ʍ] were not included as they do not occur in these three vowel contexts in the English language. Each list contained 84 stimulus items, 28 consonants combined with the three vowels. They were randomly

arranged seven times to provide a different order for each of the seven conditions: Audition (A), Lipreading (L), Audition and Lipreading (AL), Cued Speech (C), Audition and Cued Speech (AC), Lipreading and Cued Speech (LC) and Audition and Lipreading and Cued Speech (ALC). An example of one of the syllable lists utilised in the experiment is presented as Appendix I.

Key Words in Sentences

Key words in sentences were chosen as stimuli to measure speech reception in a linguistic context. As it was essential to ensure that unfamiliar vocabulary items and sentence patterns would not bias scores (Lloyd and Price, 1971), all sentence materials were specially constructed.

Selection of test words was accomplished by drawing over 300 monosyllabic nouns from the first three levels of the Basic Vocabulary and Language Thesaurus (Ling and Ling, 1977). Although these levels contain elementary vocabulary topics such as food, clothing and animals, knowledge of the words was tested by means of a picture-association vocabulary test, one month prior to the experiment. This test is presented as Appendix 2.

From this initial corpus of vocabulary, 108 items were selected for the experiment. They were divided into six groups, each containing 18 test words. An equal number of words with back, middle and front vowels were in each group, and consonants from all classes of sounds were distributed among them as evenly as possible.

Selection of the sentence patterns used in the study was

carried out through reference to the children's own expressive language. Sentence types were chosen from the language program used at St. Gabriel's School; namely, "Oral English", (Tate, 1972) and checked for expressive use through the analysis of language samples.

Test construction involving words in sentences was achieved by compiling six sentence lists of 36 items. The 18 test words were presented twice within each test. They appeared as the final word in both low predictability (LP) and high predictability (HP) sentence contexts (Kalikow, Stevens and Elliot, 1977).

Each low predictability sentence consisted of four words. The first three words, those preceding the test word, provided a prosodic pattern (question, statement or command contours), and a syntactic framework, but no semantic clues to the identity of the test words. Typical of the low predictability stimuli were sentences such as: "Where is my book?", "I like your hair.", "Go in that room."

The high predictability sentences consisted of five to nine words. They provided a prosodic and syntactic framework, and also semantic clues to the identity of the final test word. Examples of high predictability stimuli were sentences such as: "Mum's money is in her purse.", "Go to sleep in your bed." and "Is that a mouse or a rat?". Within each sentence list, the LP and HP sentences were randomly distributed. All six lists utilised in the experiment are presented as Appendix 3.

The materials were videotaped in colour by a professional team An Australian served as the speaker and used the cues that were appropriate for the Australian vowels. To provide an auditory condition, only the sound track of the videorecording had to be employed. Under the lip-reading and lipreading plus cues conditions the sound track was turned off. To present cues alone the material was recorded without speech or lip movement. The same procedure was employed in the audition plus cues condition and the sound was subsequently recorded in synchrony with the hand cues. The visual stimuli were equivalent across all conditions.

Apparatus

A Sony video taperecorder and colour television receiver with a 25" screen were used to present the speech reception test tapes. The auditory signal was fed into a custom built, four channel calibrated audio amplifier, developed at the National Acoustic Laboratory in Sydney, Australia. Four headsets with TDH 39 earphones housed in MX 41AR cushions were connected to the output channels. Each channel was capable of providing a sound pressure level of 130 dB. Output could be regulated for each child to within 1 dB of a selected level. Input to this amplification system could also be calibrated to within 1 dB. Since a 1 kHz calibration tone had been recorded on each videotape, this permitted highly reliable replication of sound levels from one test session to another.

Procedures

The subjects were tested in five groups of two to four children. They were seated in an arc four feet from the television screen, and positioned so that no child had more than 30% viewing angle. Each subject's most comfortable listening level (MCL) was determined in three trials and checked for reliability before testing began.

The syllable tests were presented first, with all groups receiving a different order of presentation to control for any learning effects. As the task in these tests was one of consonant identification rather than discrimination, the children were not

given a list of possible stimulus items. They were informed that the consonant sounds would be combined with a closed set of vowels, [u], [a] and [i] which they were to write in alphabetic spellings, i.e. oo, ar and ee. All consonant phonemes except for [ð] and [θ] could also be written with alphabetic spellings. For these two sounds, the children were requested to write th for [θ] and TH for [ð]. Five practise items were presented live before each test. Instructions were that the children write all the syllables and to guess if they were not sure. Each syllable list took twelve minutes to complete.

The key word in sentence tests were counterbalanced so that each group of subjects received a different sentence list under every condition. However, the same list was used for both Audition (A) and Lipreading (L) conditions as it was known that the children would barely distinguish the sentences through audition alone. This counterbalancing procedure is presented in Table 3.3. In addition, the conditions were presented in a random order to each group. Three practise items were given before the sentence tests, with instructions to write only the last word, and to guess if they were not sure. The 36 item lists each took eight minutes to complete.

Scoring

The syllable tests were scored by marking the responses with both the consonant and vowel in the right order, as correct. The correct responses associated with each of the vowels [a], [u], and [i] were tallied separately for each child and converted into percentage scores.

Groups	Conditions						
	L	AL	C	AC	LC	ALC	A
1	1	2	3	4	5	6	1
2	2	3	4	5	6	1	2
3	3	1	2	6	4	5	3
4	4	5	6	2	1	3	4
5	5	6	1	3	2	4	5

Table 3.3. The counterbalanced design used in the presentation of the sentence lists. The numbers given in the cells specify the sentence list used for each group under each condition.

The key words in sentences were marked as correct or incorrect. The correct responses for high predictability and low predictability sentences were also tallied separately for each child and converted into percentage scores.

Additional Measures

Additional independent variables relating to the children and relevant to this study were the adequacy of their hearing aids, their speech production abilities and levels of language acquisition. To measure these variables, the five sound test (Ling and Ling, 1978), and Phonetic and Phonologic Level Speech Evaluations (Ling, 1976) were administered, and oral language samples were obtained from each child.

The adequacy of the hearing aids was assessed in order to carry out the speech production tests. These assessments were made in accordance with the procedure outlined in Ling and Ling (1978). They revealed that, at the time of testing, all aids were functioning, twelve of the children were optimally fitted, and that six of the aids required some minor adjustment to provide a more appropriate frequency response. These results are vastly superior to those generally reported in the literature which shows that only a small proportion of hearing aids in schools for the deaf are even in actual working order at any given time. (See Ross and Giolas, 1978, pp. 280-281.) As the adequacy of aids would likely be a highly variable factor throughout a child's development (Zink, 1972), results obtained by testing hearing aids on this one occasion were not considered further in this research. (It was for this reason that an amplifier and headphones were used for the

speech reception tests in order to provide optimal listening conditions throughout the experiment (see below).

Phonetic Level Speech Evaluations were administered in a quiet, distraction-free room by a skilled examiner. The child's teacher was present throughout the assessments, and in each case verified that the results obtained represented the child's best performance. Phoneme targets consistently (✓) produced correctly were tallied to arrive at a score for these evaluations.

Phonologic Level Evaluations were carried out to assess speech production abilities within the context of spoken language. Oral language samples were obtained from each child in five different linguistic situations:

1. A conversation with parent or teacher focused upon a topic of interest to the child.
2. A description of the child's bedroom. The purpose here was to sample language used to describe spatial relationships.
3. A narrative about a sequence of pictures.
4. The sequencing of an activity.
5. Question responses to open-ended statements.

These samples were recorded on tape and the teachers transcribed what each child said. No predetermined figure was set for the number of utterances in a sample. All the children were given the same linguistic situations and could respond individually. Subject 17's sample contained 60 utterances which is the lower limit, whereas many samples contained

over 100 utterances.

Two skilled examiners made judgments from the tape recordings as to whether phonemes were consistently (✓) or inconsistently (+) present, or absent (-). Only those phonemes consistently present were tallied for the purposes of this research. The phonologic speech samples were then ranked by the two examiners for intelligibility.

The Language Measures were derived from the oral language samples. A corpus of 60 consecutive utterances drawn from each of the linguistic situations was used for these measures. Only those utterances that were both syntactically and semantically acceptable were analysed.

The score for a child's language sample was determined by both the length and complexity of each acceptable utterance. First, the number of words in each such utterance was counted. Next, its complexity was calculated by rating its content and clause structure from 1 (a single word utterance) to 7 (discourse style), according to the developmental stages outlined by Crystal, Fletcher and Garman (1976). The length and complexity ratings obtained were then combined into a single score by multiplication. Thus, for example, an utterance of four words rated at complexity level 5 resulted in a score of 20, and another utterance of five words with the same complexity rating resulted in a score of 25. Finally, the mean length x complexity score for each child was determined by adding these scores and dividing the total by 60, the number of utterances in the corpus. An advantage of this procedure was that it penalised subjects for producing syntactically or semantically unacceptable utterances since such utterances were not scored, but were included

in calculating the mean length x complexity rating. Four of the language samples are included as Appendix 4. They represent the range of linguistic abilities of the subject population and also illustrate the language scoring procedures.

Treatment of Results

Scores for each of the dependent variables, i.e. syllables in 3 vowel contexts and key words in high and low predictability sentence contexts were treated by means of separate analyses of variance. Significant main effects among results were then further analysed using the Newman-Keuls procedure (Keppel, 1973). Significant interactions were also analysed using a Test of Simple Effects (Keppel, 1973). Confusion matrices were constructed to depict the patterns of subjects' responses to the syllables presented under all conditions. Correlation coefficients between each independent and dependent variable were also calculated, as were rank order correlations between intelligibility and all other variables. Only those results which reached a .01 level of significance will be reported and discussed.

Chapter 4.

RESULTS

Conditions of Presentation

Scores obtained by the individual subjects for the syllables and the key words in sentences are presented in Tables 4.1 and 4.2. In this study, the primary interest was the relative efficiency with which the subjects were able to receive speech under the seven conditions of presentation. The differences that were obtained are illustrated in Figure 4.1. This Figure depicts the subjects' mean scores for the syllables and key words in sentences. Separate analyses of variance were carried out on the two types of materials. Summaries of these analyses of variance and the Newman-Keuls tests relating to each, are presented in Tables 4.3 and 4.4.

Syllables

Figure 4.1 shows that large differences were obtained among the conditions for the syllable materials. The results of the ANOVA indicate that these differences were significant beyond the .01 level. Under audition alone (A) the subjects' scores were negligible, whereas with lipreading and cues (LC), and audition, lipreading and cues (ALC) mean scores of over 80 percent were obtained. The Newman-Keuls test revealed that scores for audition alone (A) were significantly poorer than for all other conditions, and that scores for lipreading and cues (LC)

Table 4.1

Subjects' percentage scores correct for syllables under each condition of presentation

Subjects	A	L	AL	C	AC	LC	ALC
1	1.1	36.9	52.4	42.9	31.0	83.3	63.0
2	1.1	33.3	34.5	34.5	41.7	77.3	81.0
3	13.0	28.6	40.5	33.3	44.0	81.0	76.1
4	0	23.8	22.6	33.3	33.3	69.0	65.5
5	11.9	40.5	57.1	35.7	46.4	98.8	96.4
6	0	27.4	46.4	42.9	47.6	78.6	77.4
7	5.0	20.2	22.6	35.7	37.0	69.0	73.8
8	4.0	29.8	42.9	13.0	33.3	95.2	91.7
9	0	27.4	38.0	42.9	45.2	89.3	85.7
10	1.1	26.2	31.0	31.0	32.1	70.2	71.4
11	2.4	29.8	38.0	34.5	46.4	86.9	92.9
12	0	21.4	21.4	41.7	33.3	67.9	59.5
13	0	32.1	33.3	44.0	34.5	86.9	82.1
14	0	28.6	23.8	32.1	39.3	85.7	72.6
15	1.1	28.6	29.8	41.7	35.7	81.0	78.6
16	1.1	36.9	33.3	25.0	31.0	95.2	95.2
17	0	27.4	26.1	40.5	44.0	91.7	89.3
18	0	41.7	35.7	42.9	45.2	95.2	95.2

Table 4.2

Subjects' percentage scores correct for key words in sentences under each condition of presentation

Subjects	A	L	AL	C	AC	LC	ALC
1	2.8	25.0	72.2	33.3	66.7	100	100
2	2.8	38.9	38.9	52.8	61.1	77.7	97.2
3	5.6	19.4	52.8	41.7	77.8	100	97.2
4	0	30.6	22.2	75.0	52.8	100	91.7
5	8.3	61.1	72.2	63.9	61.1	100	100
6	0	33.3	50.0	41.7	66.7	100	91.7
7	2.8	22.2	72.2	41.7	69.4	97.2	97.2
8	0	47.2	58.3	38.9	52.8	100	100
9	2.8	19.4	27.8	38.9	63.9	86.1	88.9
10	0	22.2	44.4	41.7	72.2	94.4	97.2
11	2.8	27.8	72.2	55.6	80.6	100	97.2
12	0	30.6	16.7	52.8	69.4	91.7	100
13	0	5.6	33.3	50.0	50.0	91.7	88.9
14	0	25.0	44.4	30.6	55.6	91.7	94.4
15	0	30.6	13.9	50.0	63.9	100	97.2
16	0	30.6	47.2	25.2	52.8	100	100
17	0	30.6	50.0	55.6	69.4	100	91.7
18	0	36.1	19.4	52.8	66.7	100	94.4

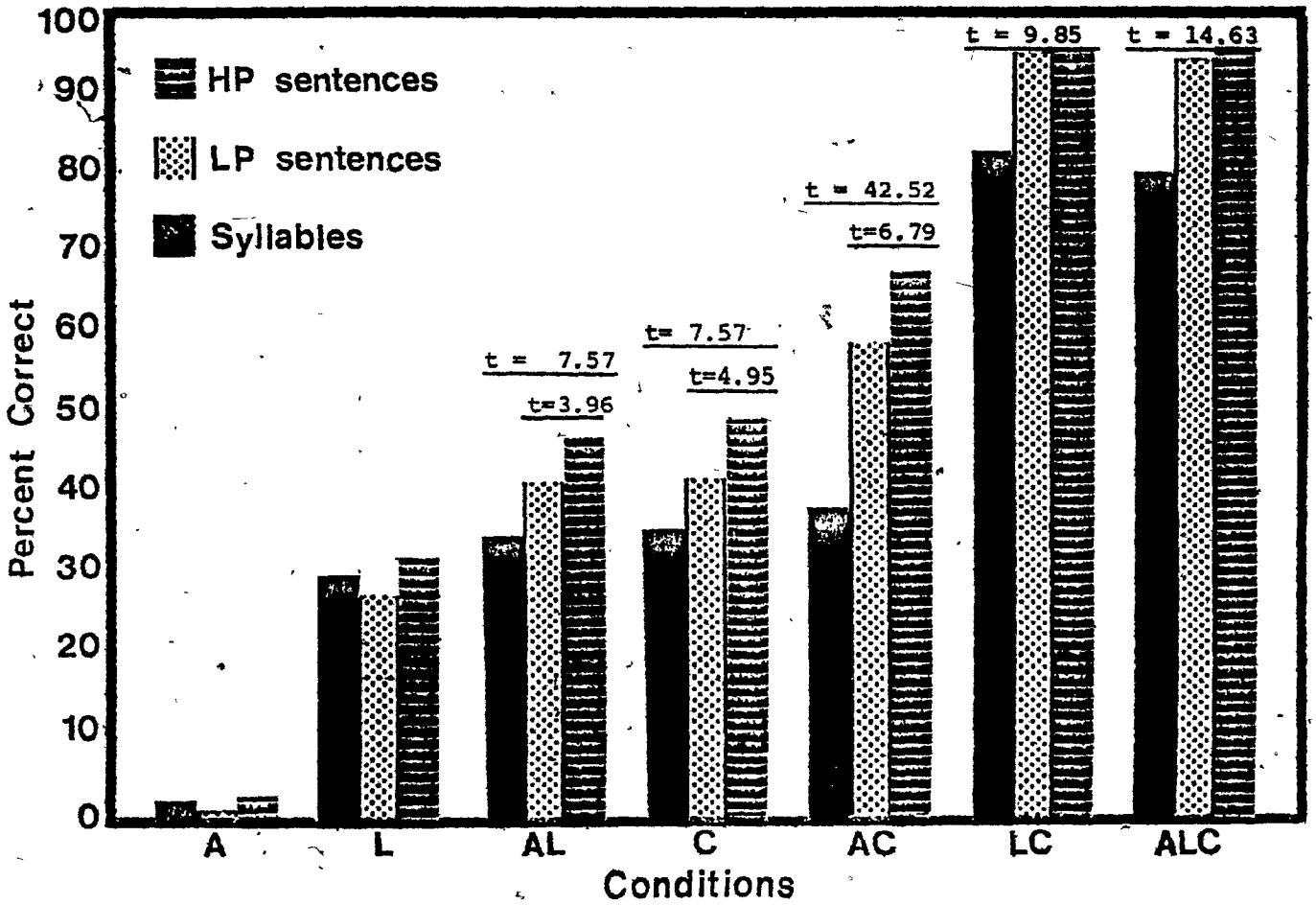


Figure 4.1. Mean scores for syllables relative to mean scores for key words in high predictability and low predictability sentences.

Table 4.3

Summary of the (A) Analysis of Variance and (B) Results of the Newman-Keuls Test of Subjects' Scores for Syllable Reception

(A)

Source of Variance	Mean Square	Degrees of Freedom	F
Conditions (C)	45362.95	6	327.31*
Error: SC	138.59	90	
Vowels (V)	991.38	2	14.47*
Error: SV	68.50	30	
C x V	165.51	12	3.65*
Error: SCV	45.33	180	

(B)

Conditions of Presentation							
A	L	AL	C	AC	ALC	LC	
-	17.06*	19.66*	21.13*	23.25*	48.85*	50.79*	A
	-	2.60	4.07	6.19*	31.79*	33.73*	L
		-	1.47	3.59	29.13	31.13*	AL
			-	2.18	27.72*	29.66*	C
				-	25.60*	27.54*	AC
					-	1.94	ALC
						-	LC

* Significant beyond the .01 level

Table 4.4

Summary of the (A) Analysis of Variance and (B) Results of the Newman-Keuls Test of Subjects' Scores for Key Words in Sentences

(A) Source of Variance	Mean Square	Degrees of Freedom	F
Conditions (C)	42509.42	6	187.42*
Error: SC	226.81	90	
Predictability (P)	1203.45	1	13.04*
Error: SP	92.24	15	
C x P	104.43	6	1.81 NS
Error (SPC)	57.68	90	

(B)

Conditions of Presentation							
A	L	AL	C	AC	ALC	LC	
-	11.18*	17.21*	17.83*	24.84*	37.49*	37.62*	A
	-	6.02*	6.65*	13.65*	26.31*	26.43*	L
		-	0.62	7.62*	20.28*	20.41*	AL
			-	7.00*	19.65*	19.78*	C
				-	12.65*	12.78*	AC
					-	0.12	ALC
						-	LC

* Significant beyond the .01 level

and audition, lipreading and cues (ALC) were significantly better than for all other conditions. There were no significant differences among the results for lipreading (L), audition and lipreading (AL), cues (C) and audition and cues (AC). Mean scores for these conditions ranged between 30 and 40 percent correct. The significant differences for the vowel context and vowel context x conditions shown in Table 4.3 will be treated later.

Key Words in Sentences

Significant differences ($p < .01$) were also found among the conditions of presentation for the key words in sentences (see Table 4.4). Figure 4.1 shows that the subjects' mean scores for the perception of these materials under the lipreading and cues (LC) and audition, lipreading and cues (ALC) conditions were 96 and 95 percent respectively. The Newman-Keuls test indicated that, in contrast to the results for the syllable materials, significant differences ($p < .01$) were obtained among all conditions except audition and lipreading (AL) and cues alone (C); and lipreading and cues (LC) and audition, lipreading and cues (ALC). There were significant increases in mean scores for audition and lipreading (AL) over lipreading alone (L), and audition and cues (AC) over cues alone (C). The subjects' performance for the audition and lipreading (AL), and cues (C) conditions was not significantly different. As in the case of syllables, the mean score for audition alone (A) was negligible. The significant difference relating to the predictability variable shown in Table 4.4 will be treated later.

The Effect of Vowel Context on Syllable Reception

The subjects' reception of consonant phonemes in the three vowel environments [a], [i] and [u], varied significantly. Mean scores for [a] and [i] were higher than for [u]. The significant interaction, plotted in Figure 4.2, shows how consonant reception was influenced by the vowel context to varying degrees under the seven conditions of presentation. A Test of Simple Effects indicated that the variances were significantly different only under five of the presentation conditions (L, AL, C, LC, ALC). The significant t scores obtained from this test are also shown in Figure 4.2. Mean scores for consonants were significantly poorer with the vowel [u] than with the vowels [a] and [i], under the L, AL, LC and ALC conditions. Under the C condition the poorest scores were associated with the vowel [a].

Confusion matrices of the subjects' responses for the consonant syllables with each vowel under each condition are presented as Appendix 5. These illustrate both the number of correct responses for the syllables and also the patterns of errors.

The Effect of Linguistic Context

The individual scores for perception of key words in high predictability and low predictability sentence contexts are presented in Table 4.5. The differences that were obtained relative to syllable reception and the predictability of the key words in sentences under the various conditions of presentation are illustrated in Figure 4.1.

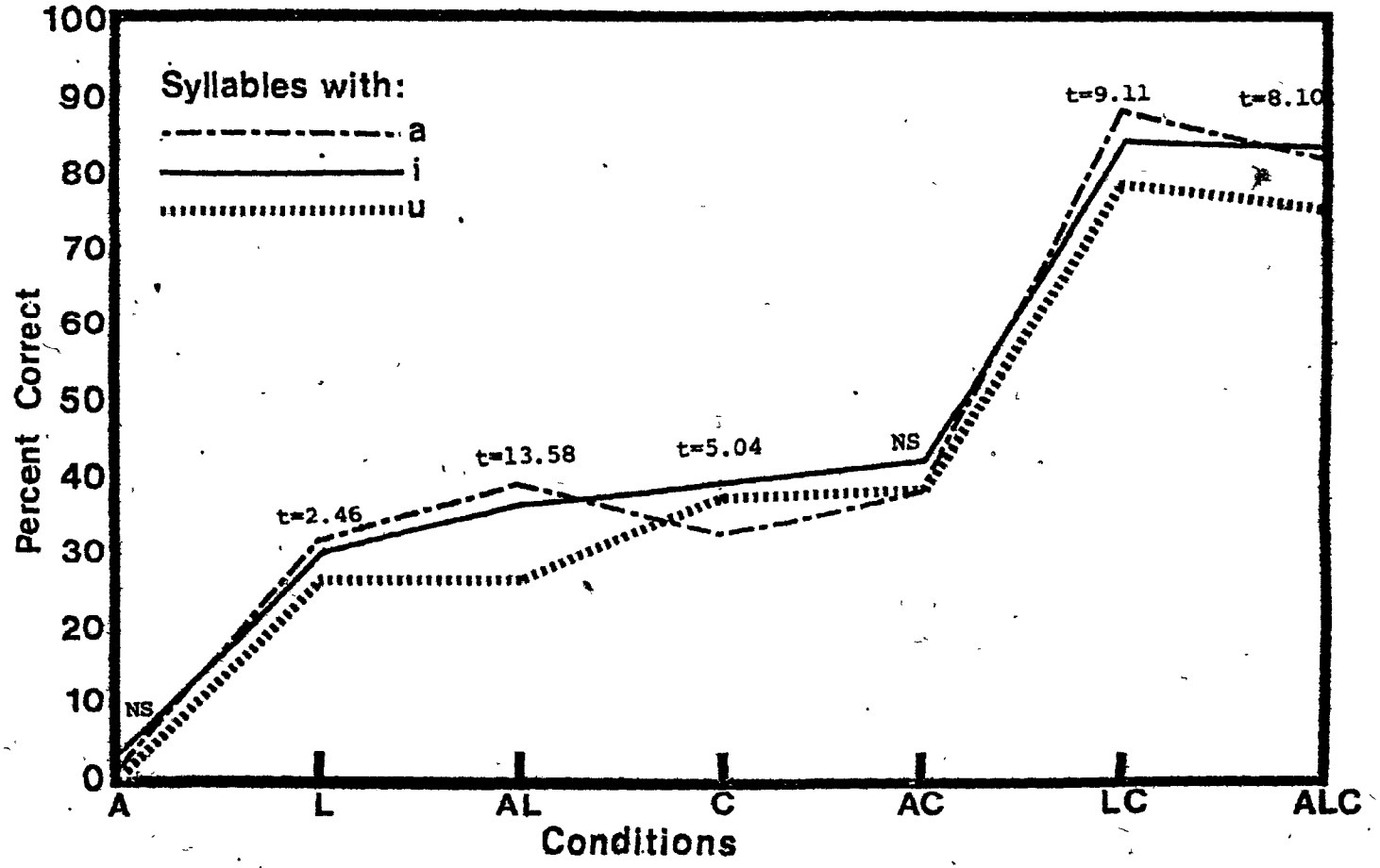


Figure 4.2. Consonants correctly identified in each of the three vowel contexts under the seven conditions of presentation.

Table 4.5

The Percentage of Key Words Correctly Identified by Each Subject in High and Low Predictability Contexts under each Condition of Presentation

Subject	A		L		AL		C		AC		LC		ALC	
	LP	HP	LP	HP	LP	HP	LP	HP	LP	HP	LP	HP	LP	HP
1	0	5.6	22.2	27.8	61.1	83.3	22.2	44.4	55.6	77.8	100	100	100	100
2	0	5.6	38.9	38.9	33.3	44.4	44.4	61.1	55.6	66.7	61.1	94.4	94.4	100
3	5.6	5.6	11.1	27.8	33.3	72.2	38.9	44.4	72.2	83.3	100	100	94.4	100
4	0	0	27.8	33.3	5.6	38.9	66.7	83.3	50.0	55.6	100	100	88.9	94.4
5	5.6	11.1	61.1	61.1	66.7	77.8	61.1	56.7	55.5	66.7	100	100	100	100
6	0	0	50.0	16.7	38.9	61.1	38.9	44.4	66.7	66.7	100	100	88.9	94.4
7	5.6	0	16.7	27.8	83.3	61.1	38.9	44.4	61.1	77.8	100	94.4	94.4	100
8	0	0	50.0	44.4	55.6	61.1	44.4	33.3	50.0	55.6	100	100	100	100
9	0	5.6	22.2	16.7	27.8	27.8	50.0	27.8	55.6	72.2	94.4	77.8	100	77.8
10	0	0	11.1	33.3	33.3	55.5	38.9	44.4	61.1	83.3	94.4	94.4	94.4	100
11	0	5.6	22.2	33.3	72.2	72.2	55.6	55.6	72.2	88.9	100	100	94.4	100
12	0	5.6	22.2	38.9	27.8	5.6	50.0	55.6	66.7	72.2	88.9	94.4	100	100
13	0	0	5.6	5.6	27.8	38.9	50.0	50.0	44.4	55.6	100	83.3	83.3	94.4
14	0	0	27.8	22.2	50.0	38.9	33.3	27.8	50.0	61.1	88.9	94.4	94.4	94.4
15	0	0	22.2	38.9	16.7	11.1	33.3	66.7	61.1	66.7	100	100	100	94.4
16	0	0	27.8	33.3	38.9	55.5	27.8	22.2	55.6	50.0	100	100	100	100
17	0	0	27.8	33.3	55.6	44.4	55.6	55.6	72.2	66.7	100	100	88.9	94.4
18	0	0	27.8	44.4	27.8	11.1	22.2	83.3	61.1	72.2	100	100	94.4	94.4

An analysis of variance comparing the results for syllables, and high and low predictability sentences was carried out. A summary of this analysis of variance is presented in Table 4.6. The perception of key words in sentences was significantly better in high than in low predictability sentence contexts (see Table 4.4) and there was a significant interaction between levels of predictability and conditions of presentation. Tests of Simple Effects revealed differences beyond the .01 level of significance among scores for the different types of materials under the L, AL, C, AC, LC and ALC conditions. As shown in Figure 4.1 no such differences were found under the auditory (A) condition of presentation.

Correlations Among the Additional and Dependant Variables

The results of the measures of language, speech intelligibility and phonetic and phonologic speech skills are presented in Table 4.7. Coefficients of correlation were calculated between these variables, age, average pure tone hearing levels, age when hearing aids were first worn, age when Cued Speech was first used, intelligence ratings and the scores for both the syllables and key words in sentences under each condition of presentation. Only those that reached or exceeded a .01 level of significance are reported below.

Phonetic Level Speech Skills correlated with:

Phonologic level speech skills ($r = .71$) and

Syllables under the LC condition ($r = .54$).

Table 4.6

Summary of the Analysis of Variance for Subjects' Scores for syllables and key words in high predictability and low predictability sentence contexts

Source of Variance	Mean Square	Degrees of Freedom	F
Conditions (C)	56504.08	6	304.02*
Error: SC	185.85	102	
Materials (M)	5140.63	2	40.15*
Error: SM	I28.03	34	
C x M	533.54	12	7.30*
Error: SMC	73.04	204	

* Significant beyond the .01 level

Table 4.7

Average Hearing Levels, Intelligibility Ranking, Scores on the Phonetic and Phonologic Level Speech Evaluations and Language Scores for each of the 18 Subjects

Subjects	Intelligibility Rating	Hearing Loss	Phonetic	Phonologic	Language Score
5	18	100	32	39	34
1	17	97	36	39	21
3	16	98	23	29	24
16	15	117	42	29	35
8	14	103	36	23	69
6	13	100	29	27	16
11	12	105	27	25	36
17	11	120	30	17	36
12	10	105	28	14	11
18	9	122	21	15	33
9	8	105	32	18	12
13	7	107	29	16	33
10	6	105	22	10	23
7	5	103	20	9	16
14	4	110	23	7	19
4	3	98	18	5	40
2	2	98	27	12	6
15	1	117	14	5	47

Phonologic Level Speech Skills correlated with:

Syllables under the L condition (r = .56)

Syllables under the AL condition (r = .86)

Sentences under the A condition (r = .57) and

Sentences under the AL condition (r = .63).

Language Scores correlated with:

Sentences under the LC condition (r = .60).

Syllable scores under the L condition correlated with:

Syllables under the AL condition (r = .64)

Syllables under the LC condition (r = .74)

Syllables under the ALC condition (r = .58) and

Sentences under the A alone condition (r = .59).

Syllable scores under the AL condition correlated with:

Sentences under the A alone condition (r = .59).

Syllable scores under the LC condition correlated with:

Syllables under the ALC condition (r = .84).

Key words in high predictability sentences under the LC condition correlated with:

Key words in HP sentences under the L condition (r = .58) and

Key words in HP sentences under the ALC condition (r = .66).

The intelligibility rankings of the subjects speech were compared with all other variables. Rank order correlations reaching the .01 level of significance emerged between intelligibility and only four

other variables:

Phonetic Level Speech Skills (Rho = .71)

Phonologic Level Speech Skills (Rho = .95)

Syllables under the AL condition (Rho = .69) and

Sentences under the AL condition (Rho = .63).

Chapter 5

DISCUSSION

The differences among the childrens' speech reception performances under the various conditions of stimulus presentation were of primary interest in this study. In the following discussion, each condition of presentation will be treated sequentially. Results for both the syllables and the key words in sentences will be examined in each section.

Audition

Results obtained for the identification of syllables and key words in sentences through audition alone, were extremely low. Correct and incorrect responses made by the subjects are illustrated in the confusion matrices (Appendices 5a, 5b and 5c). These matrices show both the stimuli and responses for consonant phonemes in each of the three vowel contexts [a, u and i]. Except for biases towards the phonemes [b, m, f and t] responses were quite random in nature. There were no observable groupings of phonemes by the subjects on the basis of low frequency acoustic information. Although acoustic cues for the discrimination of some manner groups (e.g. nasals, semi-vowels and plosives) and voiced/voiceless distinctions are available under 500 Hz, such cues were not generally identified by the children in this study. Theoretically some patterning of responses might have been expected as several of these children had some low frequency audition (see Table 3.1), and

certain acoustic cues for manner and voicing distinctions fell within their auditory range.

In previous research studies, similar findings for speech sound identification by profoundly hearing-impaired children through audition alone have been reported. Erber (1972a), Ling (1968) and Numbers and Hudgins (1948) also found that children with profound hearing impairment were unable to identify open sets of syllables and words on the basis of acoustic information alone. To be sure, some of the children in this study had extremely low hearing levels (i.e. averaging from 110 dB to 122 dB across the frequencies 500 Hz, 1000 Hz and 2000 Hz), and none of them had received training emphasising the use of audition in the early developmental period from 0 to 6 years. One might speculate that children with sufficient residual hearing who have received such training might demonstrate different performances. Such research however, has not yet been undertaken.

Training studies have generally employed discrimination tasks (e.g. same/different judgments and closed sets of stimulus materials) rather than identification tasks as pre- and post-test measures of improvement in the utilisation of residual hearing (Aston, 1972; Bennett and Ling, 1977; Lieberth and Subtelny, 1978; Novelli-Olmstead, 1979; Walden et al, 1977). In this regard, it would be important to determine whether training on discrimination tasks would lead to carry-over into identification tasks. Further, it would be valuable educationally to ascertain whether training audition alone would result in improvement in multimodal speech reception. Such amelioration might be expected, but it has not yet been demonstrated.

Lipreading

As lipreading is an essential component of profoundly hearing impaired childrens' interpersonal communication, their performances under this condition of presentation were of considerable interest. The results obtained for the lipreading of the syllable materials support the findings of previous research by Erber (1971a) and Pesonen (1968). The children in this study also demonstrated superior performances for lipreading consonant phonemes in the context of the vowels [a] and [i] than the vowel [u]. The confusion matrices for this condition (Appendices 5d, 5e and 5f) show that several consonants [w, r, l and tʃ] were masked by the liprounding associated with the vowel [u]. As this masking effect was also observed under the AL, LC and ALC conditions, it is evident that when lipreading was involved with visual or auditory support, it played the dominant role in speech reception for most of these subjects.

Almost two-thirds of the childrens' responses for consonant reception in the context of [a] (Appendix 5d) fell into the following nine viseme groups:

1. p, b, m
2. w
3. r
4. l
5. θ, ð
6. f, v
7. tʃ, dʒ, ʃ
8. k, g, k̄, ḡ
9. s, z, t, d, t̄, d̄, h

The above groupings are noteworthy in that the children had not received specific lipreading training in phoneme identification as

such. Even so, their viseme groupings were more similar to those of the subjects trained by Walden et al (1977) than the four specified by Woodward and Barber (1960). One may speculate that their lipreading ability was due to their experience with Cued Speech as this system is interdependant with the lipread patterns. This finding tentatively supports Cornett's (1970) view that Cued Speech helps children to develop lipreading skill spontaneously.

Although the childrens' speech reception performances were enhanced by linguistic contextual information under all other conditions of presentation, except audition alone (A), no such benefit was evident for lipreading. Lipreading yielded a mean score of 30 percent for the syllables and exactly the same mean for the key words in sentences. A similar score for perception of key words in the final position within sentences was reported by Erber (1974). Such findings are the rule rather than the exception (see Chapter 2). One may conclude that lipreading alone is an impoverished speech signal. These subjects, who were used to more efficient means of receiving speech (Cued Speech or audition and vision) may have lacked confidence in lipreading alone and not have done their utmost to interpret such inadequate patterns.

There was less variation in the subjects' ability to lipread syllables than to lipread sentences. Scores for syllables, as shown in Table 4.1 and Figure 5.1, differed by only 25 percent, whereas the range of scores for sentences was 55 percent (see Table 4.2 and Figure 5.2). Although most of the children could attain the usual levels of performance for lipreading syllables, some of the subjects had marked difficulty when longer sequences were involved.

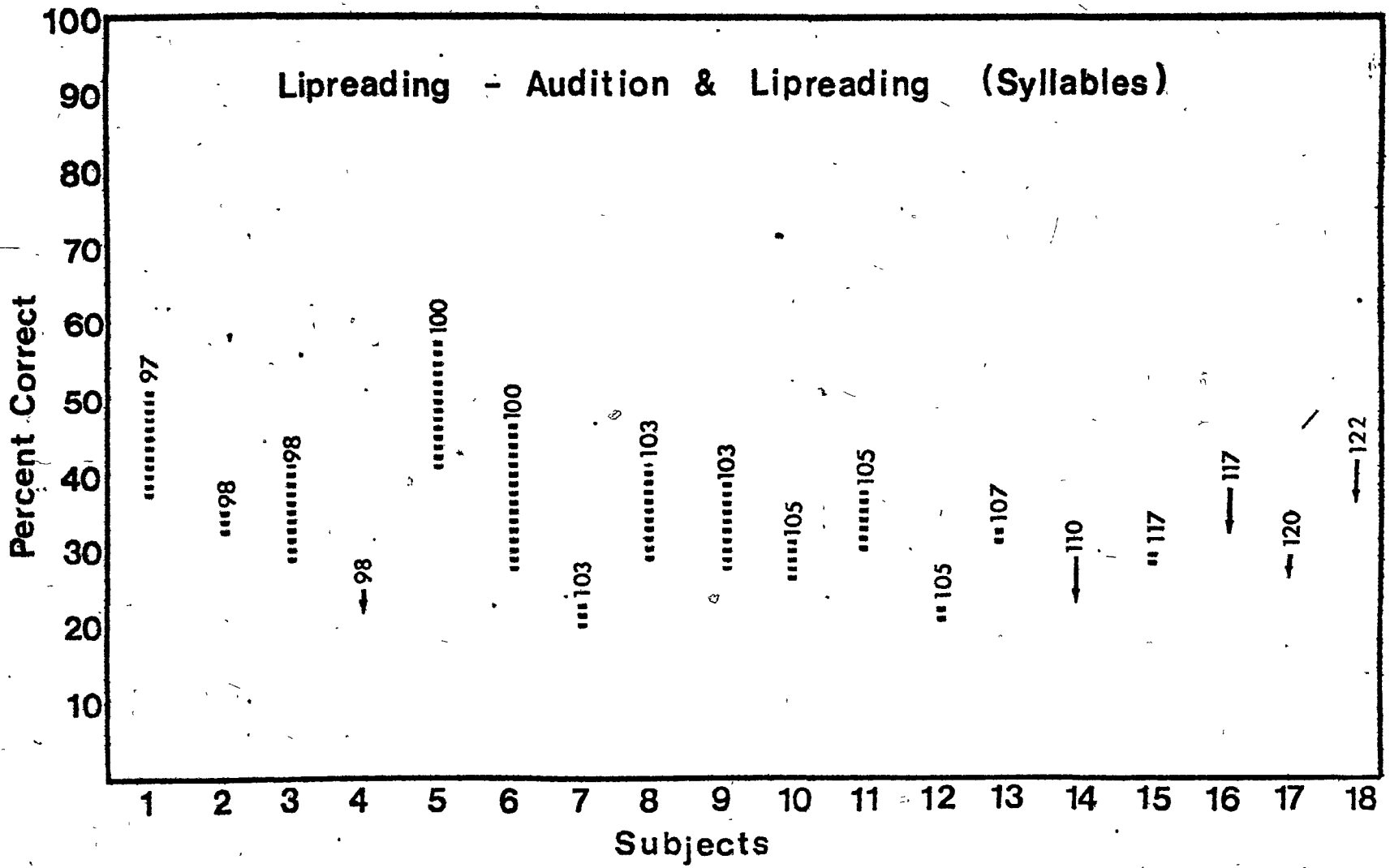


Figure 5.1. Percentage increase (dotted lines) or decrease (solid lines) for each subject when audition was combined with the lipreading of syllables. Hearing levels are shown above each subject's scores.

On the basis of previous work on the effect of sentence length (e.g. Clouser, 1977) and linguistic context (e.g. Hipskind and Nerbonne, 1973), one might have expected superior results for sentences as compared with syllables, and for scores on key words in high, as compared with low predictability sentence contexts. The finding that lipreading scores obtained in this study neither related to such factors, nor to levels of linguistic attainment suggests that visual sequential processing ability may have been an overriding variable. One may speculate that, if the benefits of contextual clues are to be made available to all subjects, those with weaker lipreading scores should receive specific training in the visual processing of increasingly longer units. Such a procedure has indeed been suggested by Erber (1977), who proposed that systematic instruction should proceed from syllables to words, to phrases and sentences. It would be of considerable interest to know whether such lipreading training alone would improve the subjects' ability both to lipread and to process materials in the auditory-visual mode.

The correlation between phonologic speech production and lipreading of syllables suggests that training in speech production might also be used as a means to improve lipreading ability. As previously mentioned, improvements in the auditory reception of syllables have been obtained following a period of training in phonetic level speech production skills (Novelli-Olmstead, 1979; Lieberth and Subtelny, 1978). Although lipreading and audio-visual speech reception abilities were not evaluated in these studies, improvements in these modes, in addition to those obtained for auditory speech reception, might also have occurred.

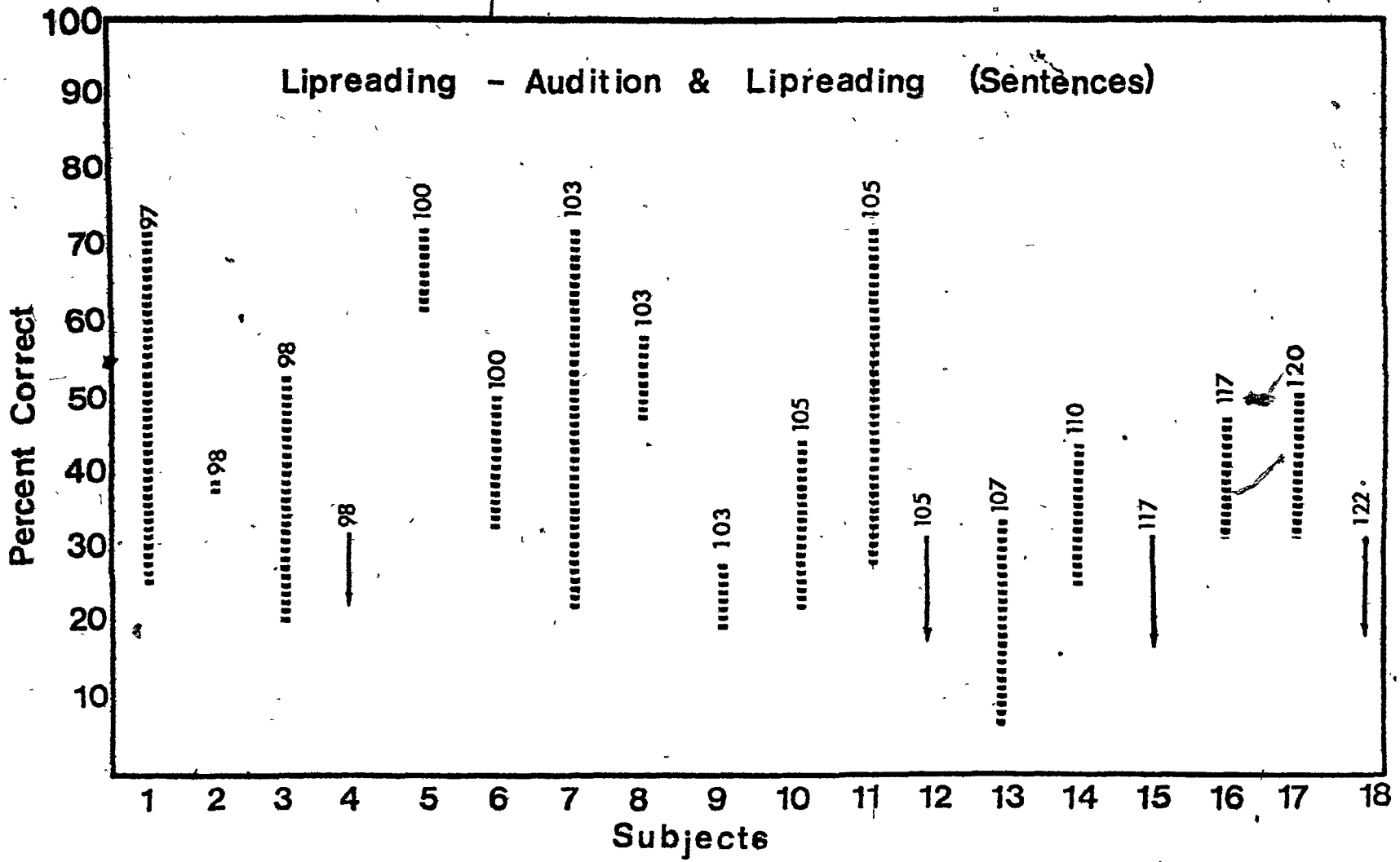


Figure 5.2. Percentage increase (dotted lines) or decrease (solid lines) for each subject when audition was combined with the lipreading of key words in sentences. Hearing levels are shown above each subject's score.

Audition and Lipreading

The results obtained from this condition of presentation are of particular importance since they relate to the concern expressed by Clarke and Ling (1976). In brief, this concern was that the use of Cued Speech might prevent the development of auditory and auditory/visual skills. In many everyday communication situations children have to rely upon their audio-visual speech reception abilities whether they are taught through the use of Cued Speech or not. Speech reception without cues is their normal mode of communication with society at large. It opens the doors of opportunity for social, integration, and educational and professional development throughout life.

The results obtained for the syllable materials indicated that, as a group, the children did not make significant gains when the auditory signal was added over their performance for lipreading alone. In view of the subjects' levels of hearing and their low scores through audition alone, this result was not surprising. Similar performances by profoundly hearing-impaired children with syllable materials have been reported in the literature (see Erber, 1972a). Erber proposed that the identification of spectral information in the acoustic signal is beyond the limits of profoundly hearing-impaired children's auditory capabilities. This view is, however, somewhat tenuous. Inspection of individual subjects' responses in the present study indicates that it would be wrong to generalise from the group mean performance on syllable reception reported above. Figure 5.1 shows the variability in the individual subjects' use of auditory information. Six children (Subjects 1, 3, 5, 6, 8 and 9) showed gains of 15%, 12%, 17%, 19%, 13% and 10%

respectively. Five subjects scored less when audition was added. The scores of the remainder did not vary significantly from those obtained through lipreading alone.

Erber (1972b) has suggested that the limited gains obtained from adding an acoustic signal to lipreading result from the subjects' utilization of time-intensity cues alone. The scores of the six best subjects reported here, however, are greater than one could expect from tactual reception or auditory processing of the time-intensity envelope. Spectral information has to have been perceived by some of these subjects in order to make gains of 10 to 19 percent over lipreading alone. This notion receives some support from a subsequent study which utilized the materials prepared for the present experiment (Leckie, 1979, in preparation). In Leckie's study, six hearing-impaired children who had average hearing levels of 90 to 100 dB, and who had received auditory training from early infancy, achieved scores on auditory-visual syllable reception that were 6 to 57 percent (mean = 23%) better than through lipreading alone.

Ling and Ling (1978) have emphasised that individual childrens' use of audition is related not only to the level, but more importantly to the range of their residual hearing across the speech frequencies. Each of the children who made marked gains in the AL as compared with the L condition in fact had residual hearing that extended to 4000 Hz. Those with hearing extending to 500 Hz or 1000 Hz achieved considerably poorer scores. This is not to say that all children with a wide range of hearing can be expected to achieve high speech reception scores. Subjects 2 and 4, who had hearing that extended to 4000 Hz were among

those whose auditory-visual speech reception skills were the weakest. Such impoverished performances may have been related to these subjects' lack of early auditory training or variables intrinsic to the children that can not be defined by current tests. In practice, it would be advisable for teachers to evaluate each child as an individual in the course of ongoing training.

In contrast to the identification task under the auditory condition of presentation, the task for audio-visual reception of syllables could be considered to be more nearly one of discrimination. The closed sets provided by the viseme groups (e.g. [p, b, m] and [ʃ, tʃ, dʒ]) would allow children with the ability to perceive manner cues to differentiate among some of the consonants in these groups (Owens, 1978). As only six of the subjects were able to utilise acoustic information in this way, the remainder may either not have received sufficient auditory training, or had such profound losses that identification of the acoustic features was impossible for them. Reference to the AL confusion matrices presented as Appendices 5g, 5h and 5i, shows that there are few differences between the AL and L conditions. Differences that do exist are attributable to only a few subjects.

Too few children scored better under the AL as compared with the L condition for group means for syllables to be significantly different. This was not the case for the sentence materials. There was a mean increase of 15% for the AL reception of these materials over the results for lipreading alone. This increase is equal to the upper limit of the range (1-15%) previously reported by Erber (1972a) as the amount of supplementary benefit from audition available to profoundly

hearing-impaired children for the reception of isolated words. Of more interest than the group mean data are the scores of individual subjects. Their performances are illustrated in Figure 6.2. This Figure shows that 4 children, Subjects 1, 3, 7 and 11, with hearing levels ranging from 97 dB to 105 dB, made gains of 48%, 33%, 51% and 50% respectively from the addition of auditory information. However, two children (Subjects 2 and 4) did not gain any appreciable benefit from such information. Subjects 3, 10, 13 and 17 made gains of over 20% and the remainder, somewhat less. Such findings illustrate the need for the appraisal of individual differences for the purposes of teaching.

Figure 5.2 shows that 4 childrens' scores (Subjects 4, 12, 19 and 18) decreased when the auditory signal was combined with lip-reading. Although decreased AL performances have been mentioned by Erber (1974), no research is available to indicate the extent of this phenomenon among the profoundly hearing-impaired population. Such research would have important implications since the current trend is to fit all profoundly hearing-impaired children with binaural hearing aids whether or not they can benefit from them. The poorer AL than L performance of some subjects in this study may not be a replicable and significant result, but it certainly suggests that one should consider providing some children with one hearing aid or none if repeated tests confirm impoverished responses when audition is added to speechreading.

One can merely speculate from this study as to the manner in which the acoustic signal was received by these profoundly hearing-impaired children. To some it may have been through tactile sensation; to others through audition. Tactile stimuli have been shown to account

for mean increases ranging only up to 18% (Gault, 1928; Erber, 1972b) over scores for lipreading alone. This implies that larger increases have to be due to the childrens' sensitivity to auditory information. Those subjects who appeared to perceive segmental cues in the syllable materials (Subjects 1, 3, 5, 6, 8 and 11), also obtained large increases (up to 50%) in the sentence contexts. They were evidently able to process segmental as well as suprasegmental auditory information in running speech. For most of the children, however, suprasegmental information alone must have accounted for the improved performances when the auditory signal was added. This suggestion accords with that of Risberg and Agelfors (1978) who have shown that the prosodic elements of speech (intensity, duration and pitch) can play an important role as supporting information during lipreading.

The large variability in profoundly hearing-impaired subjects' auditory-visual speech reception abilities in this and other research studies illustrates the need for diagnostic evaluations to be undertaken in the course of on-going training. As linguistic development is dependant on the quality of input received, those children with limited ability should be identified early as requiring supplementary support. Hearing levels alone can not be utilised for such purposes. The lack of any correlation between hearing levels and speech reception performances indicates that factors such as age of detection, the adequacy of hearing aids, functional hearing aid use, the type and effectiveness of training, and the presence or absence of additional learning problems must have played an important role. Data from representative groups of the hearing-impaired population, including those from auditory-oral, visual-oral, Cued Speech and Total Communication programs, however,

would be needed to determine the effects of such variables on profoundly hearing-impaired childrens' auditory capabilities.

A further aspect to be highlighted relative to the AL condition concerns the utilisation of linguistic contextual information by the children with the sentence materials. Their superior performances in perceiving the final key words in high predictability contexts indicates that sufficient benefit was gained from the additional auditory information combined with lipreading for linguistic processing to occur. This result is in contrast to that obtained for lipreading alone where the contextual information was of no additional benefit. Even when the children were more reliant on acoustic-phonetic information in the low predictability sentence contexts, their performance was superior to that for the AL reception of the syllable materials. Such factors as meaning, suprasegmental information, the varying vowel contexts of the final key words and the fact that the sentence is the most common unit of communication in conversation, must underlie the improved AL performances with both types of running speech as compared with syllable identification.

The numerous correlations obtained between variables under the AL condition testify to the importance of this mode of communication. Subjects who performed most adequately when audition and lipreading were combined also had the best phonologic level speech scores, were the best able to lipread syllables and had the highest ranking for speech intelligibility. These correlations reflect the close ties between speech perception and speech production which workers at the Haskin Laboratories frequently emphasize (see Liberman et al, 1967).

On the basis of the data obtained in this research, the view that Cued Speech leads to serious deficits in the use of audition is clearly untenable. Improvements in scores for key words in sentences in this combined condition over those yielded through lipreading alone are comparable to those reported for programs that specialise in the de-emphasis of vision. To be sure, more effective training might yield higher scores than those obtained in this study. Research aimed at defining the type of training that could lead to such improvement is certainly necessary.

Cues

Under this condition, the materials were presented solely with the hand cues in the absence of the associated lip movements. The group of phonemes represented by each hand configuration or hand position can only be disambiguated by reference to the lipread pattern. Thus, when they received the cues alone the children were forced to guess the speaker's intent. Their mean performance with the syllable materials, shown in Figure 4.1 reflects the ambiguity of the signal they received and approximates the level of chance performance. One hand configuration represents either three or four phonemes and an average of 36% was yielded, with all but one of the children scoring in the range 25 to 44 percent correct.

The confusion matrices for this condition (Appendices 5j, 5k and 5l) show that only isolated errors occurred outside of the expected confusions within the groups of phonemes for each hand configuration. The homogeneity of the childrens' performance indicates their precise

knowledge of the phoneme groups associated with each cue.

The data obtained for the perception of key words in sentences were not anticipated. Figure 4.1 shows that results were similar to those achieved for the same materials through audition and lipreading. Cues clearly provided more information than lipreading alone. Although the mean scores for the hand cues and the lipread patterns were equivalent in the non-meaningful contexts of syllables, higher mean scores were yielded from the cues alone than from lipreading in meaningful linguistic contexts. Two of the factors likely to have contributed to these differences will be discussed below.

1. Differences in the Cued and Lipread Patterns. The cues in running speech provide a continuous signal in contrast to the 'chunked' information in lipreading. For example, in lipreading the sentence, "Wear a raincoat in the rain," only parts of the pattern are visible. The unstressed function words, such as "a", "in", and "the" may not be visible at all. In contrast to the lipread information, the cues alone provide a continuous stream of information. Some information is present throughout the entire message.

2. Process of Elimination. The number of alternatives provided by the possible combinations of cues alone are fewer than in lipreading. The word "ball" will serve as an example. There are at least 22 feasible homophenous responses through lipreading (ball, balls, board, boards, bog, bogs, box, morse, moss, Maude, mall, pore, pores, port, ports, paw, paws, pork, sport, sports, spore, spores and spot). For the same word presented by Cues alone, there are only two common

nouns that can be derived (ball and bell). Such differences stem from the fact that most cue groupings represent three (in one case four) phonemes, whereas in lipreading all alveolar and some velar phonemes may be homophenous.

The use of Cues alone is not met in real life situations. The inclusion of the condition in this study was solely for the purposes of comparison with other conditions in which cues were involved as a support system. Such conditions will be discussed in the following pages.

Audition and Cues

The childrens' ability to use audition in conjunction with cues, a condition not met in real life situations, clearly shows that the hand cues do not detract from the use of residual hearing. For key words in sentences significantly better scores than for either Cues or audition alone, were achieved by the group as a whole when the two modes of presentation were combined. There was, however, no such advantage realized for syllable materials. As can be seen from Figure 5.3, few subjects made substantial gains and some even achieved poorer scores. Results for audition and Cues parallel those for audition and lipreading. This is illustrated by the confusion matrices constructed for the two conditions (Appendices 5g, 5h and 5i, and 5m, 5n and 5o).

The poorer scores for syllables as compared with sentences again reflect the subjects' limited ability to perceive the segmental information. In the sentences, the additional suprasegmental information apparently contributed to the comparatively better scores. Even those

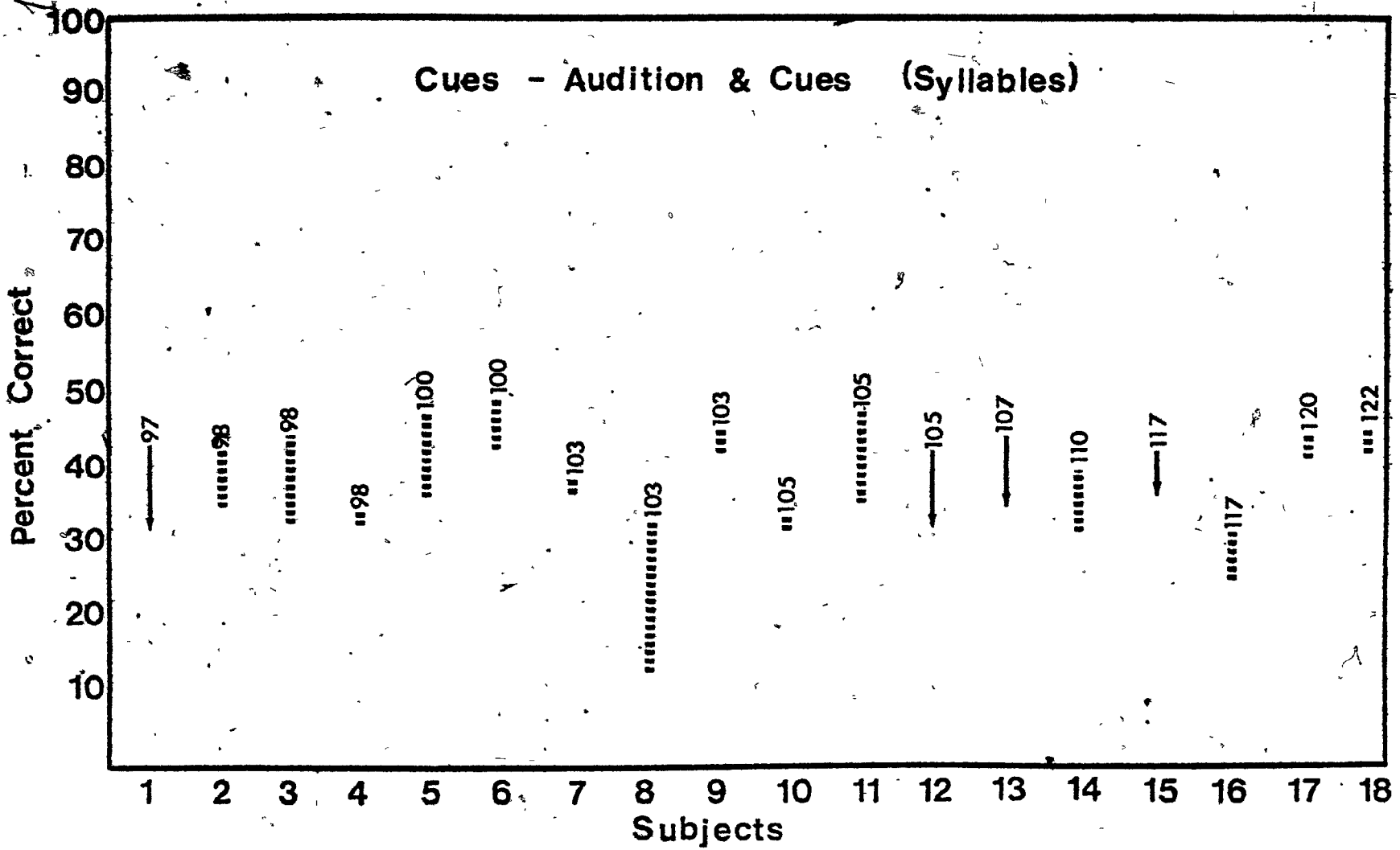


Figure 5.3. Percentage increase (dotted lines) or decrease (solid lines) for each subject when audition was combined with cues in the reception of syllables. Hearing levels are shown above each subject's scores.

children with the least hearing made gains of 13% to 25% when audition was added to cues (see Figure 5.4). Only two subjects, (4 and 5) failed to utilise the supplementary information provided by audition.

It is traditional to train discrimination prior to identification. Since Cues provide a closed set of syllables this condition could well be exploited to train hearing-impaired childrens' auditory discrimination in a Cued Speech program.

Lipreading and Cues

The subjects' responses under this condition were outstandingly and uniformly good (see Tables 4.1 and 4.2). They merit considerable attention. They strongly support the claims for Cued Speech made by Cornett (1967), in that the system clearly enabled totally and profoundly hearing-impaired children to receive relatively precise phonemic and linguistic information both at a syllabic level and in running speech. Speech reception at an equally high level of accuracy by such children has not previously been reported. The childrens' average scores of over 80 percent for the reception of syllables is within the range of normally hearing listeners reception of similar materials through audition (Fletcher, 1953).

The few confusions that occurred under this condition are shown in the matrices presented as Appendices 5p, 5q and 5r. In the context of the vowel [a] the only major confusion was between [dʒ] and [g]. In the [i] context, more errors were made. Again [dʒ] and [g] were most frequently confused. Other major mistakes in the [i] context

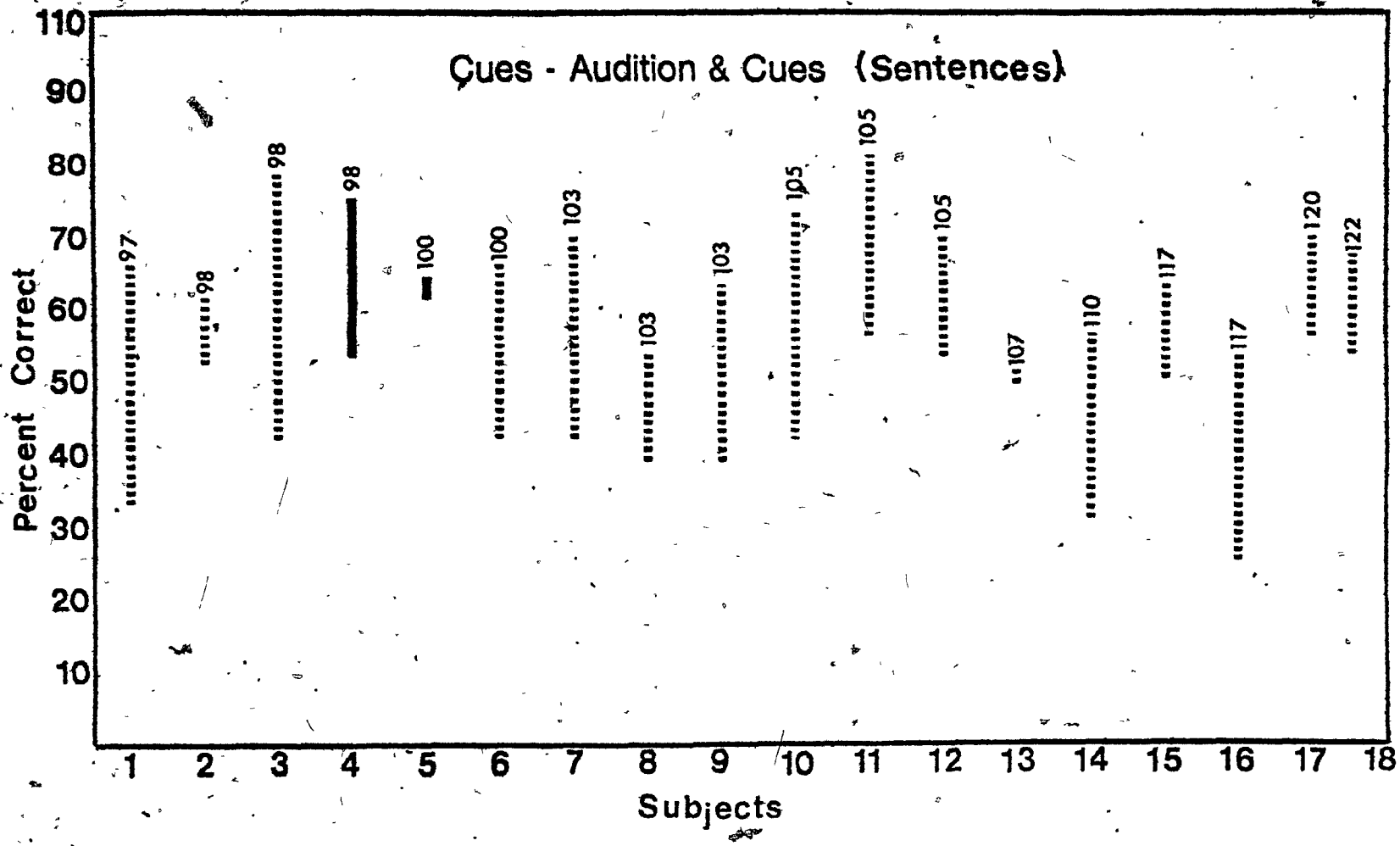


Figure 5. 4. Percentage increase (dotted lines) or decrease (solid lines) for each subject when audition was combined with cues in the perception of key words in sentences. Hearing levels are shown above each subject's scores.

were between [z] and [k], [j] and [tʃ] and [p̄] and [n]. There were significantly more errors in the context of [u]. The most outstanding were [tʃ] and [j], [dʒ] and [g], [ʃ] and [l], [d̄] and [p̄], and [k] and [z]. The greater number of errors in the vowel [u] context could be expected on the basis of Pesonen's (1968) findings that the lip rounding associated with [u] obscures tongue positions and movements. This expectation, of course, implies that the errors were due more to lip-reading problems than to the interpretation of the hand cues. The type of confusions made support this view. Further, they illustrate that the use of Cued Speech demands attention to both the lips and the hands as interrelated features of speech reception.

Cued Speech was designed by Cornett (1967) on the basis of data provided by Woodward and Barber's (1960) study, in which consonant reception was tested only in the [a] context. Had data also been available on consonant reception in the contexts of [i] and [u], Cued Speech might have been designed to avoid such confusions as occurred in this study. While results demonstrate that the system is not perfect, they also show that its weaknesses are of negligible importance, particularly in the reception of speech in sentences.

The mean score of over 95 percent for the perception of key words in sentences highlights the effectiveness of the supplementary cues in the context of running speech. These near perfect results were obtained with both high and low predictability sentences. Such levels of performance illustrate the childrens' ease in perceiving linguistic information through Cued Speech whether they are more reliant on segmental information, as in the case of LP sentences, or whether they are provided with linguistic contextual clues to meaning.

The results for Lipreading and Cues are in contrast to those obtained under all other conditions previously discussed. The childrens' scores under those conditions were poorer for the LP than for the HP sentences. Such differences due to linguistic context present a basic dilemma to teacher/therapists in the field of aural rehabilitation. On one hand, highly developed linguistic skills are required to help children interpret the inadequate signal provided by lipreading, audition or both. On the other, many children have difficulty in developing effective linguistic skills from such impoverished input. The use of Cued Speech appears to resolve this dilemma in that it provides both the means to develop lipreading ability and, at the same time, an unambiguous avenue for linguistic growth. That the linguistic abilities of the subjects permits them to disambiguate speech as it is received under most conditions in the absence of Cues is evidenced by their generally superior scores for key words in HP sentences. Since the subjects acquired their current linguistic skills relatively recently, more adequate performance under such conditions might be expected with further experience. There is need for longitudinal study of subjects taught by means of Cued Speech in order to determine what levels of speech reception without cues can be achieved after adequately long and intensive training.

One would normally use voice in combination with Cued Speech; hence the reader might assume that this condition in which no sound was presented is artificial. This is not so. Total dependence on visual information is common. Totally hearing-impaired children have to rely entirely upon visual information. At a distance of more than a few feet, in noise, or when hearing aids are out of order or inadequate,

profoundly and even severely hearing-impaired children can likewise derive no benefit from the acoustic signal.

The subjects' ability to process the visual input conveyed by lipreading and cues is relevant to current views on speech and language processing. The results obtained indicate that Liberman's (1974) opinion, that the speech decoding mechanism may only be reached and activated by an auditory signal, is untenable. The children in this study demonstrated the ability to receive highly accurate information on the speech signal entirely through vision.

The implications of these findings to the field of aural rehabilitation are far-reaching. They indicate that Cued Speech can provide profoundly and totally hearing-impaired children with access to precise phonemic information as a basis for verbal learning. The correlation between scores in this condition on both phonetic level speech production and language scores strongly support Ling's (1976) contention that residual hearing, while advantageous, is not essential to the development of spoken language skills.

The children in this study had acquired language well after the normal developmental period from 0 to 6 years, when language, cognition and speech develop in synchrony. For this reason they must be considered as having received remedial rather than developmental teaching. Nevertheless, their language abilities were exceptionally high (see Appendix 4). Only one child (Subject 7) acquired language approximately within the normal stages.

Normally hearing babies, in the first few months of life are capable of making many fine auditory discriminations in speech, such as the voice/voiceless contrast (Morse, 1974). With access to the complete speech stream they learn to select and identify those elements that are uniquely meaningful to them. Research is needed to investigate whether similarly early linguistic development is possible for hearing-impaired infants through visual information provided by Cued Speech. It would be of particular interest to determine the age at which Cued Speech can begin to be processed by hearing-impaired infants.

Audition, Lipreading and Cues

The findings from this condition are of both basic and applied interest in the field of aural (re)habilitation. Under optimal conditions, the three signals (audition, lipreading and cues) are received together.

The results for the syllable materials are not significantly different from those obtained under the LC condition. Indeed, in no mode did the addition of the auditory signal significantly increase scores for syllables (see Figure 4.1). The similarity of responses under the LC and the ALC conditions can also be seen by comparing the confusion matrices presented as Appendices 5p, 5q, 5r and 5s, 5t and 5u.

Although results for sentences in previously discussed conditions have shown that subjects do, in fact use hearing, the present study does not permit inferences to be drawn relative to the use of audition in receiving syllables. Further study is required to determine

if and how subjects use residual hearing in perceiving syllables when they are presented with Cued Speech. Research modelled on that undertaken by McGurk (1976) could be employed to investigate this question. McGurk presented syllable materials to normally hearing listeners with the auditory and visual signals mismatched. Thus, the subjects may have seen the syllable /ba/ and heard /da/. The results obtained by the subjects, both children and adults, showed differences in the reliance placed on the two modalities of audition and vision when they were forced to chose between them. Young children were more dependant on audition whereas the older subjects relied more on the visual modality.

Research by the writer (Nicholls, in preparation), utilising materials similar to those employed by McGurk, was carried out on the subjects used in the present study. Preliminary findings showed that several children who could perceive some manner distinctions and the voice/voiceless contrast, in fact used audition to discern the mismatched syllables. Further research including children with varying levels of hearing loss ranging from moderate to total deafness is required. Such research may lead to the development of diagnostic procedures for assessing hearing-impaired childrens' auditory and visual speech reception capabilities. Used in conjunction with other tests, such procedures could help specify more appropriate training strategies for individual children.

Scores for the perception of key words in sentences under this condition (see Figure 4.1) were approaching the possible maximum. Thus, ceiling effects limit the interpretation of differences in scores due to the addition of the auditory signal over those obtained for lipreading

and cues. Several children obtained 100 percent for these materials with the lowest score being 89 percent (see Table 4.2). Hearing may or may not have been used by some children in the achievement of results under this condition. Further research is required to determine the role of audition when Cued Speech is employed. Presumably, if subjects were presented with more difficult materials than those used in the present study, children with useful residual hearing would score better than those without. To show such differences, the materials would have to be so demanding that few if any of the subjects could achieve maximum possible scores. An alternative strategy for studying the use of residual hearing in this condition would be to measure reaction times with and without the acoustic signal. One would expect the acoustic signal to aid those who have useful audition and hence permit them to respond more rapidly than those who have little or none.

The ceiling scores obtained under this condition and the previous one, also prevent the emergence of any possible effects due to linguistic context. High levels of perceptual accuracy were achieved with both LP and HP sentences. It would be useful to determine, through further research, whether all elements of such sentences could be perceived with equal accuracy. As the structural elements such as determiners, connectives, modals and tense markers tend to be unstressed acoustically, as well as being difficult to lipread, these elements are generally not perceived by profoundly hearing-impaired children. The more complete phonemic information conveyed by Cued Speech, however, appears to give them more prominence. It would be of interest to investigate whether Cued Speech permits profoundly hearing-impaired

children to develop comprehension of linguistic elements in similar ways to those in which normally hearing children develop them. Examples of the children's language samples (see Appendix 4) show that the structural elements are generally present and correctly used in these childrens' expressive language. The six children with the highest language scores consistently produced highly accurate and complex sentences. It can only be assumed that Cued Speech contributed to such unusually high levels of linguistic attainment.

The results obtained for the perception of running speech in this experiment are much superior to those reported by Ling and Clarke (1975) and Clarke and Ling (1976). Their subjects however, had only been exposed to Cued Speech for two years. Even so, their speech reception skills were sufficient for clear communication of the spoken language at the sentence level (Beadles and Brown, 1979). The subjects in the present study had longer exposure to Cued Speech than those previously investigated. However, they were still in the process of acquiring communication skills. The scores obtained and discussed above do not, therefore, represent performance at their limits of learning. Longitudinal study is required to determine how scores for materials under each of the seven conditions of presentation will change with time. The large differences between the last two conditions discussed and other conditions may not be a persistent pattern. With further training improvement in the reception of both cued and uncued materials might be expected.

Conclusions

Satisfactory answers to the three questions investigated were yielded in this study. One may conclude that performance of the children who served as subjects showed that:

1. Linguistic information can be received with exceptionally high levels of accuracy through Cued Speech and that the prolonged use of this system does not adversely affect the subjects' abilities to process information in the absence of Cued Speech. If anything, lipreading and audition were used as well by these subjects as by comparable children taught in more traditional oral programs.
2. Simultaneous use of two modalities enhances speech reception for both syllables and sentences. However, since there are several additional variables involved, scores on syllable materials can not be used to predict how well a child will receive key words in sentences.
3. Strong correlations exist between speech perception, speech production and linguistic skills. Speech reception involving audition and/or lipreading relates closely to speech production skills and intelligibility, whereas language attainments are more closely associated with reception through Cued Speech.

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APPENDIX-1

An example of a Syllable List employed

Appendix 1.

1. li/li
2. gi/gi
3. ða/ða
4. ub̄/ub̄
5. it̄/it̄
6. θa/θa
7. bi/bi
8. at̄/at̄
9. dʒi/dʒi
10. ru/ru
11. ad̄/ad̄
12. ut̄/ut̄
13. za/za
14. ap̄/ap̄
15. di/di
16. nu/nu
17. zu/zu
18. na/na
19. ðu/ðu
20. mu/mu
21. ga/ga
22. tʃi/tʃi
23. va/va
24. ri/ri
25. wi/wi
26. ra/ra
27. gu/gu
28. vu/vu
29. ka/ka
30. ba/ba
31. ak̄/ak̄
32. fu/fu
33. pi/pi
34. ku/ku
35. zi/zi
36. hi/hi
37. ʃa/ʃa
38. tu/tu
39. ði/ði
40. pa/pa
41. tʃa/tʃa
42. θu/θu
43. ig̃/ig̃
44. du/du
45. sa/sa
46. ʃi/ʃi
47. ji/ji
48. ʃu/ʃu
49. uk̄/uk̄
50. ab̄/ab̄
51. dʒa/dʒa
52. wa/wa
53. ib̄/ib̄
54. ki/ki
55. ni/ni
56. ag̃/ag̃
57. bu/bu
58. tʃu/tʃu
59. vi/vi
60. ja/ja
61. ta/ta
62. la/la
63. θi/θi
64. si/si
65. su/su
66. fi/fi
67. ik̄/ik̄
68. ma/ma
69. lu/lu
70. ha/ha
71. ud̄/ud̄
72. ju/ju
73. fa/fa
74. ug̃/ug̃
75. id̄/id̄
76. ti/ti
77. hu/hu
78. dʒu/dʒu
79. pu/pu
80. ub̄/ub̄
81. ip̄/ip̄
82. mi/mi
83. da/da
84. wu/wu

APPENDIX 2

Pictures used in the Vocabulary Test Designed for Ensuring Subjects' Familiarity with Test Items

Key to Picture Item

Page 100

mouth	teeth	feet	foot
leg	heart	neck	hair
toe	toes	eyes	nose
knees	shin	finger	ankle

Page 101

hands	elbow	lungs	shirt
socks	watch	ring	boot
tie	shoes	bow-tie	coat
comb	hat	sock	brush
cap	pants	hall	room

Page 102

chair	mat	shower	picture
floor	table	lamp	bag
jet	train	van	cart
ship	bus	bike	cab
truck	wagon	steering-wheel	plan

Page 103

car	wheel	leaf	log
roots	rose	bud	seed
flower	plant	nurse	boy
king	witch	girl	men
lady	cowboy	pilot	woodcutter

Page 104

surfboard	farmer	queen	giant
Father Christmas	baby	deliveryman	ladies
paper	book	word	name
map	race	show	bomb
card	letter	mike	note

Page 105

ice	grass	petrol	money
toast	bread	coffee	water
board	hose	box	web
hole	gate	roof	path
sun	wave	moon	shell

Page 106

logs	oil	soap	cheese
wheat	rice	soup	jam
wool	corn	tea	ham
fire	ship	rockhill	fur
wire	dirt	juice	sand

Page 107

nut	cake	lunch	pie
sauce	bone	pear	peach
grapes	potatoe	eggs	apple
chip	sandwich	potatoe	rice bubbles
milk	apple pie	meat pie	vegetables

Page 108

spider	mouse	wing	polar bear
bear cub	lion cub	tiger	cow
wolf	robin	hippo	giraffe
dolphin	butterfly	owl	cat
fox	tooth	face	chin

Page 109

bull	cows	bird	pig
monkey	dog	lamb	whale
worm	horse	goat	sheep
bear	bees	shark	duck
bee	ducklings	tail	fish

Page 110

lid	pan	cup	pot
saucer	jar	plate	doll
ball	toy	kite	bat
rope	tennis ball	rooster	hen
reindeer	caterpillar	rat	lion

Page 111

pod	bubblegum	meat	purse
bag	rubbish bin	knot	fan
pipe	bed	wall	map
mat	bath	key	lock
phone	light	vase	door

Page 112

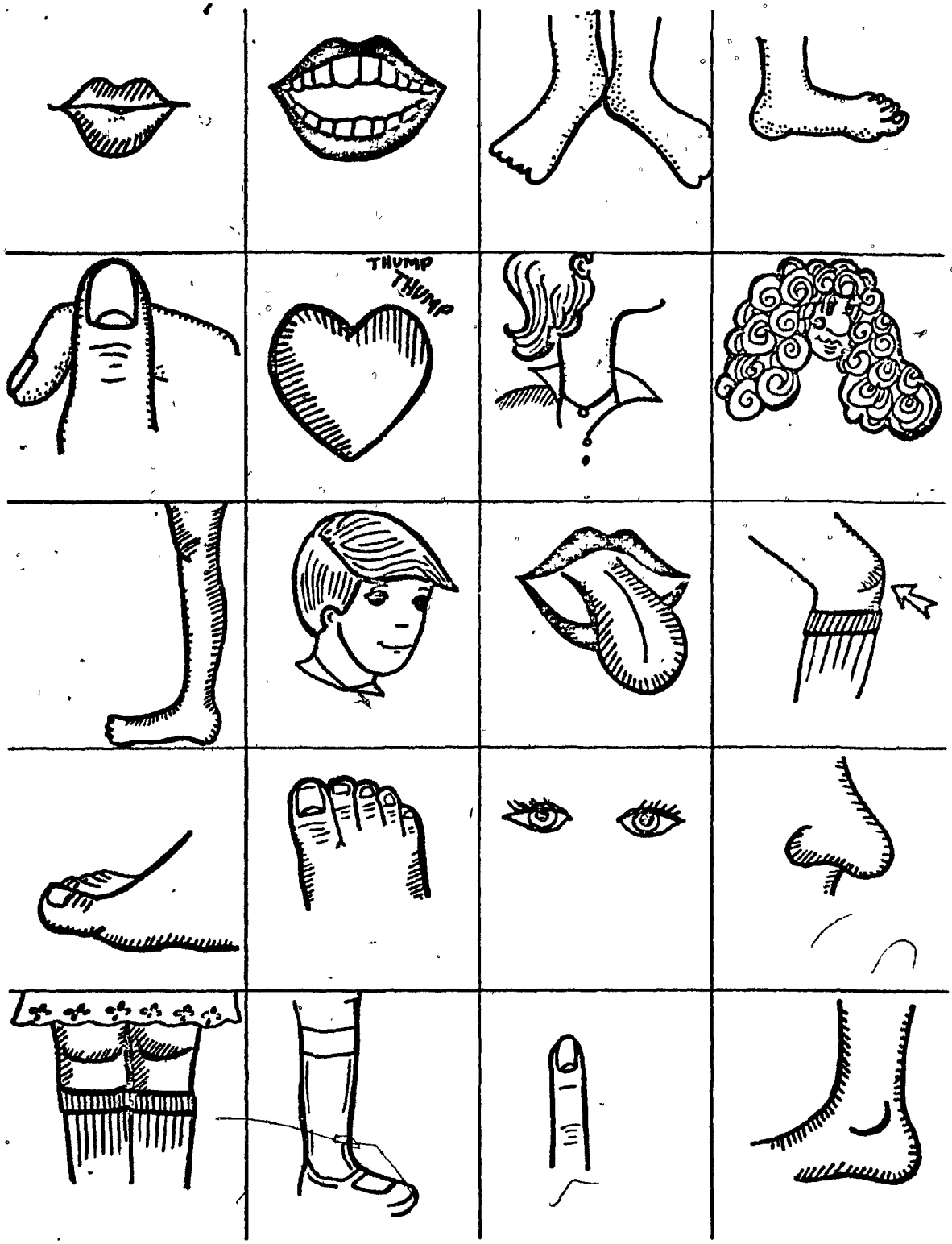
pen	rope	needle	pins
cigarettes	baseball	football	tennis ball
gun	tin	umbrella	country
bell	fork	jug	bottle
mug	pie dish	knife	bowl

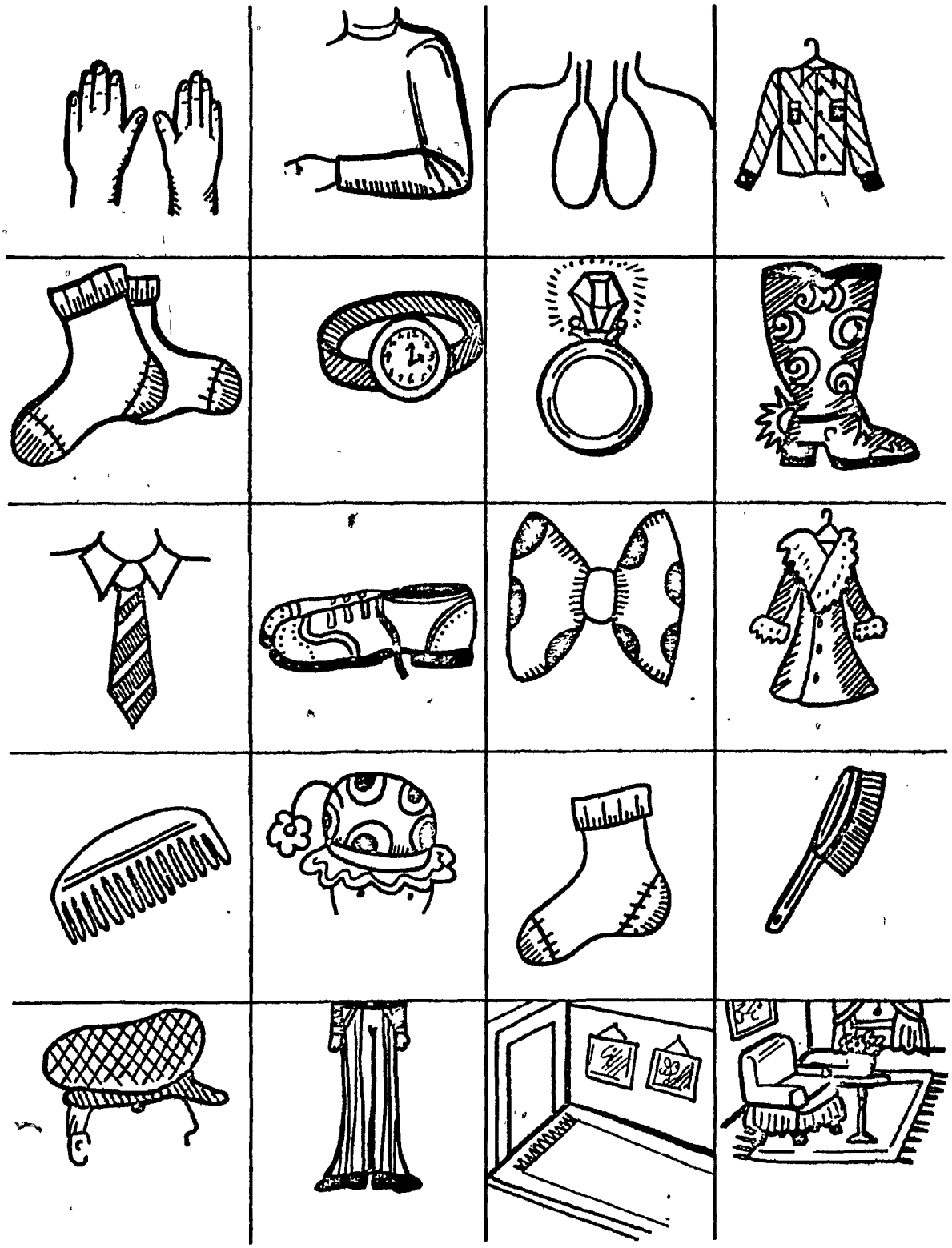
Page 113

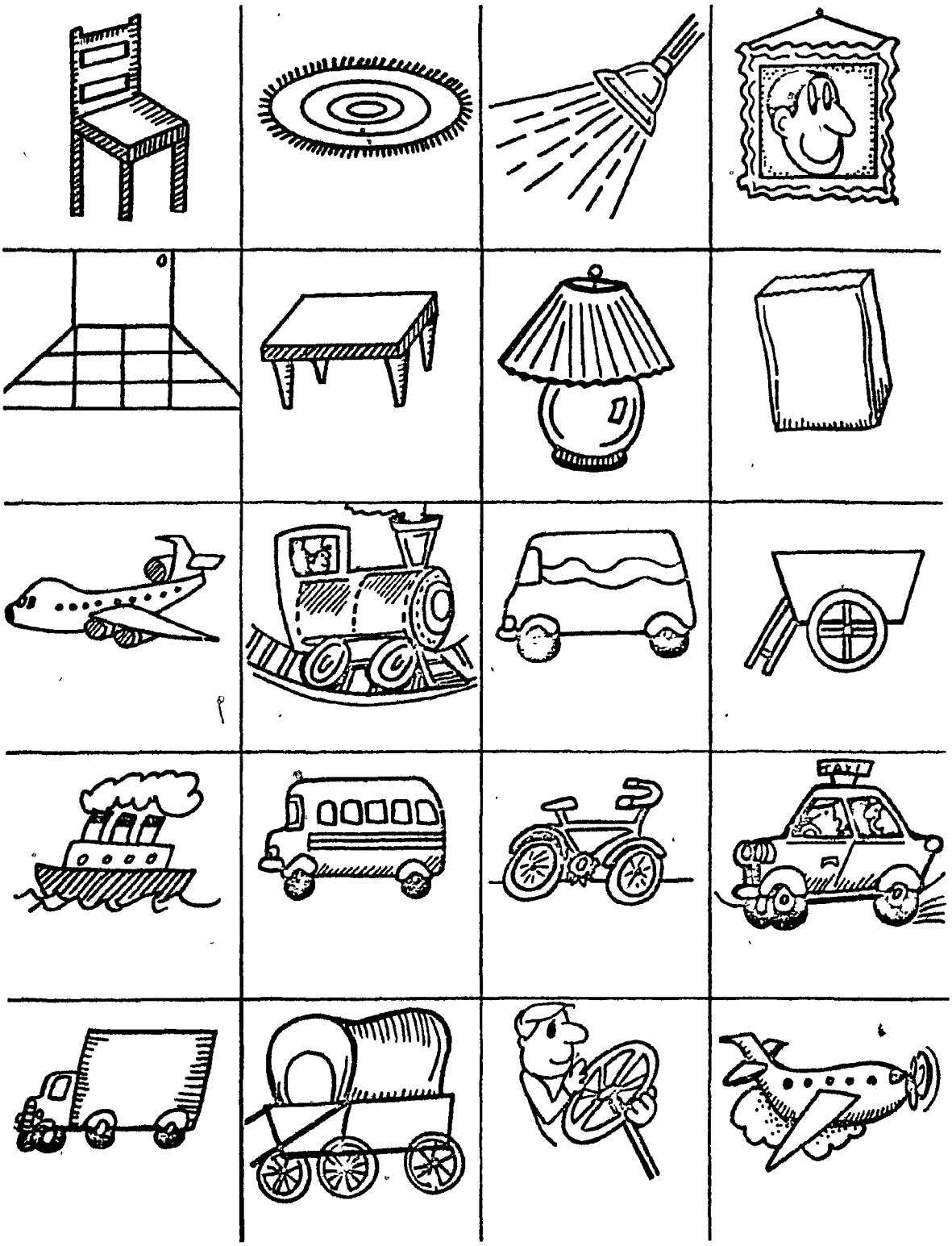
barn	cage	park	hill
farm	pool	cave	shed
church	beach	zoo	edge
back	top	side	front
middle	doctor	waves	shop

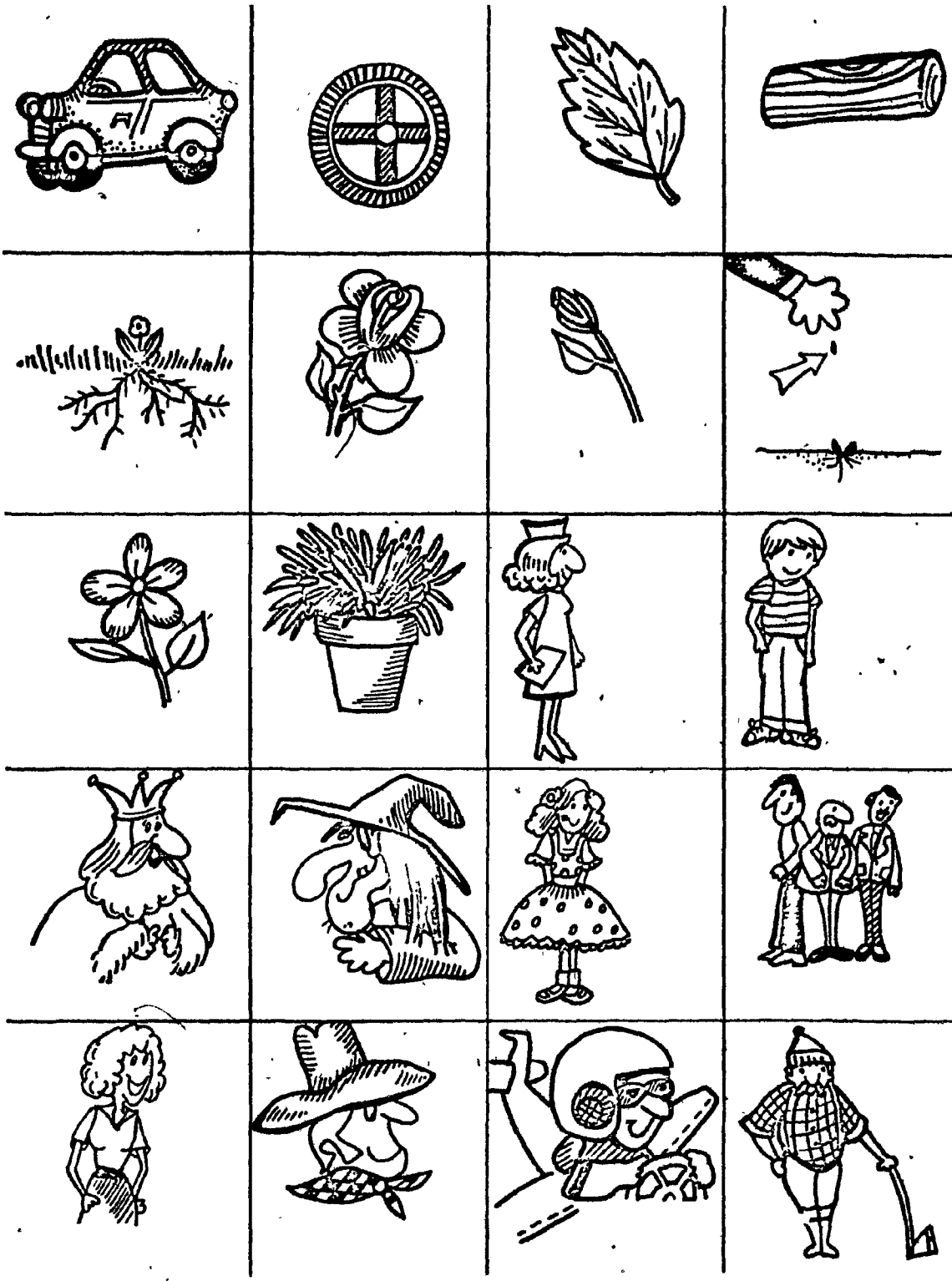
Page 114

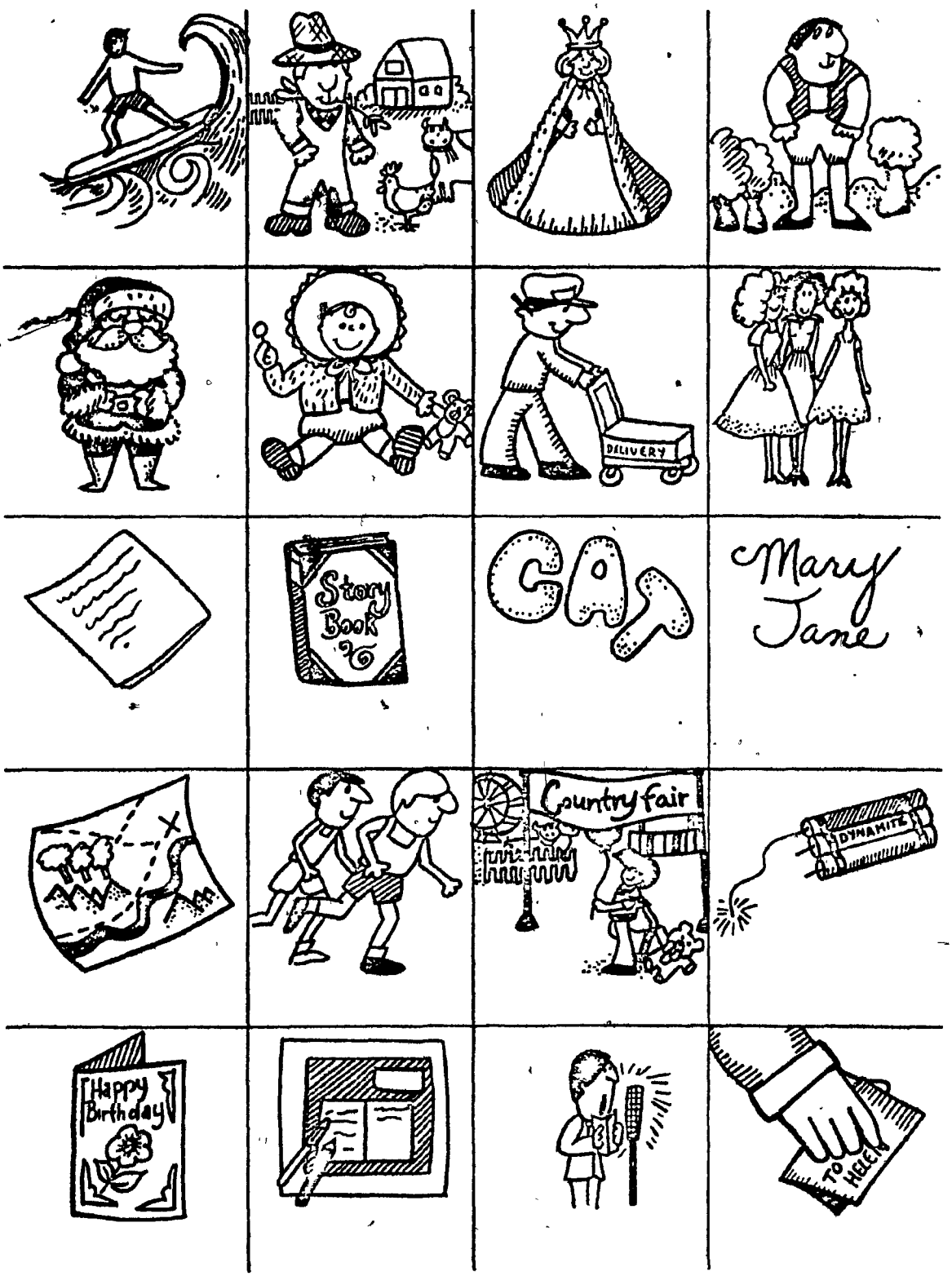
rain	house	telegraph pole	net
boat	road	seat	stars
bush	chimney	tap	

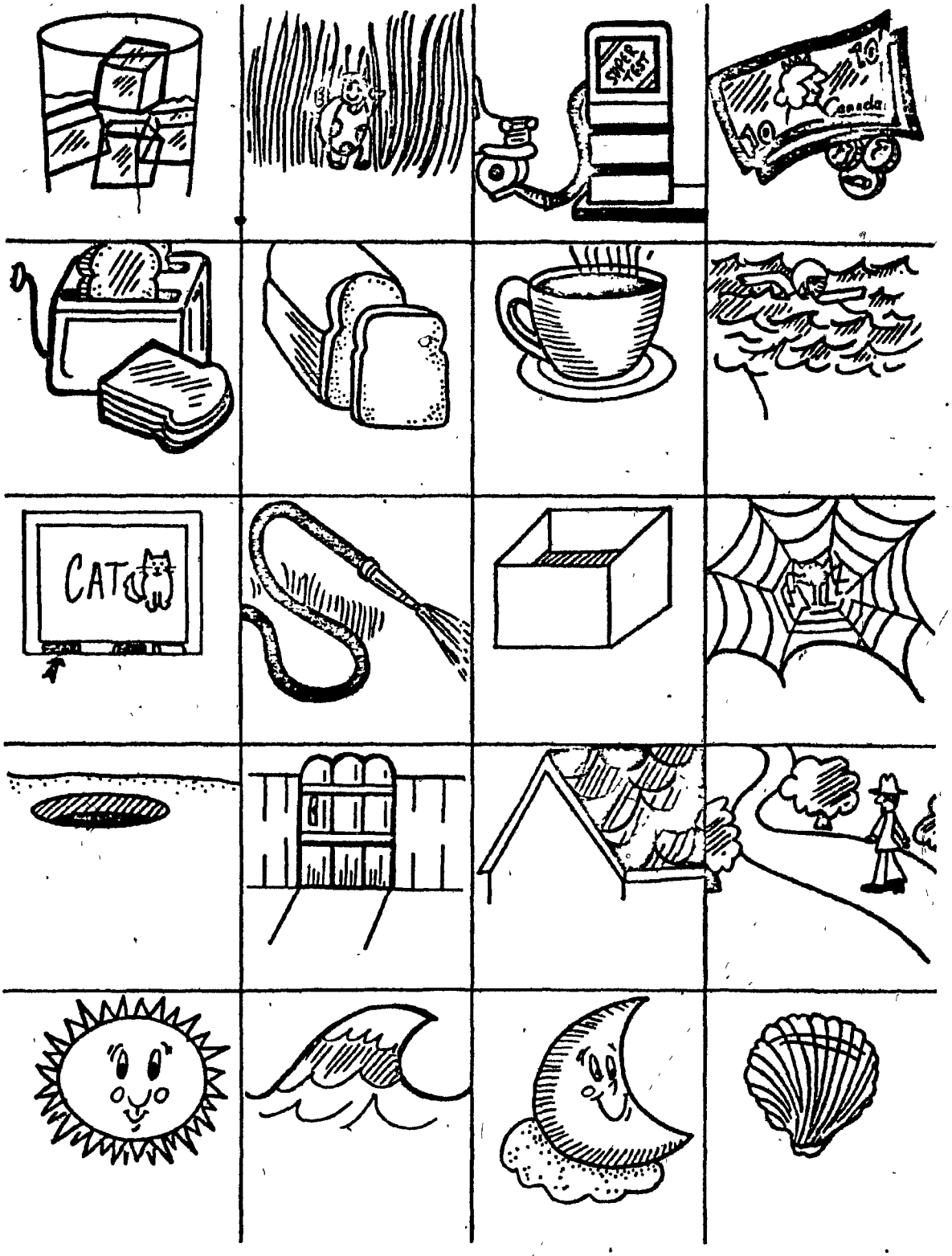

THUMP
THUMP








DELIVERY
Story Book
GO
Mary Jane
Country fair
DYNAMITE
Happy Birthday
TO HELEN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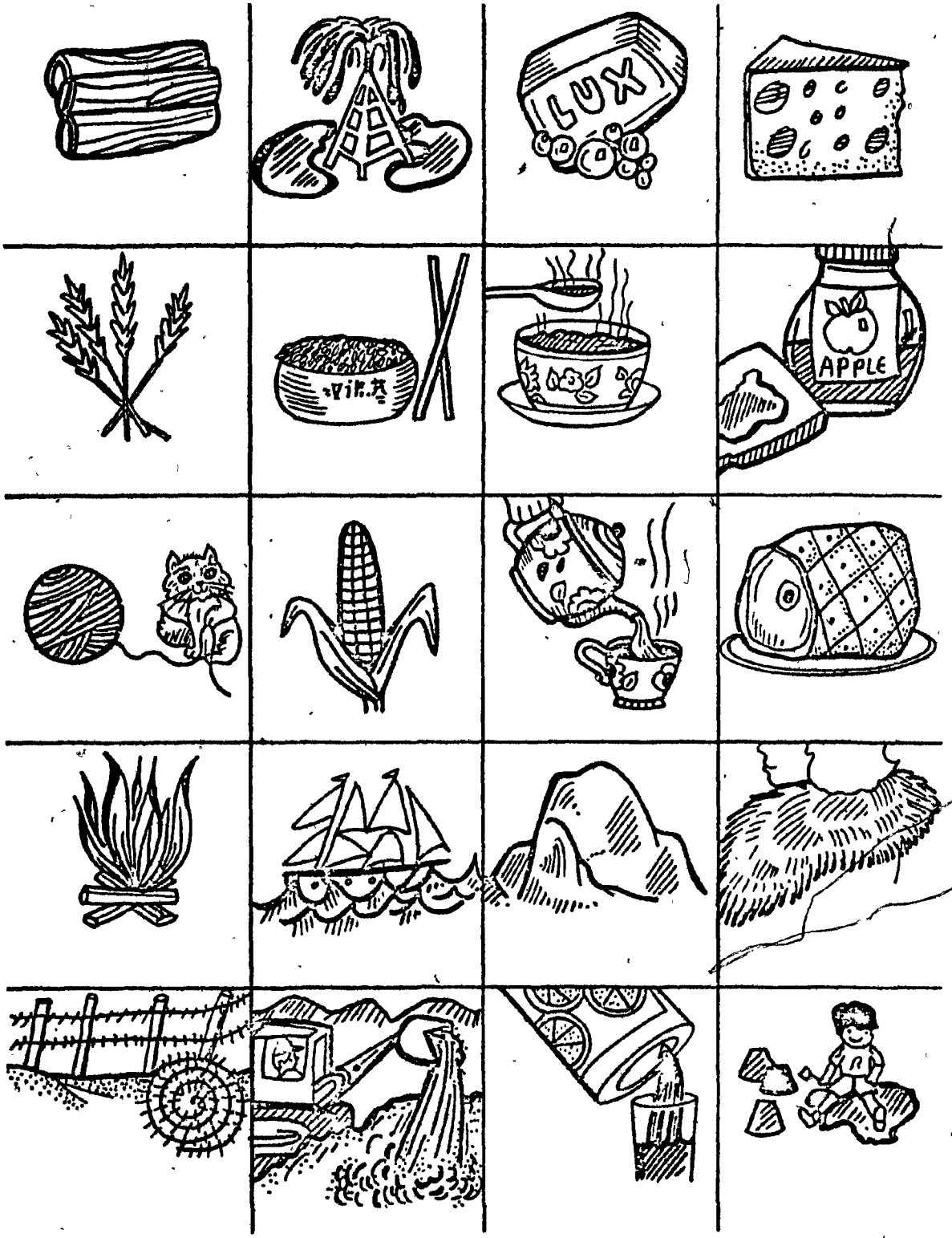
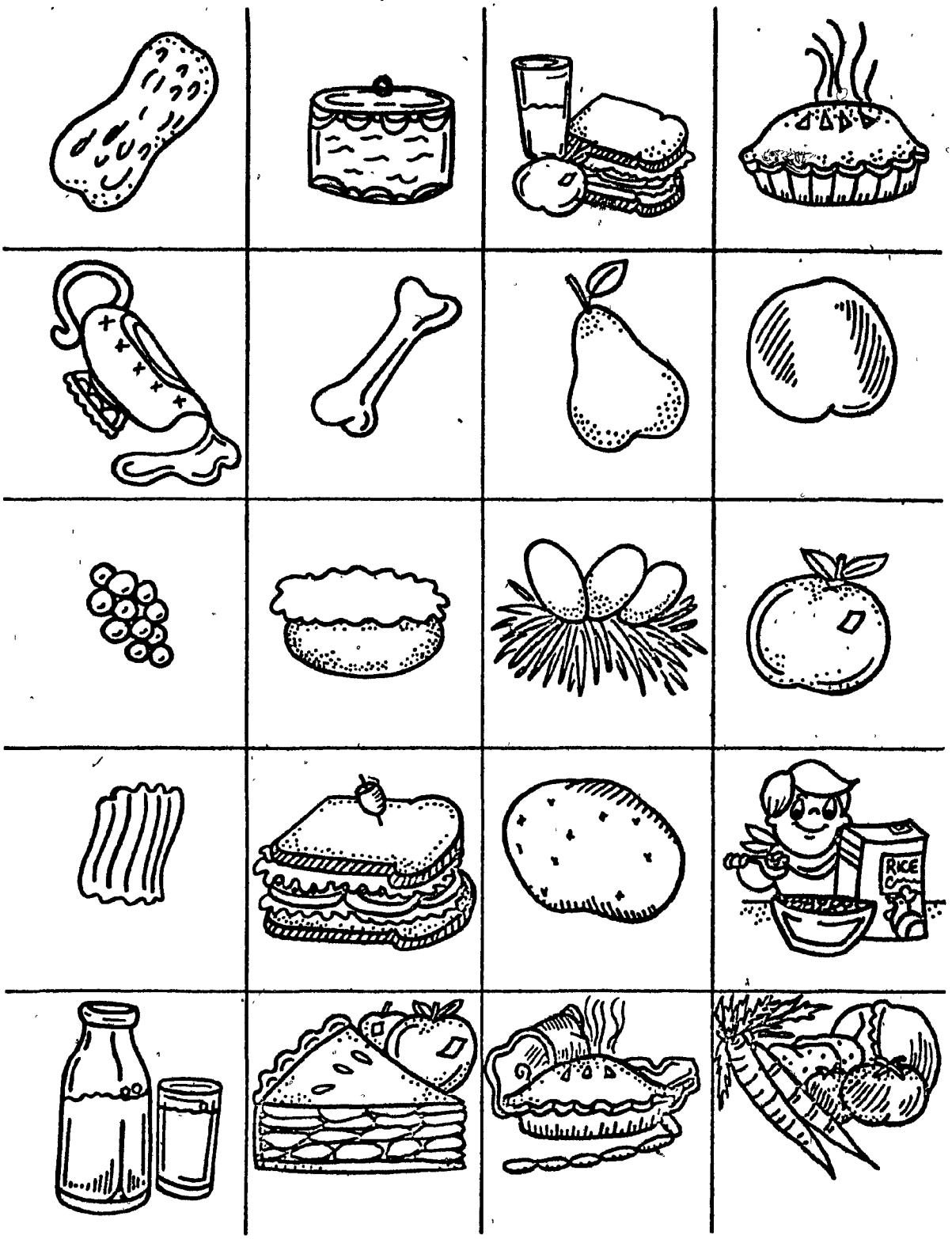
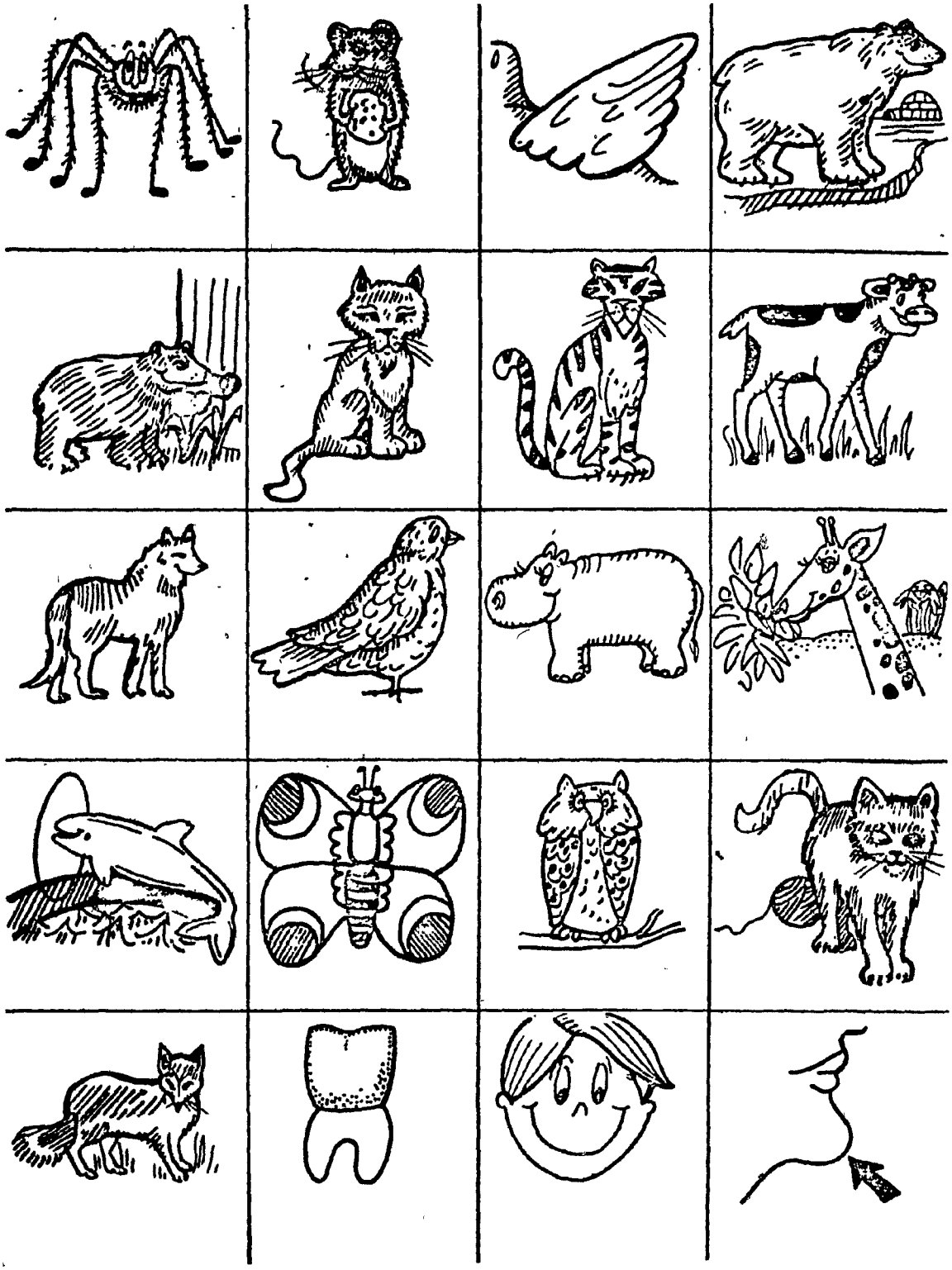
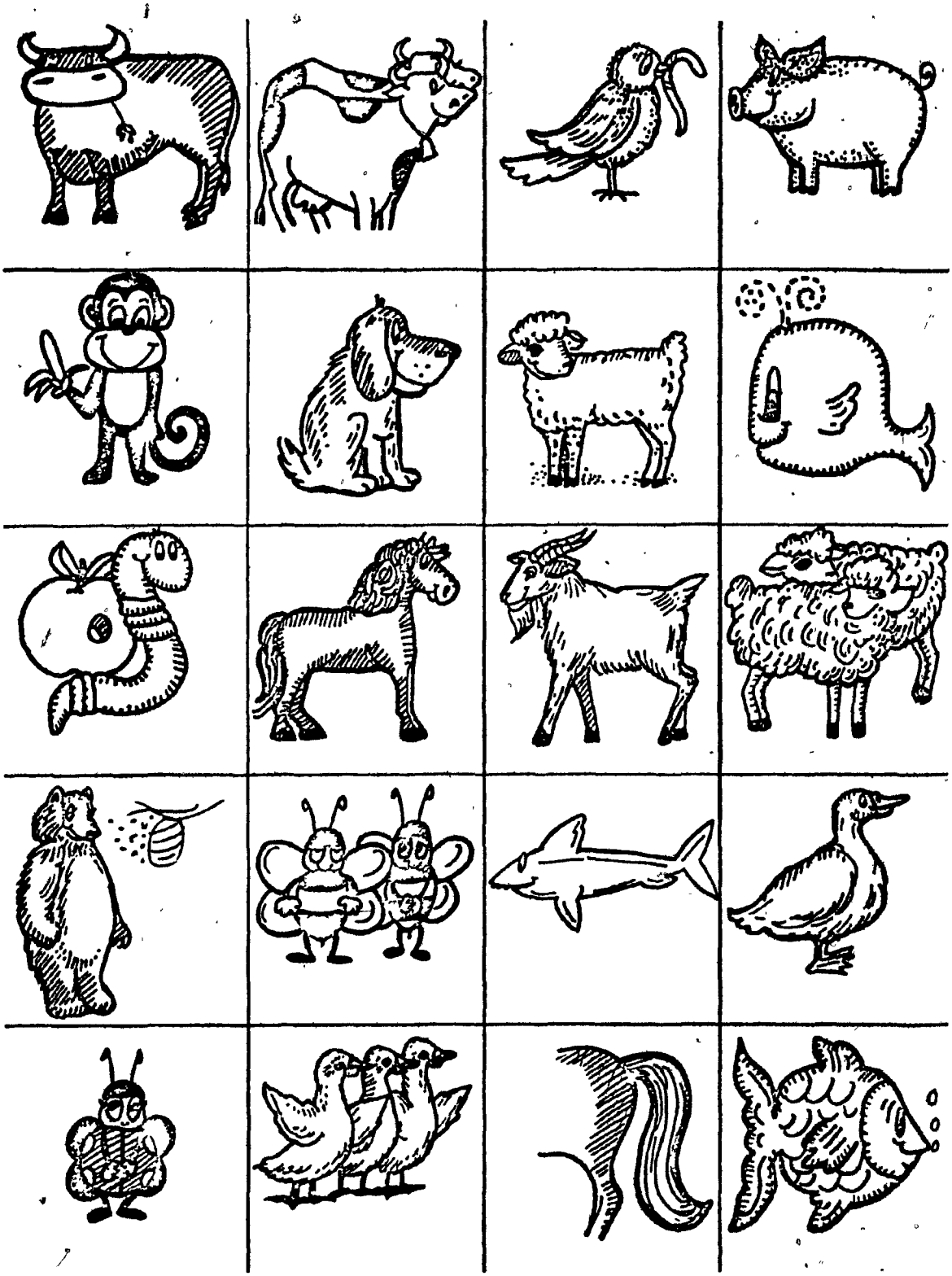
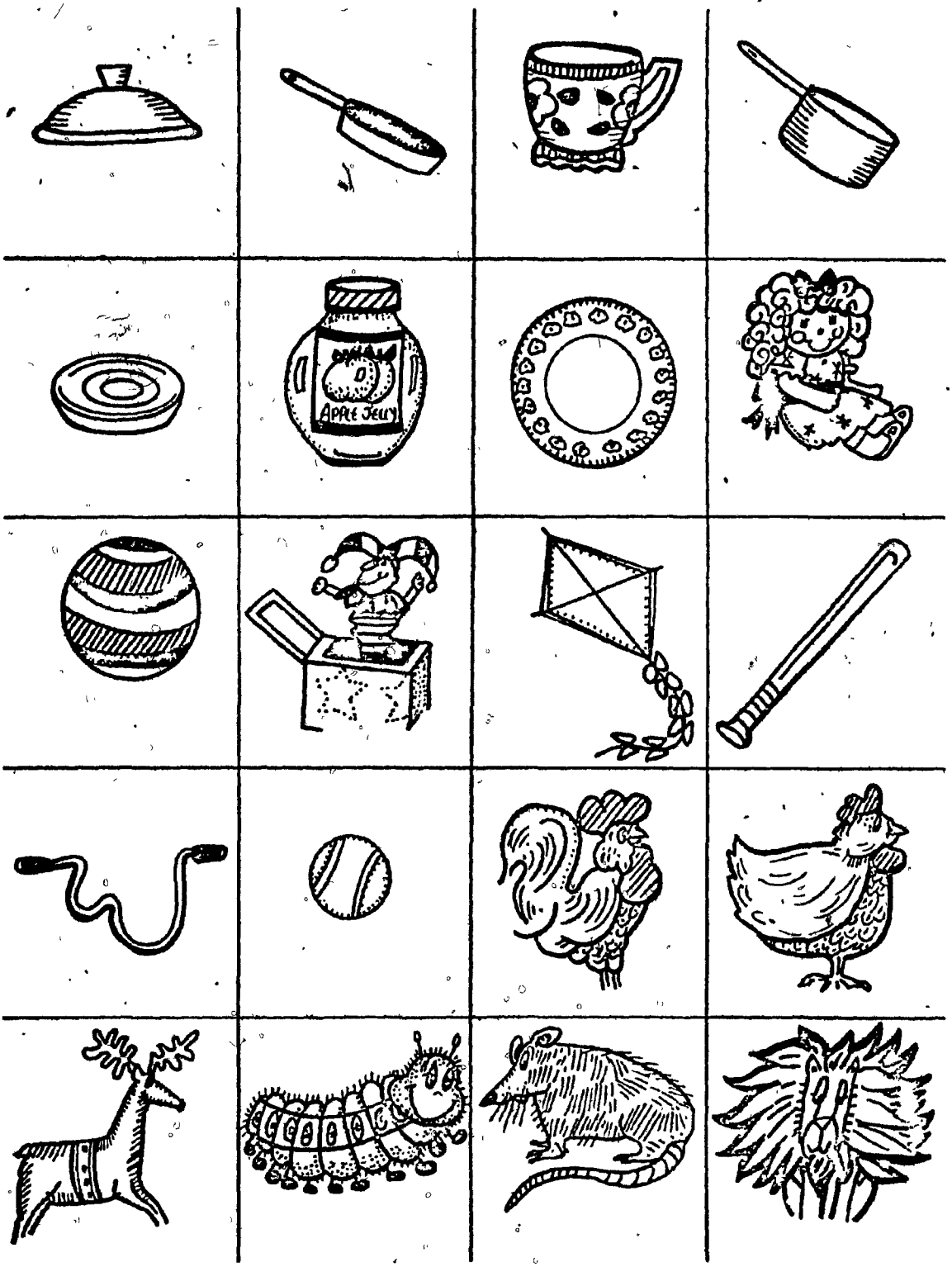
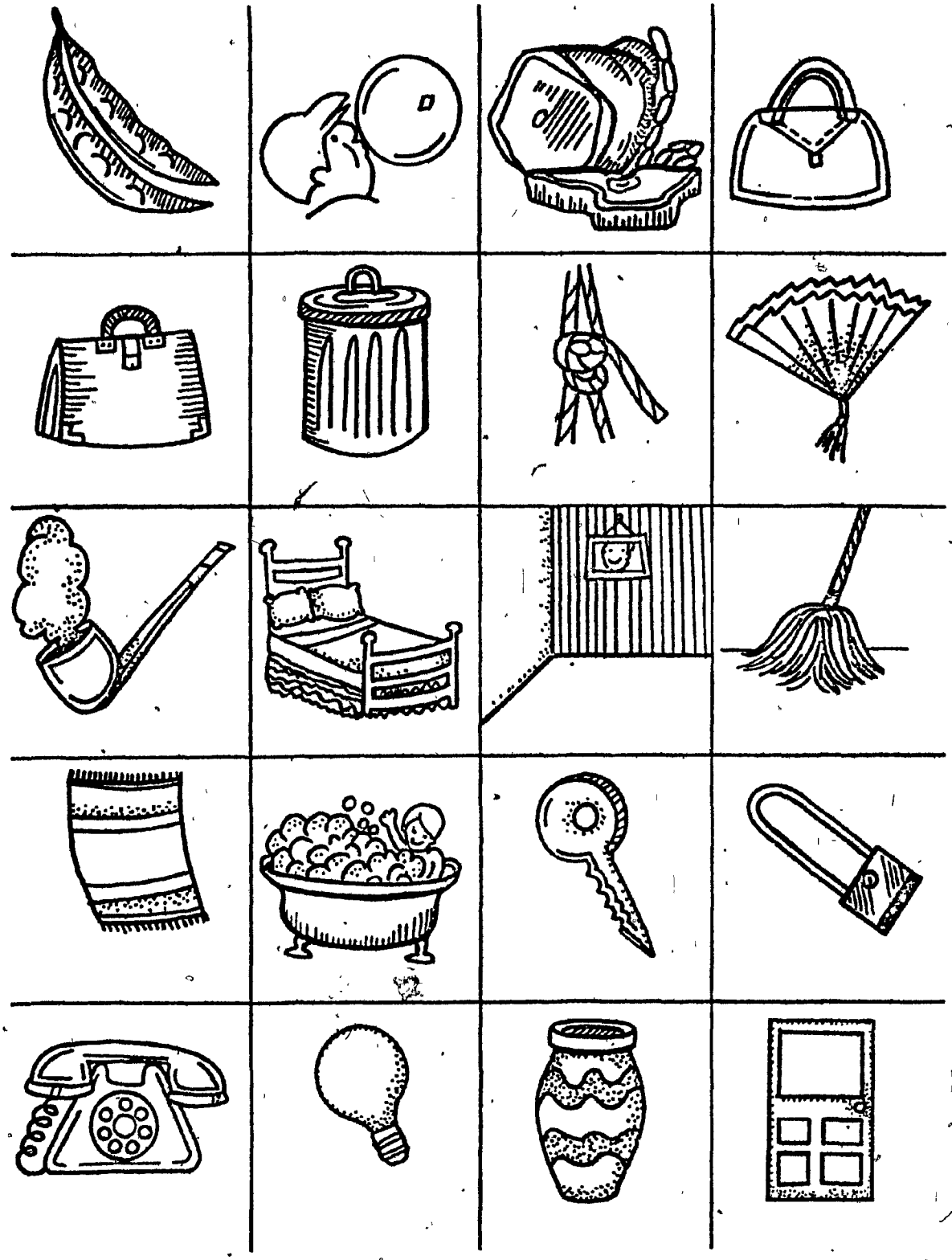

LUX
APPLE


RICE

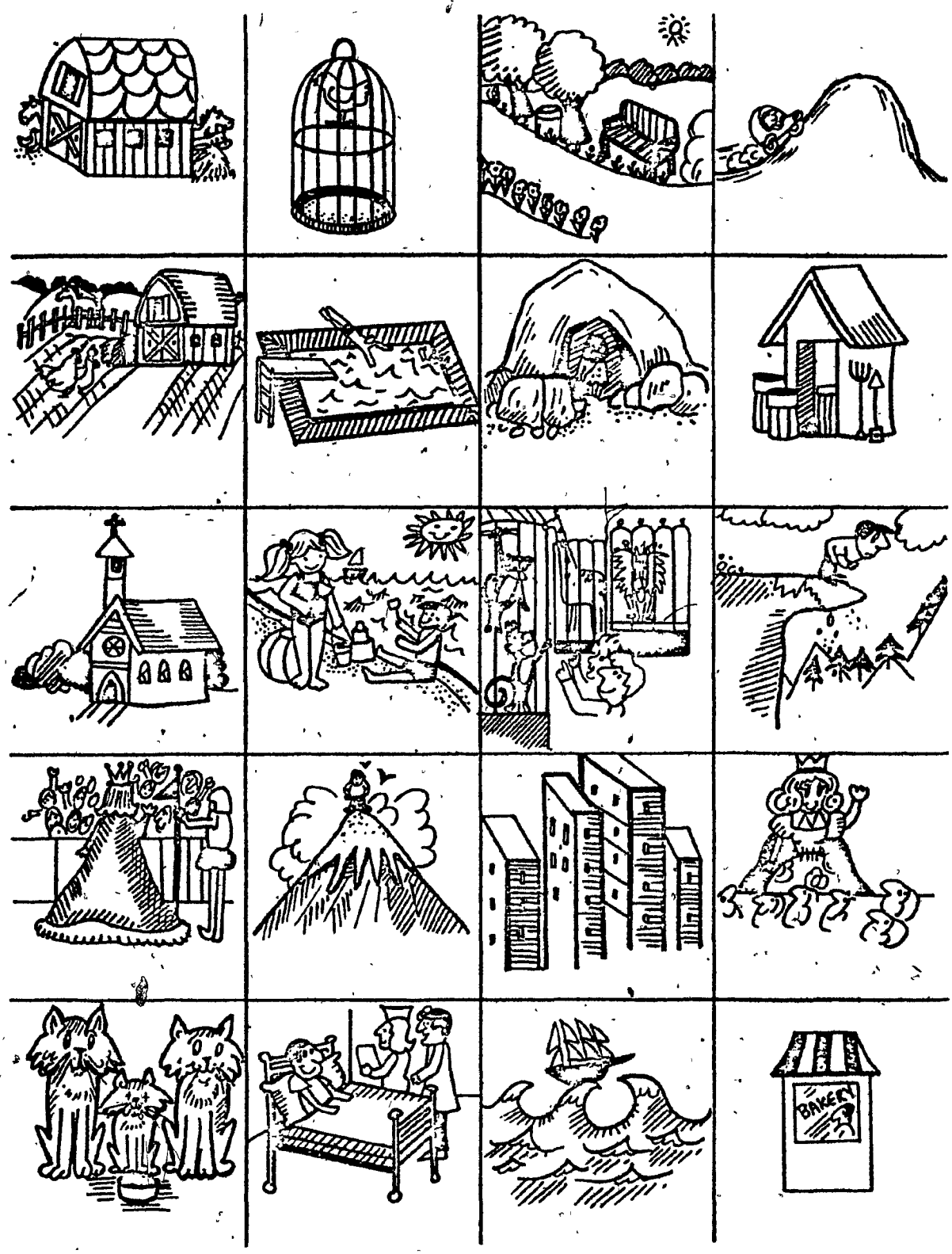


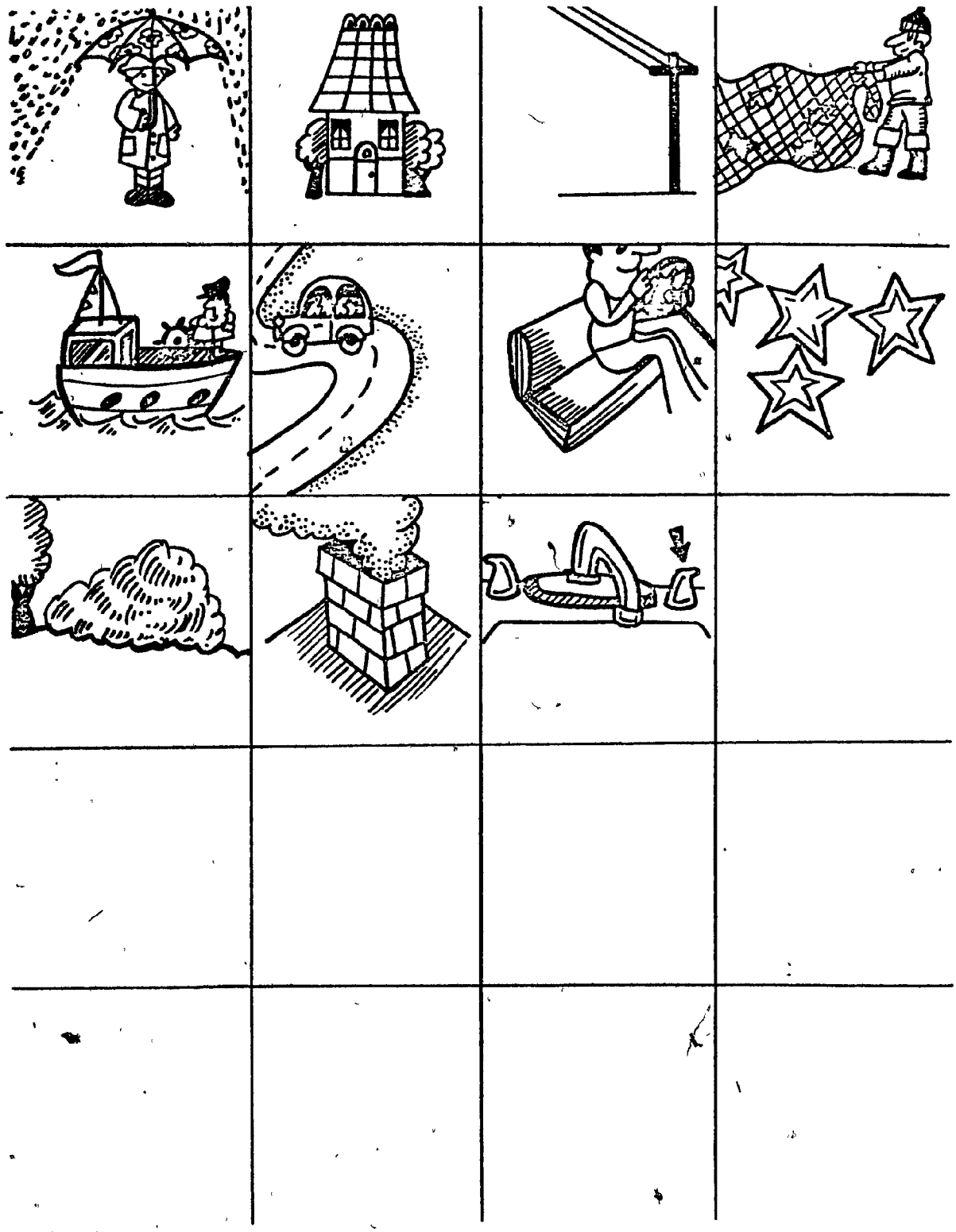



APPLE JELLY




MARK
10
Soup


BAKERY



APPENDIX 3

The Six Sentence Lists Designed to Test Perception of Key Words in Sentences

Appendix 3.

List 1	List 2
1. I got some oil.	1. Give him the ball.
2. What is your name?	2. The pilot flew the jumbo jet.
3. He is the king.	3. Play tennis with a tennis ball.
4. She is a nurse.	4. This is my top lip.
5. I want some gum.	5. Get me the mop.
6. Who wants some cake?	6. Look at the sun.
7. Dad got some petrol and oil.	7. These are my teeth.
8. Watch T.V. in the living room.	8. He smokes cigarettes and a pipe.
9. Put the picture on the wall.	9. He has a pipe.
10. The monkey ate a nut.	10. Look at my tooth.
11. The farmer shot the fox.	11. Wear a raincoat in the rain.
12. I like your hair.	12. Draw the moon and sun.
13. Water the grass with the hose.	13. I brushed my teeth.
14. I will read a book.	14. We have a kite.
15. Go in that room.	15. Look at the lion.
16. Draw a sheep, cow and pig.	16. I want toast and jam.
17. Who wants a nut?	17. Turn on the light.
18. Show me his name.	18. Is that a jet?
19. Is that a hill?	19. The dentist pulled out my tooth.
20. They locked the lion in the cage.	20. That bird is an owl.
21. Is that a fox?	21. Would you like potatoes or rice?
22. I ate some chewing gum.	22. Clean the floor with a mop.
23. There's a doctor and nurse.	23. Is it dark or light?
24. Dad drove our car.	24. Do you like rice?
25. Who saw the rat?	25. Talk to all the ladies and men.
26. Where is my book?	26. Wear your other rain boot.
27. I ate some birthday cake.	27. Show me your lip.
28. Brush and comb your hair.	28. Where are the men?
29. We heard the church bell.	29. Look at the rain.
30. Look at the wall.	30. We saw a tiger and lion.
31. That is a pig.	31. We saw the owl.
32. That's the queen and king.	32. Get a knife and fork.
33. Is that a mouse or rat?	33. Where is my boot?
34. That is our car.	34. Is this your fork?
35. Get me the hose.	35. Pass me the jam.
36. It's in the cage.	36. Let me fly the kite.

List 3

1. It's in the tin.
2. Stand on one foot.
3. Put the rubbish in the rubbish bin.
4. Do you like ham?
5. This is my towel.
6. Who wants eggs and ham?
7. Fish swim in the sea.
8. The spider made a web.
9. A giraffe has a long neck.
10. It's near the web.
11. I hurt my foot.
12. I've a sore neck.
13. Skip with a skipping rope.
14. It's in the sea.
15. The children were scared of the witch.
16. Where is your house?
17. A bear sleeps in a cave.
18. Rudolph is a red nosed reindeer.
19. That is a rope.
20. Play with the boy and girl.
21. I have a watch.
22. The bride got married in church.
23. We live in a big house.
24. See the time on your watch.
25. There is the girl.
26. What's in the cave?
27. Get some water from the tap.
28. Turn on the tap.
29. What's in its mouth?
30. Dry yourself with a towel.
31. In your mouth is your tongue.
32. A hippo has a big mouth.
33. Is that the church?
34. We saw a deer.
35. Show me your tongue.
36. She drew a witch.

List 4

1. Get a cup, plate and dish.
2. That is a log.
3. Here is the jug.
4. That's a worm.
5. Do you like cheese?
6. The mouse ate some cheese.
7. That is an earthworm.
8. The chimney is on the roof.
9. The sheep has soft wool.
10. Look at the dirt.
11. I have no meat.
12. Is this the day?
13. Tell me the month, week and day.
14. Go to the farm.
15. Is that the moon?
16. Who broke the dish?
17. The biggest fish is the whale.
18. Turn over the other side.
19. Show me the fire.
20. A watch tells the time.
21. The firemen hosed the fire.
22. Don't walk in the mud and dirt.
23. Show me the wool.
24. Farm animals live on the farm.
25. Look at the stars and the moon.
26. That is a doll.
27. Eat your vegetables and meat.
28. Show me the time.
29. The girl played with her doll.
30. I like the pool.
31. It's on the roof.
32. This is my side.
33. Who saw the whale?
34. The woodcutter sawed the log.
35. The milk is in the milk jug.
36. We swim in the swimming pool.

List 5

1. This is my chin.
2. Look at the hill.
3. Wear your shoes on your feet.
4. I have four fingers and a thumb.
5. Dad shaves the hair off his chin.
6. Is that a hen?
7. Look at the rock.
8. The plant has leaves and a root.
9. There's a rooster and hen.
10. Wash your hands and face.
11. Mum bought some food.
12. Jack and Jill fell down the hill.
13. Do you like corn?
14. Cornflakes are made from corn.
15. We have some food.
16. I hurt my toe on a rock.
17. I hurt my head.
18. Wash your hands with the soap.
19. What's in the jar?
20. Is that the root?
21. The jam is in the jam jar.
22. Is it on the bottom or top?
23. Bread is made from wheat.
24. Put your hat on your head.
25. Where is my mug?
26. Is that a bull?
27. Put on your shirt.
28. These are my feet.
29. It's on the top.
30. This is my thumb.
31. Wear your pants and shirt.
32. Look at the wheat.
33. Who has some soap?
34. Who drew that face?
35. The bullfighter fought the bull.
36. Who has a cup or mug?

List 6

1. I like tomato soup.
2. The door has a key and lock.
3. Where is your bed?
4. It has a tail.
5. Where is my sock?
6. The cake is in the cake tin.
7. I found my purse.
8. Mum's money is in her purse.
9. Here is a chair.
10. I saw a fish.
11. Have you a cat or dog?
12. That is her ring.
13. I went fishing and caught a fish.
14. Go to sleep in your bed.
15. The cowboy rides his horse.
16. The ducklings swam with the duck.
17. It's in the tin.
18. Open your book at this page.
19. Look at the duck.
20. Cut the bread with a knife.
21. I don't like soup.
22. He has a gun.
23. This is my leg.
24. Look at the horse.
25. I saw a mouse.
26. Mum has a diamond ring.
27. I have no knife.
28. This is my arm and leg.
29. Show me the page.
30. Sit down on the chair.
31. Where is my shoe and sock?
32. I like that dog.
33. Where is the lock?
34. The dog is wagging its tail.
35. The cat chased a mouse.
36. The farmer shot the fox with a gun.

APPENDIX 4

Four Examples of Language
Produced by the Subjects

Subject 8 Age 15 years Hearing Loss 103 dB

Mean Length x Complexity Score = 69

Picture Sequence (S.R.A. Card 9/51)

		Length	Complex.
1.	I think at the beginning the dog was trying to cross the road, but he wasn't quick enough when the car came up and hit him.	26	7
2.	The car didn't bother to pick up but a kind man in another car stopped and picked him up.	-	-
3.	The man is thinking that the dog wouldn't live so he'll take him to the vet.	16	7
4.	The dog is now better, but the doctor is checking to make sure he's alright.	15	7
5.	The vet is saying to the dog, "I think I'll call you a name."	14	7
6.	It's no good calling you "it" or "a dog".	9	7
7.	I think I'll call you Spotty.	6	6
8.	I think you are fine at the moment, but I think I'll keep you in quarantine."	16	7
9.	The shopkeeper at the cage is saying to the animals, "The people will all soon come up to see you, and to take some of you away to keep."	29	7
10.	The man is saying to the boy, "Would you like that dog?"	12	7
11.	The boy says, "Yes I would, but do you think it would be dear to feed it?"	17	7

Subject 8 | Age 15 years | Hearing Loss 103 dB

Picture Sequence (cont'd)

12.	"No I can afford to keep a dog."	8	7
13.	"O.K., we'll take this one."	5	7
14.	The boy says, "Oh, that's right, we'd have to buy some things to make the dog comfortable."	17	7
15.	The man says, "We'll buy these for the dog."		
16.	There's some dishes and some leashes with a collar to choose from.		
17.	The boy says, "I would like the yellow leash and a beautiful collar to put on the dog."		
18.	The man says, "Anything else?"		
19.	The boy says, "Oh, we nearly forgot to buy the leash too."		
20.	The man said, "What about putting the things together so that we can buy them properly and not steal them."		

Subject 8 Age 15 years Hearing Loss 103 dB

Manipulation of Space

		Length	Complex.
1.	My bed is on the left side near the door.	10	4
2.	My desk is also on the left side but in the corner.	12	7
3.	My hanging clothes are on the right side of the door.	11	4
4.	Between the bed and the clothes stand is a door.	10	7
5.	There is a drawer in the corner on the right side near the clothes stand.	15	4
6.	On that side, near the drawer, there's a window in the middle.	12	7
7.	In the corner, on the side near the window is a bookstand.	13	7
8.	Between the desk and the bookstand is a press for clothes, and in the middle there is a light.	20	7
9.	There's another light for my reading in bed.	8	5
10.	My bedroom is upstairs, facing north.	6	5

Subject 8 Age 15 years Hearing Loss 103 dB

Conversation with Teacher

Brother "Good afternoon Paul, how are you?"

		Length	Complex.
1.	Fine thanks, Brother.	3	3
2.	I think I'll talk about Christmas.	6	6
3.	I think I'm going away but I don't know where to go.	12	6
4.	My mother and father has been trying to find a place where we can go, not too far from Sydney.	-	-
5.	We will probably go away after Christmas.	7	4
6.	We may be going with some friends of mine.	9	4
7.	I was going to get a watch for Christmas, but my father's friend can't get it till after Christmas so I'm going to get a new wetsuit instead.	28	7
8.	I may gϕ away with Joshua to some places, but I haven't got much money at the moment.	18	5
9.	I may be working at Christmas holidays.	-	-
10.	I need the money badly, because I have made a lot of friends and they keep haunting me to go to some places.	23	7
11.	In the past few days, we have been having a lot of free work at Oakhill.	16	7
12.	I'm going to finish school in two days' time.	9	4

Subject 8 Age 15 years Hearing Loss 103 dB

Manipulation of Time

		Length	Complex.
1.	First, I will get some things ready for a cup of Milo.	12	7
2.	I will get a pint of milk, and some Milo and some sugar, and of course, the most important thing, a cup.	22	7
3.	Secondly, you pour in milk and then you put in two teaspoonsful of Milo.	14	7
4.	Then you really mix them up if you want to make it smooth.	13	7
5.	Then you add some sugar, if you like sugar.	9	7
6.	And then if you want some ice, you get some ice and put it in the cup.	17	7
7.	That makes it an iced Milo drink.	7	7
8.	Firstly, I got some things for the Milo.	8	7
9.	I had a pint of milk, and Milo and some sugar.	11	4
10.	Then I poured some milk into the cup.	8	7
11.	Then I put in two teaspoons of Milo.	8	7
12.	Then I really made it smooth.	6	7
13.	Then I put in some ice.		
14.	Then I had instant Milo drink.		
15.	Then I drank it all up, including the ice.		

Subject 8 Age 15 years Hearing Loss 103 dB

Question Forms

Brother "Last Saturday I went to Cronulla."

		Length	Complex.
1.	What were you doing at Cronulla?	6	4
2.	Was your father pleased to see you?	7	5
3.	Was he expecting you?	4	4
4.	Why did you want to see your father?	8	5
5.	What were you doing last week?	6	4
6.	I mean when you last saw him a week or so ago?	12	7
7.	How did you get there with the petrol shortage?	9	4
8.	But I thought Cronulla and other suburbs hadn't much petrol.	10	7
9.	Was there a lot of trouble getting petrol there?	9	4
10.	What time did it open then?	6	4
11.	In the afternoon?	3	3
12.	So that means that you probably left here about two.	10	7
13.	Why then were you so long?		
14.	Who did you go to the beach with?		
15.	Did the Hastings family go with you to see your father?		
16.	How did they get home, by themselves?		

Subject 17 Age 14 years Hearing Loss 120 dB

Mean Length x Complexity Score = 37

Picture Sequence (S.R.A. Card 6/34)	Length	Complex.
1. The boys' father said, "Would you like to go to shop and buy something for me?"	16	7
2. The boy said, "Thank-you."	5	7
3. They went to the shop and they asked the shopkeeper.	10	5
4. They wanted cornflakes and something else.	6	4
5. He said, "Is that all?"	5	7
6. "Give me two dollars."	4	7
7. They were playing on the bars and the boy with the blue shirt said, "It is fun to play on the bars."	22	7
8. The money has fallen down to the ground but they didn't know.	12	5
9. The father said, "Give me some change and put the things away."	12	7
10. The boy said, "No, I haven't any."	7	7
11. The boy is looking for the money but he can't find it.	12	5
12. The boys were afraid of him because he was very angry with them.	13	5
13. The father said, "Where's the money?"		
14. But the boy said, "I think it fell over when we were playing with the bars."		

Subject 17 Age 14 years Hearing Loss 120 dB

Manipulation of Space

		Length	Complex.
1.	Will I talk about the wallpaper?	6	4
2.	It looks like flowers and pink lines.	7	7
3.	There is only one window.	5	4
4.	It's about there.	3	7
5.	The curtain is pink.	4	4
6.	There are two beds for me and Jenny.	8	4
7.	They are near the window.	5	7
8.	The small drawer is between the beds.	7	4
9.	There are three drawers.	4	4
10.	Two drawers are for socks, the other one is for shorts.	11	7
11.	I have two big cupboards on the left side.	9	4
12.	I have the dressing table on the front wall.	9	4
13.	The carpet is dark brown and light brown.		
14.	All the rooms have the same carpet.		
15.	The kitchen and laundry have no carpet.		
16.	If you spill the water the carpet will get dirty.		
17.	The bookshelf is between the cupboard and the dressingtable.		
18.	There are three shelves.		
19.	There are about thirty books.		

Subject 17 Age 14 years Hearing Loss 120 dB

Conversation with parent.

		Length	Complex.
1.	My name is Dianne Jardine.	5	4
2.	There are five people in my family.	7	4
3.	They are Michael, Jenny, Mum, Dad and myself.	8	7
4.	I live in North Rocks.	5	4
5.	Yes I do.	3	3
6.	Because I have a lot of friends here and I like my school this year.	15	5
7.	I want a school port, a hair dryer, some pencils, a pump for my air mattress and some skis.	19	4
8.	Well, well.	-	-
9.	I am going to Victoria	5	4
10.	Yes I am.	3	3
11.	I will see my Grandmother and Grandfather	7	4
12.	I will learn how to ski in the lake.	8	5
13.	Alright.		
14.	Yes, but she doesn't like some teachers.		
15.	No.		
16.	Of course, I love all sport.		
17.	My favourite sports are tennis, netball, football, soccer, softball and shotput.		
18.	I am going to Luna Park for free.		
19.	We are going there because Women's Weekly gave us some free tickets.		

Subject 17 | Age 14 years | Hearing Loss 120 dB

Manipulation of Time

		Length	Complex.
1.	I'm going to take one teaspoonful of milo.	8	4
2.	Now I'm going to put it into the bowl.	9	7
3.	I will take the lid off.	6	4
4.	I'm taking one teaspoonful of sugar and putting it into the bowl.	12	5
5.	I'm shutting the jar.	4	4
6.	I'm pouring the milk into the bowl.	7	4
7.	I'm mixing the milk.	4	4
8.	I'm pouring the mix into the glass.	7	4
9.	I've tried some before but I don't like it.	9	7
10.	One teaspoonful of milo was taken.	6	6
11.	Then it was put into the bowl.	7	7
12.	Next the jar was opened.	5	7
13.	One teaspoonful of sugar was taken and put into the bowl.		
14.	Then the mix was mixed.		
15.	The mix was poured into the glass, but it wasn't drunk.		
16.	First I took one teaspoonful of milo.		
17.	Then I dropped it into the bowl.		
18.	Then I opened the tin.		
19.	I took one teaspoonful of sugar and put that into the bowl.		
20.	Next I mixed the mix.		
21.	Then I poured it into the glass but I didn't drink it.		

Subject 17 Age 14 years Hearing Loss 120 dB

Question Work

Brother "I went to Townsville last Thursday."

		Length	Complex.
1.	What time did you go there?	6	4
2.	How many minutes did the plane take to Townsville?	9	4
3.	Was the weather hot?	4	4
4.	Did your friend wait for you?	6	4
5.	Who waited for you to come?	6	5
6.	Who's he?	2	3
7.	What did you do first at the airport?	8	4
8.	Has he any children?	4	4
9.	How many children does he have?	6	4
10.	Are they his daughters or sons?	6	4
11.	Is one person deaf?	4	4
12.	Which one?	2	2
13.	What's his name?		
14.	How old is he?		
15.	Did you have any tea with them?		
16.	Did you go somewhere?		
17.	Where did you go?		
18.	Did you have any meeting?		
19.	Was it boring or interesting?		
20.	Did you go to the school to see the deaf children?		
21.	Could you understand them?		
22.	Did you know some children?		
23.	Yes, she has red hair.		

Subject 17 Age 14 years Hearing Loss 120 dB

Question Work (cont'd)

24. What did you do on the weekend?

25. Did you see James and Peter?

26. Why didn't you see Peter?

27. Did you want to see Peter?

Subject 3 Age 13 years Hearing Loss 98 dB

Mean Length x Complexity Score = 24

Picture Sequence (S.R.A. Card 9/49)

		Length	Complex.
1.	He took a bottle pills.	5	4
2.	He ate them.	3	7
3.	He said, "Don't eat them."	5	7
4.	"The pills will make you more sick."	7	7
5.	He said, "Alright."	3	7
6.	"I won't eat any more."	5	7
7.	He told his mother.	4	4
8.	He said his brother took a bottle of pills.	9	7
9.	She said, "Really! Where is he?"	6	7
10.	The boy said, "He's on the table on the bathroom."	10	7
11.	The boy said, "You are a silly boy."	8	7
12.	You ate them too much.	5	4

13. The mother said, "My son got pain in tummy."
14. He had the pills too much.
15. The sound carries the noise of the siren.
16. The doctor says, "I hope you won't die."
17. The mother said, "I hope not."
18. The mother is patting her son's hair.
19. He is lying on the bed and still better.
20. The mother said, "Are you better?"
21. "You will come home very soon."
22. "I hope you won't eat the pills any more."

Subject 3 Age 13 years Hearing Loss 98 dB

Manipulation of Space

		Length	Complex.
1.	Draw a square.	3	3
2.	The door's at the bottom.	5	4
3.	A dressing table is at the side back of the wall.	-	-
4.	Draw a mirror stand at the wall.	7	4
5.	The small cupboard is a side front of the wall.	-	-
6.	The big cupboard is behind the small cupboard.	8	4
7.	That's wrong.	2	3
8.	The two beds are at the corner of the wall.	10	4
9.	The big cupboard and two beds are between the chair.	-	-
10.	The mat is in the carpet on the floor.	-	-
11.	The mat is nearly the middle.	-	-
12.	I have a small bedroom.	5	4

13. I will change my bedroom.
14. Because, so I will get more drawers and bookshelves.
15. Yes, sometimes.
16. The windows are at the wall.
17. The windows are at the back of the wall.
18. The windows are near my bed.
19. I thought you were talking about my bedroom.
20. There's a light switch on the door.
21. There's the standing up light can't move.
22. There is one light standing in wall.
23. In my bedroom.

Subject 3 | Age 13 years | Hearing Loss 98 dB

Conversation with parent.

		Length	Complex.
1.	We will go to Dubbo to pick my cousin.	-	-
2.	Then we will go to Canberra.	6	7
3.	We will see my Aunty and friends.	7	4
4.	We might go camping in Bateman's Bay.	7	5
5.	Yes we went.	3	3
6.	We had a swim on the beach with my aunty and uncle.	12	4
7.	My aunty and uncle slept in the caravan.	8	4
8.	We went to the snow for three days.	8	4
9.	There were forty two children.	5	7
10.	The snow was beautiful.	4	4
11.	We played in the snow.	5	4
12.	It was cold.	3	7

13. I would like to go to America.
14. I would like Disneyland.
15. I would like to ride.
16. I would like to ride some fair.
17. Yes it's called.
18. The building, the large building is called a skyscraper.
19. Dad went there before a plane.
20. I would like to go and see.
21. I never go in the skyscraper.
22. I never go in the large buildings in New York.
23. Yes I might go to North...
24. We will go to Hollywood to see what do they play.

Subject 3 Age 13 years Hearing Loss 98 dB

Manipulation of Time

	Length	Complex.
1. I am taking a spoonful of Milo.	7	4
2. I am going to put the Milo in the bowl.	10	7
3. I taking the spoonful of Milo again.	-	-
4. I am going to put the Milo in the bowl.	10	4
5. I am taking the lid off the jar.	8	4
6. Wait.	1	1
7. I am taking a spoonful of sugar.	7	4
8. I am putting the sugar in the bowl.	8	7
9. I am going to put it on the top jar.	-	-
10. I am pouring more milk in the bowl.	8	4
11. What's it called?	3	4
12. I am going to put the mixer in the bowl.	10	4
13. I am turning the mixer.		
14. Would you like to drink that?		
15. I am pouring the milk out of the bowl.		
16. It's too sweet.		

Subject 3 Age 13 years Hearing Loss 98 dB

Question Forms

Teacher "I saw an accident."

		Length	Complex.
1.	What happened?	2	2
2.	Did the people kill themselves by the car?	-	-
3.	What did they do in the car?	7	4
4.	Did they break their arm or leg or toe?	9	4
5.	What did they break?	4	4
6.	Did the other people die?	5	4
7.	Was there someone got blood all over their body?	-	-
8.	Where did they crash at?	5	4
9.	You said Queensland.	3	3
10.	How many cars did they crash?	6	4
11.	How did you felt?	-	-
12.	Why?	1	1

13. Who rang the phone about crash?

14. What did you talk about?

15. What about ambulance?

Subject 12 Age 13 years Hearing Loss 105 dB

Mean Length x Complexity Score = 11

Picture Sequence (S.R.A. Card 6/34)

		Length	Complex.
1.	I think they want some more money to buy some...	11	7
2.	I think they want to go to the shop.	9	7
3.	They want sell him.	-	-
4.	They want some books for school,	6	4
5.	I think he's very happy forgave you.	-	-
6.	Some money.	2	2
7.	That's all.	2	3
8.	They are playing around.	4	4
9.	Because they other school or home.	-	-
10.	Some dog will take the bag.	-	-
11.	The dog will take some food.	6	4
12.	The man, "Where's my money?"	-	-

13. They haven't got any money.

14. I think they give him some more money.

15. He want his money--his change.

16. The man very angry with them.

17. The boy very worried about the money.

18. I think he will tell the man about over there.

Subject 12 Age 13 years Hearing Loss 105 dB

Manipulation of Space

		Length	Complex.
1.	I have a very big my bedroom.	-	-
2.	My bed is very big behind the window.	-	-
3.	The window is back.	-	-
4.	The window is behind.	4	4
5.	It short.	-	-
6.	It small.	-	-
7.	Those are blinds behind my window.	-	-
8.	Cupboard in my bedroom.	-	-
9.	The wall paper purple, pink and white.	-	-
10.	All there, all bedroom.	-	-
11.	The cupboard taller.	-	-
12.	The door on the top.	-	-
13.	No, not the top. No over - there.		
14.	The cupboard corner.		
15.	My bedroom near the window.		
16.	On the top, yes.		
17.	Pillow, the pillow is corner the window.		
18.	A mirror, the mirror near my bedroom.		
19.	On the top.		
20.	No too big.		
21.	I have only one picture.		
22.	Over there.		
23.	No, near cupboard.		
24.	I have only one table--the corner.		
25.	I have one rug on the floor in the middle.		

Subject 12 | Age 13 years | Hearing Loss 105 dB

Conversation with parent.

		Length	Complex.
1.	Next week my family they went away on holidays.	-	-
2.	They want to see my Nanna and Pop.	8	4
3.	We family sleep in the caravan park.	-	-
4.	Next week Kim and Kassey come to my place, have a holiday because they haven't be see my place.	-	-
5.	They want to sleep, play with me.	-	-
6.	Next Sunday all go to my friends water skiing.	-	-
7.	My friends went to on the boat.	-	-
8.	I ride down.	3	3
9.	I can't water-ski.	4	4
10.	My brother can water-ski.	5	4
11.	It's too cold for a swim.	6	4
12.	What you say?	-	-
13.	I understand you.		
14.	Next week we be able to swim.		
15.	I would like...my family.		
16.	That's all.		

Subject 12 Age 13 years Hearing Loss 105 dB

Question Forms.

Teacher "I saw some blood."

		Length	Complex.
1.	Really!	1	1
2.	How come the red blood?	-	-
3.	I see.	2	2
4.	What's it called?	3	4
5.	Nothing.	1	1
6.	The tree will blow up.	-	-
7.	I don't know.	3	3
8.	Some people saw the tree.	-	-
9.	How you saw blood on the road?	-	-
10.	I think the tree will die.	-	-
11.	Some people have got red blood all...	7	4
12.	Body.	-	-

Subject 12 | Age 13 years | Hearing Loss 105 dB

Manipulation of Time

		Length	Complex.
1.	You will take a glass.	5	4
2.	Then you will open the tin.	6	7
3.	Then you will put the milo in the glass.	9	7
4.	And the spoon there.	-	-
5.	Take the sugar in the glass.	6	4
6.	What's it for?	3	4
7.	You will take the spoon, put in the milk.	-	-
8.	Then the milo and you take...	7	7
9.	Then the mix spoon.	-	-
10.	Shake in the bowl for two minutes.	7	4
11.	Then you will eat.	-	-
12.	You put the spoon in the bowl.	7	4
13.	Then you put some milo in the bowl.		
14.	Only half sugar in the bowl.		
15.	Then you will shake about 4 minutes.		
16.	Then put some drink put in the glass.		
17.	Then you will drink the milk in the glass.		
18.	Then you said, "It beautiful."		

APPENDIX 5

Confusion Matrices for Consonants under each condition of presentation and in each vowel context. The figures in brackets represent the number of correct consonant-vowel responses. Numbers adjacent to bracketed figures indicate correct consonant but incorrect vowel identifications.

Appendix 5a: Confusions under Auditory (A) condition in the [a] vowel context

Response	[p]	[b]	[m]	[p̈]	[b̈]	[w]	[r]	[f]	[v]	[θ]	[ð]	[l]	[n]	[tʃ]	[dʒ]	[ʃ]	[j]	[s]	[z]	[t]	[d]	[ẗ]	[d̈]	[k]	[g]	[k̈]	[g̈]	[h]
[p]	1	1	-	1	1	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-	1	1	-	-	1
[b]	3	(0)	2	3	3	2	2	6	1	4	3	1	4	3	3	5	1	2	1	3	8	1	4	4	5	3	5	4
[m]	2	2	3(1)	2	2	3	7	1	4	-	-	2	2	1	1	-	2	2	1	-	-	-	2	-	2	1	1	1
[p̈]	-	1	-	(3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	1	1	-	1	1	-
[b̈]	-	-	-	-	(0)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
[w]	1	-	-	-	-	(0)	-	-	-	-	1	-	1	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-
[r]	-	-	2	-	-	2	(1)	-	-	-	-	2	1	-	-	-	3	-	-	-	-	-	-	-	1	-	1	1
[f]	2	3	-	-	-	-	-	1(0)	2	-	1	-	3	3	-	1	2	1	1	-	-	5	-	-	2	-	-	1
[v]	1	1	-	-	-	-	-	-	(1)	-	-	1	1	-	-	-	1	1	-	1	1	1	1	-	-	1	-	-
[θ]	-	1	-	1	-	-	-	2	-	1(0)	-	-	2	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-
[ð]	-	-	-	-	-	1	-	-	2	-	(0)	2	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-
[l]	-	-	-	-	-	1	1	-	2	-	-	1(0)	1	1	1	3	1	-	-	1	1	-	-	1	-	1	-	-
[n]	-	-	1	-	1	-	-	-	-	-	-	-	(0)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
[tʃ]	-	1	-	-	-	-	-	-	-	-	-	-	-	(1)	1	1	-	-	1	-	-	-	-	-	-	1	-	1
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	1	-	-	(0)	-	-	-	-	-	-	-	-	-	-	-	-	-
[ʃ]	-	1	-	-	-	1	-	1	1	2	1	1	-	1	1	(2)	-	1	-	1	-	-	-	2	1	2	1	-
[j]	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0)	-	1	-	-	-	-	-	1	-	-	-
[s]	1	1	2	1	-	1	-	2	-	-	-	1	-	1	1	-	-	1(0)	1	2	-	-	-	-	1	1	-	-
[z]	-	-	-	1	1	2	-	1	-	-	-	-	-	-	-	-	-	1	(0)	-	-	-	-	-	-	-	-	1
[t]	2	1	1	2	3	1	2	1	1	2	-	2	1	2	2	-	1	4	-	(2)	1	3	2	1	3	1	-	-
[d]	-	-	-	1	-	-	-	1	2	-	1	-	1	-	-	1	-	-	1	-	(0)	-	-	1	-	-	-	-
[ẗ]	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	1(0)	1	-	-	-	1	-
[d̈]	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0)	-	-	-	-	-
[k]	1	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	1(1)	-	1	1	-
[g]	1	-	-	-	1	-	-	-	-	-	2	-	-	-	-	-	1	-	-	-	-	-	-	-	(0)	-	-	-
[k̈]	-	-	-	-	-	-	1	1	-	2	-	-	-	-	-	-	-	-	1	-	-	1	1	-	-	(1)	1	-
[g̈]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	(0)	-
[h]	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[a]	-	-	-	-	1	1	-	-	-	-	-	-	1	-	-	-	-	-	1	1	-	-	1	-	-	-	1	1
[u]	1	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	1	-	-	-	-	1	-	-
[i]	-	-	-	-	1	-	1	-	1	1	1	1	-	-	1	1	-	-	-	-	1	-	-	1	-	-	1	1
MR	2	3	4	3	2	3	3	1	1	6	7	1	2	-	6	2	4	3	8	6	3	2	4	5	1	3	3	5
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5b: Confusions under Auditory (A) condition in the [i] vowel context

Response	[p]	[b]	[m]	[p̪]	[b̪]	[w]	[ɾ]	[f]	[v]	[θ]	[ð]	[l]	[n]	[tʃ]	[dʒ]	[ʃ]	[ʒ]	[s]	[z]	[t]	[d]	[t̪]	[d̪]	[k]	[g]	[k̟]	[g̟]	[h]
[p]	(1)	1	1	2	1	3	1	1	1	-	1	-	-	1	1	-	-	1	1	-	1	1	-	-	3	-	1	-
[b]	2	(2)	1	2	2	-	5	6	4	4	3	1	3	3	2	1	3	-	4	1	6	1	3	2	5	2	2	2
[m]	1	2	(6)	-	2	1	3	-	3	-	2	3	8	-	1	2	3	3	2	1	2	2	-	3	3	1	2	1
[p̪]	-	-	-	(1)	1	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	2	-	1	-	2	-	-
[b̪]	-	-	-	-	(0)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[w]	1	-	-	-	-	(0)	1	-	-	-	-	-	1	-	-	-	-	-	1	-	1	-	-	1	-	-	-	-
[ɾ]	-	-	-	-	-	-	1(0)	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-
[f]	1	2	2	1	1	3	-	(2)	-	1	-	2	-	-	-	1	1	4	-	-	1	1	-	2	1	-	-	2
[v]	-	-	-	3	-	-	1	2	(0)	-	2	-	1	1	-	-	1	-	-	2	1	-	-	-	2	-	-	1
[θ]	1	-	1	1	1	1	-	1	1	(0)	-	-	-	1	-	-	1	-	-	1	-	-	-	-	-	1	3	1
[ð]	-	-	-	-	-	-	-	-	-	1	(1)	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-
[l]	-	-	-	-	-	-	1	-	1	-	1	(0)	1	-	-	-	2	-	2	-	1	1	-	1	1	1	-	1
[n]	-	-	-	-	-	-	-	-	-	-	1	-	(1)	1	1	-	-	1	-	-	-	-	-	-	-	-	-	1
[tʃ]	-	1	-	-	-	-	-	-	-	-	-	-	-	(0)	-	2	-	-	-	-	-	-	-	-	-	-	-	-
[dʒ]	-	-	-	-	1	-	-	-	-	1	-	-	-	-	(0)	-	-	-	-	-	-	-	-	-	-	-	-	-
[ʃ]	1	-	1	-	-	-	-	1	1	1	-	-	1	-	4	(2)	-	-	-	1	-	-	1	-	-	-	2	1
[ʒ]	-	-	1	-	-	1	-	-	-	-	1	-	-	1	-	-	(0)	-	-	-	-	1	1	-	-	-	-	-
[s]	1	2	-	-	1	-	1	1	-	2	2	1	-	-	1	1	1	(0)	-	-	-	-	2	1	-	-	1	-
[z]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	(0)	-	-	-	-	-	-	-	-	-
[t]	1	3	-	2	1	1	-	-	2	1	-	6	-	1	2	3	1	2	4	4(3)	2	3	1	2	-	2	-	1
[d]	-	-	-	1	-	2	-	1	-	-	2	-	-	2	-	1	1	1	-	-	(0)	-	-	1	1	1	-	1
[t̪]	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	(1)	1	-	-	1	-	-
[d̪]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0)	-	-	-	-	-
[k]	2	1	-	-	-	1	-	1	2	-	-	-	-	-	-	-	-	1	-	-	-	-	-	(1)	1	-	-	1
[g]	1	-	1	1	-	-	-	-	1	1	1	1	-	1	1	-	-	-	1	-	-	-	1	-	(1)	1	2	-
[k̟]	-	-	-	1	-	-	2	-	-	-	-	-	-	-	1	1	-	-	-	-	-	1	1	-	-	(2)	2	-
[g̟]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0)	-
[h]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0)
[a]	-	1	-	-	-	-	-	-	-	1	-	1	1	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-
[u]	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	-	1	1
[i]	1	-	1	1	1	-	1	-	-	-	-	-	-	-	-	-	1	-	-	1	1	-	-	1	-	-	-	-
NR	3	3	3	2	6	4	1	2	2	4	-	3	1	5	4	3	2	4	-	3	2	3	6	2	-	4	2	5
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5c: Confusions under Auditory (A) condition in the [u] vowel context

Response	[p]	[b]	[m]	[p̪]	[b̪]	[w]	[ɕ]	[f]	[v]	[θ]	[ð]	[l]	[n]	[tʃ]	[dʒ]	[ʃ]	[j]	[s]	[z]	[c]	[ɖ]	[t̠]	[d̠]	[k]	[q]	[x̠]	[ɣ̠]	[h]
[p]	(0)	-	-	1	-	-	-	1	1	-	-	1	-	1	1	-	-	-	-	-	-	-	1	-	2	-	-	-
[b]	3	4(0)	2	4	4	3	2	3	2	6	1	2	5	2	-	3	3	4	1	5	4	1	3	6	2	2	-	6
[m]	2	2	3(0)	-	3	2	4	-	3	1	6	2	3	-	3	1	6	-	5	-	2	-	-	4	-	-	1	1
[p̪]	-	-	-	(0)	-	1	-	-	1	-	-	-	-	1	-	1	-	-	-	-	-	2	-	1	-	1	1	-
[b̪]	-	-	-	-	(0)	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[w]	-	-	-	-	-	(0)	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-	-
[ɾ]	1	-	-	1	1	1	(0)	-	-	-	-	-	1	-	-	1	-	-	-	-	-	1	-	-	2	1	1
[f]	2	1	1	2	-	3	-	(0)	1	1	-	-	-	-	2	-	1	-	-	-	-	3	1	-	1	1	-	-
[v]	-	-	-	1	-	-	-	2	(0)	-	3	-	-	1	1	1	-	-	-	-	-	-	2	-	-	-	-	-
[θ]	-	-	-	-	-	-	-	-	-	1(1)	-	-	-	1	-	-	-	-	-	2	-	1	-	-	1	-	2	-
[ð]	-	-	1	-	-	-	-	-	-	-	(1)	-	-	-	-	1	-	1	2	-	-	-	-	-	-	-	-	-
[l]	2	-	1	-	2	1	-	-	2	-	-	2(0)	1	-	-	-	-	-	-	1	1	-	1	-	2	1	-	1
[n]	1	-	-	-	-	-	-	-	1	-	-	1	(0)	-	-	-	2	-	1	-	-	-	1	-	-	1	-	-
[tʃ]	-	-	-	-	-	-	-	1	-	-	-	-	1	(0)	1	1	-	-	-	1	2	1	-	-	-	-	-	-
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1(0)	-	-	-	-	-	-	-	-	-	-	-	-	-
[ʃ]	-	-	2	1	1	-	1	1	-	-	-	-	1	2	1	1(0)	2	-	-	1	-	1	-	-	-	1	-	1
[j]	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	(0)	-	1	-	1	-	-	-	-	-	-	-
[s]	-	1	-	-	-	-	1	1	-	1	1	2	-	1	1	1	-	(0)	1	-	-	1	-	2	-	-	1	1
[z]	-	-	1	-	-	1	-	-	-	-	-	2	-	-	-	-	-	-	(0)	-	2	1	-	-	-	-	1	-
[c]	-	2	1	1	1	1	-	1	-	-	2	1	-	4	1	1	3	2	1	1(1)	1	1	2	-	1	4	2	1
[ɖ]	-	-	-	2	-	2	-	1	-	-	-	-	-	-	-	-	-	2	-	1	(0)	-	1	-	1	-	-	-
[t̠]	-	-	-	-	-	-	-	-	-	-	1	-	2	-	1	2	-	-	1	-	-	(0)	-	-	-	-	-	-
[d̠]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1(0)	-	-	-	-	-
[k]	1	-	-	1	-	-	-	1	1	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	2(0)	-	-	1	1
[q]	-	2	-	-	1	-	1	1	1	-	-	-	1	-	1	-	-	1	1	1	-	-	-	-	1	(0)	1	1	-
[x̠]	-	-	-	1	-	-	2	-	-	1	1	1	-	-	-	-	-	1	-	-	-	1	-	-	-	1(1)	1	-
[ɣ̠]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	(0)	-
[h]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	(0)
[i]	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	1	1	-	-	-	2	1	1	-	-	-
[ə]	-	-	-	-	-	1	-	1	1	-	-	-	1	1	-	-	1	-	-	1	1	-	-	-	-	-	1	-
[u]	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
NR	6	5	6	3	4	2	6	3	4	5	-	4	2	3	3	2	-	5	3	1	4	4	2	1	6	-	5	5
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5d: Confusions under Lipreading (L) condition in the [a] vowel context

Response	[p]	[b]	[m]	[p̄]	[b̄]	[w]	[ɹ]	[f]	[v]	[θ]	[ð]	[l]	[n]	[tʃ]	[dʒ]	[ʃ]	[j]	[s]	[z]	[t]	[d]	[t̄]	[d̄]	[k]	[g]	[k̄]	[ḡ]	[h]
[p]	1(9)	5	3	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[b]	6	(10)	5	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[m]	2	3	(8)	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[p̄]	-	-	1	(12)	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
[b̄]	-	-	-	2	(5)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[w]	-	-	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[ɹ]	-	-	-	-	-	-	(14)	4	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
[f]	-	-	-	1	-	-	1	9(3)	8	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
[v]	-	-	-	-	-	-	-	1	3(4)	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
[θ]	-	-	-	-	-	-	-	-	3	13(5)	-	-	-	-	-	-	2	-	-	-	1	-	-	-	1	-	-	-
[ð]	-	-	1	-	-	-	-	1	-	-	(10)	6	-	-	-	-	1	-	1	-	1	-	-	-	-	-	-	-
[l]	-	-	-	-	1	-	-	-	-	-	1	(11)	1	-	-	-	1	-	-	1	-	-	-	3	2	-	2	2
[n]	-	-	-	-	-	-	-	-	-	-	-	1	(0)	-	-	-	1	-	-	-	1	-	-	-	-	1	1	-
[tʃ]	-	-	-	-	-	-	-	-	-	-	-	-	1	(6)	4	6	-	-	-	-	-	-	-	-	-	-	-	-
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	1	(3)	3	-	-	-	-	-	-	-	1	-	-	-	-
[ʃ]	-	-	-	-	-	-	-	-	-	-	-	-	-	8	7	(8)	-	-	-	-	-	-	-	-	-	-	-	-
[j]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0)	-	-	-	-	-	-	1	-	-	-	-
[s]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(4)	5	2	3	3	1	-	-	-	1	1
[z]	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	2	(2)	2	2	-	2	-	-	-	-	-
[t]	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	3	5	5	1(8)	6	1	-	2	-	-	3	-
[d]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	4	3	2	(1)	-	-	1	2	-	-	-
[t̄]	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	(9)	9	1	-	5	4	4
[d̄]	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	3	(2)	-	-	1	-	1
[k]	-	-	-	-	-	-	-	-	-	-	-	3	10	-	-	-	2	-	-	-	2	1	-	1(5)	11	-	2	3
[g]	-	-	-	-	-	-	3	-	-	-	-	1	1	3	3	1	1	-	1	-	-	-	-	-	(1)	-	1	2
[k̄]	-	-	-	1	-	-	-	-	-	-	-	1	1	-	1	-	1	-	-	-	-	1	2	-	1	(10)	1	4
[ḡ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	(1)	-
[h]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(1)
NR	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	2	-	-	-	1	-	1	2	-
N	18	18	18	18	18	18	18	18	18	18	18	18	18	16	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5e: Confusions under Lipreading (L) condition in the [i] vowel context

Response	[p]	[b]	[m]	[p͡f]	[b̥]	[w]	[r]	[f]	[v]	[θ]	[ð]	[l]	[n]	[tʃ]	[dʒ]	[ʃ]	[j]	[s]	[z]	[t]	[d]	[t̠]	[d̠]	[k]	[g]	[k̠]	[g̠]	[h]
[p]	2(6)	8	3	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
[b]	9	(8)	9	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[m]	-	2	(6)	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[p͡f]	-	-	-	(13)	7	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
[b̥]	1	-	-	-	(2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[w]	-	-	-	-	-	(14)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[r]	-	-	-	-	-	-	(13)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[f]	-	-	-	-	-	1	-	(8)	5	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	-	-	-	-
[v]	-	-	-	-	-	-	-	5	(7)	1	-	-	-	-	-	-	-	-	-	1	1	1	-	-	-	-	-	-
[θ]	-	-	-	-	-	-	-	3	1	3(14)	1	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
[ð]	-	-	-	-	-	-	-	-	-	-	3(14)	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
[l]	-	-	-	-	-	-	-	-	1	-	-	1(2)	1	-	1	-	1	-	-	-	-	-	-	1	-	-	1	1
[n]	-	-	-	-	-	2	-	-	-	-	-	3	(3)	-	-	-	2	1	1	-	-	-	1	2	1	1	1	2
[tʃ]	-	-	-	-	-	-	-	-	1	-	-	-	-	(1)	1	2	-	-	-	-	-	-	-	-	-	-	-	-
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	2	(2)	-	-	-	-	-	-	-	-	-	-	-	-	-
[ʃ]	-	-	-	-	-	-	-	-	-	-	-	-	-	10	7	1(9)	-	-	-	-	-	-	1	-	-	-	1	-
[j]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(3)	-	1	-	-	1	-	-	-	-	-	-
[s]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(7)	2	4	3	4	2	-	-	2	-	-
[z]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	(3)	1	3	2	1	-	1	-	1	-
[t]	-	-	-	-	-	1	-	1	-	-	-	1	2	-	-	1	3	7	3	(7)	5	2	5	1	4	3	4	2
[d]	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	1	2	2	4	(4)	3	-	-	-	3	-	-
[t̠]	-	-	-	-	-	-	1	-	-	-	-	2	1	-	-	-	-	-	3	-	-	(3)	3	-	2	2	-	1
[d̠]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0)	-	1	-	1	-
[k]	-	-	-	-	-	-	1	-	-	-	-	1	5	-	-	-	4	-	-	-	-	-	1	2(7)	1	4	1	5
[g]	-	-	-	-	-	-	1	-	-	-	-	1	-	5	5	5	-	-	-	-	-	-	-	2	(2)	-	-	1
[k̠]	-	-	-	-	-	-	-	-	-	-	-	4	1	-	-	-	-	-	1	1	1	-	1	1	3	(2)	3	3
[g̠]	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	(0)	-
[h]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(1)
NR	-	-	-	1	-	-	1	-	2	-	-	3	1	-	2	-	2	-	-	-	1	-	2	2	1	1	5	2
N	18	18	18	18	18	18	18	18	16	18	18	18	18	18	18	16	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5f: Confusions under Lipreading (L) condition in the [u] vowel context

Response	[p]	[b]	[m]	[p̄]	[b̄]	[w]	[r]	[f]	[v]	[θ]	[ð]	[l]	[n]	[tʃ]	[dʒ]	[ʃ]	[j]	[s]	[z]	[t]	[d]	[t̄]	[d̄]	[k]	[g]	[k̄]	[ḡ]	[h]
[p]	(10)	9	11	-	1	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[b]	6	(3)	2	-	1	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	-	-	1	-
[m]	2	2	(3)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
[p̄]	-	2	1	(11)	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
[b̄]	-	-	-	-	(0)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[w]	-	-	-	-	-	(12)	1	-	-	-	-	2	1	-	-	-	-	-	-	-	-	2	-	3	-	6	-	2
[r]	-	-	-	-	-	-	(4)	-	-	-	-	-	1	-	-	-	1	-	-	1	-	-	-	-	-	-	1	-
[f]	-	-	-	1	-	-	3	(11)	9	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
[v]	-	-	-	1	-	-	-	3	(3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[θ]	-	-	-	-	-	-	1	3	2	1	(17)	-	-	-	-	-	-	-	-	2	5	3	1	1	1	-	-	-
[ð]	-	-	-	-	-	-	-	-	-	-	(17)	-	2	2	1	1	2	1	-	1	1	2	-	-	6	1	-	-
[l]	-	-	-	-	-	1	-	-	-	-	-	(5)	4	-	-	-	1	-	-	-	-	-	-	1	1	1	-	1
[n]	-	-	-	-	-	-	-	-	-	-	-	-	(1)	-	-	-	1	-	1	-	-	-	2	1	-	-	2	1
[tʃ]	-	-	-	-	-	-	-	-	-	-	-	1	-	(1)	2	2	-	-	-	-	-	-	-	-	-	-	-	-
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0)	2	-	-	-	-	-	-	-	-	-	-	-	-
[ʃ]	-	-	-	-	-	-	-	-	-	-	-	1	-	5	10	(10)	3	4	3	4	2	-	-	-	-	-	-	1
[j]	-	-	-	-	1	-	1	-	-	-	-	1	3	2	2	-	(4)	1	-	-	1	1	3	3	4	1	3	2
[s]	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-		(2)	2	3	1	-	-	-	1	-	-	-
[z]	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	1	3	(3)	3	1	1	1	-	1	-	-	-
[t]	-	-	-	-	-	-	2	-	1	-	-	1	1	3	-	-	-	5	3	1(2)	3	-	1	1	2	-	3	-
[d]	-	1	-	1	-	-	-	-	-	-	-	1	-	3	1	2	-	2	3	-	(2)	-	-	1	-	-	1	-
[t̄]	-	-	-	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	1	(3)	2	1	-	-	2	2
[d̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(1)	-	-	-	-	-
[k]	-	-	-	-	-	-	-	-	-	-	-	1	3	-	-	-	4	-	-	-	1	-	-	(5)	2	2	1	3
[g]	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	1	1	-	-	-	-	1	1	-	(0)	-	1	-
[k̄]	-	-	-	-	-	-	-	-	1	-	-	3	-	-	-	-	-	-	-	-	-	1	3	-	-	(3)	-	2
[ḡ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0)	-
[h]	-	-	-	-	1	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	1	1	-	3	-	(2)
NR	-	1	1	2	1	1	3	-	1	-	1	1	1	-	-	-	-	-	3	-	-	2	1	-	-	1	3	2
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5g: Confusions under Auditory and Lipreading (AL) conditions in the [a] vowel context

Response	[p]	[b]	[m]	[p͡]	[b͡]	[w]	[ɹ]	[f]	[v]	[θ]	[ð]	[l]	[n]	[tʃ]	[dʒ]	[ʃ]	[j]	[ə]	[æ]	[ɛ]	[ɑ]	[ɔ]	[ɔ͡]	[ɑ͡]	[k]	[g]	[k͡]	[g͡]	[h]
[p]	(10)	5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[b]	8	(11)	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[m]	-	1	9(1)	1	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[p͡]	-	-	-	(16)	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
[b͡]	-	-	1	1	(5)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
[w]	-	-	-	-	-	1(16)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[ɹ]	-	-	-	-	-	1	1(14)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-
[f]	-	-	-	-	-	-	-	5(9)	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[v]	-	-	-	-	-	-	-	4	(4)	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
[θ]	-	-	-	-	-	-	-	-	-	2(14)	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
[ð]	-	-	-	-	-	-	-	-	-	-	3(15)	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[l]	-	-	-	-	-	-	-	-	-	-	-	1(12)	2	-	-	-	4	1	-	-	-	-	1	1	2	-	-	1
[n]	-	-	-	-	-	-	-	-	-	-	-	1	(2)	-	-	-	1	-	1	1	-	-	-	-	1	-	-	-	-
[tʃ]	-	-	-	-	-	-	-	-	-	-	-	-	-	(5)	3	4	1	-	-	-	-	-	-	-	-	-	-	-	-
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	3	(4)	3	-	-	-	-	-	-	-	-	-	-	-	-	-
[ʃ]	-	-	-	-	-	-	-	-	-	-	-	-	-	5	7	3(4)	-	-	-	-	-	-	-	-	-	-	-	-	-
[j]	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	(3)	-	-	-	1	1	-	1	1	-	-	-
[ə]	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	2	(4)	3	1	4	3	-	-	-	-	-	-
[æ]	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	1	(3)	2	3	-	-	-	-	-	-	-
[ɛ]	-	-	-	-	-	-	-	-	1	-	-	-	4	-	-	-	2	6	3	2(5)	6	1	-	2	2	1	1	-
[ɑ]	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	5	4	3	(3)	-	-	-	3	-	-	-
[ɔ͡]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(8)	10	1	-	4	3	4
[ɑ͡]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	(1)	-	-	2	4	-
[k]	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	-	1	-	1	3	1	-	1	1(9)	7	1	-	1
[g]	-	-	-	-	-	-	2	-	-	-	-	-	1	3	4	4	-	-	-	-	-	-	-	1	(1)	-	-	-
[k͡]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	1	-	(7)	6	10
[g͡]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0)	-
[h]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1(0)
NR	-	1	-	-	-	-	1	-	-	2	-	3	1	2	-	-	3	-	3	1	-	1	2	1	-	1	3	1
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5h: Confusions under Auditory and Lipreading (AL) condition in the [i] vowel context

Response	[p]	[b]	[m]	[p̄]	[b̄]	[w]	[r]	[f]	[v]	[θ]	[ð]	[l]	[n]	[tʃ]	[dʒ]	[ʃ]	[ʒ]	[s]	[z]	[t]	[d]	[t̄]	[d̄]	[k]	[g]	[k̄]	[ḡ]	[h]
[p̄]	(10)	3	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[b]	4	2(12)	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[m]	-	-	(10)	1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[p̄]	1	-	-	1(14)	13	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-
[b̄]	-	-	-	1	(2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[w]	-	-	-	-	-	4(14)	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[r]	-	-	-	-	-	-	(12)	5	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[f]	-	-	-	-	-	-	-	5(8)	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[v]	-	-	-	-	-	-	-	-	(8)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[θ]	-	-	-	-	-	-	-	-	-	2(15)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[ð]	-	-	-	-	-	-	-	-	-	-	(11)	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
[l]	-	-	-	-	-	-	-	-	-	-	1	(2)	1	-	-	-	2	-	-	-	-	-	-	3	4	1	1	-
[n]	-	-	-	-	-	-	-	-	-	-	5	3	1(7)	-	1	-	3	-	-	-	-	-	2	-	2	-	3	1
[tʃ]	-	-	-	-	-	-	-	-	-	-	-	-	1	(1)	1	1	1	-	-	-	-	-	-	-	-	-	-	-
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	1	(2)	2	-	-	-	-	-	-	-	-	-	-	-	-
[ʃ]	-	-	-	-	-	-	1	-	-	-	-	-	-	10	9	(12)	1	-	-	-	-	-	-	-	-	-	-	-
[ʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	(1)	-	-	-	-	-	1	-	1	1	-	-
[s]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(7)	6	2	4	2	1	-	-	-	1	-
[z]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	(1)	2	2	1	-	-	-	-	-	-
[t]	1	-	-	-	-	-	-	-	1	-	-	3	1	-	-	-	4	6	4	(8)	6	-	2	4	6	1	2	3
[d]	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	1	1	3	3	(2)	-	-	1	-	-	-	1
[t̄]	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	(8)	4	-	-	2	2	1
[d̄]	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	(0)	-	-	-	-	-
[k]	-	-	-	-	-	-	-	-	-	-	-	5	2	-	-	-	4	-	-	-	1	-	2	(6)	3	6	1	6
[g]	-	-	-	-	-	-	1	-	-	-	-	2	1	6	3	3	-	-	-	-	-	1	-	1	(0)	1	-	1
[k̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	3	2	-	(6)	4	-
[ḡ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0)	-
[h]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0)
[i]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
[e]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
NR	2	1	-	-	-	-	2	-	-	1	1	1	2	-	1	-	1	-	3	3	2	2	3	-	2	-	3	3
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5i: Confusions under Auditory and Lipreading (AL) condition in the [u] vowel context

Response	[p]	[b]	[m]	[p̈]	[b̈]	[w]	[r]	[f]	[v]	[θ]	[ð]	[l]	[n]	[tʃ]	[dʒ]	[ʃ]	[j]	[s]	[z]	[c]	[ɟ]	[c̈]	[ɟ̈]	[k]	[g]	[k̈]	[g̈]	[h]
[p]	(12)	4	3	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[b]	4	(8)	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[m]	1	3	(8)	-	1	1	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[p̈]	1	-	-	(17)	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[b̈]	-	-	-	-	(1)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[w]	-	-	-	-	-	(10)	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-	-
[r]	-	-	-	-	-	1	(5)	5	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-
[f]	-	-	-	-	-	-	1	(9)	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[v]	-	-	-	-	-	-	-	1	(3)	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
[θ]	-	-	-	-	-	-	1	2	-	1	(16)	-	-	1	-	1	-	-	-	1	4	-	2	-	-	-	2	1
[ð]	-	-	-	-	-	-	-	-	-	-	-	(18)	-	1	-	-	-	-	-	-	-	-	-	-	2	-	-	-
[l]	-	1	-	-	-	2	-	-	-	-	-	-	(5)	3	1	-	-	1	-	1	-	-	-	1	2	2	1	7	4
[n]	-	-	-	-	1	-	1	-	-	1	-	2	(3)	-	-	-	-	4	-	2	-	-	-	-	-	-	1	-	-
[tʃ]	-	-	-	-	-	-	-	-	-	-	-	-	-	(2)	1	-	-	-	-	-	1	-	-	-	-	-	-	-	1
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0)	2	-	1	-	-	-	-	-	-	-	-	-	-	-
[ʃ]	-	-	-	-	-	-	-	-	-	-	-	-	1	9	5	(12)	3	3	1	4	4	1	-	-	-	-	-	1
[j]	-	-	-	-	-	-	1	-	1	-	-	1	3	-	2	1	(5)	-	2	-	-	2	2	3	4	3	-	5
[s]	-	-	-	-	1	-	1	-	-	-	-	-	-	1	-	-	-	(2)	2	1	1	-	-	-	-	-	-	-
[z]	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	-	-	3	(2)	2	-	1	-	-	-	-	-	-
[c]	-	-	-	-	-	-	1	-	-	-	-	1	5	3	2	2	1	5	3	(2)	6	-	3	4	1	2	2	-
[ɟ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	1	2	3	2	(2)	1	-	-	1	-	-	-
[c̈]	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	(7)	1	-	-	3	2	-
[ɟ̈]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	(1)	-	-	-	-	-
[k]	-	-	-	-	-	-	1	-	-	-	-	5	-	-	-	-	1	1	-	1	2	-	1	(6)	4	3	2	2
[g]	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	(2)	-	-	-
[k̈]	-	-	-	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	(3)	1	-
[g̈]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0)	-
[h]	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-	-	1	(1)
[u]	-	1	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	4	-	1	-	-	1
NR	-	1	-	-	-	1	1	1	1	-	-	1	1	-	1	1	1	1	-	-	2	-	-	-	3	2	1	2
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5j: Confusions under Cues (C) condition in the [a] vowel context

Response	[p]	[d]	[b]	[n]	[tʃ]	[j]	[m]	[t]	[f]	[w]	[l]	[ʃ]	[h]	[s]	[r]	[θ]	[dʒ]	[g]	[k]	[v]	[z]	[ð]	[b̥]	[p̥]	[d̥]	[t̥]	[k̥]	[g̥]
[p]	(9)	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[d]	8	(6)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[b]	-	-	(12)	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[n]	-	-	6	2(5)	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	-	-
[tʃ]	-	-	-	-	2(7)	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[j]	-	-	-	-	9	(6)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[m]	-	-	-	-	-	-	3(5)	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-
[t]	-	-	-	-	-	-	7	(4)	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-
[f]	-	-	-	-	-	-	1	2	1(2)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
[w]	-	-	-	-	-	-	-	-	-	(2)	5	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[l]	-	-	-	-	-	-	-	-	-	10	(7)	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[ʃ]	-	-	-	-	-	-	-	-	-	6	6	(6)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[h]	-	-	-	-	-	-	-	-	-	-	-	-	(6)	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
[s]	-	-	-	-	-	-	-	-	-	-	-	-	5	(5)	5	-	-	-	-	-	-	-	-	-	-	-	-	-
[r]	-	-	-	-	-	-	-	-	-	-	-	-	7	9	2(8)	-	-	-	-	-	-	-	-	-	-	-	-	-
[θ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(1)	3	8	-	-	-	-	-	-	-	-	-	7
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	(5)	-	-	-	-	-	-	-	-	-	-	1
[g]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	10	(9)	-	-	-	-	-	-	-	-	-	-
[k]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(8)	6	7	4	-	-	-	-	-	-
[v]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	(5)	6	4	-	-	-	-	-	-
[z]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1(1)	4	-	-	-	-	-	-
[ð]	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	4	6	3	2(4)	-	-	-	-	-	-
[b̥]	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(7)	-	-	-	-	-
[p̥]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6(9)	11	-	-	-
[d̥]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	2(5)	-	-	-
[t̥]	-	-	-	-	-	-	2	3	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(3)	-	-
[k̥]	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(16)	-
[g̥]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3(6)
MR	1	1	-	2	-	-	-	2	-	-	-	-	-	1	-	-	-	1	1	-	-	-	-	-	-	2	2	1
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5k: Confusions under Cues (C) condition in the [i] vowel context

Response	[p]	[d]	[b]	[n]	[tʃ]	[j]	[m]	[t]	[f]	[w]	[l]	[ʃ]	[h]	[s]	[r]	[θ]	[dʒ]	[g]	[k]	[v]	[z]	[ð]	[b̄]	[p̄]	[d̄]	[t̄]	[k̄]	[ḡ]
[p]	(10)	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[d]	7	(7)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[b]	-	-	(17)	12	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[n]	-	-	1	(6)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-	-	-
[tʃ]	-	-	-	-	2(12)	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[j]	-	-	-	-	4	(5)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[m]	-	-	-	-	-	-	(9)	10	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-
[t]	-	-	-	-	-	-	7	(6)	9	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	2	-	-
[f]	-	-	-	-	-	-	1	1	(4)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
[w]	-	-	-	-	-	-	-	-	-	(5)	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[l]	-	-	-	-	-	-	-	-	-	9	(7)	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[ʃ]	-	-	-	-	-	-	-	-	-	4	6	(6)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[h]	-	-	-	-	-	-	-	-	-	-	-	-	(3)	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-
[s]	-	-	-	-	-	-	-	-	-	-	-	-	8	(9)	11	-	-	-	-	1	-	-	-	-	-	-	-	-
[r]	-	-	-	-	-	-	-	-	-	-	-	-	7	8	(6)	-	-	-	-	-	-	-	-	-	-	-	-	-
[θ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(4)	4	4	-	-	-	-	-	-	-	-	1	8
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	(2)	1	-	-	-	-	-	-	-	-	-	3
[g]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	12	(13)	-	-	-	-	-	-	-	-	-	-
[k]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0)	5	8	9	-	-	-	-	-	-
[v]	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	8	1(9)	10	8	-	1	-	-	-	-
[z]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-
[ð]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	(0)	-	-	-	-	-	-
[b̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1(5)	-	-	-	-	-
[p̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3(13)	13	-	-	-
[d̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(4)	-	-	-
[t̄]	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(8)	-	-
[k̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3(13)	-
[ḡ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1(6)
NR	1	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	1	2	1	-
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 51: Confusions under Cues (C) condition in the [u] vowel context

Response	[p]	[d]	[b]	[n]	[tʃ]	[j]	[m]	[t]	[f]	[w]	[l]	[ʃ]	[h]	[s]	[r]	[θ]	[dʒ]	[g]	[k]	[v]	[z]	[ð]	[p̄]	[b̄]	[d̄]	[t̄]	[k̄]	[ḡ]
[p]	(13)	9	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[d]	5	(9)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[b]	-	-	(12)	15	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[n]	-	-	5	(3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	-
[tʃ]	-	-	-	-	1(7)	7	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[j]	-	-	-	-	10	(11)	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
[m]	-	-	-	-	-	-	(3)	5	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-
[t]	-	-	-	-	-	-	11	1(7)	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	-
[f]	-	-	-	-	-	-	3	3	(0)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-
[w]	-	-	-	-	-	-	-	-	-	1(2)	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[l]	-	-	-	-	-	-	-	-	-	8	(11)	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[ʃ]	-	-	-	-	-	-	-	-	-	6	4	(6)	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
[h]	-	-	-	-	-	-	-	-	-	-	-	-	(7)	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
[s]	-	-	-	-	-	-	-	-	-	-	-	-	5	(10)	5	-	-	-	-	-	-	-	-	-	-	-	-	-
[r]	-	-	-	-	-	-	-	-	-	-	-	-	6	5	(9)	-	-	-	-	-	-	-	-	-	-	-	-	-
[θ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(0)	2	3	-	-	-	-	-	-	-	-	-	6
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	(2)	3	-	-	-	-	-	-	-	-	-	1
[g]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	13	(12)	-	-	-	-	-	-	-	-	-	-
[k]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1(0)	1	4	5	-	-	-	-	-	-
[v]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	1(6)	6	5	-	-	-	-	2	-
[z]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	8	(7)	6	-	-	-	-	-	-
[ð]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	2	-	(2)	-	-	-	-	-	-
[b̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2(5)	-	-	-	-	-
[p̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(11)	11	-	-	-
[d̄]	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	1(5)	-	-	-
[t̄]	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3(6)	-	-
[k̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	(15)	-
[ḡ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2(9)
NR	-	-	1	-	-	-	-	1	-	1	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5m: Confusions under Audition and Cues (AC) condition in the [a] vowel context

Response	[p]	[d]	[b]	[n]	[tʃ]	[ʃ]	[m]	[t]	[f]	[w]	[l]	[ʃ']	[h]	[s]	[r]	[θ]	[dʒ]	[g]	[k]	[v]	[z]	[ð]	[b̥]	[p̥]	[d̥]	[t̥]	[k̥]	[g̥]
[p]	(7)	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[d]	9	(11)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[b]	-	-	(18)	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
[n]	-	-	-	(4)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	-	-
[tʃ]	-	-	-	-	1(11)	11	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[j]	-	-	-	-	5	(7)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[m]	-	-	-	-	-	-	(8)	5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	1	-
[t]	-	-	-	-	-	-	2	(6)	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	-	-
[f]	-	-	-	-	-	-	4	2	1(3)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-
[w]	-	-	-	-	-	-	-	-	-	1(4)	2	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[l]	-	-	-	-	-	-	-	-	-	5	(9)	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[ʃ']	-	-	-	-	-	-	-	-	-	8	7	(6)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[h]	-	-	-	-	-	-	-	-	-	-	-	-	(5)	3	6	-	-	-	-	-	-	-	-	-	-	-	-	-
[s]	-	-	-	-	-	-	-	-	-	-	-	-	5	(4)	3	-	-	-	-	-	-	-	-	-	-	-	-	-
[r]	-	-	-	-	-	-	-	-	-	-	-	-	7	10	(9)	-	-	-	-	-	-	-	-	-	-	-	-	-
[θ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(4)	6	5	-	-	-	-	-	-	-	-	-	4
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	(0)	-	-	-	-	-	-	-	-	-	-	3
[g]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	12	(11)	-	-	-	-	-	-	-	-	-	-
[k]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(10)	8	8	3	-	-	-	-	-	-
[v]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	(3)	6	5	-	-	-	-	-	-
[z]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	(1)	5	-	-	-	-	-	-
[ð]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3	-	3	(5)	-	-	-	-	-	-
[b̥]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(6)	-	-	-	-	-
[p̥]	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(15)	13	-	-	-
[d̥]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	(4)	-	-	-
[t̥]	-	-	-	-	-	-	2	4	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(2)	-	-
[k̥]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	(16)	1
[g̥]	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(9)
[e]	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NR	1	-	-	1	-	-	1	1	-	-	-	-	1	1	-	-	-	1	1	3	-	-	-	-	1	-	1	1
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5n: Confusions in the Audition and Cues (AC) condition in the [i] vowel context

Response	[p]	[d]	[b]	[n]	[tʃ]	[j]	[m]	[t]	[f]	[w]	[l]	[ʃ]	[h]	[s]	[r]	[θ]	[dʒ]	[g]	[k]	[v]	[z]	[ð]	[b̥]	[p̥]	[d̥]	[t̥]	[k̥]	[g̥]
[p]	(4)	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[d]	13	(11)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[b]	-	-	(16)	11	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[n]	-	-	2	(6)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	-	-	-
[tʃ]	-	-	-	-	(12)	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[j]	-	-	-	-	6	1(7)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[m]	-	-	-	-	-	-	1(11)	7	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-
[t]	-	-	-	-	-	-	3	(7)	9	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
[f]	-	-	-	-	-	-	1	2	(2)	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-
[w]	-	-	-	-	-	-	-	-	-	(7)	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[l]	-	-	-	-	-	-	-	-	-	6	1(8)	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[ʃ]	-	-	-	-	-	-	-	-	-	5	5	(6)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[h]	-	-	-	-	-	-	-	-	-	-	-	-	(4)	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-
[s]	-	-	-	-	-	-	-	-	-	-	-	-	8	(6)	6	-	-	-	-	-	-	-	-	-	-	-	-	-
[r]	-	-	-	-	-	-	-	-	-	-	-	-	6	9	(8)	-	-	-	-	-	-	-	-	-	-	-	-	-
[θ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(6)	4	-	-	-	-	-	-	-	-	-	-	9
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	(1)	1	-	-	-	-	-	-	-	-	-	1
[g]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	12	(16)	-	-	-	-	-	-	-	-	-	-
[k]	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(8)	7	6	6	-	-	-	-	-	-
[v]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	(8)	6	7	-	-	-	-	-	-
[z]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	(3)	1	-	-	-	-	-	-
[ð]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	2	3	-	-	-	-	-	-
[b̥]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1(4)	-	-	-	-	-
[p̥]	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3(12)	15	-	-	-
[d̥]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	(3)	-	-	-
[t̥]	-	-	-	-	-	-	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(15)	-	-
[k̥]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	3(14)	1
[g̥]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1(5)
NR	-	1		1	-	-	-	1	2	-	1	-	-	-	1	1	1	1	-	-	1	1	3	1	-	-	-	-
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5o: Confusions in the Auditory and Cues (AC) condition in the [u] vowel context

Response	[p]	[d]	[b]	[n]	[tʃ]	[j]	[m]	[t]	[f]	[w]	[l]	[ʃ]	[h]	[s]	[r]	[θ]	[dʒ]	[ɑ]	[k]	[v]	[z]	[ð]	[b̃]	[p̃]	[d̃]	[t̃]	[k̃]	[g̃]
[p]	(8)	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[d]	10	(13)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[b]	-	-	(13)	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[n]	-	-	3	(8)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	-	-
[tʃ]	-	-	-	-	(7)	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[j]	-	-	-	-	11	1(13)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[m]	-	-	-	-	-	-	(11)	7	6	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-
[t]	-	-	1	-	-	-	4	(9)	7	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	1	-	-
[f]	-	-	-	-	-	-	-	-	(6)	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	2	-	-
[w]	-	-	-	-	-	-	-	-	-	(1)	1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
[l]	-	-	-	-	-	-	-	-	-	12	(14)	8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[ʃ]	-	-	-	-	-	-	-	-	-	5	3	(9)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[h]	-	-	-	-	-	-	-	-	-	-	-	-	1(5)	4	6	-	-	-	-	-	-	-	-	-	-	-	-	-
[s]	-	-	-	-	-	-	-	-	-	-	-	-	4	(7)	7	-	-	-	-	-	-	-	-	-	-	-	-	-
[r]	-	-	-	-	-	-	-	-	-	-	-	-	6	6	(4)	-	-	-	-	-	-	-	-	-	-	-	-	-
[θ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(2)	2	6	-	-	-	-	-	-	-	1	-	8
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	(0)	2	-	-	-	-	-	-	-	-	-	-
[ɑ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	13	15	(8)	-	-	-	-	-	-	-	-	-	-
[k]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1(2)	3	4	4	-	-	-	-	-	-
[v]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	(3)	2	2	-	-	-	-	2	-
[z]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	7	12	(9)	8	-	-	-	-	1	-
[ð]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	(2)	-	-	-	-	-	-
[b̃]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(4)	-	-	-	-	-
[p̃]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1(12)	14	-	-	-
[d̃]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	(3)	-	-	-
[t̃]	-	-	-	-	-	-	2	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1(5)	-	-
[k̃]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1(11)	-
[g̃]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1(6)
[u]	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
NR	-	-	1	-	-	-	1	1	3	-	-	-	2	1	-	1	1	1	3	-	1	2	1	1	1	3	3	3
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5p: Confusions in the Lipreading and Cues (LC) condition in the [a] vowel context

Response	[p]	[b]	[m]	[p̄]	[b̄]	[w]	[r]	[f]	[v]	[θ]	[ð]	[l]	[n]	[tʃ]	[dʒ]	[ʃ]	[j]	[ɑ]	[æ]	[ɛ]	[d]	[t̄]	[d̄]	[k]	[g]	[k̄]	[ḡ]	[h]
[p]	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[b]	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[m]	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[p̄]	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-
[b̄]	-	-	-	-	(14)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[w]	-	-	-	-	-	(17)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[r]	-	-	-	-	-	-	1(17)	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
[f]	-	-	-	-	-	-	-	(18)	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[v]	-	-	-	-	-	-	-	-	(14)	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-
[θ]	-	-	-	-	-	-	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-
[ð]	-	-	-	-	-	-	-	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[l]	-	-	-	-	-	1	-	-	-	-	-	1(17)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[n]	-	-	-	-	4	-	-	-	-	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[tʃ]	-	-	-	-	-	-	-	-	-	-	-	-	-	1(13)	-	-	5	-	-	-	-	-	-	-	-	-	-	-
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(9)	-	-	-	-	-	-	-	-	-	2	-	1	-
[ʃ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-
[j]	-	-	-	-	-	-	-	-	-	-	-	-	-	4	-	-	(12)	-	-	-	-	-	-	-	-	-	-	-
[ɑ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(16)	-	-	-	-	-	-	-	-	-	-
[æ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(14)	-	-	-	-	1	-	-	-	-
[ɛ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(18)	-	-	-	-	-	-	-	-
[d]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(18)	-	-	-	-	-	-	-
[t̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(17)	-	-	-	-	-	-
[d̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(15)	-	-	-	1	-
[k]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	(16)	-	-	-	-
[g]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	-	1	-	-	-	-	-	-	-	(16)	-	-	-
[k̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	(18)	-	-
[ḡ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(13)	-
[h]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	(17)
NR	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5q: Confusions in the Lipreading and Cues (LC) condition in the [i] vowel context

Response	[p]	[b]	[m]	[p̪]	[b̪]	[w]	[r]	[f]	[v]	[θ]	[ð]	[l]	[n]	[tʃ]	[dʒ]	[ʃ]	[j]	[s]	[z]	[t]	[d]	[t̪]	[d̪]	[k]	[g]	[k̪]	[g̪]	[h]
[p]	1(16)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
[b]	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[m]	-	-	(18)	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[p̪]	-	-	-	1(16)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
[b̪]	-	-	-	-	(12)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[w]	-	-	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[r]	-	-	-	-	-	-	(16)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
[f]	-	-	-	-	-	-	-	(16)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[v]	-	-	-	-	-	-	-	-	(14)	-	-	-	-	-	-	-	-	1	2	-	-	-	-	2	-	-	-	-
[θ]	-	-	-	-	-	-	-	-	2	2(15)	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	3	-
[ð]	-	-	-	-	-	-	-	-	-	3(15)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[l]	-	-	-	-	-	-	-	-	1	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[n]	-	-	-	-	6	-	-	-	-	-	-	-	(18)	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
[tʃ]	-	-	-	-	-	-	-	-	-	-	-	-	-	(15)	-	-	7	-	-	-	-	-	-	-	-	-	-	-
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(3)	-	-	-	-	-	-	-	-	-	2	-	-	-
[ʃ]	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-
[j]	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	3(8)	-	-	-	-	-	-	-	-	-	-	-
[s]	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	(16)	-	-	-	-	-	-	-	-	-	1
[z]	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	(9)	-	-	-	-	-	-	-	-	-
[t]	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	(16)	-	-	-	-	-	-	-	-
[d]	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(17)	-	-	-	-	-	-	-
[t̪]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	(18)	-	-	-	-	-	-
[d̪]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(13)	-	-	-	-	-
[k]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	(16)	-	-	-	-
[g]	-	-	-	-	-	-	-	-	-	1	-	-	-	-	15	-	-	-	-	-	-	-	-	-	(16)	-	-	-
[k̪]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(18)	-	-
[g̪]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(15)	-
[h]	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(14)
NR	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5r: Confusions in the Lipreading and Cues (LC) condition in the [u] vowel context

Response	[p]	[b]	[m]	[p̄]	[b̄]	[w]	[r]	[f]	[v]	[θ]	[ð]	[l]	[n]	[tʃ]	[dʒ]	[ʃ]	[j]	[s]	[z]	[t]	[d]	[t̄]	[d̄]	[k]	[g]	[k̄]	[ḡ]	[h]
[p]	(18)	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[b]	-	(18)	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[m]	-	-	(17)	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-
[p̄]	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	-	-	-	-	1
[b̄]	-	-	-	-	(13)	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[w]	-	-	-	-	-	(13)	2	-	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[r]	-	-	-	-	-	-	(11)	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	4
[f]	-	-	-	-	-	-	-	(17)	1	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-
[v]	-	-	-	-	-	-	-	-	(13)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-
[θ]	-	-	-	-	-	-	-	-	-	1(17)	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	5	-
[ð]	-	-	-	-	-	-	-	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[l]	-	-	-	-	-	3	-	-	-	-	-	1(13)	-	-	-	8	-	-	-	-	-	-	-	-	-	-	-	-
[n]	-	-	-	-	3	-	-	-	-	-	-	-	(15)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[tʃ]	-	-	-	-	-	-	-	-	-	-	-	-	-	(6)	-	-	1	-	-	-	-	-	-	-	-	-	-	-
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(4)	-	1	-	-	-	-	-	-	-	4	-	1	-
[ʃ]	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	(10)	-	-	-	-	-	-	-	-	-	-	-	-
[j]	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	(16)	-	-	-	-	-	-	-	-	-	-	-
[s]	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	(15)	-	-	-	-	-	-	-	-	-	2
[z]	-	-	-	-	-	-	1	-	3	-	-	-	-	-	-	-	-	-	(17)	-	-	-	-	6	-	1	-	-
[t]	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	(18)	-	2	-	-	-	-	-	-
[d]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(18)	-	-	-	-	-	-	-
[t̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(13)	-	-	-	-	-	-
[d̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-	-	-
[k]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	(10)	-	-	-	-
[g]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	-	-	-	-	-	-	-	-	-	(13)	-	-	-
[k̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(17)	1	-
[ḡ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(11)	-
[h]	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(11)
NR	-	-	1	-	-	-	1	1	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5s: Confusions in the Audition, Lipreading and Cues (ALC) condition in the [a] vowel context

Response	[p]	[b]	[m]	[p̄]	[b̄]	[w]	[r]	[f]	[v]	[θ]	[ð]	[l]	[n]	[tʃ]	[dʒ]	[ʃ]	[ʒ]	[s]	[z]	[t]	[d]	[t̄]	[d̄]	[k]	[g]	[k̄]	[ḡ]	[h]
[p]	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[b]	-	(17)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[m]	-	-	(18)	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[p̄]	-	-	-	(16)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-
[b̄]	-	-	-	1	(13)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[w]	-	-	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[r]	-	-	-	-	-	-	(16)	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	3
[f]	-	-	-	-	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[v]	-	-	-	-	-	-	-	-	(8)	-	-	-	-	-	-	-	-	-	2	-	-	-	-	1	-	-	-	-
[θ]	-	-	-	-	-	-	-	-	10	(17)	-	-	-	-	-	-	-	-	6	-	-	-	-	1	5	-	3	-
[ð]	-	-	-	-	-	-	-	-	-	-	(17)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[l]	-	-	-	-	-	-	-	-	-	-	-	1(17)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[n]	-	-	-	-	4	-	-	-	-	-	-	-	(17)	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
[tʃ]	-	-	-	-	-	-	-	-	-	-	-	-	-	(16)	-	-	7	-	-	-	-	-	-	-	-	-	-	-
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(7)	-	-	-	-	-	-	-	-	-	1	-	1	-
[ʃ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-
[ʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	(10)	-	-	-	-	-	-	-	-	-	-	-
[s]	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	(16)	-	-	-	-	-	-	-	-	-	-
[z]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(4)	-	-	-	-	-	-	-	-	-
[t]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(18)	-	-	1	-	1	-	-	-
[d]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(16)	-	-	-	-	-	-	-
[t̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(17)	-	-	-	-	-	-
[d̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	(13)	-	-	-	-	-
[k]	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	5	-	-	-	-	(15)	-	-	-	-
[g]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	-	-	-	-	-	-	-	-	-	(12)	-	-	-
[k̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(16)	1	-
[ḡ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(11)	-
[h]	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	(15)
MR	-	1	-	1	-	-	-	-	-	1	-	-	1	1	-	-	1	-	1	-	1	1	2	1	-	2	1	-
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5t: Confusions in the Audition, Lipreading and Cues (ALC) condition in the [i] vowel context

Response	[p]	[b]	[m]	[p̄]	[b̄]	[w]	[r]	[f]	[v]	[θ]	[ð]	[l]	[n]	[tʃ]	[dʒ]	[ʃ]	[j]	[s]	[z]	[t]	[d]	[t̄]	[d̄]	[k]	[g]	[k̄]	[ḡ]	[h]
[p]	1(17)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
[b]	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[m]	-	-	(18)	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[p̄]	-	-	-	(17)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-
[b̄]	-	-	-	-	(13)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[w]	-	-	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[r]	-	-	-	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	2
[f]	-	-	-	-	-	-	-	(16)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[v]	-	-	-	-	-	-	-	-	(13)	-	-	-	-	-	-	-	-	-	4	-	-	-	-	1	-	-	-	-
[θ]	-	-	-	-	-	-	-	-	3	1(17)	-	-	-	-	1	-	-	-	2	-	-	-	-	1	-	-	5	-
[ð]	-	-	-	-	-	-	-	-	-	-	(17)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[l]	-	-	-	-	-	-	-	-	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[n]	-	-	-	-	3	-	-	-	-	-	-	-	1(17)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[tʃ]	-	-	-	-	-	-	-	-	1	-	-	-	-	(15)	-	-	-	6	-	-	-	-	-	-	-	-	-	-
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(5)	-	-	-	-	-	-	-	-	-	1	-	-	-
[ʃ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-
[j]	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	(7)	-	-	-	-	-	-	-	-	-	-	-
[s]	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	(17)	-	-	-	-	-	-	-	-	-	1
[z]	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	(9)	-	-	-	-	-	-	-	-	-
[t]	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	(17)	-	2	-	-	-	-	-	-
[d]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(16)	-	-	-	-	-	-	-
[t̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	(16)	-	-	-	-	-	-
[d̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(13)	-	-	-	-	-
[k]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	(16)	-	-	-	-
[g]	-	-	-	-	-	-	-	-	-	-	1	-	-	-	12	-	1	-	-	-	-	-	-	-	(16)	-	1	-
[k̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(18)	-	-
[ḡ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(11)	-
[h]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(15)
NR	-	-	-	1	1	-	-	-	-	-	-	-	-	1	-	-	1	-	1	-	1	-	-	-	1	-	1	-
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18

Appendix 5u: Confusions in the Audition, Lipreading and Cues (ALC) condition in the [u] vowel context

Response	[p]	[b]	[m]	[p̄]	[b̄]	[w]	[r]	[f]	[v]	[θ]	[ð]	[l]	[n]	[tʃ]	[dʒ]	[ʃ]	[j]	[s]	[z]	[t]	[d]	[t̄]	[d̄]	[k]	[g]	[k̄]	[ḡ]	[h]
[p]	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[b]	-	(16)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[m]	-	-	(18)	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[p̄]	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	6	-	-	-	-	-
[b̄]	-	-	-	-	(10)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[w]	-	-	-	-	-	(14)	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[r]	-	-	-	-	-	-	(10)	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	3
[f]	-	-	-	-	-	-	-	(12)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[v]	-	-	-	-	-	-	-	-	(6)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[θ]	-	-	-	-	-	-	-	-	2	(18)	-	-	-	-	1	-	-	-	2	-	-	-	-	-	3	-	6	-
[ð]	-	-	-	-	-	-	-	-	-	-	(16)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[l]	-	-	-	-	-	3	-	-	-	-	-	(15)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[n]	-	-	-	-	6	-	1	-	-	-	-	-	(16)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
[tʃ]	-	-	-	-	-	-	-	-	-	-	-	-	-	(6)	-	-	4	-	-	-	-	-	-	-	-	-	-	-
[dʒ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(5)	-	-	-	-	-	-	-	-	-	2	-	1	-
[ʃ]	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	(18)	-	-	-	-	-	-	-	-	-	-	-	-
[j]	-	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	(13)	-	-	-	-	-	-	-	-	-	-	-
[s]	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	(16)	-	-	-	-	-	-	-	-	-	4
[z]	-	-	-	-	-	-	-	-	8	-	-	-	-	-	-	-	-	-	(15)	-	-	-	-	6	-	1	-	-
[t]	-	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-	-	1	(17)	-	-	-	-	-	-	-	-
[d]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(17)	-	-	-	-	-	-	-
[t̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	(17)	-	-	-	-	-	-
[d̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(12)	-	-	-	-	-
[k]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(8)	-	-	-	-
[g]	-	-	-	-	-	-	-	-	-	-	2	-	-	-	12	-	-	-	-	-	-	-	-	-	(12)	-	-	-
[k̄]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(15)	-	-
[ḡ]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	(10)	-
[h]	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	(9)
NR	-	2	-	-	1	1	1	1	2	-	-	-	2	2	-	-	1	-	-	-	-	1	-	4	1	2	1	2
N	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18