SPEECHREADING DISCRIMINATION

Of

HOMOPHENES

LATTHE.GA

A DISSERTATION SUBMITTED IN PART FULFILMENT FOR
THE DEGREE OF
MASTER OF SCIENCE (SPEECH AND HEARING)
UNIVERSITY OF MYSORE
1978

DEDICATION

To

Parents.Brother

&

Dr.N.Rathna

CERTIFICATE

This is to certify that the dissertation titled "SPEECHREADING DISCRIMINATION OF HOMOPHENES" is the bonafide work in part fulfilment for the degree of MSc (Speech and Hearing) of the student with Reg.No. 4

23/9/78

Director
All India
Institute of Speech and
Hearing Mysore 570006

CERTIFICATE

This is to certify that this dissertation has been prepared under my supervision and guidance.

Guide.

DECLARATION

This dissertation is the result of my own study undertaken under the guidance of Dr. Hf. Rathna, Professor, Head, Department of Speech Pathology, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier at any University for any other degree or diploma.

Mysore: |
Dated: 1978| Reg.No.4

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CONTENTS

CHAPTER I

INTRODUCTION

Human society would not have been possible without communication. In fact communication through speech has made man unique among all animals.

Speech is a code consisting of a set of arbitrary vocal symbols. Meaningful exchange through the speech code results in communication. The following conditions should exist for communication to take place.

1. A speaker (Encoder, or decoder, or Transmitter or sender)
2. A listener (Decoder or receiver)
3. A code shared by the speaker and the listener.
4. An appropriate medium or channel for transmission of the code.

Speech consists of sounds and is meant to be perceived by ear. It appears that the auditory system is innately best suited for speech perception (Eimas and Morse 1974 quoted by Pickett 1975). Certain acoustic characteristics associated with speech sounds i.e., phonemes help in perception of speech. These features are called distinctive features.

Normal hearing capacity is necessary for the perception of speech. Deaf persons do not perceive speech as normal persons do. Their difficulties in speech perception vary with the type and the degree of hearing loss; the age of onset and the duration of hearing loss and whether or not any remedial measures have been taken. Such persons often even after rehabilitative efforts have to adopt alternate means for speech perception. Use of hearing aids reduces the difficulties to a certain extent, but hearing aids are by no means satisfactory despite their present day technical sophistication (Pickett, 1969).

Lipreading or speechreading is used by deaf individuals for speech perception. In this process one understands speech by observing mainly facial movements, body gestures, facial expression of the speaker and contextual cues. Speechreading is possible because the movements for speech production are accompanied by visually observable cues. These cues are termed "visemes" by Fisher (1968) and are comparable to the acoustically perceived phonemes. Like phonemes visemes also have certain features which help in distinction among visemes.

Visemes however are not efficient symbols for communication, because of the following reasons :

1. Being auditory in nature speech is not meant to be perceived by vision. What the eyes observe is merely a byproduct of speech-sound production activity.

2. Many speech sounds hare similar facial and articulatory movements and therefore they are visually confusable.

3. Certain speech movements occur deep inside the oral cavity - e.g., the production of /k/ and /g/. Such movements are not visible on the face.

Thus although a deaf person uses speechreading, there are inherent limitations in this mode of speech perception. Much research has been done on speechreading in order to understand and solve the difficulties faced by speechreaders.

One particular area of research in speechreading relates to the analysis of confusions among visually perceived speech elements. These confusable groups of visemes are called "homophones". Traditionally the homophenes are grouped into twelve groups by Bruhn (1942)j Burchett (1950); Clegg (1953); Swing (1967). But Woodward and Barber (1968) and Fisher (1968) proposed four and five groups respectively. Berger (1972) however thinks that the traditional twelve groups are essentially correct. There is no general agreement among investigators on this point.

It is observed that many deaf persons perceive the homophenes correctly. The differences of voicing-unvoicing and nasality-nonnasality are not visible but these persons seem to "somehow" perceive them. This could be attributed to contextual cues and/or in some cases to the presence of low frequency residual hearing. Erber (1972b) studied the distinction between eight common consonants /p, b, m, t, d, n, k, g/ in the bisyllabic context /a/-c-/a/. Three groups of subjects namely normal hearing, severely hearing impaired and profoundly deaf children were used. All three groups were able to distinguish between the places of articulation (bilabial, alveolar, velar) but not within each place category. However, it appears that correct perception of confusable visemes within the same homophenous category may be possible because of certain subliminal cues or some obvious yet hitherto unsuspected cues. Walden and Prosek (1974) attempted to train hearing impaired adults to distinguish visually within the woodward and Barber (1960) categories. Two weeks of training resulted in considerable improvement in this direction, This would suggest that there might be some cues. It will be interesting to investigate the above observation experimentally. The following study attempts the same:

The purpose of the present study.

The present study attempt to answer the question whether correct perception of homophenes is a matter of chance or whether there are some other cues not yet known? Is the correct perception of homophenes possible and if it is possible how is it possible? These questions need an answer.

The Hypothesis.

The following null hypothesis is put to test in this study.

"Correct identification of homophenes within the same category is no more than a matter of chance".

Need for the study.

The need for more research on speechreading in general has been expressed by many. O'Neill and Oyer (1961); Jeffers and Barley (1971); Roberta (1976); Shepherd (1977).

The existing data on the analysis of visual confusions during speechreading give conflicting evidence which needs to be resolved. More information in this area can be fruitfully used in constructing tests of lipreading ability, in improvement of instructional strategies, in refining the electronic speechreading aids and ultimately in improving the rehabilitation for the deaf.

"Since the phonemic confusions that occur in lipreading can frequently be important factors in the success or failure of intended communication, investigations of confusions encountered by the lipreader in discriminating the phonetic elements of the language would appear to be of significant value" Richard and Kimble (1972).

A brief plan of the study.

Subjects : 10 young adults with normal vision and normal hearing participated in the study. They were studying graduate course in speech and hearing. They were familiar with the speechreading process and had worked with deaf cases for speech and language therapy. However, they themselves had received no instruction or formal practice in speechreading. Their competence in the English language required for the present study was adequate.

The stimulus material.

The two groups of homophenes /p, b, a/ and /t, d, n/ were taken for the study. C V C combinations were constructed using these consonants with vowel/æ/ as the nucleus. No single consonant occurred both in the initial and the final position in any given combination. Combinations such as PAT, TAP etc., were formed.

Recording and Testing.

A male and a female speaker delivered the stimuli in random order which were recorded on the black and white type Video Tape. An interval of five seconds were given between two successive stimuli.

The Video-tape was played back during testing and the sub- - jects were required to speechread. The subjects marked their responses on a cyclostyled response sheet which contained multiple choices. The Auditory and contextual cues were eliminated.

Variables controlled

The variables associated with the speakers, the environment and the subjects were controlled wherever possible and others minimized.

Analysis of the Results.

The responses of the subjects were analyzed for various response trends such as percentage correct responses, variations among the two sexes, variations among homophenous categories. The results were analyzed statistically.

Limitations of the study.

1. Only two groups of homophones were used for the study.
2. Video-taping made the task of speechreading unnatural.
3. Some stimuli were meaningful and some were not meaningful.
4. Words do not erpresent the ideal linguistic level for investigation.
5. A time gap of five seconds after each stimulus seemed to be slightly inadequate for response marking. The subjects expressed so. (This was overcome by triple presentation of the whole series of stimuli).
6. A large number of subjects was not used.
7. An experimental group of deaf subjects could be used keeping normals as the control group.
8. The linguistic background of the speakers and the subjects was not the same though all of them had enough competence in the English language called for by a study such as this.
9. A colour Video-tape would have been more desirable.

CHAPTER II

REVIEW OF LITERATURE

Speechreading came under experimentation only in 1914. Kitsan in 1914 tried to study experimentally the factors related to speechreading (O'Neill and Oyer, 1961).

Mishra & Palmer (1964) pointed out that speechreading was known in India as early as 500 B.C. It was part of initiation of priests into religious training. Students were required to attend to "silent sermons " where they used speechreading. This practice later died out.

Many become interested in rehabilitating the deaf around the 16th century. Because of this interest many methods of teaching speech and language to the deaf developed. An Italian named Jerome Carden showed that the deaf can be trained to speak. A Spaniard by name Juan Pablo Bonet (1620) published a book describing a method to teach the deaf to speak. He believed speechreading to be an art that few learned. About 30 years after Bonet John Bulwer wrote a book and suggested lip-reading as an important mode by which the deaf could learn to speak.

In the 18th century Europe became interested in lipreading. Amman a Swiss physician wrote a book in 1692 which described methods to teaching speech and lipreading hut kept his methods secret. A contemporary of Baker, Jacob Periera was famous in France as an educator of the deaf. He was interested in lipreading but he did not write much about his methods. Charles Michel De I'Epoe who was a contemporary of Periera, also wanted to teach lipreading. Because he had too many pupils in the school for the deaf he had to use manual methods. At present he is considered the father of Mannualism. Samuel Heincke of Germany criticised the manual methods and advocated lipreading.

Thomas Braidwood of Scotland is an important contributor to the development of speechreading instruction. Others did not know much about his methods because he was very secretive. Lipreading was used to teach the deaf in the U.S.A. mainly due to the efforts of Alexander Graham Bell.

Till the 19th century lipreading was used only on deaf children but Billie Warren and her assistant Edward Hitchie used lipreading with deaf adults. Hitchie made the most significant contribution to this subject later. Martha Bruhn (1949) Karl Brankmann (Jena method, 1952); Kinzie sisters (1931) made notable contributions. Swings from Manchester - Britain (1944, 1967) were the most outstanding contributors from that country.

Speechreading is a particular form of communication. Communication involves a speaker, listener and message. The interaction takes place in some given environment. Hence there are four major variables involved in speechreading namely the :

1. Speaker or sender or encoder.
2. Listener or receiver or decoder or observer i.e., speech reader.
3. Message or code or stimulus.
4. Physical environment characterised by location (space); time (day -night) etc., and everything else present in the environment.

The following review of literature is presented under these four major headings for convenience. The fourth factor, the message, or code and its nature is the main concern of the present study. It will be presented in relatively more detail.

The speaker, sender or encoder and speechreading.

0' Neill (1951) found out as to who could convey more information visually and auditorily. He compared three speakers. The speaker that conveyed most information visually-also was most intelligible in non-visual conditions,

Stone (1957) used 256 normal hearing college students and studied the effects of variables like facial exposure, facial expression and lip-mobility on speechreading. Subjects observed coloured motion pictures of trained actor. Lipreading performance was better for normal lip movements than for tight lip movements. When the speaker had a plain face rather than a smiling face. The lipreading was easier. Exposure of more than just the mouth (Full torso exposure) was

Byers and Lieberman altered the rate of stimulus presentation by altering the speed of projection and filming. They used a female speaker and students from a residential school for the deaf as subjects. Four speaking rates were studied. Slowing down of rate did not seem to significantly Influence speechreading performance.

Markides (1977) commented on Lips, tongue and mouth opening as factors in speechreading, different degrees of liprounding, spreading and protrusion give useful cues. For example the /u/ in /boot/ has much liprounding while for the /i/ in /seed/ the lips are spread. The /t / in /church/ is recognised by considering protrusion and liprounding together. Observation of tongue position facilitates the recognition of /o, d, 1, t, d and n/ consonants. The degree of mouth opening helps in differentiating vowels e.g., /a/ in /arm/ and /I/ in /sit/.

Visual speech perception does not involve only the lips. Lowell (1974) reported speechreading performances for various degrees of face exposure. 256 normal hearing college students were presented 20 unrelated sentences as 16 mm. colour film. Four conditions of exposure were studied:

1. Mouth alone.
2. Chin to bottom of nose - including mouth and lines around mouth.
3. Chin to eyebrows - full width of face, and
4. Full face and body to chest.

Scores of speechreading systematically improved with Increasing exposure. The mean scores for various conditions were as follows:

1.	4.45
2.	5.77
3.	6.58
4*	6.95

The differences between condition 1 & 2, 1 & 3 and 1 & 4 were statistically significant.

Greenberg & Bode (1968) determined speechreading of consonants for full-face and lips only exposures. A male served as the speaker and 32 females were the subjects for speechreading.

Consonant discrimination was more accurate when the talker's entire face was exposed than when only his lips were exposed.

The speechreader, receiver or decoder and speechreading.

Mental abilities such as intelligence synthetic or analytic ability and personality and sensory abilities and their relation to speechreading have been explored. Hearing loss, training, age, sex and education have also been studied as related to speechreading ability.

Intelligence.

Kitson (1914) did the first experimental study of lipreading. He suggested that subjects with high scores in visual skills scored high on lipreading tests. A good lipreader had a large visual span and guessed well. The significance of correlations found was not mentioned. Pintner (1929) tested face-to-face lipreading in deaf students and found no correlation between lipreading scores and scores on the Pintner Non Language Mental Test. Heider & Holder (1940) developed a film test and tested students of dark school. They found no significant relation between school achievement and lipreading proficiency. Reid (1946) obtained findings similar to those of Heiders using 99 deaf girls on the filmed test. She used the

Stanford Achievement Test. Carender (1949) used normal hearing 6th, 9th and 12th graders intelligence scores (from school files) and scores on the face-to-face lipreading test did not correlate significantly.

0* Neill (1951) used Mason's filmed test on normal hearing college students. Twenty seven skills were evaluated in relation to lipreading. Only two skills out of the 27 correlated significantly with lipreading ability. One of these two skills was performance on the Wechsler-Bellevue Adult Intelligence Scale. A similar study by 0' Neill and Dandson (1956) using the Ohio State Psychological Examination reported no correlation between lipreading skills and intelligence. Simmons (1959) used the Wechsler scale on 24 hard of hearing subjects and found no significant correlation between IQ and lipreading skill.

Most of the studies indicate no significant correlation between intelligence and lipreading. But Graig (1964) and Evans (1965) found small but significant correlation between intelligence and speechreading scores. This area needs further research.

Behavioral patterns.

Strbschinski (1928) considered lipreading as speech thin- - king. He suggested 4 types of speech thinking (1) Visual (2) Acoustic (3) Speech motor (4) Script motor. Persons with visual thinking were the best suited for lipreading and those with acoustic type of thought found speechreading most difficult. 0' Neill (1951) chose normal hearing college students with varying degrees of lipreading skills. A battery of tests including the Rotter incomplete sentence test, Rorschach Test, the Knower Speech Attitude Scale and Knower-Dusenbury Test of Ability to judge emotions was given to them. Lipreading skill and performance on the battery had no significant relation. In a similar group, 0' Neill and Davidson (1956) found no significant correlation between aspiration level and lipreading skill. In a population of congenitally deaf students Worthington (1956) found no significant correlation between behavior patterns or degree of adjustment and lipreading ability. Aspiration level and sentence completion tests of Rotter and Mason lipreading test were used. Wong and Taaffe (1958) studied normal hearing college students for aptitudes and lipreading ability. He reported that general activity, personal relations and emotional instability were important personality aspects in lipreading. Aptitudes such as reasoning, ideational fluency, spontaneous, flexibility and associational fluency secured important in lipreading.

Markides (1977) feels that psychological factors like attention, attitude and motivation definitely influence lear-ning of speechreading. Kinzie (193) considered motivation as "will power" and Milesky (I960) considered motivation as the most important factor in lipreading. Myklebust (i960) felt motivation very important and suggested that the therapist should build up motivation in students of speechreading. Gets (1953) stated that good speechreaders had a more positive attitude towards themselves and others than did poor speech-readers. He also felt that speechreaders got fatigued due to concentrated visual attention and therefore they should learn to relax during training. Experimental studies in this area are not available.

Visual skills.

Kitson (1915) found that high scores on visual tasks scored high in lipreading. O' Neill (1951) and O'Neill and Davidson (1956) did not find a significant relation between visual skills and lipreading. Several tests of visual motor co-ordination were used by O' Neill and O' Neill and Davidson These included tests of block design, object assembly and digit symbol from the Wechsler-Bellevue Adult Intelligence Scale. Results indicated significant correlation between scores for digit symbol and lipreading. But no such correlation was found between block design, object assembly and lipreading. Another study used the Hanfmann-Kasanin Test. Its results showed no significant relation between lipreading and test scores. This would seem to indicate that lipreading may involve not the recognition of verbal elements but the recognition of configuration or form patterns. Simmons (1959) replicated above studying 24 deaf persons untrained in lipreading. Significant correlations were reported between the scores on digit symbol, block design picture arrangement of Wechsler Scale and the scores on two of the 3 tests of lipreading. Results on the Hanfmann-Kasanin Test did not correlate with lipreading performance.

Studies by 0* Neill (1940) and 0' Neill and Davidson(1956) showed no apparent relationship between lipreading ability and reading rate and reading comprehension. Simmons (1959) sampled five areas in reading using Iowa Reading Test. Only one of the five areas namely ability to extract key words correlated with lipreading performance as measured by Mason and Utley test of lipreading ability.

Sharp (1972) found good speech renders significantly superior to poor speechreaders on tests of visual closure; movement closure and short term memory. Evans(i960, 1965) and Berger (1972) agree that anyone with vision sufficient to see differences in movements and positions of the articulator of the speaker can learn speechreading. 20/40 vision seems to be sufficient in most conversational situations (Markides, 1977). Shepherd et al (1972) found significant product moment correlation ranging from 0.09 to 0.91 between a selected perk latency in average visual electroencephalic responses and lipreading scores in 20 adults with normal hearing and normal vision with no lipreading training.

Age of the lipreader.

Evans (1965) reported a rapid increase in speechreading scores between the ages of 8 and 11 years and then a plateau is reached. According to Farrimand (1959) speechreading ability improves from the second to the third decade of life and then it declines. He found that lipreading scores of persons over 60 years were about half those achieved by 30-35 year old people. But Conklin (1917) did not find deterioration of speechreading scores with age. Similarly the Heller's (1940) Utley (1946) and Reid (1946) reported a very low and insignificant correlation between age and speechreading performance. This point needs further investigation.

Sex of the speechreader.

Females are generally superior to males in linguistic skills. They can be expected to be superior in speechreading also in as much as speechreading can be considered to be a skill.

Most of the researchers (McEachern & Rushford, 1958; Brannan, 1961; Craig, 1969; Evans, 1965) found that females scored higher than males in speechreading but the differences were not statistically significant. Costello (1963) and Frisina, (1961, 1963) reported significant differences in speechreading ability in favour of females,

Hearing loss and speechreading.

Lipreading ability and degree of hearing loss and age of onset have been compared. But type of hearing loss, audiogram configuration or the rate and age of development of hearing loss and speechreading have not been compared.

The Holder's (194-0) found speechreading and hearing loss correlated favouring the child with better hearing. Simmons (1959) found low and non-significant correlation between speech-reading and hearing loss. Petrovek (1961) in an autobiographical report claimed that a totally deaf person found it easier to learn speechreading than a person with hearing because the latter tends to concentrate on listening at the expense of speechreading. Lowell (1959) however in a large study reported that normally hearing persons scored higher in speechreading than did deaf people.

Length of training

Berger (1972) reported a low and significant correlation between speechreading ability and length of training for the adult hearing impaired. But the length of training given was not reported.

This is a very crucial variable that needs extensive exploration which must also consider the educational background of the lipreader and the therapist's caliber.

Utley (1946 and Reid (1947) found no significant correla- tion between education and lipreading. The Heider's (1940, 1947) found a correlation at 0.54 and 0.57.

The Environmental Factors and Lipreading.

The physical environment constitutes an important factor in speechreading. The lighting, voice, distance between the speaker and the speechreader, viewing angle and presence of other stimuli that may or may not be directly connected with speechreading all tend to influence the process of speechreading.

Mulligan (1954) found that the slower speed of projection

(16 frames/sec as compared to 24 frames/sec.) resulted in more correct recognition during speechreading. The distance between the subjects and the screen did not significantly affect the test results. Of the four distances studied (5, 10, 15 & 20 ft.) the 10 ft. distance was apparently the most favourable.

Miller and others (1958) reported effects of auditory change in the environment upon lipreading. A delayed auditory feedback 0.19 seconds resulted in increased lipreading ability.

Most of the research studies on effects of distance on lipreading recommend distances varying from four feet to eighteen feet. (0' Neill, 1954; Prall, 1957, Hutton, 1959; Magner, I960; Pauls, 1960; Evans, I960). Levinne (1960) recommended a distance of not more than 5 ft. for lipreading. Berger (1970) compared lipreading performance at 2, 12, 18 ft 24 ft.and found no significant differences. But from a distance of 24 ft. elderly subjects found difficulty in lipreading. All workers in this area agree that speech reading from very close distances i.e., less than 2 ft. is contraindicated (Markides, 1977).

Erber (1971) reported the effects of distance on visual reception of speech in the profoundly deaf. Lipreading at 5 ft. was 75% correct and at 100 ft. it was 11% correct. In another supplementary study he found that the identification of vowels was affected less by distance than that of consonants.

Erber, (1974) studied the effects and angle distance and illumination on visual speechreception in profoundly deaf children using 240 common nouns as stimuli. The lipreading performance was measured under several conditions of speaker angle, light incidence angle, illumination and distance. The best scores were obtained for 0° or 45° horizontal observation angles. The mean scores were 14% to 22% lower when the angle increased to 90°. For viewing angles within the range of 0° to 45° the smaller the distance from the speaker the greater was the visual intelligibility. Minor variations in the vertical viewing angle (-30 to +30°) had little effect on lipreading. Within 0 to 45° range of horizontal viewing angles, illumination conditions which shadowed the speaker's oral cavity lowered mean lipreading performance 3 to 12% below that which was obtained from 0 or +45° angles of light incidence. With frontal illumination of speaker a large reduction in facial luminance (from 30 to 0.03 foot lamberts) produced only 13% decrement. Under conditions of high background brightness however a reduction in facial luminance from 30 to 3 foot lamberts produced a mean decrement of 41%.

Reports by o’ Neill (1954); Sumbay and Pollack (1954) Erber (1969) and Ewertsen and Birk Neilson (1971) have provided data suggesting that the combined auditory-visual recognition of words is more resistant to noise than is the recognition by listening alone.

For a given 3/N ratio the combined auditory-visual per- -formance is typically better than is the recognition through listening above. The normally hearing subjects can achieve high speech perception scores at a lower S/N ratio through auditory-visual perception than by listening alone. This information can be used to establish S/N criteria for auditory or auditory visual perception of speech in noisy areas where communication must occur, for example in industrial and educational areas.

Based on the Miller Nicely data (1955) are might predict that an observer can tolerate a considerable high frequency loss of acoustic speech energy without much decrease in intelligibility on an auditory-visual task, because the place of articulation cues compliment the manner of articulation cues, that are present in the low frequency acoustic signal. Erber (1974 b); Sanders and Goodrich(1971) support this hypothesis Their subjects scored *24%* on an auditory word recognition when listening through 400 HE low pass filter. But when they were allowed to lipread their scores increased to 78J< correct* Binnie, Montegomery and Jackson (1974) showed that even when broad band masking (-12 dB S/N) eliminated all but voicing and nasality features. Normally hearing subjects recognised consonants through auditory-visual perception considerably, better (83£) than when they merely listened (34%). This increase was attributed to lipreading of the place of articulation information that was masked by the noise.

At a distance of 24 Ft. elderly subjects found diffi-culty in lipreading. All workers in this area agree that speech reading from very close distances i.e., less than 2 Ft. is contraindicated (Markides, 1977). Erber (1971) reported the effects of distance on visual reception of speech in the profoundly deaf. Lipreadlng at 5 Ft. was 75% correct and at 100 Ft. it was 11% correct. In another supplementary study he found that the identification of vowels was affected less by distance than that of consonants. Erber (1974) studied the effects and angle, distance and illumination on visual speech reception in profoundly deaf children using 240 common nouns as stimuli. The lipreading performance was measured under several conditions of speaker angle, light incidence angle, illumination and distance. The best scores were obtained for 0° or 45° horizontal observation angles. The mean scores were 14% to 22% lower when the angle increased to 90°. For viewing angles within the range of 0° to 45° the smaller the distance from the speaker the greater was the visual intelligibility. Minor variations in the vertical viewing angle (-30 to +30°) had little effect on lipreading. Within 0 to 45° range of horizontal viewing angles illumination conditions which shadowed the speaker's oral cavity lowered mean lipreading performance 3 to 12% below that which was obtained from 0 or +45° angles of light incidence. With frontal illumination of speaker a large reduction in facial luminance (from 30 to 0.03 foot lamberts) produced only 13% decrement. Under conditions of high background brightness however a reduction in facial luminance from 30 to 3 foot lamberts produced a mean decrement of 41%.

Reports by O'Neill (1954), Sumbay and Pollack (1954) Erber (1969) and Bwertsen and Birk Neilson (1971) have provided data suggesting that the combined auditory-visual recognition of words is more resistant to noise than is the recognition of words is more resistant to noise than is the recognition by listening alone. Costello and Purcell (1968) reported Auditory-visual perception in normally hearing adults. The performance on the word-letter association task was better under the auditory-visual condition (42.6/60 correct) than on the listening alone (28.4/60) or the lipreading alone (17.6/60) The message was 1140 Hz low pass filtered*

Reams (1950) in a study investigating the relationship between the experiences of identifying words through visual sensory stimulation and auditory stimulation, found that the obtained correlation coefficients were not sufficiently high to indicate any positive relationship between auditory intelligibility and visual identification of the same stimulus materials. Normal hearing college students served as ezperimental subjects. They viewed a specially prepared silent motion picture film which utilized the Waco multiple-choice intelligibility tests. The same subjects also listened to tape recordings of the same stimulus materials spoken by the speakers who appeared on the filmed test.

Lighting

Light on the speaker's face is an important factor in lipreading. At present there is no information as to how much light is a minimum requirement and how much is the maximum requirement. The optimum lighting required for most effective speech reading is also not known.

Distractions.

Markides (1977) summarizing his point of view in this area considers that both visual and auditory distractions influence lipreading. Dark glasses* beards, moustaches, long dangling ear-rings, long hair covering part of the face, exaggerated lip movements, visual avoidance, having a pipe, cigaratte in the mouth. Speaking with the chin in the hand are obvious visual distractions. These should be avoided in the speech reading process. There is no information on effects of visual distractions such as different colours, or moving objects behind the speaker on lipreading.

Continuous and intermittent noise, its level, intensity and frequency characteristics and also reverberation can affect speech reading ability. Presently a little is known about these aspects. There is no information on effects of stuttering, misarticulations, foreign accent or different dialects on speech reading

Miscellaneous.

Gault (1927-28) compared recognition of words by deaf subjects by vision alone and by vision plus tactile sense. About twice as many words were recognized by touch and vision together than by vision alone. The tactual stimulations was done by teletactor applied to the finger tips.

Blakeley (1953) tried to find out whether the ability to Interpret and synthesize visual cues into meaningful language as in lipreading was related to corresponding abilities in interpreting incomplete speech patterns. Normal hearing college students were given the Utley Filmed Test, a slow speech test (sentences recorded at 78 r.p.m and played back at 40 r.p.m), an auditory memory span test, and an interrupted speech test (as sentences were being recorded 65 circuit breaks per minute were introduced). Performances on various tasks were compared. No significant relationship was found between lipreading ability and auditory memory span or ability to Interpret incomplete patterns of speech. In a pilot study conducted by Edgar (1958) at John Tracy Clinic a comparison was made between lipreading ability and the auditory reception of distorted or masked speech. The results indicated that while lipreading and listening to distorted speech were somewhat related, they were not related in a linear way. The demonstrated relationship suggested that the best and worst lipreaders were poorer listeners and the middle range lipreaders were the better listeners. Simmons (1959) reported a significant correlation between the duration of hearing loss, visual memory span and lipreading proficiency, as measured by an interview type of test. The visual memory span involved a test of memory for pictured objects. In the instance of filmed lipreading tests (Mason and Utley films), there was a significant relationship between rhythm, synthetic ability and visual memory span. The Rhythm Test of part A of the seashore test of musical talent a fragmentary sentences test and the object span test were used to. evaluate ability in the areas of rhythm, synthetic ability and visual memory.

Auditory-visual intelligibility in Noise.

Background noises have been employed in a number of lip- reading experiments with normally hearing subjects. Leonard

(1962) found that speech reading performance was adversely affected when 80 dB SPL background noise. (White noise, speech and background music) were presented as auditory distractions in a visual only intelligibility task. Pettit (1963) compared the effects of cafeteria babble, traffic noise and white noise on lipreading scores to lipreading in quiet. Each type of noise was a 90 dB level and the test materials used were monosyllabic words. Speech reading scores were poorer (P 0.01) when observers responded in noise than when in quiet (55 dB background noise). Another study found noise presented Intermittently (500 sees on and 500 sees off) did not significantly Influence speech-reading scores as compared to continuous noise conditions.

Erber (1969) showed that auditory visual intelligibility at approximately -24 dB S/N improved systematically demonstrating the case by which the spondee vocabulary could be lip-read. His results supported the findings of an increased visual complement at the poorer speech-to-noise ratio down to approximately -24 dB. He speculated that detection of vowel peak energy in the stimulus words might be the acoustic cue that improves lipreading under white noise conditions.

Erber (1971 b) reported that auditory visual scores in normals rose from a low asymtote of 415. at -30 dB S/N and below to 94% at -10 dB S/N. The severely hearing - impaired revealed a low asymptote of 61% at about -15 dB S/N and a high of 95% above 0 dB S/N. The profoundly hearing impaired showed gradually rising Auditory-visual scores of 51% at -5 dB S/N to a high of 60% at +5 dB. Erber's data are very interesting because they describe the minimum suN ratios needed for maximum auditory-visual intelligibility (-10 dB S/N for normals, 0 dB S/H for severely hearing impaired and +5 dB S/N for profoundly hearing impaired).

Code or the stimulus material,

> "The difficulty of a stimulus, whether auditory or visual, is of interest to the experimenter. The responses of subjects can only be understood when the difficulty of the stimulus is understood. Studies of speech reception or intelligibility have made extensive use of stimulus materials in terms of their temporal patterns. Very few such evaluations have been made of the difficulty of lipreading stimulus materials".

Morris (1944) studied effects of three aspects of stimulus materials upon lipreading performance,

(a) The position of a sentence within a group}
(b) The position of a group within a sequence of groups, and
(c) The length of sentences;

The materials were presented in & face to face situation to a group of deaf subjects. Results indicated that there was a definite decline in lipreading scores as the length of the sentences increased. Also a word was harder to understand when placed in a long sentence than when placed in a shorter sentence; but the lipreadability of a sentence was not markedly influenced by its position within a group of sentences. The position of groups of sentences did not have any noticeble effect upon lipreading performance. Taaffe and Wong (1957) attempted to isolate those stimulus variables related to the ease or difficulty with which the material could be lipread. The IOWA Film Test of lipreading provided the stimulus materials to be analysed. This filmed test was presented to a group of normal hearing college students, and an extensive analysis was made of the materials in terms of sentence order sentence length, number of words in a sentence, number of syllables in a sentence and number of vowels and consonants. Also included was an analysis of the influence of the parts of speech and the visibility of sounds on lipreading. It appeared that lipreading performance was affected by the number of words in a sentence, the number of syllables, in a sentence and the number of vowels and consonants, as well as the length of stimulus words. O'Neill (1954) evaluated the visibility of consonants, vowels, words and phrases. He found that vision contributed 29.5% for the recognition of vowels| 57% for consonants; 38.6% for words and 17.4% for phrases. The visual recognition scores for vowels were, 76%/0%, 74% /i/, 68% /e/; 64% /u/, 63% 9V/, 58% /є/, and 58% /I/. And for consonants, 86% /s/, 84% /F/ 83% / ʃ/, 80% /p/, 77% /k/, 75% /ɵ/, 71% /t/. Vision had the greatest apparent effect in the identification of consonants and lesser effects in order on the recognition of vowels, words and phrases. Sumby and Pollack (1954) investigated the contributions of visual factors to oral speech intelligibility as a function of the speech to-noise ratio and the siee of the possible vocabulary. They found that the visual contribution to speech intelligibility increased as the speech-to-noise ratio was decreased (less intense speech signal). This visual contribution also occurred with an increase in vocabulary size (8 words to 256 words), In a somewhat similar study Neeby (1956) found that the addition of visual cues to auditory cues raised the intelligibility of received speech some twenty percent. The distance of a listener from the speaker did not have a significant effect on listener intelligibility scores within 3 to 9 foot limits.

Woodward (1957) attempted to apply the principles of lip-reading stimulus materials. Three categories of analysis were proposed - phonological, grammatical and lexical. Sets of stimuli consisting of syllable pairs (CV combinations)were filmed while spoken by one female speaker. The basic hypothesis under consideration was that absolute visibility of phonation was a function of the area of articulation. Normal hearing subjects merely judged whether the stimulus pairs were the same or different. In light of the data collected, the following sets of initial English consonants were classified in homophonous clusters,

p - b - i
f - v
wh - w - y

ch - dz - sh - zh - y
t - d - n- 1 - s - z -o
k - g - h

Further more it was stated that if lipreaders were to distinguish among the members of these sets, it must be on the basis of phonetic, lexical, or grammatical redundancy, for the articulatory differences among them are not noticed on visual observation.

Brannan and Kodman (1959) compared skilled and unskilled lipreaders on a task of identifying monosyllabic words and found that these two groups did not differ in their ability to lipread isolated words. But on a face to face presentation of Utbey sentence test the skilled lipreaders were found superior to the unskilled ones. Visibility of total movement form afforded the best one for visual identification of a word.

Differences in the else of the vertical south opening the familiarity of the word and the phonetic length of the one - syllable word did not play significant roles in the correct identification of words. The visual identification of words was directly related to the place of articulation. Thus the lip sounds were most visible while the sounds made in the back of the mouth were the least visible.

The analysis of the stimulus materials used In lipreading is a very profitable research area. In fact, this area seems to offer the greatest possibility for future, controlled rese-arch.

Degree of visibility.

> "Speech sounds are produced by the movable organs of speech (vocal cords, soft palate, jaw, tongue and lips) which modify the airflow from the lunge. The production of each sound thus involves a distinctive combination of fine articulatory movements which may or may not be visually identifiable". (Markides (1977)

The American society for the Hard of Hearing (1943) undertook a study into the relative visibility values of each sound and devised a method for calculating the visibility of any speech sample. Their results showed that consonants /k, g,ɔ & h/ were visually most difficult to identify and /p, b, ʃ, z, t.ʃ da, f, v, ɵ , δ, m, j, w/ were most easy. The vowels in general were found to be easier for visual identification than consonants with the vowels /ɛ ,3,ʊ,ʌ,and ə / being the most difficult and /a, æ, ɔ, oʊ, ɔI, aʊ, and ʊ / be most easy. The results of this study however have not been widely accepted (O'Neill 1951) as the authors failed to take into consideration the effect of adjoining phonemes in rapid speech as the visual distinctiveness of individual phonemes. Similar studies by Heider and Heider (1940) and Watson (1956) can be criticised on the same grounds.

Similarity of visible Articulatory Movements.

Speech sounds can be divided into two major groupings, vowels and consonants. Acoustically each speech sound be it a vowel or a consonant is unique in structure; visually this is not true however. Many speech sounds have Identical visual articulatory movements and such sounds are referred to as homophenes. This term must not be confused with the term homophones which refers to speech symbols that have the same sound as others.

Vowels.

Theoretically each of the vowels is visually distinctive. In practice, that is in running speech, their distinctive visibility is clouded by adjacent sounds. Although this point has been made by Nitchie (1912), Kinzie and Kinzie (1931) and by Swing (1941), it is often ignored in speech reading instruction. Woodward and Lowell (1964), Berger (1970) and Berger De Pompel and Drober (1970) produced experimental evidence which showed conclusively that none of the rowels can be visually identified correctly under conditions of pure lipreading. Fisher (1968) suggested that the vowels form only four groups of homophenes and not 12 homophones as has been hitherto accepted in the traditional, classification. Fisher’s grouping was as follows

Group 1 - |i, ɪ, ɔɪ, ɜi|
Group 2 - |e, ɛ, ʌ, ɜ, aɪ|
Group 3 - |æ, a, aγ|
Group 4 - |ɔ, ɑ, γ, u|

O'Neill found that vision alone contributed 29.5% to the recognition of vowels while Woodward and Lowell (1964) and Berger (1972) reported correct visual identification, averaging 49% and 53.1% respectively. These figures are below the acceptable performance (60 - 70% Ewing, 1941) for effective day-to-day communication.

Consonants.

Consonants can be classified according to their place of production, their manner of production and whether they are voiced, unvticed or nasalized. This classification however, is modified considerably in rapid conversational speech, Although acoustically roiced/voiceless feature and nasalization of consonants can be easily distinguished, visually it is very difficult to do so (Larr, 1959).

Most of the workers in this field (Bruhn, 1942; Burchett, 1950; Clegg, 1953; Bwing, 1967) accept that there are the following twelve categories of consonant homophones s

1	p, b, m	7	1
2	f, v	8	s, z
3	w	9	ʃ, z,
4	r	10.	j
5	ɵ δ	11 .	k, g, ⊃
6	t, d, n	12	h

This classification is mainly based on the point of contact of articulation. Woodward and Lowell (1964) challenged the above traditional classification of consonants homophenes and suggested that these are only four consonant homophenous groups.

1 p, b, m
2 f, v
3 w, r
4 ɵ, δ, t, d, n, ⊃, s, z, ʃ, tʃ, dz, j,k, g,,⊃,h

Fisher (1968) provided additional evidence against the traditional classification of the visual distinctiveness of consonants. For the initial position, he classified consonants on five homophenous groupings.

1 p, b, m, d
2 f, v
3 w, r
4 t, d, n, ⊃, s, z, ʃ , j, h
5 k, g

For the final position he found the following consonant homophones :

1 P. b
2 f, v
3 ɵ, δ, t, d, n, l, s, z,
4 ʃ, z, dz, tʃ
5 k, g, m

Berger (1972) reported that the traditional classification of consonants is essentially correct.

The cumulative writings of these authors show that correct identification of consonants through vision ranges from 30-40%

for initial consonants and only 2O-30% for final consonants. According to Swing (1941) a discrimination of 60-70% is necessary for effective understanding of speech. Clearly this cannot he achieved through vision alone.

Erber (1972 b) reported the results of a laboratory study in which normally hearing, severely hearing - impaired and profoundly deaf children were required to perceive the distinction between eight common consonants /p, b, m, t, d_f n, k, g/ in the bisyliable context /a/ -c-/a/. Through lipreading alone, all three groups were able to distinguish between the places of articulation (bilabial, alveolar, velar) but not within each place category. When normally-hearing children received acoustic information only, they recognized the consonants nearly perfectly. Severely hearing-impaired children distinguished accurately between voiceless and voiced stops and nas$_a$l consonants through listening alone. However, the listening scores of the profoundly deaf group were very low, and they perceived even voicing and nasality cues unreliably. Although both the normally-hearing and the severely hearing impaired groups achieved nearly perfect consonant recognition scores through simultaneous auditory-visual reception, the audition visual performance of the profoundly deaf group was very similar to that which they demonstrated through lipreading alone.

Walden et al (1974 b) have evaluated military personnel whose hearing loss was due primarily to noise exposure. They studied perception of consonants within CV syllables. Visual cues were found to enhance transmission of place - of -articulation, friction and duration features on an auditory visual task. Lipreading has much less effect on the transmission of sonorant and voicing information. The improvement in transmission resulting from visual input was relatively constant across patients who demonstrated a wide range of auditory word recognition scores. Walden et al (1974 a) have reported that most hearing-impaired adults with language are very similar in their ability to distinguish visually between the "homophenous" consonant categories of woodward and Barber (1960). In a latter study Walden and Prosek (1974) attempted to train hearing-impaired adults to distinguish visually within the Woodward and Barber (1960). A filmed pre-test indicated that numerous patients categorised the post dental consonants /t, d, n, 1, r, s, z, f, 3/ together. A two week training program consisted of distinguishing between CV syllable pairs as well as identifying spoken syllables containing the key consonants. After training the patients demonstrated considerable improvement in recognising items from this confusable set of post dental consonants.

Many laboratory studies have used words as stimuli.

Studies by Numbers and Hudgins (1948), Hurry (1951) Kopkins (1953), Hudgins (1954), Prall (1957), Clarke (1957) Van Uden (1960, 1970), Evans (1960), Sanders (1968), and Ross et al (1972) have examined auditory, visual and auditory visual speech-perception abilities of hearing-impaired children. All of these investigations showed that when the subjects both look and listen their scores are typically better than when they look alone or listen alone. The mean advantage of auditory-visual perception over lipreading alone usually is greater for the severely deaf children (19-28%) than for the profoundly deaf children (1-15%), presumably because of the greater contribution of audition in the severe group. In fact, the scores of the severely hearing-impaired children often reach 100% under combined auditory-visual conditions.

Very few investigators have used sentences as stimuli in auditory-visual research, probably because if is very difficult to construct diagnostically useful sentences and to score them reliably. Sentence stimuli have been employed in a few studies, however. Craig (1964) compared hearing-impaired children's auditory visual perception of sentences with their perception of the same sentences through vision alone. Mean auditory-visual performance was 5.0 - 8.5% tested profoundly deaf children on a Video-taped paragraph comprehension-test which was presented for visual and auditory perception. He found a relatively small mean increment (3.3%) for auditory visual perception relative to visual alone.

Words.

In addition to homophenous phonemes, the English language consists of a high proportion of homophenous words. There are also words which sound the same (homophonous) which a listener can only differentiate through context. Words such as /bear-hare/ /two-too/, /bad-mat-pat-pan/ are quite common in the English language and they tend to create speechreading difficulties and some times they can elicit embarrassing responses. Several authors have attempted to quantify the frequency distribution of homophenous words in the English language but their calculations are mainly based on experience rather than experimentation.

Nitchie (1915) stated that about 50% of the words in the English language are homophenous to one or more other words. Kinzie and Kinzie (1931) and Bruhn (1949) stated that 50% of all speech elements are invisible or indistinguishable while Wood and Blakeby (1953) put this down to 11-17%. According to Vernon and Mindel (1971) and Berger (1972) 40-60. of the words of the English language are homophenous. It can be concluded that whatever the actual proportion of homophenous words In the English language they are basically detrimental to speech reading accuracy.

It has been found by Taaffe and Wong (1957) that word length affects speechreading performance with two-letter words being more difficult to speech read than three-letter words. Similarly Erber (1971) found significant improvement in speech reading of spondee words as compared to monosyllables. On the contrary, Brannen (1961) did not find significant differences in speechreading difficulty between monosyllables and spondees but reported Improvement In speechreading of spondee presented in a sentence. The same results were reported by Sarrail (1951). Franks and Oyer (1967), found that familiar words are easier to speechread than unfamiliar words and this was supported by Berger (1972) who stated that three-syllable words of the familiar type were the easiest words to speechread. Schwartz and Black in 1967 found phrases to be easier to speech-read than sentences. Declarative sentences were found to be more difficult to speechread than interrogative and/or negative sentences.

The relation between nature of the stimulus material Is very important one and needs continued research.

CHAPTER III

METHODOLOGY

The Subjects.

10 subjects (five males and five females) with normal hearing and normal vision participated in the study. Their age ranged from 17 years 9 months to 21 years 4 months with a mean of 19 years 2 months. None of them ever wore glasses. They were students in the final year of a graduate course in Speech and Hearing. They had undergone several audiological evaluations and all reported normal hearing. All of them knew of the process of speechreading. They also had worked with deaf children and/or adults receiving speech and language therapy. The mother tongue of all the subjects were not the same. One subject had Tamil as her mother tongue, two males spoke Hindi and the remaining seven had Kannada as their mother tongue. However, all the subjects had enough competence in the English language. They had studied English for a minimum of ten years beginning in the school and later through college. The medium of instructions in college is English.

The Speakers.

A male speaker aged 24 years 2 months (the investigator himself) and a female speaker aged is 18 years 10 months spoke the stimulus material. The mother tongue of the male speaker was

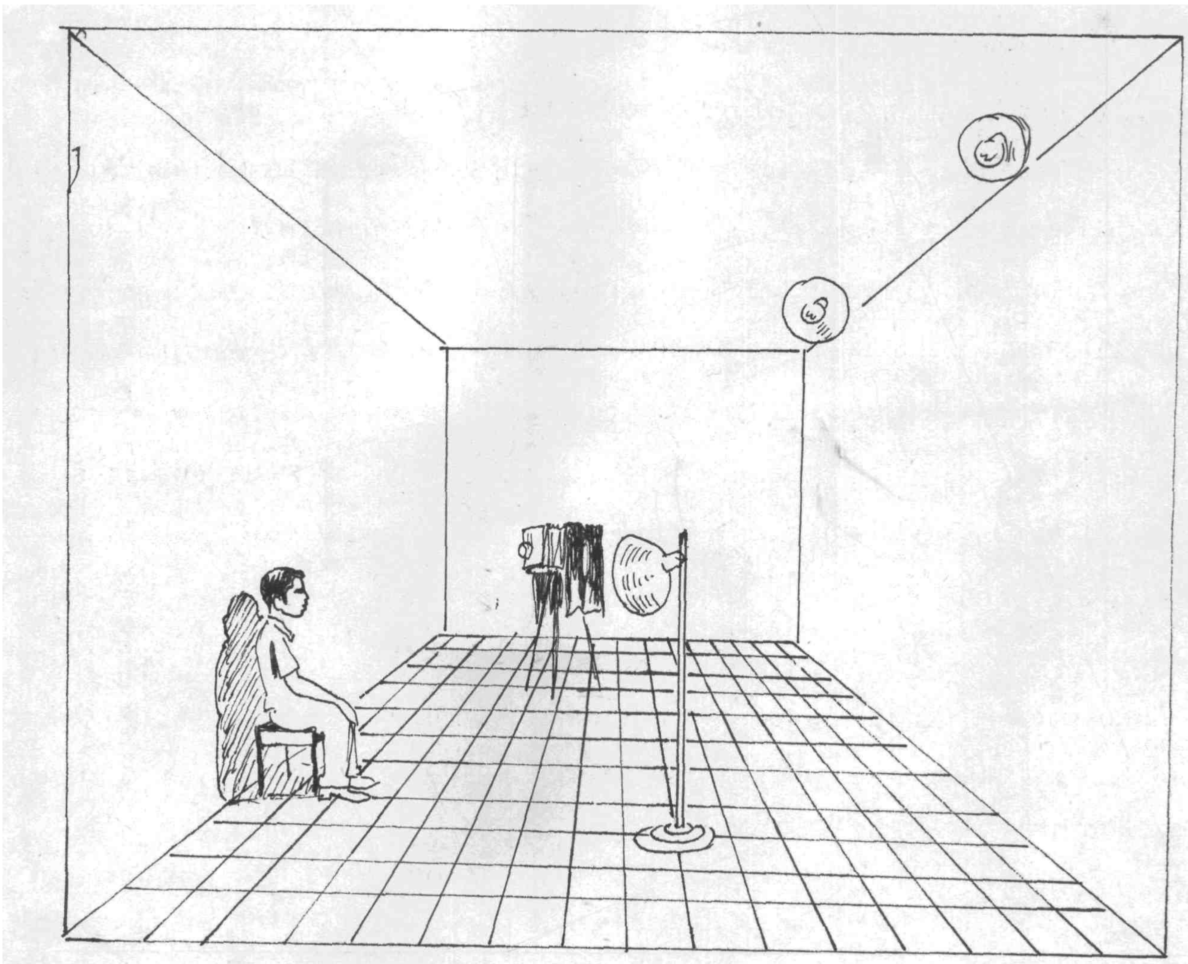
Marathi and that of the female speaker was Tamil. Both speakers however were competent in English in that they had studied and used English for a minimum of ten years,

The Stimuli.

The groups of homophenes the bilabials /p, b, m/ and /t, d, n/ the alveolars were used for the study. C V C combinations were formed using the vowel/æ/ as a constant nucleus. Whenever a bilabial consonant occurred in the initial position of the utterance the alveolar appeared in the final position and vice versa. Some of the C V C combinations were meaningful and some were meaningless. A total of 18 such combinations were formed. Nine of these containing the bilabials as initial consonants were randomly assigned to each of the two speakers and similarly the other nine of them containing the alveolars as initial consonants were randomly assigned to each of the two speakers. The list of C V C combinations as spoken by the male and the female speaker is given below:

	The Male Speaker		The Female Speaker	
Bilabials as the instant consonant	1	PAD	1	MAD
	2	MAN	2	BAD
	5	PAT	5	MAN
	4	PAN	4	PAN
	5	MAT	5	MAT
	6	BAD	6	BAN
	7	BAN	7	PAT
	8	BAT	8	BAT
	9	MAD	9	PAD
Bilabials as the initial Consonant	10	TAM	10	TAM
	11	NAP	11	DAB
	12	DAP	12	TAB
	15	NAB	15	TAP
	14	DAM	14	DAP
	15	NAM	15	NAP
	16	TAP	16	DAM
	17	DAB	17	NAB
	18	TAB	18	NAM

face was illuminated by three intense lights. One light (500 Watts) was five feet away laterally in front of the speaker at the head level. The other two ceiling lamps are shown in the diagram below which shows the set-up.



The distance between the speaker and the camera was adjusted so that the image of the speaker appeared life size on the TV screen during play back. Pull face-front view above the shoulders was recorded. Words were read to the speaker by another person since it was not possible for the speaker to hold the list in his/her hands and read. This would have interfered with the recording. The speaker's gaze was fixed on the camera constantly, to give a constant posture and expression. In interval of five seconds was given after each utterance. The recording was in black and white.

The presentation of the Stimuli: Testing.

During reproduction the image appeared on an 18" TV monitor screen. The same Video-tape machine that was used for recording was used for reproduction.

The subjects sat on the ground 6-10 feet away from the TV monitor. The monitor was kept on a stool 3 feet above the ground level. The sound was switched off as the stimuli were presented. The testing environment was a regular audio-visual laboratory which was sound treated. The air conditioner was switched off during actual testing.

Each subject was given a cyclostyled response sheet. The sheet contained multiple choice type responses. The instructions to the subjects read as follows :

> "You will see a person uttering some words on the Videotape screen. You will hear no sound as the person utters the words. All that you have to do is to watch

the person's face carefully and try to make out what he la uttering. Please underline the word which you thought was uttered, in the row given below. Please note that the words will look similar and hence try to watch them carefully".

The subjects were familiarized with the stimuli by presenting them with the sound as later the sound was switched off and the actual testing was done. The stimuli by the male speaker were presented first. After the full list of eighteen stimuli was presented by the male speaker it was repeated for two more times to permit revision of responses. After a rest of ten minutes the stimuli by the female speaker were presented in a similar manner.

APPENDIX 50a

SCORE SHEET

Instructions:

You will see a person uttering some words; on the Video tape screen. You will hear no sound as the person utters the words. All that you have to do is to watch the persons face carefully and try to make out what he is uttering. Please underline the word which you thought was uttered in the row of words given below. Please note that words will look similar and hence try to watch them carefully.

1.	MAD,	BAD,	MAN,	PAN,	MAT,	BAN,	PAT,	BAT,	PAD
2.	MAD,	BAD,	MAN,	PAN,	MAT,	BAN,	PAT,	BAT,	PAD
3.	MAD,	BAD,	MAN,	PAN,	MAT,	BAN,	PAT,	BAT,	PAD
4.	MAD	BAD	MAN	PAN	MAT	BAN	PAT	BAT	PAD
5.	MAD	BAD	MAN	PAN	MAT	BAN	PAT	BAT	PAD
6.	MAD	BAD	MAN	PAN	MAT	BAN	PAT	BAT	PAD
7.	MAD	BAD	MAN	PAN	MAT	BAN	PAT	BAT	PAD
8.	MAD	BAD	MAN	PAN	MAT	BAN	PAT	BAT	PAD
9.	MAD	BAD	MAN	PAN	MAT	BAN	PAT	BAT	PAD
10.	MAD	BAD	MAN	PAN	MAT	BAN	PAT	BAT	PAD
11.	MAD	BAD	MAN	PAN	MAT	BAN	PAT	BAT	PAD
12.	MAD	BAD	MAN	PAN	MAT	BAN	PAT	BAT	PAD
13.	MAD	BAD	MAN	PAN	MAT	BAN	PAT	BAT	PAD
14.	MAD	BAD	MAN	PAN	MAT	BAN	PAT	BAT	PAD
15.	MAD	BAD	MAN	PAN	MAT	BAN	PAT	BAT	PAD
16.	MAD	BAD	MAN	PAN	MAT	BAN	PAT	BAT	PAD
17.	MAD	BAD	MAN	PAN	MAT	BAN	PAT	BAT	PAD
18.	MAD	BAD	MAN	PAN	MAT	BAN	PAT	BAT	PAD
19.	DAB	TAM	TAB	HAM	TAP	DAP	NAP	DAM	NAB
20.	DAB	TAM	TAB	HAM	TAP	DAP	NAP	DAM	NAB
21.	DAB	TAM	TAB	HAM	TAP	DAP	NAP	DAM	NAB
22.	DAB	TAM	TAB	HAM	TAP	DAP	NAP	DAM	NAB
23.	DAB	TAM	TAB	HAM	TAP	DAP	NAP	DAM	NAB
24.	DAB	TAM	TAB	HAM	TAP	DAP	NAP	DAM	NAB
25.	DAB	TAM	TAB	HAM	TAP	DAP	NAP	DAM	NAB
26.	DAB	TAM	TAB	HAM	TAP	DAP	NAP	DAM	NAB
27.	DAB	TAM	TAB	HAM	TAP	DAP	NAP	DAM	NAB
28.	TAM	NAP	DAP	NAB	DAM	NAM	TAP	DAB	TAB
29.	tam	nap	DAP	NAB	DAM	NAM	TAP	DAB	TAB
30.	TAM	NAP	DAP	NAB	DAM	NAM	TAP	DAB	TAB
31.	TAM	NAP	DAP	NAB	DAM	NAM	TAP	DAB	TAB
32.	TAM	NAP	DAP	NAB	DAM	NAM	TAP	DAB	TAB
33.	TAM	NAP	DAP	NAB	DAM	NAM	TAP	DAB	TAB
34.	TAM	NAP	DAP	NAB	DAM	NAM	TAP	DAB	TAB
35.	TAM	NAP	DAP	NAB	DAM	NAM	TAP	DAB	TAB
36.	TAM	NAP	DAP	NAB	DAM	NAM	TAP	DAB	TAB

CHAPTER IV

RESULTS AND DISCUSSION

10 subjects were asked to speechread the Videi-taped CVC utterances which contained Visemes /p, b, m/ and /t, d_f n/ in the initial and/or the final positions. The intention was to see if they could identify among the homophenes purely by vision The subjects marked their responses on the multiple choice type of score sheet.

The results are presented in the form of percent correct responses. Tables 1 and 2 show the various percentages for each of the male and the female subjects respectively.

Table 1

Srl No! of sub-! jects !	Male Speaker				Female Speaker			
	Bilabials		Alveolars		Bilabials		Alveolars	
	Initial	Final	Initial	Final	Initial	Final	Initial,	Final
1	22.22	44.44	33.33	22.22	55.55	22.22	22.22	22.2
2	11.11	44.44	22.22	55.55	22.22	22.22	44.44	77.7
3	55.55	33.33	55.55	22.22	33.33	33.33	44.44	33.3
4	33.33	44.44	22.22	22.22	22.22	22.22	33.33	44.4
5	11.11	44.44	22.22	44.44	33.33	44.44	55.55	55.5
MEAN	26.66	42.21	31.10	33.33	33.33	28.88	39.99	46.6
Mini-mum	11.11	33.33	22.22	22.22	22.22	22.22	22.22	22.2
Maxi-mum	55.55	44.44	55.55	55.55	55.55	44.44	55.55	77.7'

Table showing the percentages of correct responses obtained by the male subjects on various tasks

TABLE 2

Srl No of sub-jects	Male speaker				Femalr speaker			
	Bilabials		Alveolar		Bilabials		Alveolar	
	Initial	Final	Initial	Final	Initial	Final	Initial	Fin
6	22,22	33.33	11.11	22.22	22.22	44.44	33.33	44.
7	22.22	33.33	33.33	55.55	44.44	11.11	33.33	
8	44.44	22.22	44.44	44.44	22.22	33*33	44.44	77.
9	33.33	44.44	44.44	53.33	44.44	11.11	55.55	66.
10	100.00	44.44	22.22	66.66	22.22	11.11	22.22	44.
Mean	44.44	35.55	39.99	44.44	31.10	22.22	37.77	46.(
Mininum	22.22	22.22	11.11	22.22	22.22	11.11	22.22	
Maximum	100.00	44.44	44.44	66.66	44.44	44.44	55.55	77.

Table showing the percentages of correct responses obtained by the female subjects on various tasks.

Observations from the tables 1 & 2.

The means of percent correct responses in both the males and the females have not exceeded 46.66 percent for any consonant in the homophenous groups either in the initial or in the final position. This would suggest that in general correct identification did not exceed chance. However, a few individuals have scored higher than is probable by mere chance. Scores such as 66.66%, 77.77% and 100% correct responses for same subjects (subject Mos. 2,8,9,10) in some tasks would suggest that their performance was not merely chance.

One female subject (NO. 10) scored 100% correct on the identification of initial bilabials spoken by the male speaker Same subject obtained 22.22% correct on the same task when the speaker was the female on the final alveolar consonants this subject scored 66.66% when spoken by the male speaker but 44.44 when spoken by the female speaker. She seemed to be so sure of her performance on the initial belabials spoken by the male speaker that she did not alter her responses as subsequent presentation of the same stimuli. Interestingly enough she gave up the task of speechreading when the female speaker presented the stimuli containing alveolars as initial consonants. Eight out of nine presentations were not attempted by this subject. It must be noted that she had correctly identified on all the trials she attempted two initial alveolars and are final bilabial. In a way she had 100% correct on whatever she attempted before giving up the task.

One male scored (subject 2) 77.77% correct response on the final alveolar consonants spoken by the male speaker. He identified 55.55% when female presented the same stimuli. Two female subjects scored 17,77% and 66.66% on the final alveolar consonants spoken by the female speaker. But a comparable performance was not observed for the male speaker. In one instance where the female was the speaker one female (subject 7) scored 0.00% on identifying the final alveolar consonant but on the same task she obtained *55.55%* correct when the male was the speaker.

Six out of the ten subjects had random responses which were attributable to chance. Pour subjects had at least one performance beyond chance (subjects 2,8,9,10).

Table 3 shows the given number of correct responses and the probability of their being chance based on the binomial expansion theorem of probabilities

No. of correct responses	Probability of being chance	
0	0.0260122	Reject H_o
1	0.0130061	
2	0.2341106	Accept H_o
3	0.270659	
	0.204648	
4	0.1024234	
5		
6	0.03414	Reject H_o
	0.0007319	
7	0.0009144	
8	0.0000508	

The criteria for acceptance of the hull hypothesis was placed at less than 6 and more than one correct responses, The probability of 6 or more correct responses being due to chance is very low, lower the 0.05 level of significance.

Table 4 shows the original responses of the 10 subjects on the various tasks. The responses that were probably not due to chance at 0.05 level of significance are underlined.

Table 4

Sri No.	Initial bilabial	Final bilabial	Initial alveolar	Final alveolar	Initial bilabial	Final bilabial	Initial alveolar	Final alveolar
1	2	4	3	2	5	2	2	2
2	1	4	2	5	2	2	4	7
3	5	3	5	2	3	3	4	3
4	3	4	2	2	2	2	3	4
5	1	4	2	4	3	4	3	5
6	2	3	i	2	2	4	3	4
7	2	2	3	5	4	1	3	0
8	4	2	4	4	2	3	4	7
9	3	4	4	3	4	1	5	6
10	I	4	2	6	2	i	2	4

Table showing the original scores by the 10 subjects on various tasks. The non-chance performances are underlined.

From table 4 it is observed that only one subject (subject 10) performed definitely on identification of bilabial visemes for the male speaker. The correct responses are nine and their being due to chance is highly improbable. Some subjects identified six times correctly the final alveolars for the male speaker. This performance was not due to chance. The final bilabial identification for female speaker was not due to chance,

The rest of the subjects show that for them the identification of visemes correctly in the Initial position and in the final position for both the bilabial and the alveolar categories were matter of a chance.

The Identification of the bilabials in both the initial and the final position when a female was the speaker, was always due to chance. The identification of the initial alveolars was also due to chance. Three subjects however had correct identification of the final alveolars beyond chance.

This still leaves the hypothesis open for further investigation that there are cues to differentiate between homophenous cognates cannot be ruled out.

The 't' test was applied to test the significance of the differences between the performances on the different visemes used.

The results of the 't' test are presented in table 5.

Table 5

Initial Bilabial Vs Final Bilabial	t= 0.3092	Not signi ficant
Initial Alveolar Vs Final Alveolar	t = -1.414	Signifi- cant
Initial Bilabial Vs Initial alveolar	t = -0.2127	Signifi- cant
Final Bilabial Vs Final alveolar	t = -2.4358	Signifi- cant

Table showing the significance of differences between various tasks at 0.05 level of significance.

The performance on the initial alveolars was significantly different from the performance on the final alveolars.

There was also a significant difference between the performance on the final alveolars and the final bilabials.

Speechreading responses of the five male and the five female subjects to the CVC combinations have been analysed on the confusion matrices. The column indicate the stimulus viseme presented and the rows indicate the responses given by subjects. The point of interception between the rows and the columns indicates that when the stimulus elicited the desired response. For example in diagram 1 when /b/ was presented as stimulus (2 column) it was perceived eight times as /b/; 5 times as /p/ and 2 times as /m/ (rows 1-3).

Thus the nature of confusions among visemes can be understood by examining various confusion matrices.

The results are analysed on confusion matrices showing the nature of confusions. The matrices are presented in the diagrams 1-10.

Diagram 1 stimulu

Response	p			t	d	n
p	3	5	4			
b	6	8	10			
m	5	2	1			
t				6	4	3
d				4	5	1
n				5	6	6

Male subjects-Hale speaker Initial position of consonants.

Diagram 2 stimulus

Respons	D	m	b	t	d	n
P	3	8	4			
b	6	4	3			
m	6	3	8			
t				8	2	1
d				3	6	4
n				4	5	1

Male subjects - Male speake: Final position of consonant;

Diagram 3

Response

	p	b	m		d	n
p	2	4	5			
b	4	5	5			
m	9	6	4			
t				5	6	8
d				5	4	2
n				6	5	5

Male subjects – Female speaker
Initial position of consonants

Diagram 4
stimulus

Response

	p	b	m	t	d	n
p	6	4	4			
b	4	7	6			
m	5	4	5			
t				7	4	
				3	2	
a				5	8	

Male subjects–Female SpI
Final position of conso nants

Diagram 5
stimulus

	p	b	m	t	d	n
p	6	4	5			
b	3	7	2			
m	4	3	7			
t				8	1	11
d				1	3	3
n				5	2	1

Female subject – male speaker
speak Initial position of consonant

Diagram 6
stimulus

Respons

	p	b	m	t	d
p	10	4	8		
b	4	8	4		
a	1	2	2		
t				9	5
d				5	4
a				1	5

Female subject–male
Final position of
conson

Diagram 7

Stimulus

	d	b	m	t	d	n
p	8	6	7			
b	2	4	4			
m	5	5	3			
t				6	3	1
d				3	5	4
n				4	3	6

Female subject-Female speaker
Initial position of consonant

Diagram 8

Stimulus

	p	b	m	t	d	
P	3	3	7			
b	1	6	3			
m	6	4	2			
t				7	1	
d				4	6	
B				3	8	1

Female subject-Female subj
Final position of consonant

Diagram 9

	p	b	m	t	d	n
p	21	19	21			
b	15	24	21			
m	23	16	15			
t				25	22	23
d				9	19	13
n				18	13	17

For initial position of bila-
bials and alveolars stimulus

Diagram 10

	p	m	m	t	d	n
p	22	19	23			
b	15	25	16			
m	18	13	17			
t				31	12	9
d				15	18	19
n				13	26	32

For final position and bila
bial and alveolars stimulus

The performance of the ten subjects was generally random. But these are significant individual scores such as (1) All 9 correct (2) 7 correct (3) 6 correct) (4) one correct and (5) zero correct.

This suggests that these are some cues available to these individuals. Apparently these cues have been correctly classified by the subject (subject 10) who scored 100% correct on initial bilabials and have been misclassified by the subject (subject 7) who scored 0.00% correct. What these cues are is not known. More study is needed to find out these cues. However, cues such as pressure in the lip approximation for the bilabials, and in the tongue contact for alveolars and/or the differences in time in articulation of different sounds and observation of laryngeal region might be the subtly perceived cues such possibilities need to be explored.

Significant differences have been found between identification of the initial alveolars and the final alveolars. This would further support the suggestion that distinctive cues are available to same subjects in same conditions.

The subjects are normal hearing people without any formal training, opportunities, or experience with speech reading. This might have been a key factor in the general random performance studied with a larger number of subjects and better choice of tasks including more homophenous categories at different linguistic levels might yield more infermation.

This study does not completely reject the null hypothesis that the correct identification of visemes within the same category is chance.

The observation of the confusion matrices suggest that some visemes in same speakers are more often correctly distinguished from their homephenous cognates than other visemes. The final alveolar nasal was the most often correctly identified (see diagram 10); in both the initial /b/ and /t/ were most often correctly distinguished (diagram 9 and 10).

This also supports the alternative hypothesis that there seem to he some cues to distinction among cognate homophemes. Hence, the null hypothesis can he rejected though with some reservations,

CHAPTER V

SUMMARY AND CONCLUSIONS

The area of speechreading is important in the rehabilitation of the deaf. Many questions in the area of speechreading need answers. Analysis of confusions among visemes of the same category is an important area for investigation in speechreading.

It has been believed that it is not possible to perceive among the visemes of the same category. However, it has been observed that many deaf individuals perceive them correctly.

The present study attempted to find out the discrimination among the visemes of the same category in 10 normal subjects.

The null hypothesis that "The correct perception of visemes within the same category is no more than a matter of chance" was tested.

Two groups of homophemes the bilabials /p, b, m/ and the alveolars (t, d, n/ were used in the study. Monosyllabic (CVC) combinations using these visemes were formed with a constant vowel /æ/ (For eg. PAT,BAT,TAP,DAM etc.,). Totally 18 such combinations were formed nine of these had the bilabials in the

initial and the alveolars in the final position and the other nine had the alveolars in the initial position and the bila-
bials in the final position.

A male speaker and a female speaker spoke these stimuli. The utterances were Video-taped. 10 young adults (five males) with normal hearing and normal vision speechread the stimuli and marked their responses on multiple choice type score sheets. The subjects were students of an under graduate course in speech and hearing and their competence in the english language was adequate. They knew of the speechreading process but were not formally trained in speechreading.

The responses were analyzed in terms of (1) the percent correct responses (2) the probability of being correct due to chance (3) the differences between different tasks. Confusion matrices were also drawn and analysed.

Findings.

1. The prohability criteria to decide whether the response was beyond chance was fixed at 6 or more correct responses (P 0.03414) and 1 or less responses? (P 0.0130061) Based on these criteria many instances of beyond chance performances were found.

2. The percent correct performance was generally random. But high scores such as 100%, 77%, 66% and 0% correct were obtained by a few subjects.

3. The performances on discrimination between the initial alveolars and the final alveolars differed significantly.

4. The performance on discrimination between the final bilabials and the final alveolars differed significantly.

5. The final alveolar nasal was most often correctly identified in both the speakers.

Conclusions.

The identification of visemes in the final position seemed to be easier than their Identification in the initial position.

The null hypothesis that "the correct perception of visemes among the same category is no more than a matter of chance" was rejected based on the general findings, but with reservations.

However, there are instances of beyond chance performances by few subjects in different conditions. Keeping in mind the fact that subjects were not formally trained in speechreading and had no experience in speechreading an alternative hypothesis that some cues were available was accepted with reservations. Some subjects correctly utilized these cues and some of them did not use them correctly.

The hypothesis is thus open for further investigation.

Limitations of the present study.

1. Only two groups of homophenes were used.
2. Only 10 subjects were used,
3. Deaf subjects were not used.
4. The study was confined to the monosyllabic level of the stimuli.
5. The interval between the two successive stimuli was 5 seconds which was slightly inadequate to permit marking of responses.

Suggestions for further study.

1. The study can be repeated with a larger number of subjects.
2. More categories of homophenes can be used.
3. Phrase level and sentence level of stimuli can be used and this study can be repeated.
4. An experimental group of deaf subjects and a control group of normals can be used and this study can be repeated,

The sound can be presented starting from inaudibility and intensity gradually increased and the improvement in speechreading can be studied. A similar study where frequencies of sounds are selectively filtered can be done.

The cues associated with beyond chance identification need to be identified a study with this aim can be done.

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