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The effect of experience and linguistic context on speechreading

Hanin, Laurie, Ph.D.

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U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

THE EFFECT OF EXPERIENCE AND LINGUISTIC CONTEXT ON SPEECHREADING

by

LAURIE HANIN

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4/11/88
Date

ARTHUR BOOTHROYD, Ph.D.
Chair of Examining Committee

4/11/88
Date

IRVING HOCHBERG, Ph.D.
Executive Officer

IRVING HOCHBERG, Ph.D.

HARRY LEVITT, Ph.D.

Supervisory Committee

BRIAN E. WALDEN, Ph.D.

External Examiner

The City University of New York

Abstract

THE EFFECT OF EXPERIENCE AND LINGUISTIC CONTEXT ON SPEECHREADING
By

Laurie Hanin

Adviser: Professor Arthur Boothroyd

It has long been known that there are marked inter-subject differences in speechreading ability. This is true for both hearing-impaired and normal-hearing individuals. The purpose of this study was to test the hypotheses that experience and use of linguistic context during the speechreading task itself are determinants of speechreading competence.

Speechreading performance was measured in 12 post-lingually deaf cochlear implant patients and in 12 normally-hearing adults, who were naive to speechreading. Performance was measured using test materials varying according to the amount of linguistic redundancy present. Percent correct scores were obtained for the recognition of words in sentences and in carrier phrase, and for the recognition of phonemes in words and nonsense syllables.

The experienced speechreaders on average, performed significantly better, on all measures, than did the inexperienced speechreaders. Experience, however, was not a guarantee of speechreading competence, nor was lack of experience incompatible with competence. The sentence data provided evidence of a division of subjects into inherently "better" and "poorer" speechreaders, regardless of experience.

Although speechreading ability was determined according to the sentence data, better speechreaders obtained higher scores on every test measure. The differences, however, between the better and poorer speechreaders, were greatest for the sentences. These results support the hypothesis that superior use of the syntactic, semantic, and topical context in sentences, during the speechreading task, is an important characteristic of the competent speechreader. While there was some evidence that better speechreaders were also better users of the lexical context in words, the findings were less clear regarding this issue.

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CHAPTER 1

INTRODUCTION

While audition is the primary modality for speech perception for normally hearing individuals and for most hearing-impaired individuals, vision is the primary modality for speech perception for the totally deaf individual. Rather than depending on visual cues to supplement incomplete auditory information as the hearing-impaired individual must do, the totally deaf individual must speechread in order to understand spoken language.

This dissertation deals with speechreading, that is, the visual perception of speech. It should be noted that the term lipreading is often used interchangeably with the term speechreading. Historically, however, the term lipreading may have been taken to mean concentration solely on lip positions and movements of the speaker. The term speechreading implies that there are other visual and linguistic clues that are valuable as a supplement to the visible movements of speech (Berger, 1972). For the purposes of this dissertation, speechreading will be the term used. It should also be noted that some writers use the term speechreading to refer to auditory-visual speech perception, that is, speech perception when vision is supplemented by amplified residual hearing (Summerfield, 1983). For the purposes of this study, however, speechreading will refer to speech perception through the use of visual cues only.

An issue that has been of concern to both clinicians and researchers is whether or not speechreading is a skill that can be taught. For many years, the assumption was made that speechreading could be taught, and the question of interest was how it should be taught. Training, however, has not been found to result in large gains in speechreading ability. While it is possible that this is due to inappropriate training methods, it is also possible that speechreading simply cannot be taught. If it cannot be taught, however, perhaps it can be learned. In other words, the hearing impaired may be able to acquire the necessary skills simply by responding to the demands of everyday conversation.

If it is possible to "learn" how to speechread, then it could be hypothesized that experienced speechreaders will demonstrate greater speechreading proficiency than inexperienced speechreaders. This hypothesis has been tested previously, but the findings have been inconsistent. The inconsistent findings may be the result of varying definitions of experience. This issue will be discussed in the following chapter. A primary feature of the present research study was the definition of experience in operational terms.

One observation made by all those who work with the hearing impaired is that there is a great deal of inter-subject variability of speechreading ability. This has been confirmed in speechreading research. Many studies have been conducted in an attempt to discover the determinants of speechreading competence. These studies will be reviewed in detail in the following chapter.

It will be seen in the next chapter that the search for the determinants of speechreading competence has not been successful. There has, however, been some indication that the ability to use linguistic contextual information plays a role in determining speechreading competence. The role of linguistic context, however, has never been tested directly using speechreading measures. Instead, the use of linguistic context has been assessed by means of pencil and paper tests. The results of such tests may actually bear little relationship to the speechreading process.

The general purposes of the present study, therefore, were to examine the effect of experience on speechreading competence and to investigate the role of the use of linguistic context as a determinant of speechreading competence. The specific goals were:

1) to compare the speechreading abilities of experienced and inexperienced speechreaders, and

2) to measure speechreading performance using materials with varying degrees of linguistic redundancy, ranging from nonsense syllables to meaningful sentences.

It was predicted that if experience is a determinant of speechreading competence, then the experienced subjects would perform better than the inexperienced subjects. It was further predicted that if superior use of context is a primary determinant of speechreading competence, then the difference between better and poorer speechreaders would become smaller as the amount of linguistic redundancy in the signal decreased. If superior use of context is the sole determinant of speechreading competence, it was predicted that the difference between better and poorer speechreaders would disappear for tasks involving the perception of phonemes in nonsense syllables.

CHAPTER 2

REVIEW OF THE LITERATURE

One of the most consistent findings in speechreading research has been the high degree of inter-subject variability of speechreading ability as measured on sentence length material (Berger, 1972; Jeffers and Barley, 1971; Sanders, 1982). Among both deaf and normally-hearing individuals it is common to find some who perform extremely well and some who perform extremely poorly. The sources of this variability have been investigated in numerous research studies, a principal motivation being the development of more effective instructional techniques (Jeffers and Barley, 1971). The following is a review of these studies.

Factors Affecting Speechreading

Jeffers and Barley (1971) provided a possible theoretical construct of the speechreading process, dividing potential factors that might have a relationship to speechreading performance into external and internal factors. External factors were described as being those imposed either by the environment or by the visibility of different speech sounds themselves. Environmental conditions, such as viewing angle, distance, and lighting must be adequate for both good and poor speechreaders (Erber, 1974). Similarly, all speechreaders are affected by the visibility of different speech sounds. For instance, it is well known that many of the sounds of speech are homophenous, that is, they are not visually distinguishable from each other (Fisher, 1968). Additionally, some sounds are inherently more visible than others. For example, sounds articulated in the front of the mouth are easier to see than those articulated in the back, and vowels are easier to speechread than are consonants (Berger, 1972).

Internal factors relating to speechreading performance were described as being those that directly related to characteristics of the speechreader. Those that have been investigated as possible correlates of speechreading competence can be grouped under three headings: psychological, physiological, and perceptual. These factors will be discussed in turn.

Psychological factors as possible correlates of speechreading performance

Psychological factors that have been considered as possible correlates of lipreading ability include I.Q., reading ability, age, educational background, reasoning capacity, and specific personality traits.

In formal studies, I.Q. has not been shown to be a strong predictor of speechreading performance. In studies using either normally hearing adults or hearing-impaired adults, low positive, but non-significant correlations between I.Q. and speechreading ability have been reported ranging from .03 to .43 (Elliott, 1970 (cited in Farwell, 1976); O'Neill and Davidson, 1956; Simmons, 1959). In studies of children, Geffner and Levitt (1987) have reported a tendency for higher I.Q. to be associated with better speechreading performance, but these authors do not report significance levels.

Reading ability and receptive language ability have been found to correlate significantly with speechreading performance in prelingually deaf children (Craig, 1964; DeFilippo, 1982; Geffner and Levitt, 1987; Myklebust, 1960), but not in normally-hearing adults (O'Neill and Davidson, 1956). Simmons (1959) did not find a relationship between general reading ability and speechreading for mildly hearing-impaired adults. She did, however, find a significant correlation between speechreading performance and the ability to extract sentence meaning and keywords from sentences. These results are in keeping with the hypothesis that poor language ability in the prelingually deaf is reflected in both reading ability and speechreading ability. The kinds of variation in reading ability found in normal or post-lingually deafened adults, however, appears to bear little or no relationship to speechreading performance.

Age has been found to be related to speechreading ability among adults. In a study of normal hearing and mildly to moderately hearing- impaired adults, Farrimond (1959) found that speechreading ability peaked between 30 to 39 years and then progressively declined. These data suggest an interaction between the improvements that might accompany maturity and experience, and the deterioration that may accompany aging.

Neither reasoning capacity nor specific personality traits have been shown consistently to be related to speechreading. One of the few studies showing a significant correlation was that of Wong and Taaffe (1958) who found that there are some personality characteristics that are weakly associated with speechreading ability. These included emotional stability and general activity level.

In summary, although some psychological characteristics have been found to bear a relationship to speechreading, none of them has strong predictive power. Within a given range of intelligence or receptive language ability, wide individual variability of speechreading performance is found. Only in prelingually deaf subjects has there been shown to be a clear relationship between receptive language ability and speechreading performance.

<u>Physiological factors as possible correlates of speechreading performance</u>

Another proposed source of individual variability of speechreading performance is differences in the visual systems of highly proficient and less proficient speechreaders. Hardick et al (1970) evaluated the speechreading performance on the Utley Test (both word and sentence portions) of 53 normally hearing college students. Sixteen of these subjects (the eight highest and eight lowest scoring) were examined opthalmologically. Although eyeblink rate varied among the subjects, this variable was not found to be correlated with speechreading performance. Subjects with perfectly normal visual acuity, however, demonstrated significantly higher speechreading scores than subjects with grossly normal, but slightly poorer acuity. This was true only for the sentence portion of the test. No significant correlation was found between visual acuity and the ability to speechread isolated words. It might be expected that poorer visual acuity would be a greater problem when speechreading isolated words, rather than sentences, since the former stimuli are shorter in length and perhaps more dependent on normal acuity. Hardick et al stated that it was possible that the word test was more difficult than the sentences and that because of this, this portion of the test was less sensitive to slight changes of acuity.

More recently, neural firing time in the visual system, as measured by the Averaged Visual Evoked Response (AVER) has been investigated as a potential correlate of speechreading ability. Shepherd et al (1977) and Shepherd (1982) reported that the AVER obtained to regularly presented flashes of light displayed components whose latencies showed a significant negative correlation with the speechreading performance of normally hearing adults on the Utley Test Form B (1946). The latency of a negative peak 130 msec. after stimulus onset (VN130) predicted speechreading scores quite well; correlation coefficients of from -.80 to -.91 were measured and accounted for as much as 83% of the variance in the speechreading scores. This finding suggested that better speechreaders had quicker neural firing times. The writers suggested that an individual's speechreading ability might be predetermined by his or her physiological system.

The results of Shepherd's work must be interpreted cautiously for several reasons. As Shepherd himself stated, the correlations he found represented the highest ever found with speechreading performance. In fact, a correlation of .91 is higher than could possibly be expected, considering the test-retest variability of the speechreading measure itself. One can only assume that such a high value was fortuitous. Unfortunately Sheperd et al do not report confidence limits for this correlation coefficient. Additionally, a causal relationship between the latency of the AVER and speechreading ability was not demonstrated.

Since the relationship between the latency of the AVER and speechreading ability required further investigation in order to determine it's significance, Samar and Sims (1983) examined the evoked response waveform in greater detail. A significant correlation was found between the latency of VN130 and the speechreading ability of normal hearing adults as measured by the Utley Test, however the correlation was much lower than that reported previously by Shepherd. The latency of VN130 accounted for only 32-34% of the variance in speechreading score (r = .58). A factor analysis procedure conducted on the AVER waveform revealed three separate factors that taken together could account for 70% of the variance in speechreading scores. One of these factors was the latency of a very early portion of the waveform, occurring 16 msec. after stimulus onset (VF16). The latency of VF16 showed the highest individual correlation of the three factors, with speechreading score (-.60), but was itself uncorrelated with VN130. The other two factors were correlated with VN130.

Since the VF16 occurred only 16 msec. after stimulation, Samar and Sims concluded that this portion of the waveform might be reflective of individual differences in fundamental processing skills, such as the regulation of attention. If this were the case, they hypothesized that varying the predictability of stimulus onset time would interfere with the response. To test this hypothesis, the AVER was measured with four types of stimuli varying according to predictability (Samar and Sims, 1984). For normally hearing subjects, none of the evoked responses were significantly correlated with speechreading performance, as measured by the Utley Test. This finding was contradictory to previous results. For hearing-impaired men, the only significant correlation was between speechreading score and the AVER to bright predictable stimuli.

In the Samar et al study, at least for one group of subjects, the relationship between latency and speechreading was greater for some predictable stimuli, and it was concluded that the VF16 response may indeed reflect attentional behavior. If this is so, then the ability to focus attention on a task may be the reason for the correlation to speechreading, rather than the speed of neural firing time.

In summary, the results of research into the physiological correlates of speechreading performance are equivocal. The failure of the latency-speechreading relationship measured by Samar et.al. to achieve the strength of prediction reported previously by Shepherd should serve as a warning to interpret the initial results cautiously. Although there does appear to be a relationship between physiological characteristics of the visual system and speechreading performance, this factor does not account consistently for the large inter-subject variability seen in speechreading.

Visual perceptual skills as correlates of speechreading performance

Another proposed source of individual variability of speechreading performance is that of differences in visual perceptual skills, specifically visual memory, visual closure and visual synthesis.

Visual Memory

Most experimenters have used a digit memory task to examine the relationship of visual memory to speechreading (Costello, 1957 (cited in Berliner, 1979); O'Neill and Davidson, 1956; Simmons, 1959). The findings of these studies are inconsistent; both O'Neill and Davidson, and Simmons reported insignificant correlations while Costello reported a significant correlation. The inconsistencies may have several causes. One is an interaction of the type of stimulus and choice of subject type. The insignificant correlations resulted when normally-hearing adults were presented with printed digits, and the significant correlation resulted when prelingually deaf children were presented verbally with digits. It should be noted that the same pattern of results was demonstrated when reading ability was examined in relation to speechreading performance, that is, significant correlations only for prelingually deaf subjects. It seems logical to assume that the task of remembering digits may not truly be a visual memory task. When shown a printed digit, a subject can immediately classify the stimulus as a linguistic unit, rather than as a temporal-spatial visual pattern. The experimental results could, therefore, be interpreted to indicate that visual memory and speechreading are not related, but may appear to be so in prelingually deaf subjects, when the visual memory task taps into linguistic skills.

DeFilippo (1982) attempted to examine the relationship between visual memory and speechreading. She used a variety of discrimination/identification tasks that were intended to measure visual memory capability, speechreading capability, and memory during speechreading. Her subjects were children and adults who had all been deafened at an early age. The adults, however, demonstrated higher receptive language levels.

The stimuli for the visual memory tasks were printed symbols or mouth shape sequences. The printed symbols tasks involved the recall of from two to seven digits and six sequential letters that were shown printed on a screen. The mouth shape sequences task involved both sentence discrimination and nonsense syllable discrimination tasks. The sentence discrimination task required the subject to speechread two sentences and determine if they were the same or different. The difference, when present, was in one phoneme in the middle of the sentence. While DeFilippo stated that the subjects were not required to identify the sentences, it should be noted that there was no way to be sure that the subjects were truly responding to this as a discrimination task and not as an identification task.

Speechreading ability was measured for nonsense syllables (closed set vowel and consonant recognition) and sentences. The 22 sentences used were from the CID Everyday Sentence Test (Barley Test, Form A; Davis and

Silverman, 1978) and were highly redundant linguistically. Fifty sentences were also developed as low redundancy material. The memory during speechreading task was the "Related Sentences Test". In this test, the talker spoke a pair of semantically related sentences. The first sentence to be speechread was the one the subject had to remember. The second sentence to be speechread was contextually related to the first, and was also shown in print to the subject.

DeFilippo's findings were that overall, the adults performed better than the children. Performance was similar for the two groups only for the vowel recognition task. Overall, receptive language ability was found to be the best predictor of speechreading performance, when performance was defined by the score on sentences (r=.78). When the results were analyzed separately for the children and the adults in a multiple regression analysis, however, different factors were found to be predictive of speechreading ability. For the children, 42% of the variance in the speechreading scores could be accounted for by the vowel and consonant recognition scores, and memory tasks were not found to be related to speechreading performance. After considering all of the variables, only 65% of the variance in the children's speechreading scores could be accounted for. For the adults, however, the combined test scores accounted for 92% of the variance in speechreading performance. 85% of the variance was accounted for by the nonsense syllable discrimination and the related sentence test.

One of DeFilippo's tentative conclusions was that the adults were encoding the visual image into linguistic memory while the children were not. All of the "memory" tasks that were used involved linguistic stimuli. Although the stimuli could have been responded to as purely visual patterns, it is not likely that this was the case. Since the adults and children demonstrated different levels of receptive language ability there was no reason to expect that the two groups would show similar patterns of performance on these tasks.

It is not clear, from DeFilippo's study, why the adults performed better than the children on the related sentence test. It might be hypothesized, however, that although she used this test as a measure of memory, the task actually allows the subject to use some of the contextual information that is present in everyday conversation. It is possible that the adults, may have been better speechreaders because of a greater ability to use the contextual information.

Visual Synthesis and Closure

Visual closure has been defined as the ability to perceive an incomplete figure or movement as a whole (Berger, 1972). Jeffers and Barley (1971) defined the process of visual synthesis as requiring perceptual closure (grouping and filling in of elements and pattern identification) followed by conceptual closure (filling in of words and message identification). Although the two processes have been discussed separately, they may be more similar than different.

A common experimental strategy employed in order to investigate the relationship between speechreading and synthetic ability has been to use completion tasks. Some experimenters have used picture completion tasks, but these tasks have not accounted for much of the variance in speechreading scores for either children or adults (Wong and Taaffe, 1958; Simmons, 1959; Sharp, 1972).

Several researchers have hypothesized that good speechreaders would also perform well on orthographic letter and word prediction tasks. A study was done by Tatoul and Davidson (1961) in which normal-hearing adults had to complete every word (where letters were missing) in a sentence. Speechreading was measured in 100 subjects using the John Tracy Lipreading Test Form A. Performance for the 25 best and poorest speechreaders was compared for the completion task. Twenty sentences from Form B of the John Tracy test were used for the letter prediction task. The subjects were given a key word in the sentence and then had to predict, one at a time, the letters of each word of the sentences. The letter prediction task did not differentiate between the good and bad speechreaders. The conclusions of the experimenters were that either 1) there was no relationship between speechreading ability and synthetic ability, or 2) orthographic letter prediction tasks were not indicative of synthetic ability. It should be noted, however, that the range of scores on the letter prediction task was very narrow for both groups of subjects, thus a third interpretation of their results could have been that their chosen task did not differentiate among individuals with a greater or lesser degree of synthetic ability.

Bode et al (1970) also attempted to correlate performance on a letter prediction task with speechreading ability. Speechreading ability was measured using the 31 sentences of the Utley Test, while sentences from the CID Everyday Sentence Test were presented orthographically with alternate second and third letters omitted. The speechreading task was always administered first and normal hearing subjects were used. A low but significant correlation between the speechreading test scores and the orthographic test scores was obtained. The score on the orthographic test, however, accounted for only 13% of the variance in speechreading scores. Bode et al noted that the scores on the orthographic task fell into a bimodal distribution. The subjects at either end of the distribution were later examined as separate groups. A significant correlation, accounting for 32% of the variance in speechreading score was found within the low scoring group, but not within the high scoring group.

A major criticism of all of the above mentioned studies is that visual synthetic ability was assessed with "paper and pencil" tasks. Such tasks probably require different processing strategies than does speechreading. For example, in the orthographic tasks, subjects could take as much time to respond as they wished, whereas response time during speechreading is at least partially determined by the speaking rate of the talker.

In an attempt to overcome this problem, Albrecht and Haas (1982) replicated the Bode et al study with two additions: a second orthographic task that required the subjects to fill in missing words in a passage of text, and a time constraint for all tasks such that there was not sufficient time for subjects to backtrack and repeat prior items. Performance on both of the timed tasks was significantly correlated with speechreading performance. Scores on the letter predictability task accounted for 44.9% of the variance in speechreading score. Scores on the word omission task, however, accounted for only 16% of the variance in speechreading score. The authors concluded that the addition of a time constraint made the visual synthesis task more similar to the task of speechreading.

In summary, it has been shown that certain visual perceptual tasks bear some relationship to speechreading performance. The relationship, however, appears to be limited to those tasks that more closely resemble the speechreading process i.e. those with a time constraint and that tap some aspect of linguistic ability. It would be unwise, therefore, to conclude that "good visual synthesis" is a prerequisite for speechreading proficiency. The tasks used in the studies described could also be reflective of processing speed and the subject's knowledge and use of the linguistic rules or constraints of language. This issue will be discussed in the next section.

Use of linguistic constraints as a correlate of speechreading performance

Another proposed source of individual variability of speechreading performance is the knowledge and use of linguistic constraints. As early as 1960, Woodward and Barber stated "since many articulatory differences among phonemes are not detectable visually, successful speechreading performance apparently must be based primarily on the viewer's perception and utilization of phonetic, lexical, and grammatical redundancy within connected speech signals" (cited in Jeffers and Barley, 1971). Summerfield (1983) also stated that the expert speechreader may overcome the problems imposed by a restricted sensory input by a superior use of semantic context. Knowledge and use of linguistic redundancy could be the key factor that allows proficient language users to use incomplete sequences of phonemes to form words, and incomplete series of words to form sentences.

Linguistic constraints exist at the phonological, lexical, syntactic, and semantic levels. At the phonological level, only certain sound patterns are used to determine or change word meaning. These phonemic patterns occur with differing frequencies, and some phoneme sequences are more probable than others. Language users have implicit knowledge of the phonemes, their probabilities, and their transitional probabilities. Similarly, lexical constraints operate to specify which sequences of phonemes form meaningful words, and what the relative probabilities of occurrence of different words are. Syntactic constraints govern word modifications and sequencing in sentences. Semantic, topical, and pragmatic constraints require that syntactically ordered strings of words should also be meaningful, both inherently and in relation to the situation in which they are generated. Only through knowledge and use of these constraints can individuals perceive speech under conditions of degraded and/or missing information.

The use of linguistic constraints in visual speech perception has not been studied extensively. There is, however, a long history of research on this topic in auditory speech perception. In a landmark experiment, Miller, Heise, and Lichten (1951) evaluated auditory speech perception in noise while varying the type and amount of contextual information. Two normal hearing subjects alternated as talker and listener. One phase of the experiment examined the effect of the context supplied by the knowledge that a test item is one of a small vocabulary of items. Word recognition scores were obtained for closed sets of 2,4,8,16,32, and 256 words, and for an open set of stimuli. A threshold (50% of the words correctly identified) was obtained in noise for each size set of stimuli. The signal to noise ratio to obtain threshold varied from -14 dB for a set size of two, to -4 dB for a set size of 256.

Miller et al also examined the effect of the context supplied by the knowledge of items that precede or follow a given word in a sentence. Specifically, they measured word recognition in isolation and in sentences. The words in isolation were the same words as in the sentences. Words in sentences were found to be easier to perceive than words in isolation, the difference in scores being as high as 30 percentage points. The authors suggested that the effect of the sentence context is comparable to that of a restricted vocabulary. The range of possible alternatives for choices of words in a sentence are limited by the syntactic and semantic constraints of the language.

Although the Miller et al findings were reported extensively, and used as primary examples of the effect of context on speech perception, there were some criticisms of this work. Specifically: 1) only two subjects were used, 2) these subjects were highly sophisticated (the experimenters themselves), and 3) live voice was used. In order to determine whether these factors had affected the findings, O'Neill (1957) replicated part of the study using a larger group of subjects and pre-recorded stimuli. Word recognition was measured for words in isolation, and for words in sentences. The S/N ratio for 50% recognition of words in sentences was similar to that found by Miller et al. The scores regarding S/N ratio for words in isolation were slightly different. In both studies, however, the change in S/N ratio for 50% recognition, resulting from the addition of sentence context, was approximately 6dB.

Note that the studies just described examined auditory speech perception. The effect of the use of linguistic context on <u>speechreading</u> performance has been measured in a study by Haas (1982). Haas tested the hypothesis that speechreading performance was related to use of lexical contextual information, and to the speed of processing. The speechreading ability of 30 normal hearing college students was measured using the Utley Test. Haas then constructed sequences of eight alphabet letters with varying degrees of approximation to English words. The closest approximations to real words were fourth order approximations (i.e. any randomly selected sequence of four letters could appear within real words). Haas also varied exposure durations of the stimuli from 2 to 100 msec. Subjects were required to write down the letters which were flashed on the screen. The only measure that correlated significantly with speechreading performance was the recognition of fourth order approximations, with a 2 msec. exposure duration. This measure accounted for 32% of the variance in the speechreading scores. Haas concluded that people who were better able to use knowledge of the sequential probabilities of letters in words were better speechreaders.

Berliner (1979) attempted to test the hypothesis that the use of lexical, syntactic, and semantic contextual information could account for a significant portion of the variance in speechreading performance.

The measure she employed to determine the degree of use of contextual information was the "Word Boundary Test". This is a paper and pencil test in which passages of text are typed as unbroken strings of letters. The text varies from random words to sentences. Performance on this test was compared with speechreading performance as measured by the John Tracy Lipreading Test. Berliner evaluated 30 post-lingually, profoundly deaf adults and 22 normal hearing adults. A significant negative correlation was found for the normal hearing males only, implying that male, normal hearing, poor speechreaders performed best on the Word Boundary Test.

The correlations of the Word Boundary Test score with speechreading performance were examined using a total Boundary Test score of items correct. Berliner noted that this score can be influenced by reading speed. She therefore partialed the total score into a score for the random words portion and a score for the sentence portion, and subtracted one from the other. The difference provided a measure of the use of context, with the effects of reading speed partially removed. She then divided the subjects into "high" and "low" context users (above and below the mean difference score) and found that the "high" context users exhibited greater variability of speechreading scores than the "low" context users. Berliner took these findings as evidence in favor of the notion that ability to use context is related in some way to speechreading performance, and that the topic needs further investigation.

Lyxell and Ronnberg (1987), using a word and sentence completion task, examined the relationship between "guessing" and speechreading in normal hearing adults. The words and sentences had a time constraint imposed on them so that they appeared on a screen only for a short period of time. Additionally, the subjects were provided with the situational context of the sentences. The speechreading task used sentences the researchers developed that varied in length (3, 6, and 12 word sentences were used). Their hypothesis was that proficient speechreaders take greater advantage of semantic, syntactic, and contextual cues, and that this would be more apparent for longer sentences.

The score on the sentence completion task, which may be considered as a measure of the use of semantic and syntactic context, was not related, on average, to general speechreading ability. However, those subjects with high sentence completion scores, did perform better than those with low sentence completion scores on the longer sentences. The score on the word completion task, which may be considered as a measure of use of lexical context, was related to speechreading ability. The better speechreaders evidenced higher word completion scores. Their general conclusions were that "guessing", or use of contextual information were related to speechreading performance, but that it is not possible to make predictions from the results of one single guessing test about the entire speechreading process.

In summary, it has been shown that for auditory speech perception, knowledge and use of linguistic constraints improves word recognition scores under difficult listening conditions. This was demonstrated by measuring perception using test materials containing greater and lesser degrees of linguistic constraints. Studies examining the relationship between speechreading and the use of linguistic constraints, however, have only used "paper and pencil" tests. The conclusions from this research is that a relationship exists between speechreading and the use of linguistic constraints, but the specific role of these constraints is not clear.

Experience as a correlate of speechreading performance

It was stated in the beginning of this review that a principal motivation for the attempts to discover the source of the variability seen in speechreading performance was the development of more effective instructional techniques. Implicit in this statement is the assumption that speechreading is a skill that can be taught, and that practice will increase proficiency. One method of examining this assumption is to explore the differences in the speechreading performance between experienced and inexperienced speechreaders.

Very few research studies have been conducted for the specific purpose of examining the differences in speechreading performance between experienced and inexperienced speechreaders. This may result from an assumption that experienced speechreaders have better speechreading abilities than do inexperienced speechreaders. As discussed in the previous sections, however, the results from the few studies that have addressed this issue have been conflicting.

One reason for the conflicting findings regarding the effect of experience on speechreading performance may be the specific subject populations used. Normal hearing adults have almost always been selected as inexperienced speechreaders. Several studies have shown that normally-hearing inexperienced subjects often speechread as well as, or better than hearing-impaired experienced subjects (Benguerrel and Pichora-Fuller, 1982; Clouser, 1977; Conrad, 1977; Danhauer and Appel, 1974; Owens and Blazek, 1985).

There are several factors that could contribute to the finding of better speechreading performance in normally-hearing inexperienced subjects than in hearing-impaired experienced subjects. The first is that in all of the above studies, the hearing-impaired subjects were prelingually hearing impaired, most with severe to profound impairments. It is well known that pre-lingual deafness is generally correlated with deficient receptive language abilities (Boothroyd, 1978; Levitt, 1987; Ross and Giolas, 1978). Even for those with relatively good language skills, there are few, if any prelingually deaf individuals with as good a facility with spoken language as that of the normally-hearing. Since speechreading is the perception of spoken language, prelingually deaf subjects are at an obvious disadvantage.

The second factor concerns the specific type of normal hearing subject selected. Most of the normal-hearing subjects used in the studies mentioned above were college students. As a group they were more likely to have been accustomed to test taking. They also were often paid for their participation, and may, therefore have been highly motivated. It should also be noted that some of the normally-hearing subjects were graduate students in speech and hearing or the experimenters themselves, and may therefore, have brought considerably more insight to the speechreading task than the hearing-impaired subjects. The effect of the choice of the particular type of normal hearing subjects used, however, has not been explored.

The problems of subject selection just referred to were addressed in the design of a study by Berliner (1979). She examined the issue of the effect of experience on speechreading by evaluating the speechreading ability of 30 post-lingually, profoundly hearing-impaired adults and 22 normal hearing adults who were not professionals in the speech and hearing field. Percent correct scores for words in sentences were significantly higher for the deaf subjects than for the normal hearing subjects. The intra-group variability was high, however, for both groups. Since the major difference between the two groups was experience, she concluded that good speechreading performance involves some specific ability or abilities that can be learned. She noted, however, that experience was not a guarantee of improved speechreading ability since there were normally hearing subjects who did better than some of the deaf subjects.

Berliner's work provided some evidence that experienced subjects are better speechreaders than are inexperienced subjects, however two factors require that these results be interpreted cautiously. The first is that live presentation of the stimuli could have biased the results. It is possible that the speech was not presented consistently to all subjects. The second factor is that the speechreading score was based on only 30 sentences (188 words). Only one administration of the speechreading test was given to these subjects, therefore there is no measure of intra-subject variability.

In summary, previous studies comparing the speechreading performance of experienced and inexperienced speechreaders have not consistently demonstrated greater speechreading proficiency of the experienced subjects. This is very likely due to the fact that the experienced subjects were, in general, pre-lingually deaf and less proficient in receptive language abilities than the inexperienced, normally-hearing subjects. The one study that used post-lingually deaf adults as the experienced group did find this group to be more proficient, on average, than inexperienced speechreaders.

Factors Affecting Speechreading: Research Design Issues

It has been shown that the search for the determinants of speechreading success has not resulted in conclusive findings. It may be that it is not possible to discover the factors accounting for speechreading success. There are, however, several issues relating to the design of many of the past research studies that may have contributed to these inconsistent findings. They are 1) the choice of subjects, 2) the choice of test measures for the independent variables, and 3) the choice of speechreading test measure.

Many of the studies that sought correlates of speechreading competence used prelingually deaf subjects as the experimental population, while others used normally-hearing subjects. Since a major difference between these two types of subject groups was likely to be receptive language ability, and speechreading is essentially the visual perception of spoken language, it is not surprising that inconsistent findings resulted. A further complicating issue relating to subject choice is the particular type of normally-hearing subject used, as explained in the previous section.

Most of the studies that have examined the relationship between speechreading and visual perceptual skills used perceptual tasks with stimuli that may not have actually measured purely visual skills. The chosen tasks were such that the results were probably more representative of linguistic skills. All of the studies that examined the relationship between speechreading and either visual perceptual skills or use of linguistic constraints, used "pencil and "paper" tasks as indices of performance. It is not reasonable to expect that the skills necessary to perform well on such tasks are the same skills necessary to be a competent speechreader.

The choice of speechreading test used to measure competence is a third issue that may have contributed to the inconsistent findings noted previously in this review. Three speechreading tests have been used in the past studies: the Utley Test, the John Tracy Test of Lipreading, and the CID Everyday Sentence Test. Of these three, the Utley Test Form B was used in the majority of the studies. However, this test consists of only 31 sentences, and no mention was ever made of the test-retest variability that characterizes this test. As mentioned previously with respect to the results of Shepherd (1977, 1982), a test that has high inherent test-retest variability cannot be expected to show high correlations with other variables.

While it is possible that there is no single factor that can account for speechreading competence, when subjects with deficient language abilities (i.e. prelingually deaf subjects) are excluded from consideration, the following factors tend to correlate with speechreading performance:

1) amount of speechreading experience,

2) visual perceptual abilities, as measured by word and sentence completion tasks with the imposition of a time constraint, and

3) physiological functioning, specifically the absolute latency of portions of the average visual evoked potential.

The present study, as indicated in the introduction, addressed two issues:

1) the role of speechreading experience, and

2) the ability of the speechreader to take advantage of linguistic constraints in the stimulus.

CHAPTER 3

METHOD

Research Questions

The experiment to be described had two goals. The first was to examine the effect of experience on speechreading competence. The specific question asked was: Do experienced speechreaders perform better than inexperienced speechreaders? The second goal was to examine the role of use of linguistic context as a determinant of speechreading competence. The specific questions asked were: 1) Do competent speechreaders take greater advantage of linguistic context than do incompetent speechreaders?, and

2) Do the differences between competent and incompetent speechreaders disappear for tasks involving nonsense syllables?

Subjects

Most of the previous studies that compared the speechreading performance of experienced and inexperienced speechreaders did not show experience to have a significant effect on speechreading competence. The definition of experience, however, is open to question. In particular, the use of prelingually deaf subjects as experienced speechreaders is not justified because of their probable linguistic deficit. It should be noted, however, that it is difficult to arrive at a definition of experience that allows for placement of subjects in two discrete groups, inexperienced and experienced. It is naive to think that normal hearing individuals have no experience at speechreading or that all deaf individuals have similar speechreading experience. However, it is reasonable to assume that deaf individuals have more experience than do normal hearing individuals. It is also reasonable to assume that deaf individuals who demonstrate a high degree of motivation to communicate orally have more experience than do non-motivated deaf individuals.

In the present study, the issue of subject selection was addressed by: a) using two groups of subjects who were linguistically and educationally equivalent, and b) selecting experienced subjects who not only had been deaf for at least one year, but who had demonstrated a strong motivation to improve their communicative competence.

1. Experienced subjects:

The experienced subjects were post-lingually deaf cochlear implant patients who were part of the Cochlear

Implant Program of New York University Medical Center. As part of this program, they received training in speechreading both with and without the implant. Therefore, even though all of the subjects had quite different backgrounds regarding previous training, they had all recently been through the same ten week rehabilitation period. Note, however, that the implant was not used during any of the testing in the present study.

There were 12 subjects in this group, ranging in age from 17 to 64 years, with a mean of 39.6 years. Number of years of deafness ranged from one to 56 years, with a mean of 21.3 years. Three were male and nine were female. Seven of the subjects were college graduates, four were high school graduates, and one was a high school student. Table 3.1 provides background information for these subjects.

Table 3.1

Background Information for Experienced Subjects

Subject	Age	Years Deaf	Sex	Education
1	25	6	F	C+
2	59	53	M	H
3	26	21	F	C+
4	56	4	F	H
5	64	56	F	H
6	39	22	F	C
7	31	3	F	C
8	55	21	F	C
9	44	41	F	H
10	17	12	M	H
11	23	1	M	C+
12	36	15	F	C

(H=high school; C=college; C+=graduate school)

Summary data:

Mean:	37	21	M: 3	H:5
Std.Dev:	19	19	F: 9	C:4
Range:	17-64	1-56		C+:3

2. Inexperienced subjects: The second subject group, inexperienced speechreaders, consisted of normal-hearing adults. None of these subjects had participated in previous speechreading studies. Additionally, none were professionally involved in speech and hearing and therefore had no special knowledge of speech perception and/or production or of speechreading. Specifically, the subjects were recruited through personal contacts and were not paid for their participation

These subjects were chosen in such a way that the two subject groups were matched for age and educational level. The two groups were matched for age since this variable has been shown to be related to speechreading performance (Farrimond, 1959). Within each group of subjects, for each decade of age, there was an equal number of subjects. As mentioned previously, it was believed that the effect of speechreading experience not be confounded with linguistic ability. It was assumed that subjects matched according to educational level would also be relatively equivalent regarding linguistic ability. Therefore, within each decade of age there was an equal number of high school and/or college graduates. The inexperienced subjects ranged in age from 16 to 63 years, with a mean of 38.6 years.

There was one male and eleven females. Table 3.2 provides background information for these subjects.

The inexperienced subjects had no known history of speech, hearing, or language problems. All subjects had normal or corrected to normal vision. All subjects completed a questionnaire regarding this information (see Appendix A).

Table 3.2

Background Information for Inexperienced Subjects

Subject	Age	Sex	Education
1	55	F	H
2	32	M	C
3	35	F	H
4	30	F	C+
5	29	F	C+
6	31	F	C+
7	23	F	C
8	34	F	C
9	57	F	H
10	59	F	C
11	16	F	H
12	63	F	H

(H=high school; C=college; C+=graduate school)

Mean:	39	M: 1	H:5
Std.Dev:	16	F: 11	C:4
Range:	16-63		C+:3

Speechreading Tests

In order to address the research questions concerned with the role of use of linguistic context as a determinant of speechreading competence, a variety of speechreading tasks were used. The tasks ranged from the perception of phonemes in nonsense syllables to the perception of words in sentences of known topic.

1. Measures:

Four measures of speechreading performance were obtained:

a) percent recognition of phonemes in nonsense syllables,

b) percent recognition of phonemes in words,

c) percent recognition of words in a carrier phrase,

d) percent recognition of words in sentences of known topic.

The difference between the scores for a) and b) reflects the use of lexical context, while the difference between the scores for c) and d) reflects the use of syntactic, semantic, and topical context.

2. Materials:

a) Nonsense syllables:

The nonsense syllables consisted of CVC combinations that did not constitute meaningful words.

The phoneme sequences used, however, were only those allowable in the English language. The percent correct recognition of phonemes, therefore, provided a measure of phoneme recognition in a context that offered only phonological constraints. Thus, the subject could use knowledge of the phoneme set of English, the relative probabilities of occurrence of the phonemes in this set, and the probability of occurrence of phoneme sequences. Fifteen lists, of 10 nonsense syllables each, were created. Each list contained the same 30 phonemes (20 consonants and 10 vowels); each nonsense syllable occurred only once throughout the lists. The same set of 30 phonemes was used in these lists as in the AB isophonemic word lists (Boothroyd, 1968).

The nonsense syllables were constructed by randomly selecting two consonants (one initial, one final), and one vowel for each syllable. If the random selection yielded a real word, the phonemes were put back in the pool and another selection was made. One further constraint was that each consonant (except h, r, and w) should be represented in both initial and final positions. A result of this was that a phoneme appeared in both positions at least five times. Only 12 of the 15 lists were used and each subject saw the same 12 lists. The lists are shown in Appendix B.

b) Meaningful CVC words:

The AB isophonemic word lists were used to provide a measure of phoneme and word recognition in a context that offered both phonological and lexical constraints. (Boothroyd, 1968). These word lists were used to provide two measures; percent recognition of phonemes in meaningful words and percent recognition of words in carrier phrase. Each list contains 10 CVC monosyllables for a total of 30 phonemes. Each phoneme appears only once in each list, and the same 30 phonemes appear in every list. Each word appears in only one of the 15 lists. Only 12 of the 15 lists were used in the present study and each subject saw the the same 12 lists. The lists are shown in Appendix B.

c) Topic-related sentences:

A topic-related sentence test that was developed at the City University Graduate Center for this and related projects was used as a measure of word recognition in a context offering phonological, lexical, syntactic, semantic, and topical constraints. The test contains 48 different sentence sets. Each set has 12 sentences, with 102 words in each set. Each sentence in each set is about one of the following topics: food, family, work, clothes, homes, animals, sports and hobbies, weather, health, seasons and holidays, music, and money. Sentence length varies uniformly from 3 to 14 words in each set. There are an equal number of declaratives, interrogatives, and imperatives in each set. Sentence length and type are counterbalanced across the 48 sets. Twenty-four of the forty-eight sets were used in the study. All subjects saw the same 24 sets, which are shown in Appendix B.

One goal in the development of this test was that the sentence content should be appropriate to everyday conversation among adults. In order to determine whether or not the sentences met this criterion, three staff members audited a recording of the first draft of the sentences and were asked to judge if the sentences were likely to occur in a conversation. Any sentence judged not likely to occur by one listener was modified until all three listeners were in agreement.

Recording of Test Materials

The test materials were video-recorded by a female speaker, who was a native of the Mid-Western United States. The recordings were made using a Panasonic 3240 videocamera and a SONY VO5850 3/4" videotape recorder. The speaker sat 12 feet in front of the camera. The zoom lens on the camera was adjusted so that the length of the speaker's head, from chin to crown, measured eight inches on a SONY KX1901A 19" RGB/analog video monitor. The picture was focused manually. Two studio flood lights were placed six feet from the speaker at 45 degree angles.

The audio signal was recorded using an Electrovoice 635A microphone four inches from the speaker's mouth. The signal was recorded through the microphone input onto audio channel 1 of the videorecorder. Figure 3.1 shows a block diagram of the recording instrumentation. A 1/2" test tape was copied from the original recording using a Panasonic AG6300 videorecorder.

The nonsense syllables and the AB words were presented in the carrier phrase "You will say _______ please." The sentences were preceded by "number one" etc.

Procedure

1. Test Instrumentation

The videotaped recordings of the test materials were presented to the subjects using a Panasonic AG6300 1/2" videorecorder and were shown on a SONY KX1901A 19" RGB/analog video monitor. The subjects were seated four feet from the monitor, in a quiet room. Figure

3.2 shows a block diagram of the testing instrumentation.

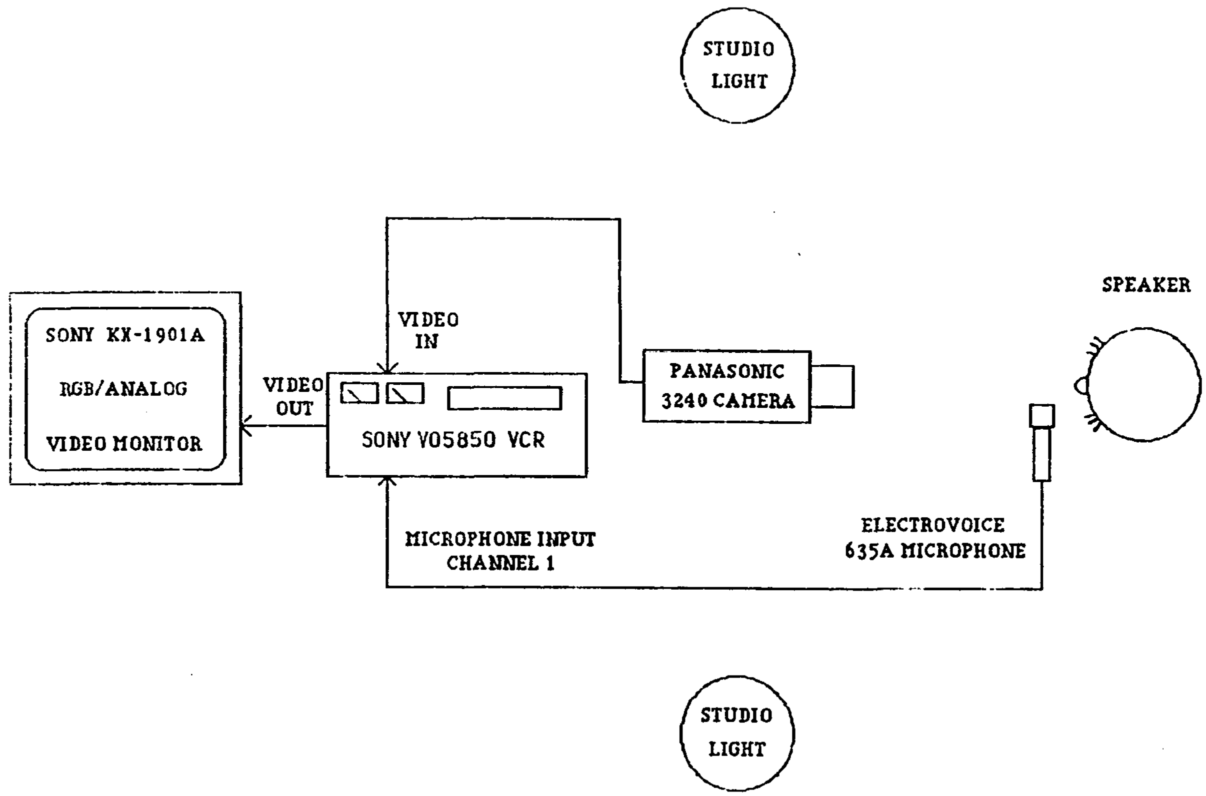

FIGURE 3.1 INSTRUMENTATION FOR THE INITIAL RECORDING OF TEST MATERIAL

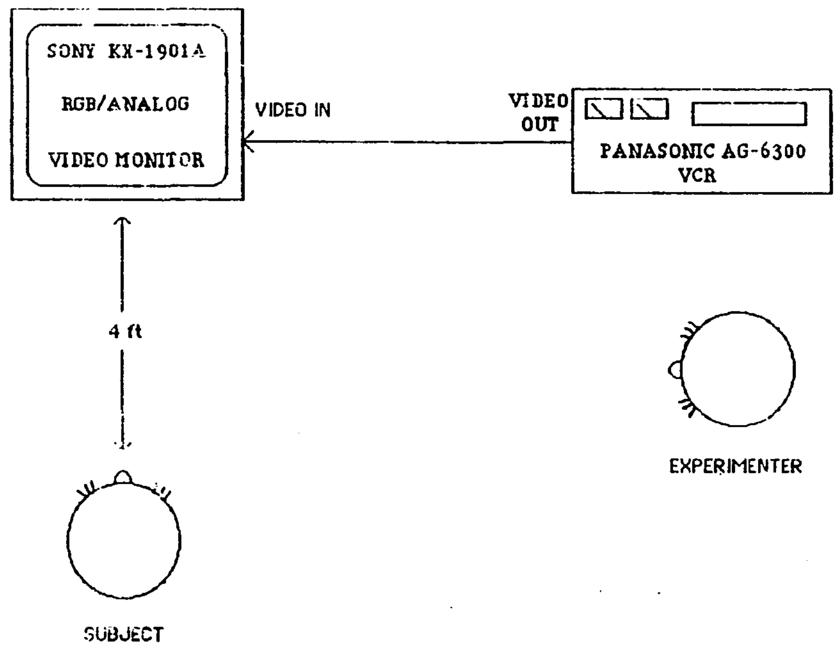

FIGURE 3.2 BLOCK DIAGRAM OF EXPERIMENTAL SET UP

2. Test Administration and Scoring

Each subject viewed a total of 12 nonsense syllable lists, 12 AB word lists, and 24 sentence sets. Each subject received one additional list/set of each type of material for practice. The intent of the practice trial was to familiarize the subjects with the different tasks.

Subjects were seen individually in two, one and a half hour sessions. Each subject was presented with six nonsense syllable lists, six AB word lists, and 12 sentence sets during each session. The order of presentation of material type was counterbalanced across subjects and between sessions so that each subject received a different order of presentation in the two sessions. The same order of presentation was used for both groups of subjects.

The order of presentation of the sentence sets was selected at random while the order of presentation of the nonsense syllable lists and the AB word lists was determined by a randomized Latin Square design. Thus, the lists were not only randomized, but counterbalanced. That is, each list appeared the same number of times in each testing position across subjects. The orders of presentation can be found in

Appendix C.

The procedure for the presentation of the nonsense syllables and the AB words was as follows. The subjects were shown the tape of the speaker saying the word/syllable in a carrier phrase on the TV monitor. Subjects had as much time as they needed to respond. The subjects were required to respond verbally, repeating as much as they perceived. The experimenter recorded their response on an answer form. Any subjects whose speech intelligibility was not good were additionally required to write down their responses on an answer form identical to that of the experimenter.

The test procedure for the presentation of the sentences was similar in that the subjects were shown the speaker saying a sentence on the monitor. Subjects were given a printed list of the topics of the sentences. The subjects were required to respond verbally. The experimenter recorded the responses by circling the correctly perceived words on an answer sheet.

Written instructions were given to the subjects. The instructions are included in Appendix D.

CHAPTER 4

RESULTS

Each subject provided the following data:

a) 24 scores for the percent correct recognition of words in sentences; each score derived from one sentence set, containing 102 words;

b) 12 scores for the percent correct recognition of CVC words in a carrier phrase; each score derived from 10 words;

c) 12 scores for the percent correct recognition of phonemes in CVC words in a carrier phrase; each score derived from 30 phonemes;

d) 12 scores for the percent correct recognition of phonemes in CVC nonsense syllables in a carrier phrase; each score derived from 30 phonemes.

These scores will be found in Tables E.1 through E.8 in Appendix E. Repeated measures analyses of variance of these data showed little or no short-term learning effects. The only measure for which there was a significant effect of trial was word recognition in sentences for the inexperienced subjects (see Appendix F). The effect, however, was small. For all statistical analyses, the mean percent correct score for each type of material, for each subject was used.

Word Recognition Scores

The individual mean scores for word recognition in carrier phrase and in sentences are shown in Table 4.1. along with the group means and standard deviations. For experienced speechreaders the mean score for the recognition of words in carrier phrase was 27.3% (S.D. = 6.9%) and in sentences, 64.1% (S.D. = 22.0%). For the inexperienced speechreaders the corresponding scores were 14.0% (S.D. = 6.0%) for words and 35.0% (S.D. = 18.9%) for sentences. These results are illustrated in Figure 4.1. It will be seen in Table 4.1 that the within group variance (as measured by the standard deviations) for the scores in phrase context was lower than the variance for the scores in sentence context. In order to increase the homogeneity of variance, the data were subjected to an arcsine transformation prior to repeated measures analysis of variance (Brownlee, 1965).

Table 4.1

Mean Percent Correct Recognition of Words in Sentences and in Carrier Phrase for Experienced and Inexperienced Speechreaders

Group:	Experienced		Inexperienced	
Context:	Phrase	Sentence	Phrase	Sentence
Subject:				
1	35.8	74.1	6.7	24.0
2	22.5	70.5	12.5	16.7
3	26.7	77.6	5.8	17.9
4	13.3	14.7	23.3	42.7
5	26.7	71.5	14.2	51.8
6	37.5	86.8	20.0	60.1
7	29.2	62.7	10.8	32.4
8	25.0	54.4	20.0	60.3
9	30.8	83.6	10.0	7.2
10	29.2	75.9	15.8	25.8
11	18.3	26.9	20.8	58.2
12	32.5	69.0	7.5	22.6
Mean	27.3	64.1	14.0	35.0
S.D.	6.9	22.0	6.0	18.9

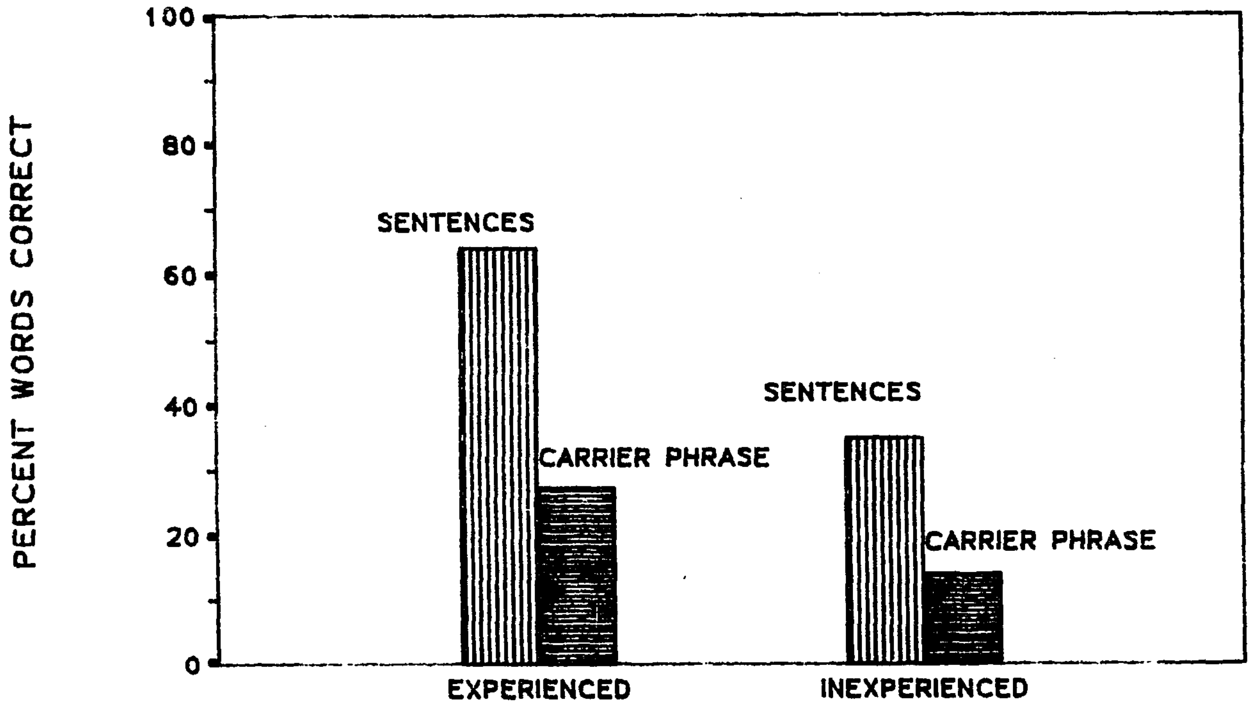

FIGURE 4.1 MEAN PERCENT CORRECT RECOGNITION OF WORDS IN SENTENCES AND IN CARRIER PHRASE FOR EXPERIENCED AND INEXPERIENCED SPEECHREADERS

The results of a repeated measures analysis of variance of the arcsine transformed data are shown in Table 4.2. The main effect of experience was highly significant (F (1,22) = 15.90, p=.0006), which confirmed that the mean score of the experienced group, collapsed across the two measures, was higher than that of the inexperienced group. It can be seen, however, that there were some inexperienced subjects who were quite competent speechreaders. Similarly, there were some experienced subjects who were almost incompetent speechreaders. The issue of the overlap in these data will be addressed later.

The main effect of context was also highly significant (F (1,22) = 89.33, p<.0001) which confirmed that the mean score for recognition of words in sentences, collapsed across the two groups, was higher than that for words in carrier phrase. The interaction between experience and context reached the 5% level of significance (F (1,22) = 4.51, p=.045). This indicated that the effect of sentence context was greater for the experienced subjects than for the inexperienced. In order to confirm that the effect of sentence context was significant for the inexperienced subjects, a t-test for related measures was done. A context effect was calculated for each subject, which was the difference between the percent correct scores for the recognition of words in sentences and in carrier phrase. The mean value was significantly different from zero (t (11) = 4.25, p<.01). Therefore, it was concluded that while both groups of subjects recognized more words in the presence of sentence context, the effect of sentence context was greater for the experienced subjects.

Table 4.2

Anova Summary Table for Effects of Experience and Sentence Context

Source	dF	Mean Square	F	P
Experience (E)	1	.704	15.9	.0006
error	22	.044		
Context (C)	1	1.194	89.33	<.0001
error	22	.013		
E x C	1	.060	4.51	.0452
error	22	.013		

Effect of Sentence Length

Since each of the sentence sets used in this study contained sentences varying in length from 3 to 14 words, it was possible to examine the effect of experience on the recognition of words in sentences as a function of sentence length. The data were re-analyzed in order to calculate the percentage of words correctly perceived in short (3-6 words), medium (7-10 words), and long (11-14 words) sentences.

The individual scores as a function of sentence length are shown in Table 4.3 and are illustrated in Figure 4.2. For the experienced group, the mean scores for short, medium, and long sentences respectively were 71.2%, 65.1%, and 61.6%. For the inexperienced group, the corresponding scores were 48.7%, 39.1%, and 32.5%. The results of a repeated measures analysis of variance of the arcsine transforms of the data are shown in Table 4.4.

The main effect of experience was significant, which was already demonstrated in the previous analysis. The main effect of length was also highly significant, (F (2,44) = 117.00, p =<.0001), which confirmed that longer sentences were more difficult to speechread than were shorter sentences. The interaction of length by experience was also significant (F (2,44) = 7.90, p = .0012), which confirmed that the effect of experience was greater for the longer sentences. A t-test for independent measures revealed that the effect of experience was still present for the shortest sentences (t (22) = 3.23, p <.01). It was concluded, therefore, that the effect of sentence length was significant for both groups of subjects, but that the effect was greater for the inexperienced group.

Table 4.3

Mean Percent Correct Recognition of Words in Sentences as a Function of Sentence Length and Experience

Group:	Experienced			Inexperienced		
Length:	Short	Medium	Long	Short	Medium	Long
Subject:						
1	81.3	73.9	72.6	41.7	24.3	17.1
2	78.9	73.3	70.5	32.4	15.4	11.7
3	81.5	80.4	75.9	30.3	21.2	11.2
4	21.9	17.3	10.6	53.9	44.4	37.4
5	79.8	72.6	67.9	59.5	51.6	49.0
6	88.9	87.2	85.6	64.8	64.2	55.0
7	76.6	58.8	60.7	46.5	35.8	24.9
8	61.1	55.5	51.2	69.9	61.9	55.8
9	85.6	88.6	80.2	18.1	6.1	4.1
10	83.7	75.1	74.6	35.6	26.7	21.6
11	40.0	29.0	23.3	69.0	57.1	54.2
12	75.3	70.1	66.4	36.8	23.3	17.3
Mean:	71.2	65.2	61.6	46.5	36.0	29.9
Std. Dev:	20.4	22.0	22.8	16.8	19.4	19.2

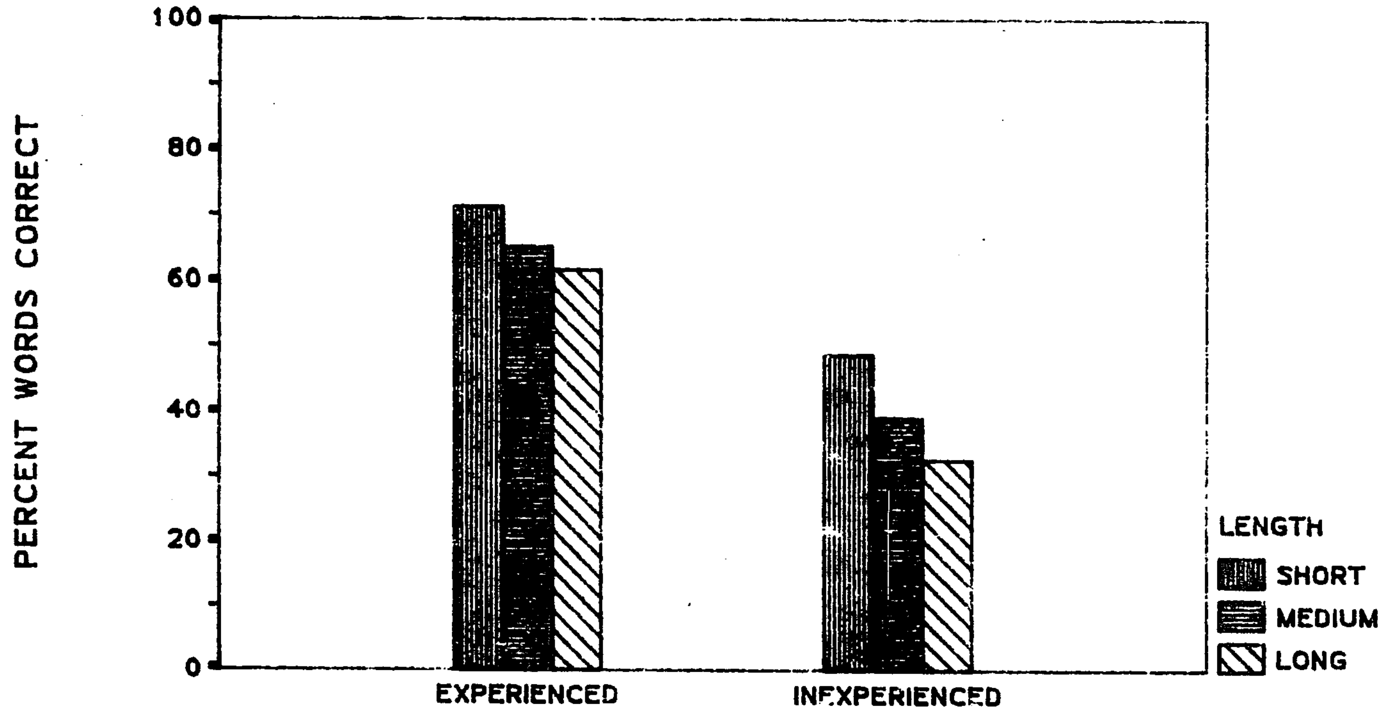

FIGURE 4.2 MEAN PERCENT CORRECT RECOGNITION OF WORDS IN SENTENCES AS A FUNCTION OF SENTENCE LENGTH AND EXPERIENCE

Table 4.4

ANOVA Summary Table for Effect of Sentence Length

Source	dF	Mean Square	F	P
Experience (E)	1	1.7421	11.97	.0022
error	22	.1455		
Length (L)	2	.1402	117.00	<.0001
error	44	.0012		
E x L	2	.0095	7.90	.0012
error	44	.0012		

Phoneme Recognition Scores

The individual mean percent correct scores for phoneme recognition in meaningful words and in nonsense syllables are shown in Table 4.5. along with the group means and standard deviations. For experienced speechreaders the mean score for the recognition of phonemes in meaningful words was 53.5% (S.D. = 5.9%) and in nonsense syllables, 39.7% (S.D. = 4.9%). For the inexperienced speechreaders the corresponding scores were 39.1% (S.D. = 8.0%) for words and 32.0% (S.D. = 7.0%) for nonsense syllables. These results are illustrated in Figure 4.3. The data were subjected to an arcsine transformation prior to repeated measures analysis of variance.

The results of a repeated measures analysis of variance of the arcsine transforms of the data are shown in Table 4.6. The main effect of experience was significant ($\underline{F}$ (1,22) = 18.5, $\underline{p}$=.0006), which confirmed that the mean score for the experienced group, collapsed across the two measures, was higher than that of the inexperienced group. T-tests for independent measures revealed that the phoneme recognition scores for the experienced group were significantly higher than those for the inexperienced group for both meaningful words (t (22) = 2.86, $p<.05$) and for nonsense syllables (t (22) = 3.16, $p<.01$).

The main effect of context was also significant (F (1,22) =214.9, $p<.001$), which confirmed that the mean score for recognition of phonemes in meaningful words, collapsed across the two groups, was higher than that for phonemes in nonsense syllables.

The interaction between experience and context was significant (F (1,22) = 18.5, $p=<.001$). This indicated that the effect of lexical context was greater for the experienced subjects than for the inexperienced. In order to confirm that this effect was significant for the inexperienced subjects a t-test for related measures was done. A context effect was calculated for each subject, which was the difference between the percent correct score for the recognition of phonemes in meaningful words and in nonsense syllables. The mean value was significantly different from zero (t (11) = 7.51, $p<.01$). Therefore, it was concluded that while both groups were able to utilize lexical context, the experienced subjects gained more benefit from this context.

Table 4.5

Mean Percent Correct Recognition of Phonemes in Words and Nonsense Syllables for Experienced and Inexperienced Speechreaders

Group:	Experienced		Inexperienced	
Context:	Word	Syllable	Word	Syllable
Subject:				
1	58.1	42.5	30.3	30.0
2	53.1	40.3	40.6	36.1
3	51.1	36.9	25.8	18.3
4	41.7	30.8	49.4	37.2
5	55.0	39.2	40.3	34.7
6	64.7	43.9	46.7	40.8
7	54.7	47.5	40.6	32.5
8	54.2	43.3	48.3	36.9
9	55.8	39.4	29.7	20.8
10	54.5	42.8	36.9	32.2
11	44.7	31.9	47.2	38.0
12	54.4	38.3	33.0	26.4
Mean	53.5	39.7	39.1	32.0
S.D.	5.9	4.9	8.0	7.0

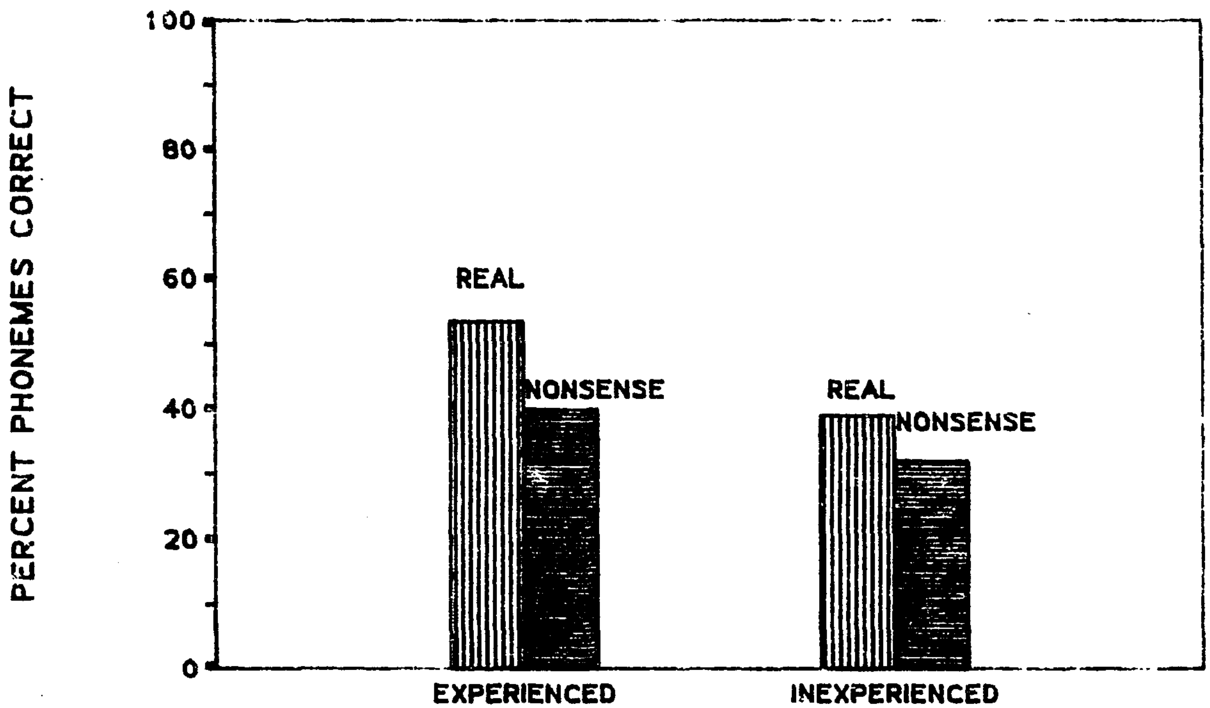

FIGURE 4.3 MEAN PERCENT CORRECT RECOGNITION OF PHONEMES IN WORDS AND NONSENSE SYLLABLES FOR EXPERIENCED AND INEXPERIENCED SPEECHREADERS

Table 4.6

Anova Summary Table for Effects of Experience and Lexical Context

Source	dF	Mean Square	F	P
Experience (E)	1	.16	18.5	<.001
error	22	.01		
Context (C)	1	.13	214.9	<.001
error	22	.001		
E x C	1	.01	18.5	<.001
error	22	.001		

The mean for phoneme recognition in nonsense syllables was significantly higher for the experienced group suggesting that this group was better able to perceive phonetic detail in the visual stimulus. In order to examine this further, these data were re-analyzed to obtain separate recognition scores for the vowels and the consonants. These scores are shown in Table 4.7 and are illustrated in Figure 4.4. For experienced speechreaders the mean scores for the recognition of vowels was 49.4% (S.D. = 7.8%) and for consonants, 34.8% (S.D. = 3.5%). For the inexperienced speechreaders the corresponding scores were 38.4% (S.D. = 10.9%) for vowels and 28.6% (S.D. = 6.0%) for consonants. The data were subjected to an arcsine transformation prior to an analysis of variance.

The results of a repeated measures analysis of variance are shown in Table 4.8. The main effect of phoneme type was significant (F (1,22) = 82.49, $p<.0001$), confirming that the perception of vowels was better than that of the consonants. The interaction of experience and type of phoneme, however, was not significant (F (1,22) = 1.91, p = .18) indicating that the difference in recognition for the different types of phonemes was similar for the two subject groups.

Table 4.7

Mean Percent Correct Recognition of Vowels and Consonants in Nonsense Syllables for Experienced and Inexperienced Speechreaders

Group:	Experienced		Inexperienced	
Type:	Vowel	Consonant	Vowel	Consonant
Subject:				
1	50.0	37.9	33.3	29.2
2	48.8	35.4	37.5	34.2
3	42.5	34.6	20.0	17.5
4	38.3	25.8	41.7	34.6
5	50.0	32.5	45.0	30.0
6	59.2	36.7	55.0	34.2
7	63.3	37.9	42.5	27.1
8	53.3	38.3	50.8	30.4
9	46.7	35.0	20.0	20.4
10	56.7	36.7	32.5	31.7
11	39.2	31.7	45.8	33.3
12	44.2	35.4	36.7	20.4
Mean	49.4	34.8	38.4	28.6
Std.Dev.	7.8	3.5	10.9	6.0

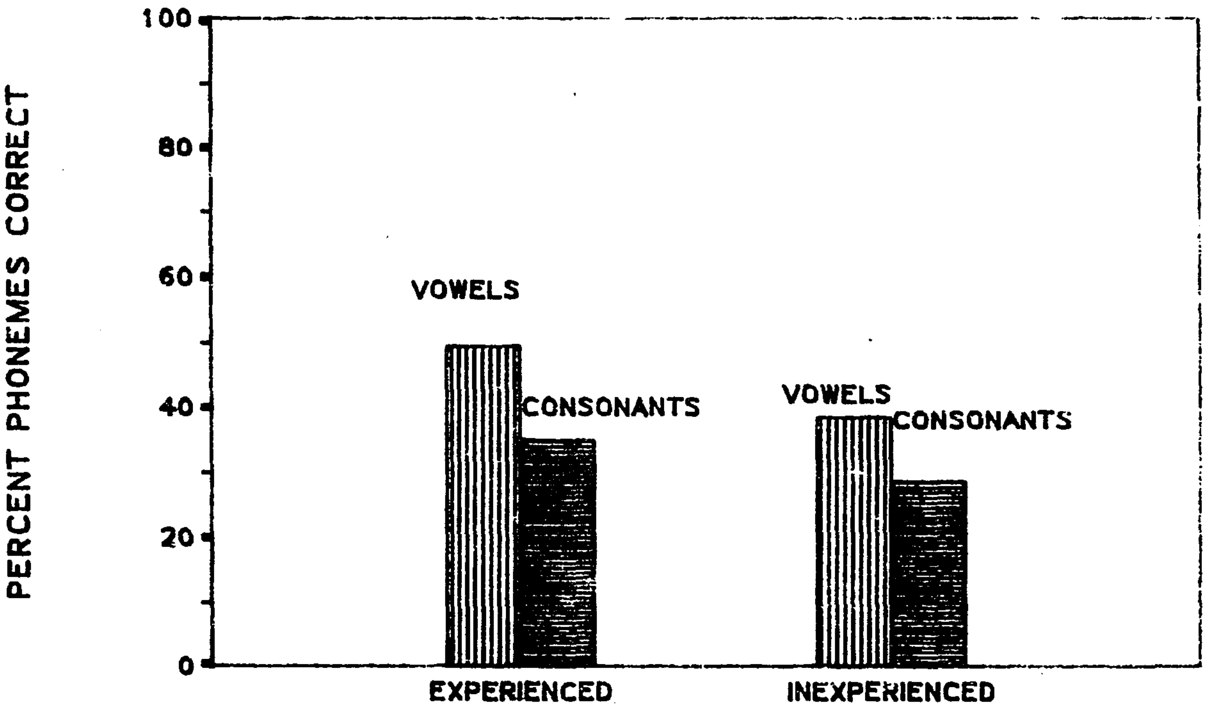

FIGURE 4.4 MEAN PERCENT CORRECT RECOGNITION OF VOWELS AND CONSONANTS IN NONSENSE SYLLABLES FOR EXPERIENCED AND INEXPERIENCED SPEECHREADERS

Table 4.8

Anova Summary Table for Effect of Experience and Phoneme Type

Source	dF	Mean Square	F	P
Experience (E)	1	.0065	9.43	.006
error	22	.0007		
Type (T)	1	.0116	82.49	<.001
error	22	.0001		
E x T	1	.0003	1.91	.180
error	22	.001		

Summary of Results

1. As hypothesized, the experienced subjects were, on average, significantly better speechreaders than the inexperienced subjects. This was true for all test measures.

2. The speechreading performance of the experienced subjects was less affected by sentence length than that of the inexperienced subjects.

3. The use of syntactic, semantic, and lexical context was significantly better for the experienced subjects than for the inexperienced subjects.

5. The perception of vowels was significantly better than the perception of consonants for both groups of subjects.

Although the experienced subjects were, on average, better speechreaders than the inexperienced, examination of the individual results showed considerable overlap of performance between the two groups. In other words, experience was not a guarantee of competence and lack of experience did not preclude competence. The issue of speechreading competence will be examined in more detail in the next chapter.

CHAPTER 5

ANALYSIS OF SPEECHREADING COMPETENCE

An initial assumption that led to the choice of experimental subjects was that speechreading experience and speechreading competence would essentially be the same thing. This was not found to be the case. There were some inexperienced subjects who were extremely competent speechreaders, and there were some experienced subjects who were quite poor speechreaders. Although the results in the previous chapter indicated that experienced speechreaders were able to make significantly better use of the linguistic context found in sentences than the inexperienced speechreaders, this effect was not strong. It was felt that this might be due to the finding of quite competent, inexperienced speechreaders. Thus, it was decided that the use of linguistic context during speechreading would be re-examined as a function of speechreading competence, rather than as a function of experience. The specific question to be answered was: to what extent can the difference between better and poorer speechreaders be attributed to the use of linguistic context? A consideration of this question is the focus of this chapter.

It was decided that the criterion for speechreading competence would be the recognition of words in sentences, as this was the measure that most closely resembled everyday communication. Figure 5.1 shows the distribution of this score for all subjects. A chi-square goodness of fit test showed that the scores were not normally distributed ($X^2(7) = 28.2$, $p < .005$). In fact, the distribution appears to be bimodal, suggesting that the subjects naturally divided into two groups, one of "better" speechreaders and one of "poorer" speechreaders. Within each group, the distribution of scores may be normally distributed. Only two subjects fell in the region of overlap between these two groups. It was decided, therefore, that those two subjects would be excluded from all of the following analyses. The result of the new grouping was 14 better speechreaders, operationally defined as having mean sentence scores over 50%, and 8 poorer speechreaders having mean sentence scores below 30%. The better group consisted of 10 experienced and 4 inexperienced speechreaders, while the poorer group consisted of 2 experienced and 6 inexperienced speechreaders. There were significantly more experienced subjects who were rated as better speechreaders than there were inexperienced ($x^2(1) = 4.41$, $p<.05$), confirming the findings of the earlier analysis that experienced speechreaders tend to perform better than inexperienced speechreaders.

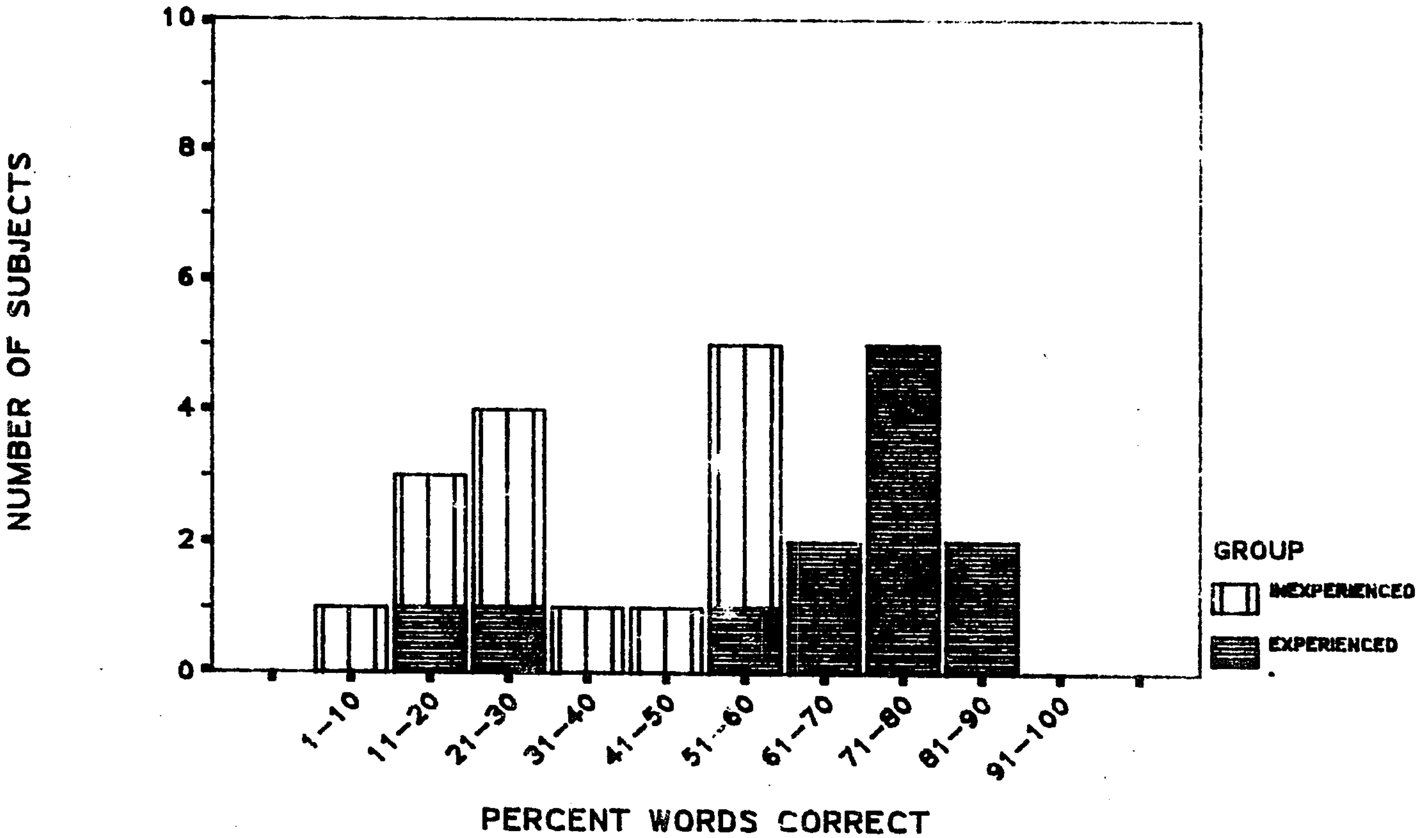

FIGURE 5.1 DISTRIBUTION OF SCORES FOR THE RECOGNITION OF WORDS IN SENTENCES

Word Recognition Scores

The individual mean scores for word recognition in carrier phrase and in sentences are shown in Table 5.1 along with the group means and standard deviations. For better speechreaders the mean score for the recognition of words in carrier phrase was 26.5% (S.D. = 6.6%) and in sentences, 68.3% (S.D. = 10.7%). For the poorer speechreaders the corresponding scores were 11.2% (S.D. = 4.5%) for words and 19.5% (S.D. = 6.6%) for sentences. These results are illustrated in Figure 5.2.

The results of a repeated measures analysis of variance of the arcsine transforms of the data are shown in Table 5.2. The main effect of skill was highly significant (F (1,20) = 97.14, $p<.001$), which confirmed that the mean score for the better group, collapsed across the two measures, was higher than that of the poorer group. This is not surprising, since the two groups were selected according to their sentence scores. However, the better speechreaders also performed significantly better on words in carrier phrase (t (20) = 5.8, $p<.01$).

Table 5.1

Mean Percent Correct Recognition of Words in Sentences and in Carrier Phrase for Better and Poorer Speechreaders

Group:	Better		Poorer	
Context:	Phrase	Sentence	Phrase	Sentence
Subject:				
1	35.8	74.1	6.7	24.0
2	22.5	70.5	12.5	16.7
3	26.7	77.6	5.8	17.9
4	26.7	71.5	10.0	7.2
5	37.5	86.8	15.8	25.8
6	29.2	62.7	7.5	22.6
7	25.0	54.4	13.3	14.7
8	30.8	83.6	18.3	26.9
9	29.2	75.9		
10	32.5	69.0		
11	20.8	58.2		
12	14.2	51.8		
13	20.0	60.1		
14	20.0	60.3		
Mean	26.5	68.3	11.2	19.5
S.D.	6.6	10.7	4.5	6.6

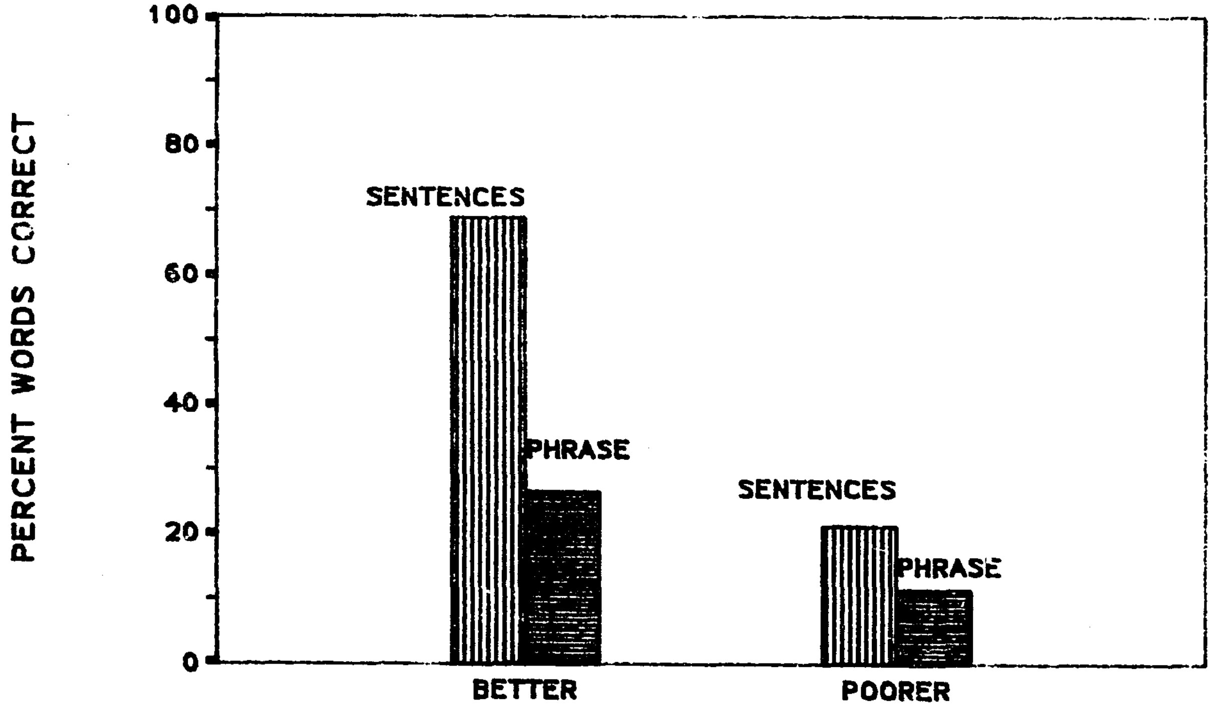

FIGURE 5.2 MEAN PERCENT CORRECT RECOGNITION OF WORDS IN SENTENCES AND IN CARRIER PHRASE FOR BETTER AND POORER SPEECHREADERS

The interaction between speechreading skill and context was significant ($\underline{F}$ (1,20) = 70.8, $\underline{p}$<.0001). It may be concluded, therefore, that the effect of sentence context was greater for the better subjects than for the poorer subjects. In order to confirm that the effect of sentence context was significant for the poorer subjects, a t-test for related measures was done. A context effect was measured for each subject, which was the difference between the percent correct score for the recognition of words in sentences and in carrier phrase. The mean value for the poorer speechreaders was significantly different from zero ($\underline{t}$ (7) = 3.4, $\underline{p}$<.01). Therefore, it was concluded that while both groups of subjects recognized more words in the presence of sentence context, the better speechreaders gained more benefit. An important finding of this analysis is that the interaction between speechreading competence and context was much stronger than that between speechreading experience and context.

Table 5.2

Anova Summary Table for Effect of Skill and Sentence Context

Source	dF	Mean Square	F	P
Skill (S)	1	1.353	97.14	<.0001
error	20	.014		
Context (C)	1	.786	205.64	<.0001
error	20	.004		
S x C	1	.271	70.78	<.0001
error	20	.004		

Interaction of Skill and Sentence Length

As in the earlier analysis, the data were re-analyzed in order to calculate the percentage of words correctly perceived in short (3-6 words), medium (7-10 words), and long (11-14 words) sentences. The group means as a function of sentence length are illustrated in Figure 5.3. For the better group, the mean scores for short, medium, and long sentences respectively were 75.4%, 69.3%, and 65.7%. For the poorer group, the corresponding scores were 32.1%, 20.4%, and 14.6%. The results of a repeated measures analysis of variance of the arcsine transforms of the data are shown in Table 5.3.

The relevant finding of this analysis was the significance of the interaction of length by skill ($\underline{F}$ (2,44) = 16.04, $\underline{p}$ = .0001), which confirmed that the effect of length was greater for the poorer speechreaders. The effect of skill was still present for the shortest sentences ($\underline{t}$ (20) = 10.93, $\underline{p}$ <.01). It can be concluded, therefore, that while the effect of sentence length is a significant factor for both groups of subjects, the effect is greater for the poorer speechreaders. In other words, the difference between better and poorer speechreaders is greater for longer sentences.

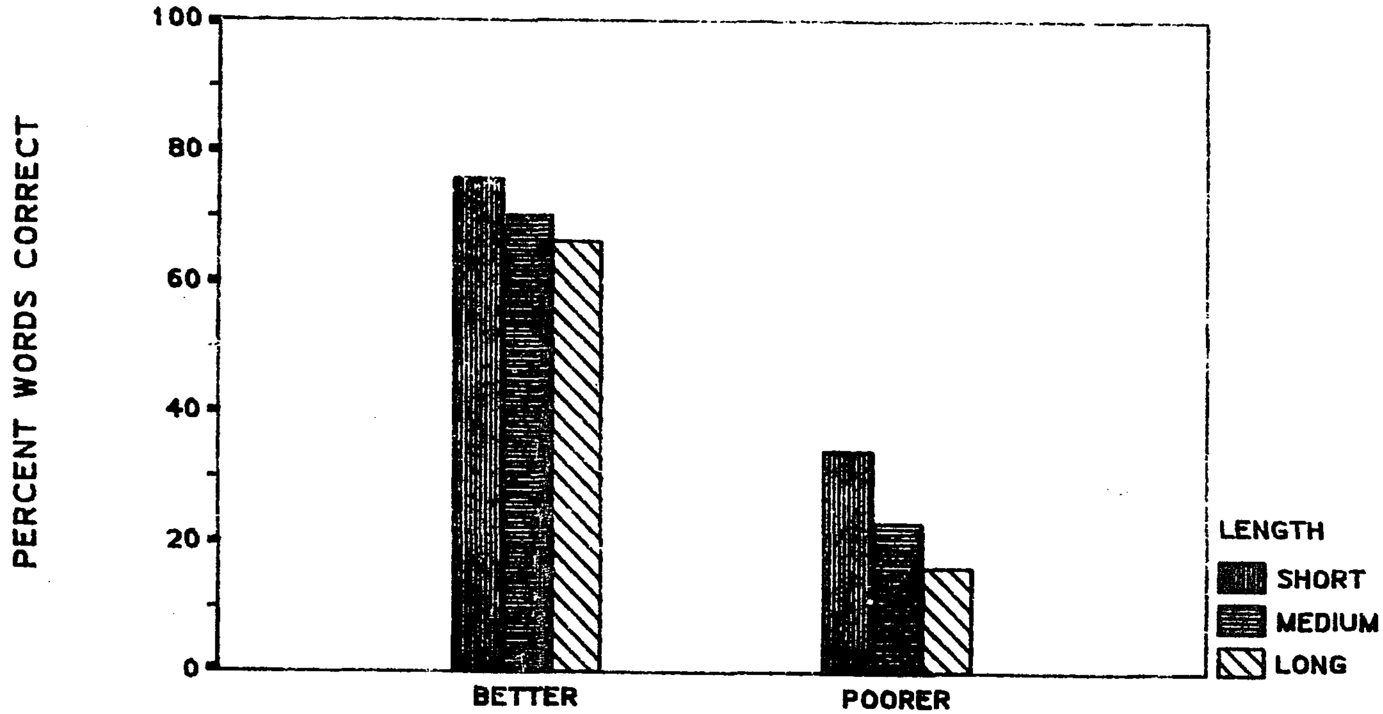

FIGURE 5.3 MEAN PERCENT CORRECT RECOGNITION OF WORDS IN SENTENCES AS A FUNCTION OF SENTENCE LENGTH FOR BETTER AND POORER SPEECHREADERS

Table 5.3

ANOVA Summary Table for Effect of Skill and Sentence Length

Source	dF	Mean Square	F	P
Skill (S)	1	4.1054	111.03	<.001
error	20	.0370		
Length (L)	2	.1366	144.75	<.001
error	44	.0009		
S x L	2	.0151	16.04	<.001
error	44	.0009		

Phoneme Recognition Scores

The individual scores for phoneme recognition in meaningful words and in nonsense syllables are shown in Table 5.4 along with the group means and standard deviations. For better speechreaders the mean score for the recognition of phonemes in meaningful words was 52.7% (S.D. = 5.8%) and in nonsense syllables, 40.3% (S.D. = 3.4%). For the poorer speechreaders, the corresponding scores were 35.3% (S.D. = 6.7%) for words and 26.9% (S.D. = 6.4%) for nonsense syllables. These results are illustrated in Figure 5.4.

Table 5.4

Mean Percent Correct Recognition of Phonemes in Words and Nonsense Syllables for Better and Poorer Speechreaders

Group:	Better		Poorer	
Context:	Word	Syllable	Word	Syllable
Subject:				
1	58.1	42.5	30.3	30.0
2	53.1	40.3	40.6	36.1
3	51.1	36.9	25.8	18.3
4	55.0	39.2	29.7	20.8
5	64.7	43.9	36.9	20.8
6	54.7	47.5	33.0	26.4
7	54.2	43.3	41.7	30.8
8	55.8	39.4	44.7	31.9
9	54.5	42.8		
10	54.4	38.3		
11	40.3	34.7		
12	46.7	40.8		
13	48.3	36.9		
14	47.2	38.0		
Mean	52.7	40.3	35.3	26.9
Std.Dev.	5.8	3.4	6.7	6.4

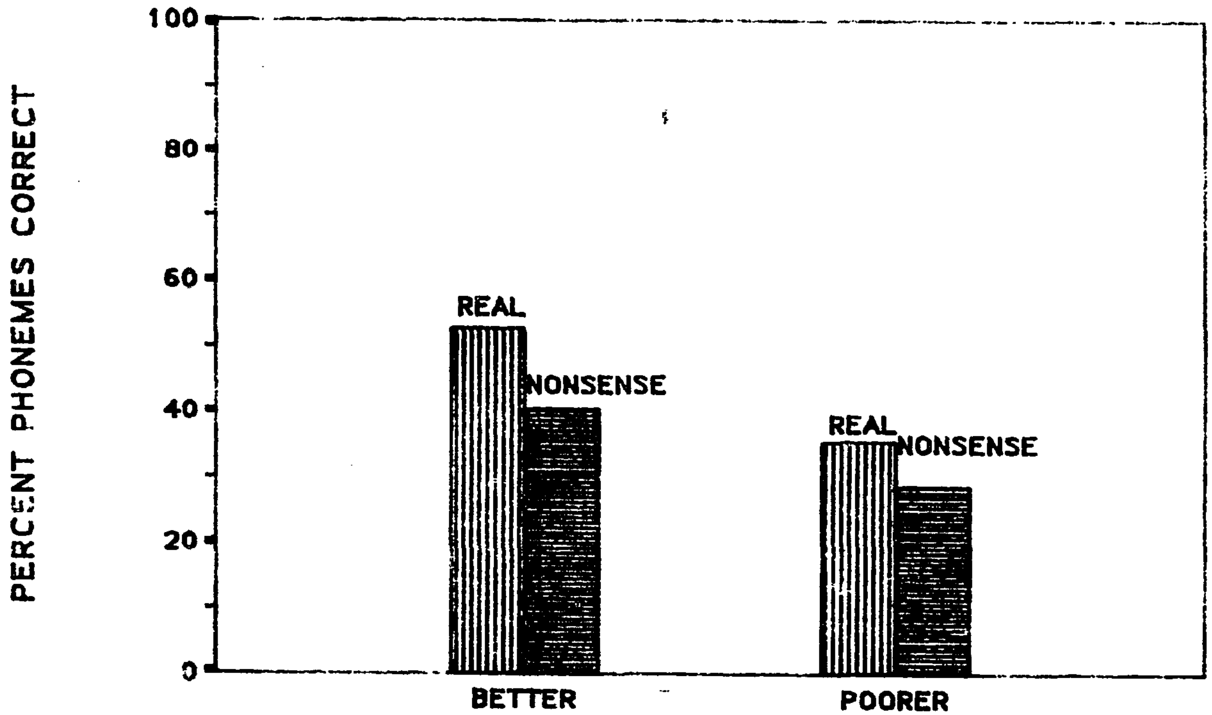

FIGURE 5.4 MEAN PERCENT CORRECT RECOGNITION OF PHONEMES IN WORDS AND NONSENSE SYLLABLES FOR BETTER AND POORER SPEECHREADERS

The results of a repeated measures analysis of variance of the arcsine transforms of the data are shown in Table 5.5. The main effect of skill was significant ($\underline{F}$ (1,20) = 41.21, $\underline{p}$<.0001), which confirmed that the mean score for the better speechreaders, collapsed across both phoneme recognition measures, was higher than that of the poorer speechreaders. The phoneme recognition scores for the better speechreaders were significantly higher than those for the poorer speechreaders for both meaningful words ($\underline{t}$ (20) = 8.37, $\underline{p}$<.01) and for nonsense syllables ($\underline{t}$ (20) = 6.51, $\underline{p}$<.01).

The main effect of context was also significant ($\underline{F}$ (1,20) = 110.54, $\underline{p}$<.0001) which confirmed that the mean score for recognition of phonemes in meaningful words, collapsed across the two groups, was higher than that for phonemes in nonsense syllables.

The interaction between skill and context was also significant ($\underline{F}$ (1,20) = 7.63, $\underline{p}$ = .012). It may be concluded, therefore, that the effect of word context was greater for the better speechreaders than for the poorer speechreaders. In order to confirm that the effect of lexical context was significant for the poorer speechreaders, a t-test for related measures was done. A context effect was measured for each subject, which was the difference between the percent correct score for the recognition of phonemes in meaningful words and in nonsense syllables. The mean value was significantly different from zero (t (7) = 5.3, p<.01). Therefore, it may be concluded that while both groups recognized more phonemes in the presence of lexical context, the effect of this context was greater for the better speechreaders.

Table 5.5

Anova Summary Table for Effect of Skill and Lexical Context

Source	dF	Mean Square	F	P
Skill (S)	1	.2336	41.21	<.001
error	20	.0057		
Context (C)	1	.0995	110.54	<.001
error	20	.0009		
S x C	1	.0069	7.63	.012
error	20	.0009		

Since the subjects were divided according to speechreading competence on the basis of word recognition in sentences, the finding of a significant difference for phoneme recognition in nonsense syllables was of particular interest. Thus, it was decided that the data from the nonsense syllable task would be re-analyzed in order to determine the relative contributions to these differences of vowels, initial consonants, and final consonants. The separate scores are shown in Table 5.6 and are illustrated in Figure 5.5.

For better speechreaders the mean score for the recognition of vowels was 50.8% (S.D. = 6.1%), the mean score for initial consonants was 35.7% (S.D. = 4.1%), and the mean score for final consonants was 33.9% (S.D. 5.0%). For the poorer speechreaders the corresponding scores were 32.2% (S.D. = 7.9%) for vowels, 29.4% (S.D. = 5.4%) for initial consonants, and 23.7% (S.D. = 8.2%) for final consonants.

The results of a repeated measures analysis of variance are shown in Table 5.7. The relevant findings of this analysis are first, that the main effect of type of phoneme was significant ($\underline{F}$ (1,20) = 38.95, $\underline{p}$<.0001). On average, there was no significant difference in the perception of initial and final consonants (t (21) = 1.57, p = .13). Perception of the vowels, however, was significantly better than both initial (t (21) = 3.99, p <.001) and final (t (21) = 4.71, p <.001) consonants.

The interaction of skill and type of phoneme was significant (F (1,20) = 8.05, p = .001). The difference in performance between the better and poorer speechreaders was most marked for vowels (t (21) = 5.78, p <.001), and significant, but smaller for both initial consonants (t (21) = 2.84, p <.05), and for final consonants (t (21) = 3.20, p <.05). Additionally, as can be seen in Figure 5.5, the better speechreaders obtain significantly higher scores on vowels than on consonants (t (13) = 7.30, p <.0001), while the poorer speechreaders did not (t (7) = 1.55, p = .17).

Table 5.6

Mean Percent Correct Recognition of Vowels and Initial and Final Consonants in Nonsense Syllables for Better and Poorer Speechreaders

Group:	Better			Poorer		
Type:	Vowel	Initial	Final	Vowel	Initial	Final
Subject:						
1	50.0	43.3	32.5	33.3	26.7	31.7
2	48.8	36.7	30.8	37.5	37.5	30.8
3	42.5	41.7	27.5	20.0	24.2	10.8
4	50.0	35.8	29.2	20.0	21.7	19.2
5	59.2	30.0	45.0	32.5	33.3	30.0
6	63.3	39.2	36.7	36.7	26.7	14.2
7	53.3	36.7	40.0	38.3	30.8	22.5
8	46.7	38.3	31.7	39.2	34.2	30.0
9	56.7	34.2	39.2			
10	44.2	34.2	36.7			
11	45.0	31.7	28.3			
12	55.0	34.2	32.5			
13	50.8	29.2	31.7			
14	45.8	34.2	32.5			
Mean	50.8	35.7	33.9	32.2	29.4	23.7
S.D.	6.1	4.1	5.0	7.9	5.4	8.2

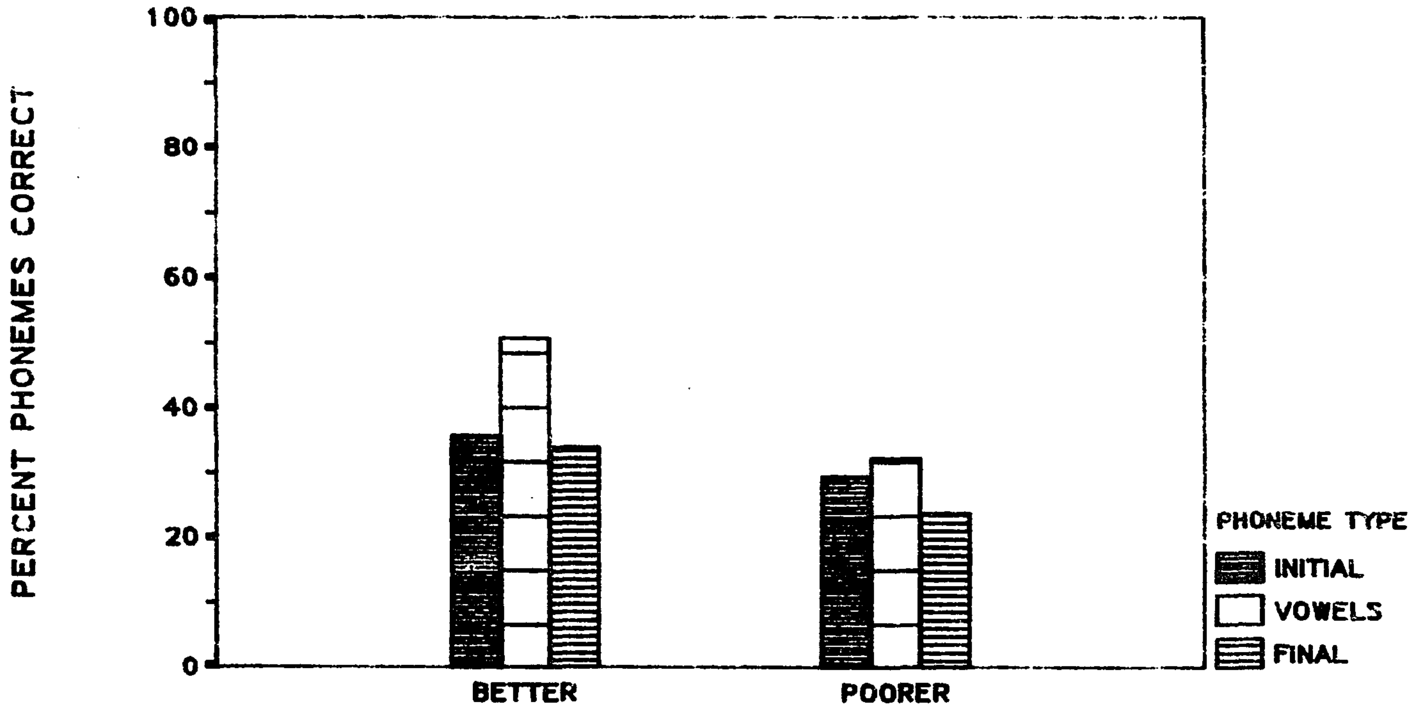

FIGURE 5.5 MEAN PERCENT CORRECT RECOGNITION OF VOWELS AND CONSONANTS IN NONSENSE SYLLABLES FOR BETTER AND POORER SPEECHREADERS

Table 5.7

Anova Summary Table for Effect of Skill and Phoneme Type

Source	dF	Mean Square	F	P
Skill (S)	1	.2450	30.88	<.0001
error	20	.0079		
Type (T)	2	.0977	38.95	<.0001
error	40	.0025		
S x T	2	.0202	8.05	.0012
error	40	.0025		

Summary of Results

1. The better speechreaders, as defined by their score for word recognition in sentences, obtained significantly higher scores than did the poorer speechreaders for word recognition in carrier phrase, for phoneme recognition in words, and for phoneme recognition in nonsense syllables.

2. The better speechreaders made significantly greater use of the syntactic, semantic, and topical context present in the sentences, and of the lexical context in the words than did the poorer speechreaders.

3. The negative effect of increasing sentence length on performance was significantly greater for the poorer speechreaders.

4. For both groups of subjects, the perception of vowels, on average, was significantly better than the perception of both initial and final consonants in nonsense syllables.

5. While the better speechreaders obtained significantly higher scores for vowels, initial consonants, and final consonants, the difference in performance between the two groups was most marked for the recognition of vowels.

Preliminary Discussion

The difference between better and poorer speechreaders has been shown to be related to the ability to use linguistic context. However, this has not proven to be the sole determinant of speechreading competence. Better speechreaders, as defined by their score for word recognition in sentences, also demonstrated a greater speechreading ability for phoneme recognition in nonsense syllables. It was necessary, however, to question the method used to quantify use of linguistic context. This will be the focus of the next chapter.

CHAPTER 6

RE-ANALYSIS BY K AND J FACTORS

Up to this point, context effects have been expressed in terms of differences between either percent correct scores, or their arcsine transforms in the analyses of variance. As demonstrated by Boothroyd and Nittrouer (1988), however, these difference scores are affected by the absolute score. For example, if a subject scores 90% without context, the increase resulting from context cannot be greater than ten percentage points. Similarly, if he/she scores 10% with context, the drop in score resulting from removal of that context cannot be greater than ten percentage points. Boothroyd (1978) has shown that these "ceiling" and "floor" effects can be eliminated if the context effect is expressed as the ratio of the logarithms of the error probabilities for the context and no context conditions. This ratio, which Boothroyd refers to as the k factor, is derived by application of probability theory to phoneme or word recognition data. He has shown that the k factor can be thought of as the number by which the channels of statistically independent sensory data would need to be multiplied in order to provide an increase of recognition probability equal to that produced by context. The relationship between the probability of recognition with and without context is :

$$Pc = 1 - (1 - Po)^{k} \quad \ldots\ldots\ldots\ldots\ldots \quad 1$$

where Pc is the probability of recognition with context, Po is the probability of recognition without context, and k is a constant representing the magnitude of the context effect.

In order to confirm that the context effects found in the previous analyses were not artifacts resulting from "ceiling" or "floor" effects, the data were re-analyzed using the k transform.

Word Recognition Data

Table 6.1 shows the k factors that reflect the use of sentence context for the better and poorer speechreaders. For the better speechreaders the group mean k factor was 3.96 and for the poorer speechreaders, 2.13. The difference between the means was significant (t (20) = 4.36, $p<.01$). It was also confirmed that the mean k factors for each group was significantly greater than the value of 1 that would be obtained if context had no effect on word recognition (t (14) = 14.4, $p<.01$); (t (7) = 2.64, $p<.05$). This is consistent with the findings of the analysis of variance indicating that better speechreaders make greater use of the syntactic and semantic context found in sentences.

Table 6.1

Mean k Factors Reflecting the Influence of Sentence Context on Word Recognition for Better and Poorer Speechreaders

Group: / Subject:	Better	Poorer
1	2.98	3.98
2	4.79	1.36
3	4.83	3.28
4	4.04	.71
5	4.31	1.73
6	2.86	3.29
7	2.82	1.11
8	4.90	1.55
9	4.13	
10	2.98	
11	4.77	
12	4.11	
13	4.14	
14	3.74	
Mean	3.96	2.13
Std. Dev.	.77	1.21

Note: The formula for *k* is:
k = log (1-Ps)/log (1-Pc) where
Ps = probability of word recognition in sentences
Pc = probability of word recognition in carrier phrase

Phoneme Recognition Data

Table 6.2 shows the *k* factors reflecting the use of lexical context for the better and poorer speechreaders. For the better speechreaders the group mean *k* factor was 1.46 and for the poorer speechreaders, 1.33. The difference between the means was not significant (t (20) = 1.57, p>.05). It should be noted that this finding is different than that of the analysis of variance of the arcsine transformed data.

Table 6.2

Mean k Factors Reflecting the Influence of Word Context on Phoneme Recognition for Better and Poorer Speechreaders

Group: Subject:	Better	Poorer
1	1.57	1.01
2	1.47	1.16
3	1.55	1.48
4	1.61	1.51
5	1.80	1.19
6	1.23	1.31
7	1.38	1.46
8	1.63	1.54
9	1.41	
10	1.63	
11	1.21	
12	1.20	
13	1.43	
14	1.33	
Mean	1.46	1.33
Std. Dev.	.18	.20

Note: The formula for k is:

$k = \log(1-Pm)/\log(1-Pn)$ where

Pm = probability of phoneme recognition in meaningful words

Pn = probability of phoneme recognition in nonsense syllables

J Factor Analysis

Since the analysis of the difference between the mean k factors and the analysis of variance of the arcsine transformed data yielded different results, it was decided to examine the effect of lexical context on phoneme recognition further. Boothroyd (1985) and Boothroyd and Nittroeur (1988), have shown that the effect of lexical context can be quantified by comparing the recognition probability for phonemes within words to the recognition probability for whole words. The expected relationship is :

$$Pw = Pp^{j} \quad \ldots\ldots\ldots\ldots\ldots\ldots 2$$

where Pw is the probability of recognition of a word, Pp is the probability of recognition of a phoneme within a word, and j is a constant reflecting the magnitude of the effect of lexical context. In a CVC unit, the expected value of j for nonsense syllables is 3 (i.e. equal to the number of phonemes in the unit). The extent to which j is less than 3 reflects the use of lexical constraints within words.

Table 6.3 shows the j factors obtained using the phoneme and word recognition scores for meaningful words. For the better speechreaders, the mean j factor was 2.11. For the poorer speechreaders, the mean j factor was 2.15. The difference between the means was not significant (t (20) = .123, p>.05). This is consistent with the findings of the analysis of the difference of the means of the k factors.

Table 6.3

Mean j Factors Reflecting the Influence of Word Context on Phoneme Recognition for Better and Poorer Speechreaders

Group:	Better	Poorer
Subject:		
1	1.89	2.26
2	2.36	2.31
3	1.97	2.10
4	2.21	1.90
5	2.25	1.85
6	2.04	2.34
7	2.26	2.30
8	2.02	2.11
9	2.03	
10	1.85	
11	2.18	
12	2.11	
13	2.21	
14	2.09	
Mean	2.11	2.15
Std. Dev.	.15	.19

Note: The formula for j is:

j= log(Pw)/log(Pp) where

Pw= probability of recognition of a word

Pp= probability of recognition of a phoneme

<u>Relationship Between Phoneme Recognition in Nonsense Syllables and Word Recognition in Sentences</u>

One of the advantages of expressing the contribution of linguistic context as <u>k</u> and <u>j</u> factors is that the resulting values can be manipulated mathematically. For example, equations 1 and 2 can be combined in order to predict the relationship between different measures of speechreading competence. One such prediction is the prediction of the probability of recognition of words in sentences from the known probability of recognition of phonemes in nonsense syllables. The equation for this prediction is derived as follows:

From equation (1), the relationship between the probability of recognition for phonemes in nonsense (${}^{n}P_p$) and phonemes in words (${}^{w}P_p$) is:

$${}^{w}P_p = 1-(1-{}^{n}Pp)^{kp} \ldots\ldots\ldots\ldots 3$$

where kp is the k factor for the effect of lexical context on phoneme recognition. From equation (2), the relationship between the probability of recognition for phonemes in words (${}^{w}P_p$) and whole words (${}^{w}P_w$) is:

$${}^{w}P_w = ({}^{w}P_p)^{j} \ldots\ldots\ldots\ldots 4$$

where j is the j factor for CVC words. Substituting ${}^{w}P_p$ from equation (3) gives:

$${}^{w}P_w = [1-(1-{}^{n}Pp)^{kp}]^{j} \ldots\ldots\ldots\ldots 5$$

From equation (1), the relationship between the probability of recognition for whole words (${}^{w}P_w$) and words in sentences (${}^{s}P_w$) is:

$${}^{s}P_w = 1-(1-{}^{w}P_w)^{ks} \ldots\ldots\ldots\ldots 6$$

where ks is the k factor for the effect of syntactic, semantic, and topical context on word recognition. Substituting for $^{w}p_{w}$ from equation (5) gives:

$$^{s}p_{w} = 1-(1-[1-(1-^{n}p_{p})^{kp}]^{j})^{ks} \ldots 7$$

which is the derived relationship between recognition probabilities for phonemes in nonsense syllables and words in sentences.

Figure 6.1 is a scatter plot of the scores for phoneme recognition in nonsense syllables against the scores for words in sentences. The two lines represent the different theoretical relationships between the two measures for the better and poorer speechreaders. The predicted relationship is obtained by substituting the obtained values of the j and k factors for each group separately, into equation (7).

The predicted relationships are different for the better and poorer speechreaders for two reasons. The first is the higher scores of the better speechreaders for the recognition of phonemes in nonsense syllables. The second is the greater ability of the better speechreaders to take advantage of syntactic, semantic, and topical constraints. It should be noted that the data shown in the figure represent the scores for all 24 subjects, and not only the 22 classified as either better or poorer.

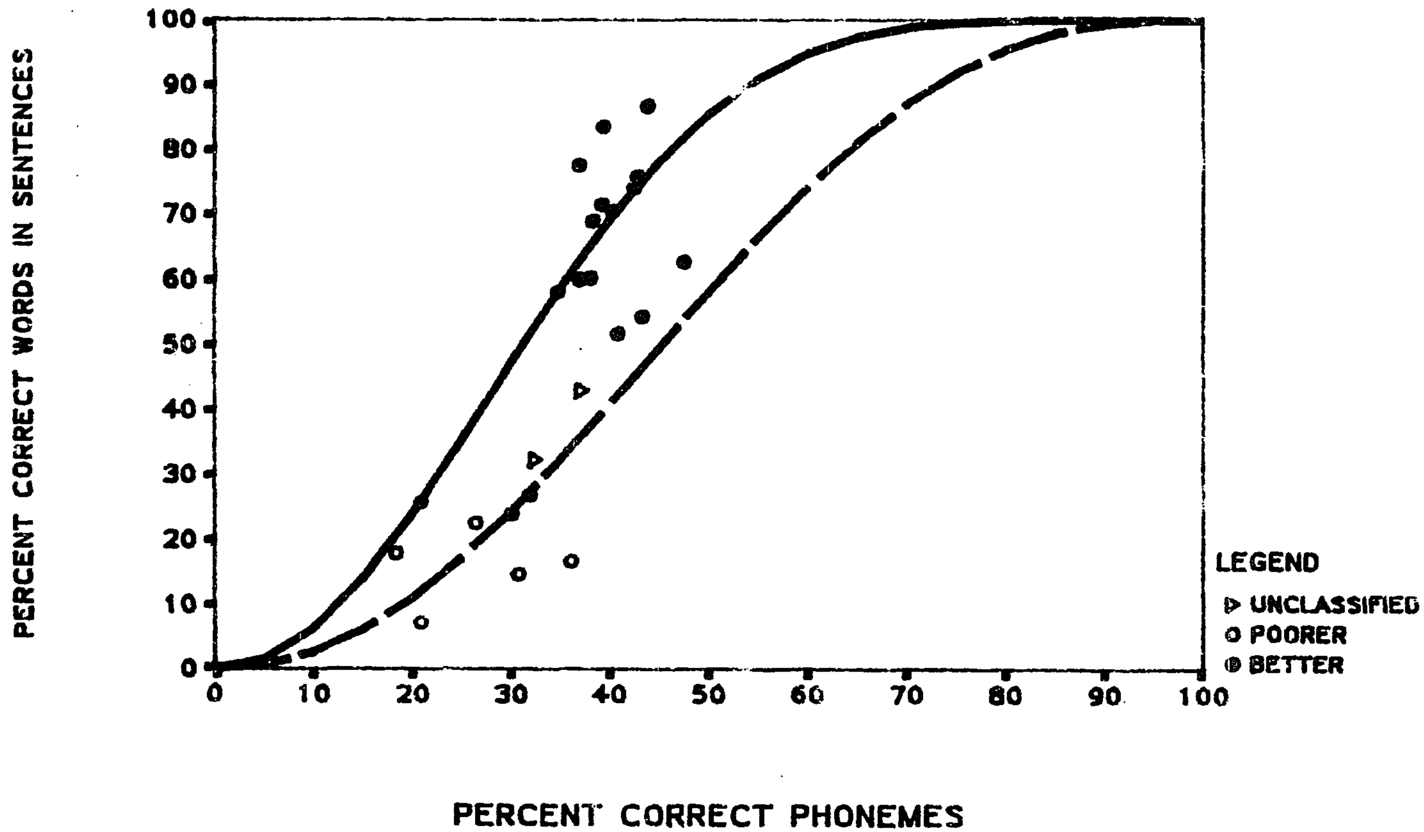

FIGURE 6.1 PREDICTION OF PERCENT CORRECT WORD RECOGNITION IN SENTENCES FROM PERCENT CORRECT PHONEME RECOGNITION IN NONSENSE SYLLABLES

Summary of Findings

1. The better speechreaders, as defined by their score for word recognition in sentences, demonstrated significantly higher *k* factors for the effect of sentence context on word recognition than did the poorer speechreaders. This reflects a greater use of the context found in sentences, specifically, syntactic, semantic and topical context. This result was consistent with the findings of the analysis of variance of the arcsine transformed data, which also indicated that better speechreaders make better use of syntactic, semantic, and topical context.

2. The better speechreaders did not demonstrate significantly higher k factors for the effect of lexical context on phoneme recognition than did the poorer speechreaders. This finding was different from that of the analysis of variance of the arcsine-transformed data, which indicated that better speechreaders make better use of lexical context.

3. Additionally, the better speechreaders did not demonstrate significantly higher *j* factors for the effect of lexical context on phoneme recognition than did the poorer speechreaders.

CHAPTER 7

DISCUSSION

Experience

These results support the hypothesis that experienced speechreaders perform better on speechreading tasks than do inexperienced speechreaders. This was true for all four test measures: word recognition in both carrier phrase and sentences, and phoneme recognition in both nonsense syllables and meaningful words.

The finding of greater speechreading competence for experienced subjects is similar to the finding of Berliner (1979), and contradictory to those of several other researchers (Clouser, 1977; Conrad, 1977; Benguerrel and Pichora-Fuller, 1982; Owens and Blazek, 1985). It is likely that the choice of subjects was responsible for the difference in findings. In the present study, as in Berliner's (1979), the selection of subjects was such that the two subject groups were roughly equivalent in terms of oral language abilities. The experienced subjects were deafened post-lingually, and it can be expected that they all had normal receptive language abilities. Pre-lingually deafened subjects were used to examine the effect of experience in those studies showing results different from those reported here. The poorer receptive language ability associated with pre-lingual deafness (Geffner and Levitt, 1987) is most likely responsible for the different results. It should also be noted that, in general, the experienced subjects in this study were also highly motivated to learn to speechread.

An examination of individual subject data, however, indicates that there was an overlap of scores between the two groups, such that there were highly competent inexperienced speechreaders, and very poor experienced speechreaders. Therefore, it does not follow from these results that experience, per se, is a guarantee of speechreading competence. Before this conclusion is accepted, however, it is necessary to question the confidence limits of the speechreading scores of the individual subjects. In other words, are the scores for the recognition of words in sentences precise enough to state, with confidence, that the better inexperienced speechreaders were truly better than the poorer experienced speechreaders?

Each individual score for the recognition of words in sentences was based on multiple measures, therefore, it was possible to determine the confidence limits from the error term in a two-way repeated measures analysis of variance, with subject and replication as the two factors (see Appendix G). These analyses indicate that the probability of the scores for two subjects differing by six percentage points or more, is less than 0.05. From Figure 5.1 it can be seen that the degree of overlap between the experienced and inexperienced subjects was about 30 percentage points. It can, therefore, be stated with confidence, that the difference between subjects was not due to random variability of the scores, but to true differences of speechreading competence.

The issue of test-retest variability has not been addressed adequately in much of the previous speechreading research. This may, at least in part, explain the difficulty encountered in statistically determining the correlates of speechreading competence. Speechreading performance has most often been measured using one of the following speechreading tests: the Utley Test, the CID Everyday Sentence Test, or the John Tracy Clinic Speechreading Test. These tests all contain a relatively small number of test items (e.g. the Utley Test consists of 31 sentences). As a consequence, test-retest variability for these tests is high, and it is likely that the inter-subject variability exhibited in previous research was a combination of individual differences and test-retest variability.

An unexpected, and potentially significant finding of the present study, was the bimodal distribution of the scores for word recognition in sentences. This bimodal distribution was found in both the experienced and inexperienced subject groups (see Chapter 5). A chi-square goodness of fit test for a normal distribution was statistically significant at the .005 level for the inexperienced group (X^2 (4) = 16.54) and at the .05 level for the experienced group (X^2 (7) = 15.45). This suggested that the populations from which the experienced and inexperienced speechreaders were drawn were not normally distributed. It should be noted, however, that the exact forms of the two population distributions cannot be reliably determined simply from the sample data. However, it can be stated with some degree of confidence that the population distributions were not normal, and that the sample distributions were bimodal. The sample distributions of test scores for the other three measures were not bimodal. Since the use of the linguistic context found in sentences was an important determinant of speechreading competence, it is not surprising that only the scores for the sentence task were bimodally distributed.

A bimodal distribution within the inexperienced group of subjects suggests that there is a group of individuals who are "natural" speechreaders who show high test scores with little or no experience. While it is not known if the poorer inexperienced speechreaders in this study could become highly competent speechreaders with training, the presence of relatively incompetent speechreaders within the experienced group suggests that this is not the case. It may be that inherently poorer speechreaders never reach high levels of competence, regardless of experience, training, or motivation.

The presence of competent speechreaders within the inexperienced group suggests that experience is not necessary for competent speechreading. However, it should be noted that within the group of better speechreaders, the experienced subjects tended to have better scores than the inexperienced subjects. The difference between the mean scores of 72.6% correct for the experienced and 57.6% correct for the inexperienced was highly significant ($\underline{t}$ (12) = 4.17, $\underline{p}$ = .002). Therefore, even if there are inherently better and poorer speechreaders, such individuals may not reveal their full potential without at least some experience.

A question that then arises is: If experience will improve performance for inherently better speechreaders, how much experience is needed in order to reach their full potential for speechreading performance? It will be recalled that the inexperienced group showed a significant learning effect during this study (see Appendix F for the ANOVA summary table for this analysis). This effect, which was present only for the recognition of words in sentences, is illustrated in Figure 7.1.

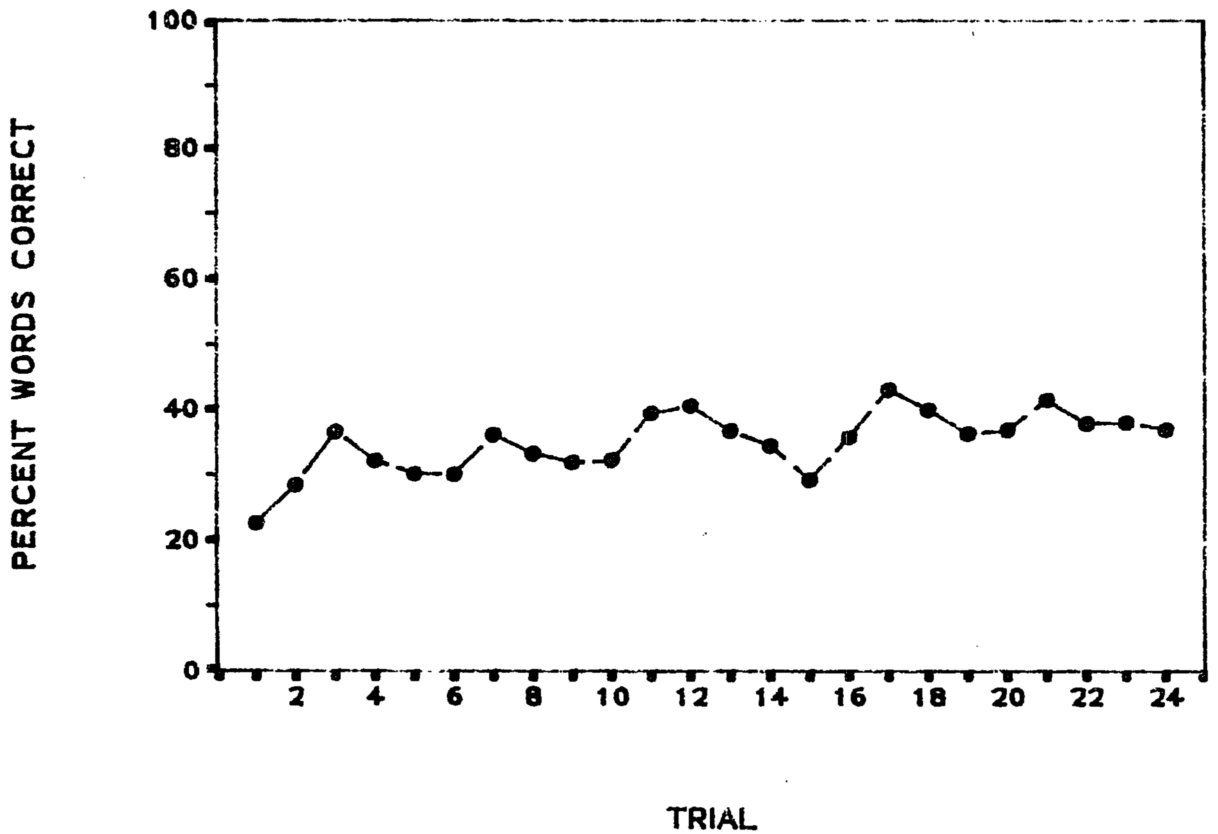

FIGURE 7.1 MEAN PERCENT CORRECT RECOGNITION OF WORDS IN SENTENCES AS A FUNCTION OF TRIAL FOR INEXPERIENCED SPEECHREADERS

It can be seen that the scores increased by about 10 to 15 percentage points during the two hours taken to administer the sentence sets. If it is assumed that learning would continue at a relatively constant rate, until the inexperienced subjects reached the same level of performance as the experienced subjects, only a total of eight hours experience on task would be required for the difference in performance to disappear. This assumption, although speculative, does suggest that long years of experience may not be necessary for an individual to reach his/her maximal level of performance. This conclusion is further supported by the absence of a significant correlation between years of deafness and speechreading performance within the experienced group ($r\ (11) = .48$).

Use of linguistic context

The results support the hypothesis that better speechreaders take greater advantage of linguistic context than do poorer speechreaders and that the use of this context is, therefore, an important determinant of speechreading competence. The largest inter-subject differences in performance are seen when syntactic, semantic, and topical redundancy are present in the stimulus. Inter-subject differences do not disappear when only lexical and/or phonological constraints are present, but the magnitude of these differences is considerably reduced.

The results provide clear evidence of the role of sentence context in successful speechreading. The results are less clear, however, concerning the use of the role of lexical context. The removal of lexical redundancy, as indicated by the change in score from phonemes in words to phonemes in nonsense syllables, produces a significant change in percent correct score. It should be recalled, however, that the k factors for phoneme recognition for the better and poorer speechreaders were not significantly different.

The negative finding of the k factor analysis may be a result of high within-group variability. On the other hand, the k transform may provide a more valid measure of the context effect than does either the difference of percent correct scores or the difference of their arcsine transforms. Clearly, more research is required on the issue of lexical context and its role in speechreading.

The results do not, however, support the hypothesis that the use of linguistic context is the sole determinant of speechreading competence. Better speechreaders, as defined by their score for the recognition of words in sentences, performed better on phoneme recognition in nonsense syllables as well. This could be interpreted to mean that the better speechreaders not only make better use of linguistic context but also are better able to perceive analytic details in the speech signal.

A question that results from the above interpretation is: What analytic details in the speech signal are more perceptible by the better speechreader? Two possible answers to this question are: 1) better speechreaders make fewer errors on those aspects of speech that are more visible, and/or 2) better speechreaders are better able to perceive the less visible aspects of speech. The present study was not designed to answer this question, however, the fact that the difference between the better and poorer speechreaders was more marked for vowels, which are generally agreed to be more visible (Berger, 1972; Sanders, 1982) may support the first answer. This question certainly needs further investigation.

It should be noted that some degree of linguistic redundancy is still present at the level of nonsense syllables since the utterances are bound by phonological constraints. Thus, the finding of superior performance at the nonsense syllable level is not inconsistent with the notion that superior use of linguistic context is a primary determinant of competence.

It is concluded, therefore, that better speechreaders perform better at all levels of the speech perception process. The difference between better and poorer speechreaders decreases with decreasing redundancy, but does not disappear at the level of nonsense syllables. The data indicate that better speechreaders use syntactic, semantic, and topical constraints to greater advantage than the poorer speechreaders. They also appear to be using lexical and phonological constraints better, but the effects of these factors are much weaker.

There are several issues that need to be addressed regarding the interpretation of the data reflecting use of context. The first is related to the word recognition tasks. It will be recalled that word recognition was measured in carrier phrase and in sentences. It will also be recalled that the difference between the scores for these two measures was considered to reflect the magnitude of the effect of syntactic, semantic, and topical context. The words in carrier phrase and in sentences were not the same however, and no attempt was made to match the words for visibility or overall difficulty. As a consequence, the estimated magnitude of the effect of sentence context may have been different from that obtained if identical sets of words had been used for both conditions. The thrust of this study, however, focussed on the interaction between speechreading competence and use of linguistic context. The significance of this interaction is not invalidated by the inability to determine the precise magnitude of the effect of context. Further research is necessary to obtain precise estimates of this effect.

The second issue is that of the use of a carrier phrase with the single words. It is possible that the demands placed on the speechreader during the sentence task (e.g. processing speed, attention, and memory) were reduced by the use of a carrier phrase. Thus, the sentence task was different, not only in terms of syntactic, semantic, and topical context, but also in other ways. If the carrier phrase task was, in fact, inherently easier than the sentence task, the study would have been biased against finding a significant effect of this type of context. However, since it was the interaction between speechreading ability and use of context that was of interest in this study, this issue is not a significant factor regarding the interpretation of the results.

In the present study, the separate effects of syntactic, semantic, and topical constraints could not be assessed. However, the effect of knowledge of topic during speechreading was examined in a previous study using the same sentence material. The results of that study indicated that the addition of topical constraints was equivalent to a 70% increase (k = 1.7) in the number of channels of statistically independent information present in the signal (Hanin et al, 1985). The overall effect of the presence of syntactic, semantic, and topical constraints in the present study was equivalent to a 200% increase in the number of channels of statistically independent information (k = 3.0). Since the k factors are multiplicative (Boothroyd and Nittroeuer, 1988), the derived value of k for the combined effects of syntactic and semantic constraints equals 1.7. Thus, the presence of topical constraints appears to be the largest single effect, and equal to the combined effects of syntactic and semantic constraints. This is consistent with the common observation that even good speechreaders experience difficulty when the topic of conversation is abruptly changed.

In summary, the following conclusions can be drawn from the results of this study:

1) Experience at speechreading, as defined in this study, results, on average, in a greater degree of speechreading competence.

2) Experience, as defined in this study, however, is not a guarantee of success, nor is lack of experience incompatible with competence.

3) Superior use of syntactic, semantic, and topical constraints is a primary determinant of speechreading competence. It is not, however, the sole determinant as better speechreaders are also more proficient at perceiving phonemes in nonsense syllables.

4) There is a strong implication from these data that speechreading is an inherent ability and that inherently poor speechreaders are both qualitatively and quantitatively different from inherently better speechreaders, regardless of experience, training, or motivation.

CHAPTER 8

CLINICAL AND RESEARCH IMPLICATIONS

One of the principal purposes of this study was to examine the contribution of experience to speechreading performance. It will be recalled that, on average, experienced speechreaders were more proficient at speechreading than were inexperienced ones. However, there were inexperienced, unpracticed subjects who were also highly competent speechreaders. This finding led to the suggestion that speechreading is an inherent ability in the general population, such that there exists a sub-population of better speechreaders, and one of poorer speechreaders. In the present study, the proportion of highly competent speechreaders in the experienced group was very high. These subjects, however, may not have been typical of the general population of the hearing impaired.

In addition to the present study, there was only one other study that used post-lingually deaf adults in order to examine the effect of experience on speechreading (Berliner, 1979). In both this and Berliner's study, the deaf subjects were cochlear implant recipients. Since this is a very motivated and select population, it is possible that with another subject group, different conclusions would be drawn regarding the effect of experience on speechreading. Therefore, it would be beneficial to obtain speechreading data on non-implant post-lingually deaf adults in order to further examine the effect of experience. One such study could be the longitudinal evaluation of the speechreading abilities of newly deafened individuals.

The finding of the generally better performance of the experienced speechreaders raises several questions of interest for the aural rehabilitation practitioner regarding speechreading training. The first question is: Is training necessary in order to be a competent speechreader? The present findings suggest that training may not be necessary for the inherently better speechreader. Whether or not training is necessary for the inherently poorer speechreader cannot be answered by this study and is an issue that needs to be investigated further. The second question raised by this study is: Is training beneficial? If we consider experience a type of informal training, then the finding that among the better speechreaders, experienced subjects performed significantly better than inexperienced subjects, is an indication that training may have improved on their inherent ability. The finding of the two experienced, poorer speechreaders, however, suggests that training may not result in a dramatic improvement in performance. Clearly the answers to these questions cannot be found in cross-sectional studies of the type reported here. Instead, further research requires longitudinal studies. An important implication of the present research, however, is that subjects in such studies should be classified on the basis of inherent speechreading ability. According to the present findings, it should not take too long to determine whether or not a subject is an inherently good speechreader.

An implication of the finding that better speechreaders are those who are better able to take advantage of linguistic context is that training should incorporate materials with linguistic contextual information present. The abilities that result in a greater use of linguistic context, however, cannot be determined from the results of the present investigation and it is not known if the ability to use context during speechreading is trainable. Rubinstein and Boothroyd (1987) found that in the auditory modality, a combination of analytic and synthetic training techniques improved performance on a test requiring the use of context. Therefore, it is possible that the ability to use context is trainable. This is an area that requires further research.

An implication, however, of the finding that better speechreaders are also better able to perceive the analytic details of speech is that it may be beneficial to incorporate an analytic approach into an overall speechreading training program. It has been demonstrated that visual consonant recognition training results in an improved visual consonant recognition performance of hearing-impaired subjects (Walden et al, 1977; Walden et al, 1981). As Figure 6.1 illustrates, a small improvement in the recognition of phonemes can result in a large improvement in the recognition of words in sentences, especially for the better speechreaders. Since the data illustrated in Figure 6.1 do not demonstrate a causal relationship, future research is needed in order to demonstrate that within a subject, an improvement in phoneme recognition results in an improvement in word recognition in sentences.

To the author's knowledge, this was the first study to measure use of context during the speechreading task itself. The measurement was accomplished by comparing performance on materials with varying types and amounts of linguistic redundancy. As pointed out in the previous chapter, the absolute magnitude of the effect of syntactic and semantic context may have been inaccurate since the words used in sentences and in carrier phrase were different. Further research is needed on the factors contributing to the context effect and on the development of clinical and research tools for further assessment.

Further investigation is also needed regarding the role of experience as a factor affecting speechreading, specifically, examining the effect of experience in a non-implant post-lingually deaf population. In addition to the present study, there was only one other study that used post-lingually deaf adults in order to examine the effect of experience on speechreading (Berliner, 1979). In both this and Berliner's study, the deaf subjects were cochlear implant recipients. Since this is a very select and highly motivated population, it is quite possible that with another subject group, different conclusions would be drawn regarding the effect of experience on speechreading.

APPENDIX A

QUESTIONAIRE

Name:____________________ Date of Birth:____________

1. Have you ever been evaluated for a speech and/or language problem?
2. Have you ever been treated for a speech, language, or hearing problem?
3. Is English your native language?
4. Do you now or have you ever worn glasses or contact lenses?
5. When was the last time you had your eyes examined?
6. Do you feel that you now have any trouble seeing?
7. Do you have a driver's license?

APPENDIX B

TEST MATERIALS

NONSENSE SYLLABLES

List 1	List 2	List 3	List 4	List 5
ʃɛn	heɪm	rɪʃ	nædʒ	tʃʌn
sot	big	dʒʌtʃ	rit	ræs
baf	wus	weɪp	pɪf	fim
rup	fəɪk	næl	waz	gɛd
zɪl	vat	θaɪb	suʃ	dʒeɪv
vʌm	dotʃ	vaf	baɪg	bul
dætʃ	θɛl	dig	mok	haɪʃ
wiθ	dʒʌn	zom	lʌd	wot
haɪdʒ	rɪz	suk	tʃɛv	kaz
keɪg	pæʃ	hɛt	heɪθ	θɪp

List 6	List 7	List 8	List 9	List 10
θʌdʒ	foʃ	gɛz	luf	saɪf
hud	ras	θom	kɛp	wuk
tʃaɪʃ	zæn	ʃis	vod	dɛdʒ
pɪv	waɪdʒ	wadʒ	dʒɪz	toʃ
wol	dɪθ	nutʃ	ʃeɪt	bɪv
rin	gip	fæp	waɪg	neɪg
gak	tʃul	kaɪd	nim	ræl
teɪb	heɪb	hɪb	rʌtʃ	maz
mɛf	vʌt	veɪt	sæθ	hitʃ
zæs	mɛk	rʌl	hab	pʌθ

List 11	List 12	List 13
zɛp	leɪp	meɪg
hɪθ	waɪθ	saf
faɪm	ræv	naɪz
tʃut	dut	lʌdʒ
wog	tʌs	wæp
keɪʃ	ham	dɪt
dʒæv	gif	hɛʃ
dʌs	dʒɪʃ	ruk
rib	kob	tʃoθ
lan	nɛz	vib

AB WORD LISTS

List 1	List 2	List 3	List 4	List 5
fish	fun	fill	badge	bath
duck	will	catch	hutch	hum
path	vat	thumb	kill	dig
cheese	shape	heap	thighs	five
race	wreath	wise	wave	ways
hive	hide	rave	reap	reach
bone	guess	got	foam	joke
wedge	comb	shone	goose	noose
log	choose	bed	not	pot
tomb	job	juice	shed	shell

List 6	List 7	List 8	List 9	List 10
hush	math	hug	fib	jug
gas	hip	dish	thatch	latch
thin	gun	ban	sum	wick
fake	ride	rage	heel	faith
chime	siege	chief	wide	sign
weave	veil	pies	rake	beep
jet	chose	wet	goes	hem
rob	shoot	cove	shop	rod
dope	web	loose	vet	vote
lose	cough	moth	June	shoes

List 11	List 12	List 13
kiss	ship	wish
buzz	rug	dutch
hash	fan	jam
thieve	cheek	heath
gate	haze	laze
wife	dice	bike
pole	both	rove
wretch	well	pet
dodge	jot	fog
moon	move	soon

Topic-Related Sentence Sets

Set 1

food	1.	Have you eaten yet?
family	2.	How many of your brothers still live at home?
work	3.	How many years of school did it take to become a nurse?
clothes	4.	Where can I get my suit cleaned?
animals	5.	Cats are easy to take care of because you don't have to walk them.
homes	6.	She just moved into a three room apartment.
sports/ hobbies	7.	I like to play tennis.
weather	8.	We couldn't fly home yesterday because of the big snowstorm.
health	9.	Remember to get plenty of rest and drink lots of fluids.
seasons/ holidays	10.	Carve the turkey.
money	11.	Make sure you deposit that check.
music	12.	Please make sure that you practice a lot before your next piano lesson.

Set 3

food	1.	Do you want fried chicken or do you want pizza for dinner.
family	2.	How long have your parents been married?
work	3.	Take the job only if you feel that the work will be more challenging.
clothes	4.	Buy that bathing suit because it fits you.
animals	5.	That dog likes to run.
homes	6.	We're going to paint the guest bedroom next week.
sports/ hobbies	7.	How mamy miles a day do you run before a marathon.
weather	8.	Did it rain?
health	9.	Remember to take all your vitamins.
seasons/ holidays	10.	You buy the food and she will buy the drinks for the barbecue.
money	11.	That place is expensive.
music	12.	The rock concerts on the pier have been very successful.

Set 4

food	1.	Do you want gravy on your potatoes?
family	2.	You have to invite all of your aunts and uncles to the wedding reception.
work	3.	Make sure you get to work on time.
clothes	4.	Throw away your old shoes.

animals	5.	My cat was chasing the bird all around the yard.
homes	6.	Did it take you a long time to find an apartment?
sports/ hobbies	7.	Do you jog?
weather	8.	Did you bring an umbrella today?
health	9.	Don't drink alcohol while you are pregnant because it's harmful to your baby.
seasons/ holidays	10.	Summer is finally here.
money	11.	I lost my checkbook so I closed the account.
music	12.	He did not learn how to play the piano until very recenty.

<u>Set 11</u>

food	1.	She baked a big apple pie.
family	2.	She shares a two bedroom apartment in the city with her two sisters.
work	3.	How's your new job?
clothes	4.	How much did they charge you for the alterations?
animals	5.	Take the dog to the vet every year for it's rabies shot.
homes	6.	Clean the guest bedroom before next weekend.
sports/ hobbies	7.	Professional football players usually have to train in the summer before the season begins.
weather	8.	When the humidity is high, it's uncomfortable outside.
health	9.	What medicine are you taking?
seasons/ holidays	10.	Do you want to go Christmas shopping with me today?
money	11.	You really should be able to save more of your salary.
music	12.	Play that song.

<u>Set 15</u>

food	1.	Do you cook big dinners every night?
family	2.	Where's your sister?
work	3.	When you want to quit give them two week's notice.
clothes	4.	Iron all of your shirts.
animals	5.	It was really very easy to teach the parrot how to say hello.
homes	6.	We are really excited about looking for a house.
sports/ hobbies	7.	Do you like camping?
weather	8.	Does it look as if the sun is trying to

		come out?
health	9.	Remember to take your medicine every four hours and rest in bed all day.
seasons/ holidays	10.	Don't wait until the last minute to do your Christmas shopping.
money	11.	I always pay my credit card bills promptly.
music	12.	I really like that new album.

<u>Set 16</u>

food	1.	Are you hungry?
family	2.	Try to visit your mother at least once a week.
work	3.	Finish that assignment by Friday.
clothes	4.	Put all your winter suits in storage and take out your spring suits.
animals	5.	The cats keep each other company during the day.
homes	6.	Where do you live?
sports/ hobbies	7.	Did you get to see any of the gymnastics competition last week?
weather	8.	Will it rain this weekend or is it supposed to be clear and sunny?
health	9.	You have to exercise as well as diet to lose weight.
seasons/ holidays	10.	There is always a parade for Memorial Day.
money	11.	I think I have some change.
music	12.	She's the one who gives singing lessons.

<u>Set 17</u>

food	1.	Defrost the freezer first, then go do your grocery shopping.
family	2.	Don't forget your father's birthday.
work	3.	Remember to keep all your receipts when you go on a business trip.
clothes	4.	Buy yourself a new coat for the cold months.
animals	5.	Where's the new puppy?
homes	6.	Will you be putting a swimming pool in the backyard this year?
sports/ hobbies	7.	How long did it take you to learn how to crochet these beautiful blankets?
weather	8.	Will you go to the beach even if it's still cloudy?
health	9.	My allergies are really acting up right now.
seasons/ holidays	10.	I like New Year's Eve parties.

money 11. She's taken out a lot of loans.
music 12. It's my guitar.

Set 20

food 1. Let the grill get really hot before you barbecue.
family 2. My mother is working.
work 3. My commute each morning is just a little bit over an hour.
clothes 4. That suit is very expensive but I think the style is perfect for you.
animals 5. Is it very difficult to take care of all those fish?
homes 6. Clean up the bedroom before you watch television.
sports/ hobbies 7. Throw him a few good pitches.
weather 8. Take a sweater in case it's chilly.
health 9. I am sick.
seasons/ holidays 10. Are you going to go apple picking in the Fall?
money 11. How much is the bill?
music 12. Do you think you would enjoy going to see an opera with me?

Set 25

food 1. Do you eat bacon and eggs for breakfast every Sunday morning?
family 2. Does he still live with his parents?
work 3. Are you learning a lot on your new job?
clothes 4. Do you need a new tie to go with that shirt you bought?
animals 5. My landlord won't let me have a dog but I can have a cat.
homes 6. Her apartment is big so she shares it with roommates.
sports/ hobbies 7. I play tennis every Tuesday.
weather 8. I'm not going to work tomorrow if it snows a lot tonight.
health 9. Cover your mouth when you cough.
seasons/ holidays 10. Buy champagne for the New Year's Eve party.
money 11. Don't cash that check.
music 12. Practice the guitar.

Set 26

food 1. Can you bake the chocolate cake tonight?
family 2. Are his sisters still single or are they married?

work	3.	Do you think that our secretary should be given a raise this year?
clothes	4.	Get your new pants shortened or you won't be able to wear them Saturday.
animals	5.	We went to the lake and fed the baby ducks.
homes	6.	The kitchen needs new wallpaper.
sports/ hobbies	7.	My friends are having a party after the football game tomorrow night.
weather	8.	Did you shovel the snow yet?
health	9.	Go to the doctor and get a physical.
seasons/ holidays	10.	Vote on Election Day.
money	11.	Lend him money.
music	12.	He always buys subscriptions to both the symphony and the ballet.

<u>Set 27</u>

food	1.	Are you having soup and a sandwich for lunch?
family	2.	Who takes care of your children when they get home from school early?
work	3.	Get a key made for both of the offices that you will be using.
clothes	4.	Buy yourself a new jacket now while they're on sale.
animals	5.	I never saw a bear.
homes	6.	My friends bought an old house and are starting to renovate it.
sports/ hobbies	7.	Who taught you to play chess?
weather	8.	Did you see the full moon last night?
health	9.	Go see the nurse.
seasons/ holidays	10.	Mow the lawn.
money	11.	It's better to pay with cash than to use credit cards.
music	12.	He plays chamber music on Wednesday nights.

<u>Set 31</u>

food	1.	Make my steak well done.
family	2.	Take these cookies with you when you go to visit your grandfather.
work	3.	Computers make typing reports much easier.
clothes	4.	The store is having a sale on nightgowns.
animals	5.	Who fed the goldfish?
homes	6.	What's your address?
sports/ hobbies	7.	Remember to stretch before you try to run a long distance.

weather	8.	Don't go outside if it's too cold.
health	9.	Crash diets can really make a person very sick.
seasons/ holidays	10.	Passover and Easter always seem to occur at the same time of the year.
money	11.	Will you lend me ten dollars until I can go to the bank?
music	12.	Did you tape the concert they broadcast on the radio?

<u>Set 32</u>

food	1.	Please slice the meat but be careful not to cut your fingers.
family	2.	My nephew is having a party.
work	3.	My friend was just fired from his job.
clothes	4.	My new shoes hurt.
animals	5.	Do parrots fly?
homes	6.	Vacuum the rugs and polish the furniture before the party tonight.
sports/ hobbies	7.	Bring your sneakers to the exercise class.
weather	8.	Don't ever stand under a tree during a thunderstorm.
health	9.	More people seem to catch colds in the winter than in the summer.
seasons/ holidays	10.	Will you be eating Thanksgiving dinner at a restaurant or at home this year?
money	11.	Did you put your savings in a high interest account?
music	12.	Where do you store albums?

<u>Set 33</u>

food	1.	I ate a big lunch today.
family	2.	My aunt and uncle live two blocks away.
work	3.	My boss is quitting.
clothes	4.	I need pants.
animals	5.	Remember to let the dog out before you go to school.
homes	6.	Paint the outside of the house first.
sports/ hobbies	7.	Take off your skis when you leave the slopes.
weather	8.	Make sure you dress warmly on days when the temperature drops below freezing.
health	9.	How long will you have to keep that big cast on your broken leg?
seasons/ holidays	10.	Why do people drink so much on New Year's

		Eve?
money	11.	Does he get an allowance?
music	12.	How many people are going to try out for the marching band?

Set 34

food	1.	The seafood restaurant had a special on lobster.
family	2.	My sister is moving.
work	3.	Filing is boring.
clothes	4.	Are you going to buy a new down coat this year?
animals	5.	Don't feed the squirrels in the park.
homes	6.	Clean out your closet before the painters get here.
sports/ hobbies	7.	Buy yourself a better racket now that you have lost your old one.
weather	8.	The wind was so strong yesterday that it blew the branches off the tree.
health	9.	I have a sore throat and a very bad cough.
seasons/ holidays	10.	When is April Fool's Day?
money	11.	Do you still think you will get a big bonus this year?
music	12.	Don't play your radio that loud.

Set 35

food	1.	I want french fries.
family	2.	My grandfather died.
work	3.	What did they give you for a present when you retired?
clothes	4.	Did you bring a sweater with you?
animals	5.	Close the windows before you open the bird cage.
homes	6.	Move the furniture into the middle of the room before you paint it.
sports/ hobbies	7.	I went camping with my friends last week and we forgot the tent poles.
weather	8.	She thinks it's warm enough to go to the beach.
health	9.	How are you feeling today?
seasons/ holidays	10.	Why do leaves always change color before they fall off the trees?
money	11.	Pay the bill at the store.
music	12.	Be careful when you use the new stereo.

Set 37

food	1.	Are you going to bake a cake for the

		birthday party tomorrow?
family	2.	Are your cousins invited to the wedding?
work	3.	Is there a new person answering phones in your office?
clothes	4.	Where did you buy your jacket?
animals	5.	When I go to the zoo I like watching the chimps.
homes	6.	Here's my house.
sports/ hobbies	7.	A lot of kids play soccer in school.
weather	8.	It's been very cold in the South this winter.
health	9.	If you still have fever tomorrow make sure you go to the doctor.
seasons/ holidays	10.	Give her flowers.
money	11.	Make sure that you don't forget to send your tax returns in on time.
music	12.	Please change the channel.

<u>Set 38</u>

food	1.	Do you want a toasted English muffin?
family	2.	Are you going to take your brother to the movies?
work	3.	Do you walk to the office?
clothes	4.	Don't wear your new boots today because the streets are slushy.
animals	5.	Cats have whiskers.
homes	6.	We have new carpeting in the living room.
sports/ hobbies	7.	I don't like to swim in an indoor pool.
weather	8.	Was it snowing when you left the house or had it already stopped?
health	9.	Don't take so much aspirin.
seasons/ holidays	10.	Remember to plant your garden early so that the vegetables are ripe by summer.
money	11.	Don't spend so much.
music	12.	Many people like to listen to the radio before going to bed.

<u>Set 39</u>

food	1.	Where do you want to go to have dinner tonight?
family	2.	Did your sister have the baby?
work	3.	Tell your boss that you need to take three days off.
clothes	4.	Tie your shoelaces.
animals	5.	I walk my dog three times a day.
homes	6.	The elevator in my apartment building broke last night.
sports/		

hobbies	7.	Do you want to go horseback riding with us at the dude ranch?
weather	8.	Will it be sunny tomorrow?
health	9.	Make sure you go to the dentist and have him look at that tooth.
seasons/ holidays	10.	Buy a Halloween costume.
money	11.	My friend's wedding reception will cost five thousand dollars, including the band.
music	12.	She plays the clarinet in a band.

Set 40

food	1.	What did you eat for breakfast?
family	2.	Your father has to go with you to buy the car.
work	3.	Call your boss.
clothes	4.	Iron that blouse before you go to school.
animals	5.	My friend has a horse that I can ride.
homes	6.	Which do you like better, living in a house or in an apartment?
sports/ hobbies	7.	Was your tennis racket stolen?
weather	8.	Do you think that we can go away even if it snows a lot?
health	9.	Give blood this year.
seasons/ holidays	10.	We can start going to our summer house on Memorial Day weekend.
money	11.	I always forget to balance my checkbook.
music	12.	The concert we went to last night was too loud.

Set 45

food	1.	I try not to eat red meat more than three times a week.
family	2.	My father has two jobs.
work	3.	It's important to make a good impression when you go on a job interview.
clothes	4.	That's a beautiful dress.
animals	5.	Remember not to go too close to stray dogs in the street.
homes	6.	Please don't eat in the living room.
sports/ hobbies	7.	If you're skiing for the first time, take a lesson.
weather	8.	Wax the car if it's sunny.
health	9.	Did you go to the emergency room when you fell down?
seasons/ holidays	10.	When is Thanksgiving?
money	11.	How much does your car insurance cost you?

music	12.	Where did your friend buy that new tape recorder?

Set 48

food	1.	I like ice cream.
family	2.	Did your brothers and sisters come to visit you on your birthday?
work	3.	How long have you been employed there?
clothes	4.	What should I wear to the party next Saturday night?
animals	5.	Don't pet that big black dog.
homes	6.	I think we should replace the carpeting in the living room.
sports/ hobbies	7.	I like baseball.
weather	8.	It is going to be very windy today.
health	9.	Did you break your wrist or was it sprained?
seasons/ holidays	10.	You better be very careful when you go trick or treating on Halloween.
money	11.	Give me five dollars tomorrow.
music	12.	Stop playing the radio so loud at night or I will take it away.

APPENDIX C

ORDER OF PRESENTATION

Table C.1

Order of Presentation of Type of Material

Subject	Session 1	Session 2
1	1 2 3	3 1 2
2	1 3 2	3 2 1
3	2 3 1	2 1 3
4	2 1 3	2 3 1
5	3 2 1	1 3 2
6	3 1 2	1 2 3
7	1 2 3	3 1 2
8	1 3 2	3 2 1
9	2 3 1	2 1 3
10	2 1 3	2 3 1
11	3 2 1	1 3 2
12	3 1 2	1 2 3

(1 = sentences, 2 = words, 3 = nonsense syllables)

Table C.2

<u>Order of Presentation of AB Word Lists and Nonsense Syllables</u>

Subject	Session 1						Session 2					
1	1	11	7	4	9	12	5	2	10	6	3	8
2	6	4	12	9	2	5	10	7	3	11	8	1
3	9	7	3	12	5	8	1	10	6	2	11	4
4	12	10	6	3	8	11	4	1	9	5	2	7
5	2	12	8	5	10	1	6	3	11	7	4	9
6	8	6	2	11	4	7	12	9	5	1	10	3
7	10	8	4	1	6	9	2	11	7	3	12	5
8	5	3	11	8	1	4	9	6	2	10	7	12
9	7	5	1	10	3	6	11	8	4	12	9	2
10	11	9	5	2	7	10	3	12	8	4	1	6
11	4	2	10	7	12	3	8	5	1	9	6	11
12	3	1	9	6	11	2	7	4	12	8	5	10

Table C.3

Order of Presentation of Sentence Sets

Subj:	Trial:		Number 1-12 Number 13-24									
1	12	21	11	20	4	31	3	27	32	45	18	33
	35	48	34	38	26	40	25	39	16	37	15	17
2	34	38	48	35	25	39	40	26	15	17	37	16
	18	33	45	32	11	20	21	12	3	27	31	4
3	31	4	27	3	45	32	33	18	21	12	20	11
	40	26	39	25	37	16	17	15	48	35	38	34
4	17	15	16	37	38	34	35	48	39	25	26	40
	27	3	4	31	33	18	32	45	20	11	12	21
5	32	45	18	33	12	21	11	20	4	31	3	27
	16	37	15	17	35	48	34	38	26	40	25	39
6	25	39	40	26	15	17	37	16	34	38	48	35
	11	20	21	12	3	27	31	4	18	33	45	32
7	21	12	20	11	31	4	27	3	45	32	33	18
	48	35	38	34	40	26	39	25	37	16	17	15
8	38	34	35	48	39	25	26	40	17	15	16	37
	33	18	32	45	20	11	12	21	27	3	4	31
9	4	31	3	27	32	45	18	33	12	21	11	20
	26	40	25	39	16	37	15	17	35	48	34	38
10	15	17	37	16	34	38	48	35	25	39	40	26
	3	27	31	4	18	33	45	32	11	20	21	12
11	45	32	33	18	21	12	20	11	31	4	27	3
	37	16	17	15	48	35	38	34	40	26	39	25
12	39	25	26	40	17	15	16	37	38	34	35	48
	20	11	12	21	27	3	4	31	33	18	32	45

APPENDIX D
INSTRUCTIONS

The following are the written instructions given to subjects prior to testing for each type of material.

YOU WILL BE WATCHING A SPEAKER SAY SENTENCES. SHE BEGINS EACH SENTENCE BY SAYING "NUMBER _____". PLEASE LOOK AT THE LIST OF TOPICS BEFORE YOU WATCH EACH SENTENCE. AFTER THE SPEAKER FINISHES SAYING THE SENTENCE, REPEAT AS MUCH OF THE SENTENCE AS POSSIBLE. DON'T BE AFRAID TO GUESS IF YOU ARE NOT SURE. REMEMBER, YOU WILL NOT HEAR ANY SOUND.

YOU WILL BE WATCHING A SPEAKER SAY WORDS. EACH WORD WILL BE IN THE PHRASE "YOU WILL SAY ______PLEASE." AFTER THE SPEAKER FINISHES SAYING THE PHRASE, REPEAT THE WORD. DON'T BE AFRAID TO GUESS IF YOU ARE NOT SURE. REMEMBER, YOU WILL NOT HEAR ANY SOUND.

YOU WILL BE WATCHING A SPEAKER SAY NONSENSE SYLLABLES. EACH SYLLABLE WILL BE IN THE PHRASE "YOU WILL SAY _______ PLEASE." THE SYLLABLE HAS <u>NO MEANING</u>. AFTER THE SPEAKER FINISHES SAYING THE PHRASE, REPEAT THE SYLLABLE. DON'T BE AFRAID TO GUESS IF YOU ARE NOT SURE. REMEMBER, YOU WILL NOT HEAR ANY SOUND.

APPENDIX E
RAW DATA

Table E.1

Mean Percent Correct Scores for Recognition of Words in Sentences for Experienced Speechreaders

Subject:	Trial: 1-12 / 13-24											
1	81.4	56.9	67.6	75.5	64.7	61.8	72.5	63.7	61.8	65.7	69.6	86.3
	95.1	71.6	71.6	72.5	79.4	89.2	76.5	92.2	73.5	85.3	63.7	80.4
2	59.8	63.7	81.3	97.1	64.7	67.6	83.3	52.0	45.1	69.6	93.1	69.6
	67.6	58.8	56.9	74.5	66.7	73.5	79.4	88.2	73.5	63.7	71.6	70.6
3	75.5	77.5	63.7	80.4	87.3	66.7	85.3	77.5	87.3	80.4	76.5	79.4
	62.7	71.6	83.3	79.4	79.4	85.3	74.5	61.8	77.5	99.0	75.5	75.5
4	12.7	3.9	24.5	10.8	18.6	14.7	15.7	7.8	20.6	12.7	12.7	18.6
	14.7	23.5	10.8	9.8	10.8	20.6	5.9	20.6	9.8	14.7	17.6	19.6
5	53.9	73.5	71.6	82.4	76.5	73.5	78.4	76.5	63.7	78.4	61.8	71.6
	55.9	82.4	52.0	58.8	93.1	66.7	65.7	68.6	76.5	79.4	78.4	75.5
6	86.3	91.2	97.1	79.4	79.4	78.4	95.1	89.2	89.2	86.3	86.3	92.2
	86.3	93.1	86.3	91.2	88.2	87.3	83.3	92.2	88.2	76.5	80.4	80.4
7	52.9	74.5	51.0	48.0	50.0	59.8	61.8	85.3	45.1	64.7	62.7	68.6
	72.5	86.3	60.8	64.7	61.8	67.6	72.5	71.6	76.5	47.1	47.1	52.9
8	48.0	48.0	79.4	52.0	57.8	56.9	46.1	47.1	57.8	33.3	30.4	82.4
	58.8	62.7	38.2	52.0	60.8	56.9	65.7	58.8	63.7	55.9	47.1	451.
9	88.2	81.4	98.0	71.6	65.7	71.6	72.5	91.2	93.1	92.2	77.5	91.2
	66.7	91.2	89.2	39.2	83.3	82.4	74.5	82.4	97.1	81.4	91.2	83.3
10	61.8	73.5	91.2	68.6	78.4	66.7	82.4	94.1	60.8	78.4	92.2	74.5
	80.4	77.5	63.7	79.4	77.5	86.3	65.7	68.6	73.5	59.8	81.4	85.3
11	28.4	26.5	38.2	25.5	25.5	32.4	30.4	15.7	22.5	36.3	12.7	28.4
	40.2	30.4	27.5	13.7	36.3	30.4	16.7	25.5	31.4	19.6	23.5	27.5
12	59.8	79.4	64.7	76.5	81.4	55.9	58.8	82.4	64.7	74.5	92.2	70.6
	62.7	68.6	76.5	55.9	73.5	59.8	63.7	54.9	76.5	74.5	58.8	70.6

Table E.2
Mear Percent Correct Scores for Recognition of Words in Sentences for Inexperienced Speechreaders

Subject:	Trial 1-12 13-24											
1	9.8	21.6	18.6	22.5	21.6	11.8	18.6	8.8	15.7	15.7	34.3	21.6
	38.2	52.0	19.6	29.4	19.6	27.5	23.5	41.2	21.6	27.5	26.5	29.4
2	7.8	16.7	25.5	10.8	7.8	5.9	15.7	5.9	12.7	5.9	28.4	25.5
	34.3	16.7	20.6	21.6	10.8	14.7	20.6	23.5	27.5	16.7	13.7	9.8
3	18.6	21.6	14.7	13.7	17.6	17.6	10.8	15.7	10.8	25.5	19.6	22.5
	16.7	8.8	10.8	21.6	23.5	15.7	17.6	28.4	11.8	15.7	30.4	18.6
4	15.7	16.7	45.1	41.2	46.1	34.3	67.6	47.1	61.8	45.1	37.4	52.0
	32.4	30.4	33.3	38.2	61.8	61.8	30.4	55.9	52.0	34.3	40.2	50.0
5	30.4	46.1	62.7	64.7	52.0	48.0	46.1	47.1	46.1	53.9	48.0	35.3
	33.3	56.9	50.0	52.9	71.6	63.7	52.9	64.7	39.2	51.0	53.9	71.6
6	58.8	61.8	80.4	35.3	42.2	42.2	71.6	63.7	52.9	79.4	67.6	85.3
	49.0	55.9	49.0	58.8	73.5	71.6	52.9	33.3	67.6	77.5	64.7	47.1
7	20.6	23.5	28.4	20.6	20.6	17.6	30.4	24.5	22.5	17.6	32.4	38.2
	46.1	45.1	30.4	44.1	52.8	25.5	48.0	26.5	58.8	33.3	40.2	22.5
8	38.2	64.7	57.8	64.7	61.8	62.7	52.0	66.7	45.1	45.1	72.5	78.4
	62.7	62.7	50.0	42.2	65.7	62.7	78.4	59.8	64.7	64.7	62.7	60.8
9	5.9	2.0	6.9	5.9	3.9	16.7	14.7	11.8	7.8	5.9	10.8	8.8
	2.0	16.7	1.0	8.8	4.9	2.9	1.0	2.9	12.7	7.8	4.9	5.9
10	10.8	11.8	10.8	18.6	18.6	10.8	34.3	39.2	13.7	18.6	35.3	34.3
	34.3	14.7	24.5	33.3	42.2	41.2	36.3	18.6	24.5	34.3	21.6	36.3
11	36.3	36.3	77.5	54.9	58.8	69.6	[illegible]	48.0	67.6	52.9	59.8	51.0
	70.6	42.2	45.1	47.1	69.6	66.7	60.8	52.0	76.5	60.8	70.6	68.6
12	18.6	17.6	9.8	32.4	9.8	22.5	17.6	19.6	25.5	21.6	26.5	33.3
	20.6	10.8	15.7	31.4	20.6	24.5	12.7	35.3	40.2	29.4	25.5	21.6

Table E.3

Mean Percent Correct Scores for Recognition of Words in Carrier Phrase for Experienced Speechreaders

Subject:	Trial											
	1	2	3	4	5	6	7	8	9	10	11	12
1	40.0	20.0	20.0	40.0	10.0	50.0	70.0	40.0	60.0	20.0	40.0	20.0
2	40.0	30.0	10.0	10.0	10.0	30.0	30.0	30.0	10.0	20.0	30.0	20.0
3	50.0	10.0	10.0	20.0	60.0	10.0	50.0	20.0	0.0	40.0	20.0	30.0
4	20.0	10.0	10.0	10.0	10.0	10.0	10.0	30.0	0.0	20.0	0.0	30.0
5	10.0	20.0	40.0	40.0	30.0	30.0	30.0	30.0	10.0	20.0	20.0	40.0
6	50.0	50.0	20.0	40.0	40.0	10.0	40.0	20.0	40.0	50.0	60.0	30.0
7	30.0	60.0	40.0	30.0	20.0	20.0	10.0	20.0	20.0	0.0	50.0	50.0
8	10.0	10.0	10.0	50.0	50.0	20.0	10.0	0.0	30.0	30.0	40.0	40.0
9	10.0	40.0	40.0	40.0	50.0	50.0	10.0	20.0	20.0	20.0	20.0	50.0
10	40.0	20.0	30.0	20.0	30.0	10.0	30.0	40.0	20.0	40.0	30.0	40.0
11	0.0	0.0	20.0	0.0	30.0	10.0	40.0	30.0	30.0	10.0	30.0	20.0
12	30.0	40.0	50.0	20.0	30.0	40.0	30.0	20.0	40.0	40.0	30.0	20.0

Table E.4

Mean Percent Correct Scores for Recognition of Words in Carrier Phrase for Inexperienced Speechreaders

Subject:	Trial											
	1	2	3	4	5	6	7	8	9	10	11	12
1	10.0	10.0	0.0	0.0	10.0	20.0	10.0	0.0	10.0	10.0	0.0	0.0
2	0.0	10.0	20.0	20.0	20.0	10.0	30.0	10.0	10.0	10.0	10.0	10.0
3	0.0	10.0	0.0	10.0	10.0	0.0	10.0	10.0	0.0	0.0	10.0	10.0
4	20.0	30.0	30.0	10.0	30.0	20.0	10.0	30.0	10.0	20.0	50.0	20.0
5	0.0	20.0	20.0	20.0	0.0	30.0	0.0	20.0	20.0	20.0	0.0	20.0
6	30.0	10.0	0.0	10.0	30.0	30.0	30.0	30.0	20.0	20.0	10.0	20.0
7	0.0	30.0	10.0	20.0	20.0	10.0	0.0	0.0	20.0	0.0	10.0	10.0
8	20.0	20.0	10.0	30.0	30.0	20.0	10.0	10.0	20.0	40.0	0.0	30.0
9	0.0	10.0	10.0	10.0	10.0	0.0	10.0	30.0	0.0	20.0	10.0	10.0
10	10.0	20.0	30.0	0.0	10.0	20.0	20.0	30.0	20.0	0.0	20.0	10.0
11	30.0	10.0	20.0	40.0	30.0	10.0	10.0	20.0	20.0	30.0	20.0	10.0
12	0.0	20.0	10.0	0.0	10.0	10.0	10.0	0.0	10.0	10.0	10.0	0.0

Table E.5

Mean Percent Correct Scores for Recognition of Phonemes in Meaningful Words for Experienced Speechreaders

Subject:	Trial											
	1	2	3	4	5	6	7	8	9	10	11	12
1	60.0	50.0	53.3	53.3	46.7	63.3	80.0	50.0	70.0	46.7	63.3	60.0
2	63.3	60.0	36.7	46.7	50.0	50.0	63.3	50.0	50.0	63.3	50.0	53.3
3	63.3	46.7	30.0	36.7	70.0	40.0	63.3	53.3	33.3	63.3	53.3	60.0
4	36.7	40.0	46.7	46.7	43.3	43.3	30.0	53.3	36.7	33.3	30.0	60.0
5	36.7	43.3	56.7	70.0	60.0	63.3	53.3	60.0	53.3	53.3	46.7	63.3
6	73.3	73.3	46.7	70.0	60.0	56.7	73.3	50.0	66.7	73.3	76.7	56.7
7	46.7	70.0	50.0	66.7	50.0	60.0	36.7	43.3	63.3	33.3	70.0	66.7
8	43.3	50.0	46.7	63.3	73.3	50.0	36.7	40.0	60.0	66.7	66.7	53.3
9	46.7	60.0	60.0	63.3	66.7	66.7	43.3	43.3	46.7	53.3	50.0	70.0
10	63.3	56.7	46.7	46.7	56.7	43.3	56.7	53.3	46.7	60.0	60.0	63.3
11	33.3	33.3	43.3	30.0	50.0	30.0	66.7	50.0	63.3	40.0	50.0	46.7
12	60.0	63.3	66.7	40.0	53.3	53.3	50.0	46.7	50.0	63.3	43.3	53.3

Table E.6

Mean Percent Correct Scores for Recognition of Phonemes in Meaningful Words for Inexperienced Speechreaders

Subject:	Trial											
	1	2	3	4	5	6	7	8	9	10	11	12
1	30.0	33.3	23.3	23.3	36.7	43.3	26.7	46.7	20.0	33.3	23.3	23.3
2	30.0	40.0	40.0	43.3	50.0	56.7	23.3	30.0	50.0	53.3	30.0	40.0
3	23.3	23.3	30.0	30.0	40.0	16.7	30.0	26.7	20.0	13.3	33.3	23.3
4	46.7	60.0	40.0	50.0	56.7	43.3	40.0	50.0	53.3	43.3	70.0	40.0
5	40.0	43.3	26.7	50.0	26.7	50.0	26.7	50.0	46.7	50.0	33.3	40.0
6	63.3	43.3	26.7	36.7	56.7	50.0	50.0	60.0	40.0	46.7	36.7	50.0
7	33.3	46.7	46.7	40.0	43.3	43.3	30.0	36.7	40.0	40.0	46.7	40.0
8	53.3	46.7	43.3	46.7	53.3	50.0	40.0	40.0	56.7	56.7	36.7	56.7
9	13.3	23.3	26.7	23.3	23.3	20.0	40.0	40.0	26.7	40.0	46.7	33.3
10	30.0	40.0	43.3	30.0	30.0	43.3	36.7	56.7	40.0	16.7	43.3	33.3
11	50.0	43.3	46.7	53.3	43.3	46.7	23.3	53.3	56.7	60.0	43.3	46.7
12	33.3	53.3	30.0	23.3	30.0	33.3	36.7	23.3	43.3	40.0	26.7	23.3

Table E.7

Mean Percent Correct Scores for Recognition of Phonemes in Nonsense Syllables for Experienced Speechreaders

Subject:	Trial											
	1	2	3	4	5	6	7	8	9	10	11	12
1	33.3	50.0	40.0	43.3	50.0	46.7	46.7	40.0	36.7	36.7	36.7	50.0
2	20.0	43.3	43.3	30.0	46.7	40.0	33.3	40.0	46.7	50.0	43.3	46.7
3	33.3	33.3	30.0	36.7	43.3	30.0	36.7	33.3	50.0	30.0	43.3	43.3
4	40.0	33.3	20.0	30.0	33.3	20.0	40.0	30.0	26.7	43.3	23.3	30.0
5	40.0	36.7	53.3	36.7	36.7	43.3	33.3	30.0	43.3	40.0	46.7	30.0
6	53.3	30.0	36.7	43.3	40.0	43.3	46.7	56.7	43.3	40.0	50.0	43.3
7	50.0	50.0	63.3	43.3	36.7	50.0	53.3	53.3	46.7	36.7	46.7	40.0
8	56.7	40.0	40.0	43.3	43.3	50.0	43.3	26.7	36.7	53.3	40.0	46.7
9	16.7	43.3	43.3	23.3	33.3	36.7	60.0	43.3	40.0	53.3	43.3	36.7
10	50.0	46.7	43.3	40.0	46.7	36.7	53.3	43.3	50.0	36.7	36.7	30.0
11	50.0	23.3	33.3	36.7	30.0	36.7	43.3	33.3	20.0	30.0	23.3	53.3
12	36.7	33.3	36.7	40.0	40.0	50.0	23.3	33.3	53.3	4[illegible].7	40.0	26.7

Table E.8

Mean Percent Correct Scores for Recognition of Phonemes in Nonsense Syllables for Inexperienced Speechreaders

Subject:	Trial											
	1	2	3	4	5	6	7	8	9	10	11	12
1	26.7	26.7	36.7	26.7	26.7	50.0	23.3	23.3	23.3	23.3	30.0	43.3
2	16.7	36.7	33.3	36.7	43.3	36.7	33.3	30.0	26.7	50.0	36.7	53.3
3	10.0	23.3	16.7	10.0	26.7	20.0	13.3	23.3	23.3	13.3	23.3	16.7
4	46.7	43.3	23.3	33.3	40.0	23.3	43.3	43.3	36.7	46.7	43.3	23.3
5	20.0	26.7	40.0	33.3	43.3	36.7	33.3	26.7	36.7	40.0	43.3	36.7
6	36.7	36.7	43.3	33.3	43.3	40.0	43.3	40.0	33.3	46.7	53.3	40.0
7	26.7	43 3	50.0	33.3	20.0	36.7	23.3	30.0	36.7	26.7	36.7	26.7
8	23.3	40.0	33.3	40.0	46.7	36.7	33.3	16.7	50.0	43.3	33.3	46.7
9	26.7	16.7	10.0	20.0	20.0	10.0	26.7	20.0	26.7	23.3	26.7	23.3
10	30.0	36.7	20.0	33.3	40.0	33.3	40.0	33.3	30.0	33.3	30.0	26.7
11	36.7	40.0	43.3	40.0	30.0	33.3	50.0	43.3	33.3	33.3	30.0	43.3
12	23.3	23.3	13.3	23.3	16.7	33.3	40.0	33.3	23.3	43.3	23.3	20.0

APPENDIX F

ANOVA SUMMARY TABLE FOR EFFECT OF TRIAL: INEXPERIENCED SPEECHREADERS

Table F.1

Anova Summary Table of Arcsine Transformed Data for Effect of Trial: Word Recognition in Sentences for Inexperienced Speechreaders

Source	dF	Mean Square	F	P
MEAN	1	108.945	99.24	<.0001
error	11	1.098		
Trial	23	.035	2.95	<.0001
error	253	.012		

APPENDIX G

ANOVA SUMMARY TABLES OF RAW DATA FOR EFFECTS OF SUBJECT AND REPLICATION

Table G.1

Anova Summary Table of Raw Data for Effect of Trial: Word Recognition in Sentences for Inexperienced Speechreaders

Source	dF	Mean Square	F	P
MEAN	1	35.193	41.11	.0001
error	11	.856		
Trial	23	.027	2.88	.0107
error	253	.009		

Table G.2

Anova Summary Table of Raw Data for Effect of Trial: Word Recognition in Sentences for Experienced Speechreaders

Source	dF	Mean Square	F	P
MEAN	1	117.862	100.72	<.0001
error	11	1.170		
Trial	23	.012	1.31	.1591
error	253	.009		

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