INFLUENCE OF SPEECHREADER VARIABLES ON SPEECHREADING

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MAY 2002

Dedicated to

Appa, Amma, Alanachachen,

Nachi & Joanna

Certificate

This is to certify that the dissertation entitled ***"Influence of Speechreader Variables on Speechreading*** is the bonafide work done in part fulfillment of the degree of Master of Science (Speech and Hearing) of the student (Register No. M2K18).

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May 2002

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Certificate

This is to certify that the dissertation entitled ***"Influence of Speechreader Variables on Speechreading*** has been prepared under my supervision and guidance. It is also certified that this has not been submitted earlier in any other University for the award of any Diploma or Degree.

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Declaration

I hereby declare that this dissertation entitled ***"Influence of Speechreader Variables on Speechreading*** is the result of my own study under the guidance of Dr. Asha Yathiraj, Reader & Head of Department of Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier in any other University for the award of any Diploma or Degree.

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INTRODUCTION

And the ears of the deaf shall be unstopped
- Isaiah 35.

The art of speechreading has been of interest to individuals in the field of hearing impairment for centuries, In the 16th century, it has been reported that it is possible for the deaf to "hear with their eyes" (Silverman and Kricos, 1990). Until the 18th century speechreading was typically regarded as a tool for teaching speech production rather than a method for improving speech reception (Berger, 1972).

Until the 1930's the term lipreading had been used. However, it has been suggested later that the term speechreading be used. The term speechreading connotes the process more explicitly. The speechreader literally reads speech or atleast speech movements. He/she observes lip, jaw and tongue movements that are made by the speaker as well as his facial expression. The term lip reading implies observation of just the lips (Jeffers and Barley, 1971). In addition to watching lip movements and positions, the supplementary visual cues which aid in understanding the speaker are gestures and facial expressions of the speaker as well as situational or non verbal contextual cues.

All individuals, at times may require to speechread. They may have to do so in adverse listening conditions or on account of a hearing impairment. Those who have normal hearing need to speechread in difficult conditions such as noisy environment, excessive reverberation or when speech is degraded (Jeffers and Barley, 1971).

Hearing-impaired individual who do not benefit considerably from their amplification device would require to speechread. Even individuals who benefit from their hearing aids may require to speechread in adverse listening conditions (Tiffany and Kates, 1962, cited in Sakihara, Christensen and Parving, 1998).

Over a span of 50 years, it has been reported that with the combination of auditory and visual cues, the hearing impaired performs better (O' Neill and Oyer, 1961; Erber, 1972; Boothroyd, 1987; Lyxell et al, 1993; Lidestam, 1999; Goh, Pisoni, Kirk and Remez, 2001; Walden Grant, Cord, 2001). These studies reported that the hearing impaired subjects performs better when speechreading is also used along with auditory cues.

There are several variables, which are found to affect speechreading. They can be grouped under the following three headings:

I. Environmental Variables

a. Distance (Berger, 1972; Larry, 1991)
b. Lighting (Erber, 1974; Owens and Blazek, 1985)
c. Viewing angle (Blair, 1972)
d. Distractions (Leonard, 1962; Erber, 1972)

II. Speaker Variables

a. Image of the speaker (Reid, 1947; Arnold and Kopsel, 1995)
b. Selection of the speaker (O' Neill and Oyer, 1961; Kricos and Lesner, 1985)
c. Rate of speech (Frisina, 1963; Berger, 1972)
d. Sex of the speaker (Berger and Popelka, 1971)

III. The speechreader variables

a. Intelligence (O' Neill and Davidson, 1956; Jeffers, 1967,cited in Jeffers and Barley, 1971)
b. Visual acuity (Markides, 1977; Sharp, 1973; O' Neill and Davidson, 1956)

c. Visual memory (Costello, 1957, cited in Jeffers and Barley, 1971)

d. Visual acuity (Johnson and Caccamise, 1983, cited in French-St. George and Strokes, 1988)

e. Visual skills (O'Neill and Davidson, 1951)

f. Age (Evans, 1960; Smith and Kitchen, 1972)

g. Hearing loss (Bunger, 1952)

h. Sex of the speechreader (Frisina, 1963; Berger, 1972)

i. Educational background (Kazans and Susan, 1972, cited in Berger, 1972)

j. Synthesis and analysis (Binnie, 1977; Lyxell and Ronnenberg, 1989)

k. Rhythm and pitch (Ewing and Ewing, 1967; Berger, 1972)

The extent to which these variables influence speech reading, varies from study to study. There is no consensus among the authors regarding the variables that contribute o better speechreading abilities. Lyxell, Ronnberg and Linderoth (1993) noted that only a small portion of the message could be detected visually. Additional information may be obtained only with the use of other senses such as the tactile sense (Lyxell et al., 1993) and contextual information (Smith and Kitchen, 1972).

Aim of the Study

The aim of the study is to determine some of the factors that would help an individual be a good speechreader. The correlation between speechreading abilities and the following variables will be studied:

1. Perception of slow rate of speech
2. Visual memory
    a. For spoken digits
    b. For written digits
3. Intelligence using visual based test

Need for the Study

Though technology has improved, enabling the hearing impaired to utilize cues auditory, many of them would still require to speech read. Some would have to depend on speechreading to a greater extent while others to a lesser extent.

It is found that some hearing impaired individuals are able to speechread a lot better than others. There is a need to identify the variables that help to distinguish a good speech reader from a poor one. This information will be useful during rehabilitation to help the hearing impaired develop their ability to speechread.

There is also a need to see whether the variables, which help in good speechreading, are the same as those mentioned in the available literature or whether they vary with reference to the language being studied.

REVIEW

Speechreading may be used to describe the process by which a person uses many cues to understand on going speech. The cues include lip reading, facial expression of the speaker, the residual hearing of the hearing impaired person and grammatical and syntactic context (Walden, Prosek, Montgomery, Scherr and Jones, 1977). Use of speechreading benefits almost every one when listening to speech in noisy environments, especially as people age and hearing deteriorates. (Summerfield, 1987, cited in Goh, Pisoni, Kirk and Remez). Visual cues provided by speechreading when combined with a degraded auditory signal, significantly improves speech understanding (Grant and Walden, 1996; Sumby and Pollack, 1954). The importance of visual cues to enhance speech recognition by the hearing impaired is well established (Grant, Walden and Seitz, 1998; Walden, Busacco and Montgomery, 1993).

The factors that influence speechreading has been classified as

I Environment variables

II Speaker variables

III Speech reader variables

Each of these variables has several sub variables, which are described in table: I

Table 1: Factors influencing Speechreading

Environmental variables	Speaker variables	Speech reader variables
1) Distance	1) Image of the speaker	1) Intelligence
2) Lighting	2) Selection of the speaker	2) Behavioral pattern
3) Viewing angle	3) Rate of speech	3) Visual memory
4) Distractions	4) Sex	4) Visual acuity
		5) Visual skills
		6) Age
		7) Hearing loss
		8) Sex
		9) Educational background
		10) Synthetic and analytic ability.
		11) Rhythm and pitch

I ENVIRONMENTAL VARIABLES

Various environmental factors like distance, lighting, viewing angle and distractions may negatively or positively affect understanding by speechreading.

1) Distance

It is obvious that as distance increases and the intensity remains constant, the understanding of speech by audition will gradually diminish. In the same manner, as the distance increases, speechreading will become more and more difficult and at some point impossible (Berger, 1972).

Most of the research studies on effects of distance on speechreading recommend distances varying from four to eight feet (O'Neill, 1954; Prall, 1957; Hutton, 1959, cited in Berger, 1972; Evans, 1960). However, Mulligan (1954, cited in Berger 1972) reported that the distance did not influence the test results significantly for a range of five to twenty feet. Wong and Taafe (1958) also found that by varying the distance between 12 and 40 feet, the performance might not get altered significantly.

Berger (1970) compared the speechreading performance at 2 feet, 12 feet, 18 feet and 24 feet and found no significant, differences. But from a distance of 24 feet, elderly subjects had difficulty probably due to lessened visual acuity.

Larry (1991) compared the speechreading performance in three visual distance 6 feet, 12 feet and 18 feet. There was an overall decrease in lip reading performance with increase in distance from six to eight feet. The combination of speechreading and tactile aid apparently enabled the subjects to improve their speechreading of sentences at increased distances.

Based on the findings of the above studies it can be concluded that testing would logically be most meaningful if done at a distance most representative of typical daily conversational situations, i.e., between five to ten feet.

2) Lighting

Good lighting is essential for expressive and receptive visual communication such as speechreading (http//www.chs.ca/info/access/gcpublic .html). A light source low and in front of the speaker has been found to produce better scores than normal lighting condition (Jackson, Montogmery and Binnie, 1976)

The effects of illumination on visual perception of speech by profoundly deaf children were investigated by Erber (1974). Results showed that overhead lights which cast a shadow on the oral cavity, resulted in lower speechreading performance. The scores were lowered by 3 to 12 % when overhead lighting was used instead of frontal illumination. Under conditions of high background brightness, however a reduction in facial luminance from 30 to 3 foot lamberts produced a mean decrement of 41%. He suggested that the teachers should face the window as they speak.

Berger (1972) noted that individuals familiar with the message content produce slightly diminishing scores as the intensity of room illumination decreased from thirty-foot candles to one-half foot-candle.

The placement of the light, with reference to the speaker, has been reported to effect speechreading. Erber (1979) found that mounting florescent lights on the back wall can improve classroom illumination, producing good oral/facial levels of brightness (e.g. about 7.10 fL). At this level, the post dental articulations will be visible. In addition to this, if the overhead lighting is retained, the amount of shadow cast will be reduced. They help to create a softer, more diffuse light environment throughout the room.

Owens and Blazek (1985) in their filmed speechreading test had lighting condition provided by an umbrella light (Lowell Totalight) system consisting of intense lights placed in front of the talker. The reflected light from the umbrella provided a clear, bright picture of the talkers face without much discomfort. In the testing room, the lights were dimmed.

In a classroom situation, teachers have been advised to avoid standing in front of a light source, such as window or bright light while speaking. The bright background and shadows created on the face makes it almost impossible to speechread (http://www.mc.cc.md.us/departments/dispsvc/intractn.htm).
Though good lighting is essential for speechreading, it should not be too bright. Natural light is best for speechreading (http://www.agbe/org/information/brouchures_have_win.cbm).

Thus, these studies show that the lighting during speechreading should be optimum and not too bright. A high background brightness should be avoided as it has been found to reduce the speechreading ability.

3) Viewing angle

Larr (1959, cited in Berger, 1972) compared speechreading of normal adults at different angles, front view (0°), angle (45°) and profile view (90°). The 45 ° viewing angle produced slightly better speechreading scores than the other two angles. Highest speechreading scores were reported from a 45° angle and lowest scores at 90° (Blair, 1972). Bruewar and Plomp (1986) found a significant difference in speechreading scores at 0° and lowest at 45° angle. In contrast Erber (1974) found best visual recognition scores for 0° to 45° horizontal observation angles. The mean scores were 14 to 22% lower when the angle was increased to 90°. For viewing angles within the range of 0° to 45°, the smaller the distance between the speaker and speechreader the greater was the visual intelligibility. Minor variations in vertical viewing angle (-30° to +30°) had little effect on speechreading performance.

Bauman and Hambrect (1995 cited in http://journals.asha.org / u4n3 / 067.htm) did a single case study on an adult female having post lingual hearing loss. They tested the speech perception across three viewing angles i.e., front view (0°), quarter view (40°) and side view (90^{o}). It was found that the side view was most effective as the percentage gain of improvement was more. These findings are contrary to that reported by other studies.

Most of the earlier studies reveal 0° to 45° is more visible and to be the best viewing angle between the speaker and the speech reader.

4) Distractions

A distraction is a psychological factor. If the distracting stimulus is at a high enough level, it may become a masker or a physical factor. Distractions may be visual or auditory.

a) Visual distractions

Petkovsek (1961) reported that it is distracting to speechread a person wearing dark glasses because part of face is hidden. It is noticed that females who have long hair which tends to cover a part of the face during head movements, even though the mouth area is not hidden are distracting to speech read (Berger, 1972). Berger and DePompei (1972, cited in Berger, 1972) found that movements of the hands in the area of the face, exaggerated lip movements and a speaker with a pipe or cigar in his mouth acted as visual distractions.

Markides (1977) suggested that visual distracters influence speechreading. Significant relationship was found between purposeful hand movements by the speaker and speechreading scores (Keil, 1968).

The effect of visual distractions on lip reading performance was examined by Berger, Martin and Sakoff (1970, cited in Erber, 1974). Adult males with normal hearing were required to discriminate vowels and consonants in monosyllabic words under following conditions: (1) Lights flashing near the speaker's head, (2) two competing speakers conversing near the main speaker, (3) an object rotating behind the speaker, and (4) the speaker rubbing his jaw and chin as he spoke. The effect of each of these visual distractions on lip reading performance was found to be small and non significant. The authors noted that the distractions used in the study both were anticipated by subjects and were continuous when present. They suggested that the unexpected, intermittent distractions disrupt lip reading more seriously.

From the above studies it can be presumed that visual distractions reduce speechreading ability. In daily life, the visual distractions may have a greater negative effect on speechreading. It is necessary to maintain visual attention for a considerable period of time during speechreading.

b) Auditory distractions

Auditory distractors would have an influence only in individuals who have residual hearing. It would be difficult to determine effect of auditory distractions on speechreading with the hearing impaired population. Background masking noise has been employed in a number of experiments using normal hearing subjects (Erber, 1974; O'Neill, 1954; Sumby and Pollack, 1954). The auditory distractions significantly and adversely influenced speech-reading scores even in trained subjects (Leonard, 1962). The study employed white noise, speech and background music, each presented at 80 dBSPL. The only significant difference among the three noise distractions was between white noise and music. This difference may reflect a practice or learning effect. The intermittent noise had more distraction than continuous noise since the subjects would be expected to adjust to continuous noise easily (Berger, 1972).

For a given S/N ratio, the combined auditory-visual performance is typically better than is the recognition through listening alone. The information would be used to establish S/N criteria for auditory or auditory visual perception of speech in noisy areas where communication must occur, for e.g., in industrial and educational areas. Pettit (1963) compared effects of speechreading performance in noisy and quiet conditions. The noise was at 90 dB level and the test materials used were monosyllabic words. Results indicated poorer speechreading scores than when in quiet. Binnie (1977) showed that even when broad band masking (-12dB S/N) eliminated all but voicing and nasality features, normally hearing subjects recognized consonants through auditory visual perception considerably better (83%) than when merely listened (34%). This increase was attributed to speechreading of the place of articulation information that was masked by noise.

In classroom situations, visual and auditory distractions are recommended to be kept minimal. For e.g. avoid hands in front of the face, mustaches should be well-trimmed and avoiding chewing gum while speaking. The teacher should face the student as much as possible and avoid seating children near the window even if it is tinted (www. Colorado / Carson /checklist, html.; http:// www. netac.ritedu/ downloads/TPSHT_AV_Equip.pdf).

To conclude, various studies on auditory distractions indicate a decrease in speechreading performance among normal subjects. In the hearing impaired with minimal residual hearing, contribution of auditory distractions may not be distracting because of impairment in audition.

In general it can be noted that adequate lighting, 5 to 8 feet distance between the speech reader and speaker, 0° to 45° viewing angle and distractions should be controlled prior to speechreading. The influence of individual factors on speechreading can be found and the one's which adversely affect speechreading, can be modified if needed.

II THE SPEAKER VARIABLES

A speechreader needs to converse with many persons, some of whom will be strangers. He cannot expect each speaker to modify his or her speech behavior to facilitate visual understanding. The speaker variables are:

1) Image of the speaker

How much of the speaker is in view is an important variable in speechreading especially if the person is viewing a filmed image. Filmed images are used for testing purpose as well as for training purposes. Reid's (1947) filmed test showed the upper part of the shoulders and lower three fourths of the speakers face. Most other test items have used a head and shoulders view of the speaker (Arnold and Kopsel, 1955). A waist up view has been used in several test films. Conklin (1917, cited in O'Neill and Oyer, 1951) presented a video taped sentences test where in the key word was shown in a close-up view of the mouth following a larger image of the speaker saying the entire sentence. It has been found that if more of a speaker is visible, it is easier to speech read (Stone, 1928, cited in O'Neill and Oyer, 1961). Speechreading scores were compared by Larr in 1959 (cited in Berger, 1972) when subjects were shown four images of the speaker, upper torso, head and neck, head only and lip only. Optimum image seemed to be head and neck, with lips only being most difficult.

In a consonant identification task, the speechreaders could see the full face or only lips down to upper laryngeal area (Greenberg and Bode, 1968). The results showed significant differences in favor of full image was found. It is probable that smaller image of the speaker merely rules out or minimizes useful clues and makes the task more difficult.

Preminger, Lin, Payen, and Lavitt (1998) used digital video technology to effectively mask the facial aspect. The visual masking involved entire mouth and upper part of the face and mouth and lower part of the face. When no masking was applied to the test stimuli, performance across consonant visemes was similar and consistently high. When the test stimuli were masked, a strong effect of vowel context was observed. Performance was consistently superior for consonant visemes in the /a/ and /ɔ/ vowel context and consistently inferior for consonant visemes in the /u/ vowel context.

Most of the important information available on the face was located at the level of lips and mouth especially, chin and sides of the cheek. This holds good for vowels as shown by Erber (1974), Owens and Blazek (1985).

Researchers suggest that the speaker should be positioned so that at least the head and shoulders are clearly observable to the speech reader. The articulators of the speaker should be clearly visible to enhance speechreading.

2) Selection of the speaker

Some persons are much easier to speech read than others. Therefore for speechreading tests or practice, speakers of varying degrees of non-verbal expressions should be included. Speakers should represent race, dialect, sex and age in proportion to the frequency of their occurrence in the overall population of a country. These factors should then be represented in proportion to the frequency of their occurrence in the overall population of a country. These factors should then be represented in proportion to the frequency of their occurrence in the population for which the test is built. Great care must be exercised in making random selection of speakers within the racial, dialectal age and sex categories set up. (O'Neill and Oyer, 1961). Such selection of speakers should also be considered during a therapy program. Facial expression carry a broad spectrum of information. They inform about individuals age, sex, mood, feelings or intentions (Taafe and Wong, 1957). The role of facial expressions in speechreading is to strengthen the relatively weak stimulus signal and thereby to increase the possibility of speech understanding (Lyxell, Johanson, Liedstam, and Ronnberg, 1996). This advantage was to holds good for only low level of linguistic complexity i.e., word decoding and word discrimination. It does not hold good for sentences (Lyxell et al., 1996).

In a study by Kricos and Lesner (1985) it was noted that use of different talkers significantly affect the speechreading performance of hearing impaired teenagers. Oyer and Frankmann (1975, cited in Kricos and Lesner, 1985) concluded that a natural speaking style appears to facilitate speechreading. An earlier study by Stone in 1928 (cited in O'Neill and Oyer, 1961) suggested that normal rather than tight lip mobility and smiling facial expression affected better speechreading scores. But these differences were not statistically significant. A speech reader stated that an expressionless face, immobile lips and grimaces inhibit speechreading proficiency (Woodward and Barber, 1960).

Exaggerated speech was not found to be significantly easier than non-exaggerated speech (van Uden, 1960). In a study by Berger (1972) scores gradually and significantly deteriorated as lip thickness of the speaker increased. He also noted black speechreaders were able to speech read black speakers best and white speechreaders speechread white speakers best. The speaker with thick lips is difficult to speechread because of reduced lip mobility and that a person can speechread a speaker of his own race because of more practice in communication within the race (Berger, 1972). The "most preferred" speaker was easier to speech read than "least preferred" speaker (Woodward and Blakely, 1953, cited in Berger, 1972).

Speech readers often state that for best understanding of speech, the speechreaders need not know only the language and dialect of the speaker, but also his other speech habits. Knowing the personality of a person is said to make it easier to understand him (Petkovsek, 1961). There are reports that relatives and close friends are easier to speech read than persons who are more distantly known (Berger, 1972). A study by Kricos and Lesner (1982) conclude that viseme categories do vary across talk and are related to ease with which talkers can be speechread. This may be accounted by the fact that individuals differ not only in precision with which they produce sounds but also in the manner in which they form the sounds (Jeffers and Barley, 1971).

A study was carried out to select several talkers from a pool of potential talkers, to avoid adventitiously choosing a markedly typical single talker. (Bench, Daly, Doyle and Lind, 1994). This was done to assess speechreading as a general skill rather than as talker specific and to select talkers who were acceptable to speechread and comparable with their speech readability. Totally there were 16 talkers who were equally divided into four groups (young men, young women, older men and older women). The result suggested that younger women were easiest to speechread. The talkers will significantly affect the amount that can be speechread.

A study by Lyxell, et al., (1996) noted the role of facial expression in speechreading. It was assessed by three different tests i.e. a sentence based speechreading test, word decoding and word discrimination tests. The results revealed that no general improvement as a function of expression was obtained across all the tests, which could mean that information carried by expressions, is not integrated together with verbal information.

As the speechreader is more dependant on the speaker, the more the number of speakers he can speechread, the easier it will be for him to communicate in day to day life. A natural style of speaking leads to better speechreading scores.

3) Rate of speech

A normal speech rate (120 words per minute) is said to be faster than the "optimum" for speechreading purposes (Nitchie, 1950, cited in Berger, 1972). Sumby and Pollack (1954) reported that in normal speech articulatory movements averages to twelve per sec but the eye could see only nine or ten.

In contrary to the above studies, there was no significant difference found among viewing speeds between speechreading proficiency groups (Byers and Libermann, 1959; Blair, 1972). A speechreader is not hampered by slower than average speech rates and their accompanying exaggerated lip movements (Berger, 1972).

Studies have also been carried out with the speaker talking at different rates of speech. As the speaking rate later increased, the speechreading scores were found to reduce. Escalera and Davis (1977) studied speechreading scores for slow rate (90 words /minute) normal rate (175 words/ minute) and fast rate (290 words/minute) of speech. The mean speechreading scores were 53.32, 45.42 and 37.68 respectively. They concluded that as the speaking rate increases, the scores reduce linearly.

A similar result was found by Hrehocik and Victor (1977) where they got a mean score of 26.2 for normal and 19.2 for fast rate of speech. In akinetopsic patients also similar results were found (Campbell, Zihl, Massaro, Munhall and Cohen, 1997). 80% speech could be speechread at the normal rate and less than 20% at a fast rate.

From the studies we can see that there are equivocal results regarding rate of speech influencing speechreading proficiency. Most of the studies show that the speed of focusing is less compared to articulatory movements, hence a slightly slower than average rate could enhance speechreading performance.

4) Sex of the speaker

Women are easier to speechread than men because of the use of lipstick which draws attention to their mouth and also because they use free facial expression and more gestures (Petkovsek, 1961). It is sometimes also mentioned in literature that males with moustaches, beards, and pipes in their mouth are difficult to speechread. These seem to be more a matter of distractions than sex differences as such (Berger, 1972). Ross, Daffy, Cooker and Sargeant (1972) found that female speakers produce significant differences in terms of greater rate and intensity of movement on the surface of the face during the production of selected homophenous words than males.

In a questionnaire sent to hearing impaired adult, male and female, respondents were in general agreement about the ease of speechreading males, but the male respondents indicated that females were not easy to speechread more often than did female respondents (Berger and Popelka, 1971). Shepherd and Markides (1972, cited in Berger, 1972) found no significant differences in speechreading scores produced by the sex of the speaker.

The articulatory precision of speaker, the rate, co-operation, visibility of speaker, amount of lip movement, speaker familiarity and sex of the speaker are the critical variables important in understanding them. It is important to study the factors in a speaker that contribute to easy or difficult speechreading.

III THE SPEECHREADER VARIABLES

The factors studied under speechreader variables include psychological aspects such as intelligence, synthetic or analytic ability and personality. In addition, visual skills, hearing loss, training, age, sex and education have also been studied in relation to speechreading ability.

I) Intelligence

A study was conducted on 20 normal hearing college students by O' Neill (1951) using Mason filmed tests and Weschler's Bellevere-Adult intelligence scale. Using the Mason's filmed tests, 27 skills were evaluated in relation to speechreading. One of these two skills was performed in Weschler's Bellevere-Adult intelligence scale. Results showed that only two skills out of 27 correlated significantly with lipreading.

IQ tests require analytic reasoning ability, but speechreading is a synthetic process, hence a close relationship between the two will not be present. However IQ tests that include a number of verbal subtests, should correlate better with speechreading performance (Jeffers 1967, cited in Jeffers and Barley, 1971).

Most of the studies indicate no significant correlation between intelligence and speechreading, except a study by Craig (1964) and Evans (1960). They found small but significant correlation between intelligence and speechreading scores.

2) Behavioral pattern

Stobsehinski (1928,cited in Berger, 1972) considered lip reading as speech thinking. He suggested four types of speech thinking (1) visual (2) acoustic (3) speech motor (4) script motor. Persons with visual thinking were best suited for lip reading and those with acoustic type of thinking found speechreading more difficult.

O'Neill (1951) chose normal hearing college students with varying degrees of lip reading skills. A battery of tests, including the Rotter Incomplete Sentence test, Rorscharch 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, O'Neill and Davidson (1956) found no significant correlation between aspiration level and lipreading skill in a population of congenitally deaf students. Worthington (1956, cited in O'Neill and Oyer, 1961) 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.

In contrast with the above studies, there are experts who have found a correlation between behavioral abilities and speechreading. Wong and Taafe (1958) reported that general activity, personal relation and emotional instability were important personality aspiration in lipreading. Aptitude such as reasoning, identical fluency, spontaneity, flexibility and fluency were considered important for speechreading.

Demorest and Bernstein (1992) reported that good speechreaders had a more positive attitude towards themselves and others than did poor speechreaders. They also felt that speechreading got fatigue due to concentrative visual attention and therefore they should learn to relax when having to speechread.

Thus, it can be noted that while a few studies did not find much correlation between the behavior or attitude of a person with speechreading ability other studies did.

3) Visual Memory

It is the ability to retain, at least briefly, the sensory information, i.e. the sequence of motor movements, on which the visual percepts are based. It is reasonable to assume that visual memory should play an important part in speechreading achievement. The individuals need to retain the visual imagery long enough to enable him to decide what he has seen. This is required in our jargon, to arrive at a perceptual closure, or a series of perceptual closures. This is also needed to permit him to be flexible and to form different associations if the first associations cannot be combined into a meaningful message. Costello in 1957 (cited in Jeffers and Barely, 1971) used a printed test consisting of sequences from four to eight digits. The digits were exposed one at a time at the rate of one per second. After exposure, each digit was withdrawn from view. The subject responded by reproducing each series from a set of cards before him. A positive association between skill in this test and skill in speechreading was found for both deaf and hard-of-hearing groups. In addition, the same test was given using spoken rather than printed numbers. The children were able to speech read all of the symbols used. This type of presentation would appear to be superior to the printed form because it replicates the exact task of the speech reader. A correlation coefficient of 0.511 and 0.548 was obtained for the written and spoken digit memory tests respectively.

O'Neill and Davidson (1956) used printed visual digit span tests similar to the one used by Costello (1957, cited in Jeffers and Barley, 1971) with the exception that their sequences were on slides and exposed for only 0.1 second. Both these studies reported low and non-significant correlations between visual retention scores and speechreading.

4) Visual Acuity

According to Geers and Brenner (1994), speechreading investigations typically make no mention of visual acuity testing, nor do they report results of any optometric evaluations of their subjects. Results of studies that do report effects of reduced vision are difficult to compare because of differences in the age and hearing status of subjects, as well as in the test materials and methodologies used. The contention of Parasnis and Samar (1982) that visual acuity is a fundamental visual factor in speechreading is supported by the findings of Hardick, Oyer, and Irion (1970, cited in Karp, 1989). In their study of speechreading by normal hearing college students, they reported a significant relationship between the most minor deviations in visual acuity and performance on standardized tests of speechreading sentence material.

The performance of students with non-correctable acuity problem was studied by Johnson and Snell (1986, cited in French-St. George and Strokes in 1988). They concluded that visual acuity of 20/30 in at least one eye is a necessary condition for speechreading. They also said that acuity of 20/40 in the better eye had a significantly adverse effect on speechreading scores when acuity in the worse eye was poorer than 20/100. In addition they reported that when both eyes were worse than 20/40, the mean speechreading score was roughly half that of subjects with better vision.

5) Visual skills

Kitson (1915, cited in Lyxell et al., 1993) found that those with high scores on visual tasks scored high in lipreading. However, O'Neill (1951) and O'Neill and Davidson (1956) did not find a significant relation between visual skills and lip reading. Several tests of visual motor co-ordination were used by O'Neill (1951) and O'Neill and Davidson (1951). These included tests of block design, object assembly and digit symbol from Weschler's Bellevere-Adult intelligence scale. Results indicated significant correlation between scores for digit symbol and speechreading. However, no such correlation was found between block design, object assembly and speechreading. This indicates that speechreading may involve not the recognition of verbal elements but the recognition of configuration form of patterns. Good speechreaders were found to be significantly superior to poor speechreaders on tests of visual closure, movement closure, and short-term memory (Sharp, 1972). In case of normal hearing individuals, visual memory for complex shapes significantly correlated with speechreading. For the hearing impaired, reading ability was significantly correlated with speechreading, but for the bilingual deaf, the correlation was not significant. It would be useful to learn more of the relationship between word recognition and the use of syntactic and pragmatic knowledge in reading on one hand with equivalent speechreading skills (Arnold and Kopsel, 1995; Shepherd and Markides, 1972, cited in Berger 1972).

Hieder (1940, cited in O'Neill and Oyer, 1961) found that an 'integrated type' of child (good speech reader) usually sorted geometric forms by color, while the more rigid and analytical child (poor speechreader) was more apt to sort the forms by shape of the form itself. A significant correlation (r=0.48) between a visual recognition of designs test and a filmed speechreading test was found by Evans (1960). Like wise, Costello (1957, cited in Jeffers and Barely, 1971) reported non-significant correlations between Knox cube test, which is a test for memory of movement, and speechreading performance with hearing impaired children. But she found a significant relationship between speechreading skill and ability to arrange picture sequence depicting social situations. Poor speech readers more frequently repeated incorrect choices or nonverbal concept and required most time to make choices before attaining the concept (Taafe and Wong, 1957).

Central vision plays a crucial role in speechreading performance. According to Paranis and Samar (1982), the ability to differentiate among lip movements depends on the integrity of the central visual field. That very small area of the retina comprised mainly of the cone shaped sensory receptors is responsible for recognition of fine detail. Any low vision disorder resulting in a central field scotoma would certainly comprise a person's ability to identify lip movements.

Thus, the type of vision problem has to be detected and correction of it or compensation by other modes like reducing the speaker-speech reader distance, reducing glare or improving the lighting should be in cooperated before training starts.

6) Age of the speech reader

Evans (1960) reported rapid increase in speechreading scores between six and eleven year old children and then a plateau is reached. According to Farrinand in 1959 (cited in Berger, 1972) speechreading ability improved from second to third decade of life and then it declined. He found that speechreading scores of a person over 60 years were about half of those achieved by 30-35 years old people.

A number of studies have examined the effect of chronological age on speechreading performance (Ewersten and Nielson, 1971, cited in Dancer, Krain, Thompson, Davis and Glenn, 1994; Smith and Kitchen, 1972; Delson and Prather 1974). A common finding of these studies was a decline in speechreading performance with increasing age (Lyxell and Ronnberg, 1989).

However in an earlier study, Conklin (1917, cited in O'Neill and Oyer, 1961) did not find a deterioration of speechreading scores with age. Similarly Utley (1946) and Reid (1947) reported a very low and insignificant correlation between age and speechreading performance. In a more recent study Dancer et al., (1994) found that there was a statistically significant effect of age group on speechreading scores in females. They had taken subjects between the age group of 20 and 69 years and found that 30 and 40 year old females scored higher than the other age groups.

The deterioration in speechreading scores for aged persons may be due to associated factors like reduced vision and motivation. Thus, it can be seen that the majority of studies report of a reduction in speechreading performance with age relatively fewer studies report of no change with an increase in age.

7) Hearing loss and speechreading

The effect of degree of hearing loss and age of onset on speechreading abilities has been studied by several authors. Heider and Heider (1940, cited in O'Neill and Oyer, 1961) found speechreading and hearing loss correlated, favoring the child with better hearing. This could be probably due to better vocabulary, high motivation found in these children. Petrovsek (1961) in an autobiographical report claimed that a totally deaf person found it easier to learn speechreading than a person with good hearing because the latter tend to concentrate on listening at the expense of speechreading.

Speechreading ability was investigated by Tillberg, Ronnberg, Svard and Ahlner (1995) in hearing aid users with different time of onset and different degree of hearing loss. Audio-visual and visual only performance was assessed. One group had hearing impairment early in life and the other later in life. There was no significant difference on audio-visual test performance between the groups. However, the early onset group performed significantly better on the visual only test. Hence, it was concluded that the visual information constituted the dominant coding strategy for the early onset group. An interpretation chiefly in terms of early onset may be most appropriate, since variations in degree of loss as such are not related to speechreading skill.

Erber (1969) demonstrated that the magnitude of the visual contribution, defined as the difference between audio-visual and auditory only scores, increases as the auditory channel was progressively impaired. In case of audio- visual testing, it is most likely that most of the information in pitch, intensity and time variation is available to subjects with severe hearing loss who use hearing aids and to those with the moderate hearing loss who do not use hearing aids (Tillberg et al., 1995).

Walden, Grant and Cord (2001) conducted a study to discrete the consonant information provided by amplification and by speechreading. They also studied the extent to which such information might be complementary when **a** hearing aid user can see the talkers face. Both amplification and speechreading provided a significant improvement in consonant recognition from the baseline condition. Speechreading provided primarily place of articulation information, where as amplification provided information about place and manner of articulation as well as some voicing information.

8) Sex of the speech reader

Females are generally superior to males in linguistic skills. Most of the researchers (Mc Eacher and Aushford, 1958; Brannon, 1961; Evans, 1960; Dancer et al., 1994) found females scored high in speechreading than males, but the difference were not statistically significant. Costello (1957, cited in Jeffers and Barley, 1971) and Frisina (1963) reported significant difference in speechreading ability in favor of females.

Berger (1972) sent a questionnaire to hearing impaired persons sixteen years and older. He reported, males considered groups of two or three persons as a more difficult situation in which to speech read than did females. It might be that hearing impaired males are less often in a small group conversation than females and rather are in one to one communication more often and watch television more than do females. Thus females have more experience speechreading in small groups than do males.

Though studies generally tend to show mat females are better speech readers than males, this difference is marginal. The difference could also be attributed to experience rather than inborn abilities.

9) Educational Background

It is important to consider speechreading from the standpoint of educational placement and other factors related to schooling. Pintner (1929, cited in Berger, 1972) found that day school students scored higher in speech intelligibility and speechreading than did residential school students. Day school students had better hearing sensitivity and a later on set of deafness than did residential school students. This lead to the difference in scores seen in the two groups.

Length of training or schooling and grade placement may be important variables in speechreading. A high correlation was obtained by Kazanas and Susan (1972, cited in Berger 1972). But a low correlation was reported by Reid (1947) and Jackson, Montgomery and Binnie (1976). Larr (1956, cited in Berger 1972) found small, significant relationship between speechreading scores and educational achievement test. Educational achievement, grade placement and number of years in school would seem to be interdependent. Their relative importance to speechreading performance is not clear from evidence, but reported correlations are moderately high for the most part.

In one of the recent studies by Dancer et al., (1994), they found that there were no statistically significant effects of education on the speechreading scores. The study was conducted in a sample of 50 people, which consisted of higher than average socio economic individuals ranging in age from 20-69 and having no hearing or vision complaints. They probably obtained such findings because their subjects had minimal practice with speechreading.

Rather than kind of educational program, the child attends, it is probably the amount of training the child gets to practice speechreading that would affect the speechreading scores. Thus the kind of educational setup a person attends may affect the scores, that he/ she may obtain on a speechreading test, depending on the training programme of the school.

10) Synthetic and Analytic ability

Synthesis seems to be related to closure, which is the ability to perceive an incomplete figure movement as a whole. A synthetically oriented person lets his mind fill in the portions of the overall message that he does not clearly see. He makes use of greater linguistic cues when visual cues are insufficient for meaning (Jeffers and Barley, 1971).

The analytic person presumably sees all articulatory positions in detail and therefore cannot speechread readily. Conversational speech moves too rapidly and hence analytic speechreading may be inefficient (Erber, 1969). The first published study to investigate analysis and synthesis as it relates to speechreading was by Kitson (1915, cited in Berger, 1972) who compared the ranking of adult speech readers with their ranking on a sentence completion task. The correlation was 0.65. On the basis of a similar test, Gopfert (1923, cited in Berger, 1972) concluded that synthetic ability should be dominant for successful speechreading.

Simmons (1959) suggested that synthetic ability may be necessary for success in speechreading but that a satisfactory means of measuring it has yet to be found. Using adult hearing-impaired subjects, she studied significant the correlations one live and two-filmed speechreading tests with a picture completion test and a mutilated word test. A low correlation was obtained between these variables. The correlations between speechreading and fragmentary sentence test (r = 0.40 to 0.44) were significant at the 0.05 levels with the filmed tests but not significant (r=0.06) with the live test.

In order to assess synthetic abilities, Jackson et al., (1972) conducted a study which involved letter predication task. The subjects were given a keyword within a sentence and were asked to predict the letters of the remaining words. The correlation between the scores of the test and speechreading test score (r=0.42) was not statistically significant. Persons familiar on a conscious level with lie rules of a language seem to be able to predict succeeding letters and words of a message better than chance would allow. Again this ability may show a synthetic orientation.

Tatoul and Davidson (1961) divided a group of students with normal hearing into good and poor speechreading groups, as determined by a filmed test. These subjects were given twenty sentences, one by one, from another form of the same speechreading test and were told a key word within each of the sentences. The task was to predict the sentence, one letter at a time. Mean scores for the letter prediction task between good and poor speech readers were almost identical, the difference not being significant. The correlation between speechreading and letter prediction was 0.27.

Bode, Nerbonne and Sahlstrom (1970) reported a weak but statistically significant relationship (r=0.39) between speechreading and the completion of printed sentences distorted by the omission of every third letter.

Lyxell and Ronnberg (1986) indicated that skilled guessing in terms of sentence completion task performance proved to be critical for longer sentences to be speechread. Skilled guessing as measured by a word completion task proved to be critical for speechreading situations where a low level of contextual information was offered. The results of his study suggest that speechreading and guessing skill are related to each other and mat different types of guessing tests predict different aspects of the speechreading process. Speechreading in terms of guessing is not a unitary task. Hence, it should not be possible to make predictions from the result of the single guessing test to enable speechreading process.

In summary, attempts were made by most of the investigators to relate synthetic and analytic ability. They conclude perhaps synthetic ability is related to willingness to guess, good knowledge of linguistic rules, keen sense of observation of situational and other clues. It also seems possible that at the initial stages of speechreading, analysis is employed and but with progress in speechreading skill, synthesis becomes more important.

11) Rhythm and Pitch

Speechreading test do not mention that stress patterns for words of more than one syllable may supply visual cues, but it can be inferred that visual recognition of rhythmic patterns in phrases and sentences is possible (Ewing and Ewing, 1967). The normal hearing subjects reported that the task was difficult and they were unable to explain how they arrived at their decision. The responses made by subjects for both two syllable and three syllable words suggested that stress patterns were identified more often than by chance (Berger, 1972). Speech readers appear to be able to determine terminal pitch contour of sentences on better than a chance basis (Fischer, 1961, cited in Fischer 1968).

As it is clear from the review as to what factors is more influencing to speechreading skill, those factors can be taken into consideration while rehabilitation. The factors can be manipulated or modified if possible according to the individual needs. The speaker and environmental factor are the most difficult to be manipulated and is not practical in all situations. So the speech reader factors/ skills have to be modified accordingly.

It can be seen from the review that considerably more research has been done for some variables compared to the others. Greater research has been done for those variables that have been found to influence speech reading to a greater extent. These variables include:

- Distractions
- Rate of speech
- Visual memory
- Hearing loss
- Synthetic and analytic ability
- Intelligence

METHOD

The correlation between speechreading abilities and the following three variables was studied:

1. Visual perception of slow rate of speech
2. Visual memory
   a. for spoken digits
   b. for written digits
3. Intelligence

The study was carried out in two stages. These stages were as follows:

Stage I: Recording / developing of material for the study

Stage II: Evaluation of the subjects

Stage I: Recording / developing of material for the study

Two existing tests were recorded while one test was developed and later recorded.

The tests, which were recorded, are:

1. Baseline speechreading test material
2. Material for perception of slow rate of speech and
3. Material for spoken digit memory test.

The test, which was developed, is:

1. Digit memory test (spoken and written).

Recording of speechreading test material (normal rate and slow rate)

Material

For the baseline speechreading test, Form I of the" Speechreading test material for adults in Kannada" (Mahesh, 2000) was used. For the slow rate speechreading test, the Form II of the same test was used.

Form I had 24 words, 7 two-word phrases and 6 three-word sentences. Form II had 22 words, 7 two-word phrases and 6 three-word sentences (Appendix la and lb).

Environment

The recording was carried out in a distraction free, well-lit room. The foreground light was brighter than the background light.

Training of speaker

A female, native Kannada speaker with clear articulation, served as the speaker. She was given training to enunciate the material at a rate of 160-200 syllables per min for the baseline speechreading test and at a rate of 120-140 syllables per min for the slow rate of speech.

Procedure for video recording

The recording was carried out by a professional recordist. The recording was done such that the speaker's head and shoulders were focused. After saying each word/phrase/sentence, a constant inter-stimulus interval of 5 seconds was recorded for the words and 10 seconds each for the 2-word phrases and 3-word sentences.

Development and recording of the digit memory test

Two different procedures were developed to evaluate the digit memory. These included:

1. Memory for spoken digits
2. Memory for written digits

Material

For both the spoken and written the digit memory tests, digits between zero and nine were taken. The digits were selected using a random number table. Four lists of digits were taken. Table 2 gives the details regarding the number of test tokens test tokens used. The details of the material used for both the memory tests are given in the appendix 2a and 2b. Series refers to a group of tokens and tokens refer to the individual digits in the series. The easy tasks had lesser series while the difficult tasks had more number of series.

Table 2: Details regarding materials used for digit test.

List	Number of Series	Number of Tokens/Digits per series
1	2	2 (E.g. 8 5)
2	2	4 (E.g. 3 6 7 6)
3	10	6 (E.g. 9 4 10 5 8)
4	10	8 (E.g. 0 5 7 9 2 3 19)

Equipment

For the spoken digit test a professional quality video camera was used and for the written digit test, a personal computer was used (Pentium III).

Video Recording Procedure

Spoken digit Memory Test: For the spoken memory test, the digits were spoken clearly, in Kannada at a normal rate (160-200 syllable / min). The speaker spoke each digit separately (e g. The number 4326 was said as four, three, two, six). An interval of 5 seconds was given between series for list 1 and list 2 which had lesser number of digits. List 3 and 4 had an inter series interval of 10 seconds, as they had more number of digits. First list 1, then list 2, 3 and 4 were video recorded.

Written digit memory test: The computer software "Power Point" was used for recording this test. The digits were stored such that they could be displayed one after the other. "Times New Roman" font with font size of 20 was used. The numbers were displayed in black against a white background. The "Power Point" software was also used for presenting the material. Each digit was displayed for a duration of one second. The inter series interval was maintained the same as that of the spoken digit test.

Stage II: Procedure for Testing

This involved testing normal hearing subjects utilizing the test material developed for the following four tests:

1. Baseline speechreading test
2. Slow rate speechreading test
3. Digit memory test
4. Intelligence

Subjects

The study was carried out on 30 normal subjects (15 males & 15 females). The subjects had to satisfy the following criteria:

1. Have no history of speech and hearing problems or vision problem
2. Be fluent Kannada speakers
3. Be in the age range of 18-40 years
4. Have a minimum education level of 12th grade

Test procedure for baseline speechreading test and for perception of slow rate of speech

Environment

The recorded material was played in a quiet and well lit room. The audio output was cut off so that only visual clues were available to the speechreader. The speechreader sat at a distance of 6 feet from the monitor at 0 azimuth and the television was placed at the eye level of the speechreader.

Equipment

The recorded material was displayed through a 21 inch, colour television (BPL Sanyo colour TV) using a video (JVC-video cassette recorder-HR-D217 MS).

Procedure

After the presentation of each word / phrases / sentence the subjects repeated the material that they speechread. The responses were noted down by the tester and were scored as given in appendix 3.

Test procedure for visual memory

Environment: The environment was the same as that used for the speechreading test, except that for the written memory test, a computer was used and for the spoken memory test, a TV was used.

Written subtest: A series of digits were displayed one after the other. Each digit was presented for a duration of one second. First the 2 digit series then 4, 6 and finally 8 digit series was displayed.

Spoken subtest: The recorded material, where the speaker uttered the digit one after the other, was played. After each series the subject had to recall the digits in the particular series.

The scores differed from list to list as given in the appendix 4.

Test procedure for intelligence using visual based material

Intelligence was assessed using Ravens Progressive Matrices (standard) (Raven, 1958), which assessed IQ using the visual modality. The scoring was done as recommended in the manual.

The data thus obtained from the 30 subjects was tabulated and scored. This information was then subjected to statistical analysis.

RESULTS AND DISCUSSION

The objective of the present study was to find the correlation between speechreading and the following three variables:

1) Perception of slow rate of speech

2) Visual memory

   a) for written digits

   b) for spoken digits

3) Intelligence

To study the above, the data was subjected to the statistical procedures using the SPSS software. The mean, standard deviation and range of all the variables were found out. Pearsons coefficient correlation was done to check the correlation between:

1. The speechreading test score and perception of slow rate of speech
2. The speechreading test scores and visual memory for written and spoken digits
3. The speechreading test scores and intelligence
4. Perception of slow rate of speech and intelligence
5. Perception of slow rate of speech and written digit memory
6. Perception of slow rate of speech and spoken digit memory
7. Intelligence and written digit memory
8. Spoken digit memory and written digit memory

I. Correlation between Speechreading test score and perception of slow rate of speech

The Mean, Standard deviation and correlation coefficient were calculated for speechreading scores obtained when the speech was presented at the normal rate and at a slow rate (table 2). These values were obtained by combining the word, phrase and sentence subtest scores.

Table 3: *Mean, Standard deviation range and correlation between base line speechreading and perception of slow rate of speech.*

Variable	**Mean**	**Standard Deviation**	**Range**	**Correlation Coefficient (r)**	**Level of significance**
Speechreading (word + phrase + sentence subtest)	30.48	10.60	11-48		
Perception of slow rate (word + phrase + sentence subtest)	22.35	10.67	4-38	0.823	0.01

From table 3 it can be noticed that the mean scores of the baseline speechreading test were higher than that of the speechreading scores for the slow rate of speech. The standard deviation for both was not very different. The correlation coefficient values were significant at the 0.01 levels. The speechreading score of the slow rate had the highest correlation coefficient with the baseline speechreading scores when compared to the other variables (table 3).

Contrary to the studies reported in the literature the mean speechreading score of slow rate of speech was lesser than that of the normal rate. This was evident in the combined scores of the three subtests, as well as in each of the subtests. Studies done by Escalera and Davis (1977) and Hrehocik and Victor (1977) reported that the performance was better for slow rate of speech.

The low mean scores for the slow rate of speech might be because, during the slow rate of speech, the vowels are prolonged. The speechreader may have perceived the vowel prolongation as a different phoneme or as **a** pause. Thus one word may have been perceived as multiple words. In addition, it has been reported by van Uden (1960), that an exaggerated speech may not be easier to speechread than non-exaggerated speech, The slow rate of speech would be more exaggerated than the normal rate. This could be another reason as to why the subjects obtained poorer scores on the slow rate of speech.

There is also a possibility that slower speech was beyond the memory capacity of the subjects. Hence, they probably forgot the earlier articulatory movements by the end of the utterance.

In the present study a positive correlation was seen between the slow rate and the normal rate of presentation of speech. This was obtained for each of the subtests i.e. words, phrases and sentences (Table 3). Such a finding has also been reported by Frisina (1963).

Table 4: *Correlation coefficient matrix between the subtests of speechreading tests*

Variables	Baseline speech reading-Word subtest	Baseline speech reading-Phrase subtest	Baseline speech reading-Sentence subtest	Slow rate-Word subtest	Slow rate-Phrase subtest	Slow rate-Sentence subtest
Baseline speechreading -Word subtest	1	0.542**	0.759**	0.823**	0.660**	0.650**
Baseline speechreading - Phrase subtest		1	0.655**	0.523**	0.324*	0.605**
Baseline speechreading - Sentence subtest			1	0.727**	0.635**	0.798**
Slow rate - Word subtest				1	0.494**	0.664**
Slow rate - Phrase subtest					1	0.594**
Slow rate - Sentence subtest						1

** Significantly correlated at 0.01 level of significance

* Significantly correlated at 0.05 level of significance

The results show that there is a significant positive correlation between all the subtests at the 0.01 level of significance except for the phrase subtests for the two rates of speech. The latter was significant at the 0.05 level.

2. Speechreading test and visual memory test for written and printed digits

Table 5: *Mean, Standard deviation, range and correlation between baseline speechreading and visual memory*

Variable	**Mean**	**Standard Deviation**	**Range**	**Correlation Coefficient (r)**	**Level of significance**
Baseline speechreading test	30.48	10.60	11-48		
Visual memory					
a. Written	146.63	8.28	123.5-152	0.559	0.01
b. Spoken	103.98	14.69	80-128.5	0.507	0.01

The mean scores for the written digit memory were much greater than the spoken subsection. This finding is to be expected since the subjects were more familiar reading print material when compared to speechreading. Hence the former would have been more easily recognized and recalled than the latter.

The digit memory scores significantly co-related at the 0.01 level with the base line speechreading scores. This correlation was higher for the written memory test when compared to the spoken memory test. The study done by Costello (1957, cited in Jeffers and Barley, 1971) supports the results of the present study for both spoken and written digit tests. They obtained a positive correlation coefficient between speechreading and written and spoken digit memory tests. On the contrary O'Neill and Davidson, (1956) found a low and non-significant correlation between the two. This could be on account of the variation in the method of their study. In the present study and study done by Costello (1957, cited in Jeffers and Barley, 1971), the digits were displayed for one second whereas in the latter study the display time was only 0.1 second. This was too short a period for the subjects to perceive what was displayed.

The finding of the present study clearly indicate that the individuals who have good visual memory for digits, were good speech readers, while those with a poorer visual memory for digits were poor speech readers. Hence, one way to improve speechreading ability of an individual is to improve their visual memory for digits. It could be improvement of written or spoken digits.

3. Speechreading test and intelligence

Table 6: *Mean, Standard deviation, range and correlation between intelligence and speechreading scores*

Variable	**Mean**	**Standard Deviation**	**Range**	**Correlation Coefficient (r)**	**Level of significance**
Speechreading scores	30.48	10.60	11-48		
Intelligence (Raw score) Maximum score = 60	50.03	9.2	25-59	0.696	0.01

Except for four of the subjects all the subjects had average or above average scores. The coefficient co-relation value was significant at the 0.01 level. This is consistent with the previous studies by Craig (1964) and Evans (1960). They also found a small, but significant correlation between the two variables.

4. Correlation between the dependent variables

The correlations between the dependent variables were statistically analyzed and the results are given in table 7.

Table 7: Correlation between the dependent variables

Between dependent variables	**Correlation coefficient**	**Level of significance**
Perception of slow rate of speech and intelligence	0.804**	0.01
Perception of slow rate of speech and written digit memory	0.724**	0.01
Perception of slow rate of speech and spoken digit memory	0.614**	0.01
Intelligence and written digit memory	0.858**	0.01
Intelligence and spoken digit memory	0.746**	0.01
Written digit memory and spoken digit memory	0.820**	0.01

** Significantly correlated at 0.01 level of significance

Table 7 shows that all the dependent variables are correlated with each other significantly at the 0.01 level. The correlation coefficient was the highest between intelligence and written digit memory followed by spoken and written digit memory. The variables with least correlation coefficient variables were perception of slow rate of speech and spoken digit memory. Though the correlation coefficient was the least it was significant at the 0.0l level.

From the present study can be concluded that:

1. There is a statistically significant positive correlation between speechreading and the three dependent variables taken for the study (Perception of slow rate of speech, written and spoken digit memory, intelligence)
2. The dependent variables significantly correlate with each other.
3. The mean speechreading scores for the normal rate of speech was better than that of the slow rate of speech.

4. The mean scores of spoken digit memory was poorer than the written digit memory scores.

The implications of the findings are that in order to improve speechreading skills the person could be given training to improve any one of the following skills:

a. Memory for written digit
b. Memory for speechread digits or
c. Visual identification of patterns as tested in Raven progressive matrices (standard), Raven (1958).

SUMMARY AND CONCLUSION

Speechreading is a mental activity by which the speech of other people can be understood when the words can be seen but not heard (Ewing, 1967). As the hearing impairment becomes more severe, vision gradually emerges as the lead receptive sense, while audition becomes of less value (Berger, 1972). Hence the area of speechreading is important in aural rehabilitation. Even in the present day it is accepted that speechreading is required in adverse listening conditions with or without amplification devices (Lyxell et al., 1993; Goh et al., 2001).

The aim of the present study was to find the correlation between speechreading and the following three variables: perception of slow rate of speech, digit memory and intelligence. Thirty normal hearing subject were taken and the speechreading tests (baseline and slow rate) were carried out. The digit memory test was carried out for written and spoken digits. Intelligence test was carried out using Ravens progressive matrices (standard). The data thus collected was subjected to statistical analysis. The results indicated that there was a positive significant correlation between the following variables:

4 Speechreading and
   1. Perception of slow rate of speech
   2. Visual memory for written and spoken digits
   3. Intelligence

4 Perception of slow rate of speech and
   1. Intelligence
   2. Written and spoken digit memory

4 Intelligence and written and spoken digit memory

4 Spoken digit memory and written digit memory

It can be concluded from the findings of the study that by improving these variables, the speechreading ability of a person would also improve.

From the present study it can be implied that in order to improve speechreading skills, training can be given in the following skills, which in turn would improve the speechreading skills.

a. Written digit memory
b. Memory for speechread digits
c. Visual identification of patterns

Recommendations for further research

a. To find the correlation between other variables significant to rehabilitation and speechreading.
b. To apply the results of the study in rehabilitation of hearing impaired and find the effect.
c. The correlation between the variables can be checked in hearing impaired population and results can be compared to see if it is the same as in normals.

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APPENDIX-1a

Baseline speech reading test-materials and score

Words	Score	2 Word phrases	Score	3 Word sentences	Score
/pat̥t̥i/	2	/ba:gilu mutʃid̪əru/	2	/həsu ha:lu kod̥ut̪ad̪e/	3
/bassu/	2	/hud̥uga bərut̪a:ne/	2	/mane t̪umba d̪u:rəvid̪e/	3
/mara/	2	/məgu dza:rit̪u/	2	/na:nu bəssinalli ho:d̪enu/	3
/vima:na/	3	/pa:pu al̥ut̪id̪e/	2	/kempu gula:bi aral̥id̪e/	3
/va:ra/	2	/na:vu no:d̥id̪evu/	2	/avəru u:t̥a ma:d̥id̪əru/	3
/vaja ssu/	2	/ʃa:ləge hɔrətəru/	2	/ivat̪t̪u ʃa:ləge radza/	3
/t̪a:vare/	1	/ko:ḷi sigəlilla/	2		
/t̪a:ji/	1				
/ut̪t̪ara/	2				
/kət̪t̪ari/	3				
/t̪a:t̪a/	1				
/d̪ina/	2				
/d̪o:n̥i/	2				
/d̪a:ri/	2				
/ga:d̪e/	2				
/d̪e:ʃa/	2				
/ka:d̥u/	1				
/ka:rən̥a/	3				
/nagu/	1				
/na:l̥ige/	3				
/la:ri/	2				
/ləntʃa/	2				
/dza:ga/	2				
/kod̥u/	1				
Total	46		14		18

FORM-I (MAHESH, 200a)

APPENDIX-1b

Perception of slow rate of speech-material and score

Words	Score	2 Word phrases	Score	3 Word sentences	Score
/pəd̪a/	2	/dzənaru nint̪əru/	2	/illi ni:ru baut̪ad̪e/	3
/ba:vut̥a/	3	/railu ud̪d̪avid̪e/	2	/namma de:ʃa bha:rəta/	3
/matt̪u/	2	/upəd̪e:ʃa ma:d̥id̪ ru/	2	/hud̥uga ivət̪u band̪ənu/	3
/manəsu/	3	/tʃa:ku harit̪əvid̪e/	2	/kəradi dzeinannu t̪ind̪it̪t̪u/	3
/vid̪e:ʃa /	3	/batte suttid̪e/	2	/kappu to:pi me:lid̪e/	3
/vi:n̥e/	2	/mane no:d̥id̪enu/	2	/tʃinned̪a sara ha:kidd̪a:re/	3
/t̪a:vəre/	1	/auʃəd̪i t̪and̪aru/	2		
/t̪a:rikʰu/	2				
/t̪i:ra/	2				
/hatt̪u/	1				
/sund̪əra/	2				
/ka:gəd̪a/	3				
/idd̪a:re/	2				
/nod̥u/	2				
/tʃinna/	2				
/dzəna/	1				
/ni:li/	2				
/kel̥əsa/	2				
/dzanaru/	2				
/ro:ga/	2				
/ka:ru/	2				
/gaja/	1				
Total	44		14		18

FORM-II (MAHESH,2000)

APPENDIX-2a

Material used for the written digit memory test

List	Number of series	Number of tokens	Digit / Token Sequence
1	2	2	5 8 7 2
2	2	4	6 3 6 7 4 5 2 0
3	10	6	7 9 2 4 8 6 8 1 6 3 5 2 0 5 8 9 4 1 9 2 9 0 5 3 4 7 8 0 9 7 80 12 16 4 2 6 0 9 5 0 9 7 1 3 8 6 9 2 7 9 7 7 1 4 0 9 1
4	10	8	9 0 3 5 0 5 3 7 14 1 7 0 5 7 9 2 7 1 9 5 3 4 0 34 1 2 4 7 9 3 8 9 7 6 1 8 9 2 2 3 1 9 5 2 8 7 6 9 0 7 5 6 7 0 4 7 8 0 9 2 8 7 6 2 4 0 8 7 9 1 5 2 8 7 3 5 0 4

APPENDIX-2b

Material used for the spoken digit memory test

List	Number of series	**Number of tokens**	**Digit / Token Sequence**
1	2	2	8 5 7 2
2	2	4	3 6 7 6 2 0 5 4
3	10	6	4 8 2 9 7 6 9 4 1 0 5 8 0 5 3 9 2 9 8 0 9 7 4 7 2 1 6 8 0 1 6 0 9 5 4 2 7 1 3 8 0 9 2 7 9 6 9 7 9 1 7 1 4 0 6 3 5 2 8 1
4	10	8	5 0 5 3 7 0 3 9 0 5 7 9 1 4 1 7 5 3 4 0 2 7 1 9 7 9 3 3 4 1 2 4 6 1 8 9 2 8 9 7 7 5 6 7 0 6 9 0 9 2 8 7 4 7 8 0 8 7 9 1 6 2 4 0 3 5 0 4 5 2 8 7 0 5 7 9 2 3 1 9

APPENDIX-3

Scoring for baseline and perception of slow rate of speech response

Sl.no	Response	Score
1	Correct repetition of the utterance	1
2	Correct repetition after second presentation of the utterance	0.5
3	In correct response even after second presentation	0

APPENDIX-4

Scoring for the digit memory test (written and spoken)

List	**Maximum points**	**Points given for each token**	**Points given for correct sequence of token**
1	**2**	**0.5**	**0.5**
2	**4**	**0.5**	**0.5**
3	**6**	**0.5**	**0.5**
4	**8**	**0.5**	**0.5**