TEMPORARY THRESHOLD SHIFT AND EFFERENT ACTION*

P. K. SlNHA

Pratt et. al., (1978) have shown that if the TTS in a subject is about 20 dB reduced synaptic efficacy' may be responsible for the TTS and that the dysfunction of the hair cells may be ruled out. Their conclusion was based on the fact that they did not observe reduction in cochlear microphonic although there was TTS of about 20 dB.

Cody and Johnstone (1982) have established that the action of the efferent system innervating the outer hair cells increases the sensitivity of the auditory neurons. The increase in the AP (action potential) response during bilateral stimulation (i. e., in presence of efferent action) may be explained in terms of recycling of the released neuro-transmitter (Fex et. al., 1982).

Vyasamurthy (1982, 1985) has reported that the ESIOHCs (Efferent System Innervating the Outer Hair Cells) may be responsible for ' loudness gain' during adaptation. He has cited the studies by the following, in support of it: Spoendlin, (1975), Cody and Johnstone (1982), Gerken (1984), Fex, et. al., (1982), Comis and Whitfield (1968), Hoffmann, et al (1983), Rickles (1982), Stopp, et., al. (1983).

The present study was aimed at investigation (i) whether the ESIOHCs increases the sensitivity of the auditory neurons in human subjects as Cody and Johnstone (1982) have reported, (ii) whether the efferent action has any role in changing the temporary dysfunction of hair cells caused by fatiguing stimulus.

The Beltone—200c audiometer with TDH-39 earphone and MX-41/AR Circumaural cushion, calibrated according to the specifications, given by ANSI 1969 was used for the study. Twenty one males and ten females normal subjects in age ranging from 17 years to 25 years were used in this study. Subjects were divided into 3 groups viz. A, B, C. A, B and C groups had 17, 7 and 7 subjects respectively. Experiments I and II were carried out using group A; Experiments

---

* An excerpt from the Master's Thesis, University of Mysore, 1986.

III and IV were carried out using group B and Experiments V and VI were carried out using group C. TTSo, TTS_2 was determined in all experiments.

The results of the present study show that comparison of TTSo obtained in experiments I and II with the TTSo values obtained in experiments III and IV are greater. This shows that the high frequency fatiguing stimulus produces more TTS than a relatively low frequency stimulus (i. e., 4 KHz stimulus produced more TTS than 2 KHz stimulus).

Comparison of TTSo values obtained in experiments III and IV with the TTSo values obtained in experiments V and VI shows (see the table) that there is significant difference between the TTSo values obtained in experiments V and VI, whereas there is no difference between TTSo values obtained in experiments III and IV. These results can be explained in terms of efferent action.

Pratt et al (1978) have reported that TTS of 20 dB in normal hearing subjects may be due to ' reduced synaptic efficacy '. TTSo of experiment VI was significantly less than TTSo of experiment V i.e., in the presence of contralateral / stimulation (efferent action—See Cody and Johnstone, 1982) the TTS obtained was less. In other words in experiment VI there was efferent action (due to contralateral stimulation) and there was no efferent action in experiment-V (monaural stimulation). From the results of the present study (especially the results of experiment V and VI) it is clear that due to efferent action the TTS reduces. This is in agreement with the findings of Cody and Johnstone (1982). Cody and Johnstone (1982) have established that the TTS reduces in the presence of contralateral stimulation.

Regarding the mechanism of efferent action reducing the TTS, it is quite probable that the efferent action increases the synaptic efficacy, as a result, the TTS reduces. The same explanation may hold good in the study reported by Cody and Johnstone (1982). Thus the explanation for the reduction in TTS, in experiment VI, is likely due to increase in the synaptic efficacy as a result of efferent action.

The failure to observe reduction in TTSo experiment IV (when campared to experiment III) may be due to temporary dysfunction of hair cells. Actually the present study shows more TTS in experiments III and IV than in experiments V and VI- Since dysfunction of the hair cells is responsible for TTS observed in experiments III and IV, the efferent action (which mainly changes the synaptic efficacy) might not have been effective in reducing the TTS.

Thus, it can be concluded that the efferent action changes the synaptic efficacy without bringing much changes in the dysfunction of hair cells.

TABLE

Experimental Paradigms.

cxpt	Ipsilateral exposure	Contralateral exposure	Mean TTS in dB	
			TTSo	TTS_2
I	4 KHz 110dBHL D-10'		40.29 (7.89)	29.85 (11.36)
II	4 KHz 110 dBHL D = 10'	4 KHz 80 dBHL D = 10'	39.36 (8.42)	30.14 (10.40)
III	2 KHz 100 dBHL D-10'		36.42 (8.01)	29.28 (7.31)
IV	2 KHz 100 dBHL D-10'	2 KHz 80 dBHL D-10'	35.71 (6.72)	25.00 (8.16)
V	2 KHz 100 dBHL D=5'		23.57 (5.56)	15.00 (5)
VI	2 KHz 100 dBHL D=5'	2 KHz 80 dBHL D=5'	16.42 (2.44)	12.14 (2.67)

Note: (i) Figures in parenthesis indicate standard deviation.
(ii) D indicates duration of exposure in minutes.

REFERENCES

Cody, A. R., Johnstone, B. M., (1982)—Temporary Threshold shift modified by Binaural Accoustic Stimulation, *Hearing Res.* 6, 199-205.

Pratt, H., Sohmer, H. and Barazani, N. (1978)—Surface recorded cochlear microphonic potentials during temporary threshold shifts in man. Audiology, 17, 204-212.

Vyasamurthy, M. N., (1982)—Loudness residual monaural loudness adaptation—a new concept Ph.D., Thesis, University of Mysore.

Vyasamurthy, M. N., (1985)—Models of the efferent mechanisms during auditory adaptation paper presented at the symposium on " Mechanisms of the efferent auditory system " held at Bombay.

EAR PROTECTIVE DEVICES — THE STATE OF THE ART

GEETHA MUKUNDAN & MALINI, M. S.*

ABSTRACT

In this paper, an attempt is made to describe the various types of ear protective devices and to discus their merits and demerits. The methods of evaluating the effectiveness of ear protective devices are also described. Suggestions are given for moiivating the workers to use these devices.*

Industrialization has brought in its wake the spectre of noise pollution along with other hazards. The adverse effects of noise on the human system have been well documented. Less known is its subtle but far ranging impact on the hearing mechanism. Irreversible sensorineural hearing loss is the premium exacted for prolonged exposure to this pollutant.

As the long run economics of safeguarding the health of industry's power horse—the workers—became apparent, attention focussed on the problem of controlling the runaway monster. Methods of reducing generation of machinery noise as well as cutting it down in the transmission path were introduced. The notion of using devices to protect the ear took birth when, despite the above measures, noise levels continued to pose a threat to hearing health.

Ear protective devices (EPDs) of various types inundate the market today. The search continues for the perfect device—one that would provide good attenuation, comfortable wear and yet not interfere with speech communication. A review of the types of EPDs available, their merits and demerits, procedures used in the measurement of attenuation properties and the utility of EPDs under actual working conditions forms the theme of the present paper.

Types of Ear Protective Devices :

EPDs can be classed into two main categories, namely ear muffs and ear inserts.

• AIISH, Mysore.

Ear Muffs:

They are plastic domes that encircle ears and are connected by a head-band. The band is generally adjustable so as to accommodate varying head size and ear positions. Cushions filled with air, foam or liquid are attached to the side where they contact the head.

Lining the domes with opencell foam facilitates further sound absorption and damping. It has been observed that the size of the enclosed volume within the dome is directly related to low frequency attenuation. If maximum protection is required, the domes must be formed by rigid, dense, imperforate material. The seals should have a small circumference so that acoustic seal takes place over the smallest possible irregularities in head contour. This would ensure that leaks caused by jaw and neck movements are minimal. The force applied by the connecting headband has a direct bearing on the amount of protection provided. Compromise must be made in selecting the suspension force on the basis of performance versus comfort.

The mean attenuation values for ear muffs for puretones (125-8000Hz) was, found to range from 8.2 to 29.3dB (NAL, 1979).

Advantages :

1. Protection provided is generally greater and less variable between wearers.
2. A Single size usually fits a large percentage of wearers.
3. They can be readily seen at a distance. Hence the wearing of such protectors is easily monitored.
4. They are more acceptable at the beginning of a hearing conservation program.
5. They can be used on collapsed ears or ears with minor infections.
6. They are less likely to be misplaced or lost.
7. Employees with deformed or missing digits would find them easier to use.
8. They are longer lasting if parts can be replaced.

Disadvantages :

1. In hot environments, they are uncomfortable.
2. They are not easily stored or carried.
3. They are not compatible with other personally worn items such a eyeglasses, head gear, ear rings etc.,

4. Muff suspension force may reduce with usage so that protection afforded would be curtailed.

5. Such devices would interfere where the head must be manoeuvred in close quarters.

6 They are more expensive than other EPDs.

Inserts :

Insert or plug type protectors fit directly into the ear canal. To ensure proper fit, contact must be made along the entire circumference of the canal walls.

The mean attenuation afforded by inserts for pure tones in the frequency range 100 to 10,000 Hz was found to fall between 7.3 to 21.9dB (NAL, 1979).

Inserts are generally available in four varieties.

(i) Premolded :

There are three configurations commonly used. V51-R is suitable for most canals except those that are very straight and round. On the other hand, the bullet shaped design is best suited for such ear canals. Premolded universal design is manufactured with two or more flanges on the stem. All three are available in different sizes.

(ii) Custom molded :

They are made by mixing silicone material with a fixative agent and inserting into the ear canal and outer ear. The impression is then cured to obtain a permanent custom fit for each ear. Alternatively, an ear impression is first made using special material. After processing, a product of hard plastic is obtained.

Both of thess are more expensive than the premolded variety. However, they have a longer service life.

(iii) Malleable ear plugs :

These protectors are manufactured using material such as cotton, glasswool, wax, sponge rubber, spun glass or moldable silicone. The size and shape of the ear canal does not cause problems with fitting. Such ear plugs are typically made by introducing a small cone of the material into the ear canal with sufficient force so that it takes up the shape of the ear canal and holds itself in position. The use of non-porous material for plugs provides attenuation values approximating those of the molded varieties. However, since clean hands must be employed in forming and inserting the material, they are a poor choice for use in dirty areas.

Further, they can be used only two to three times. They may therefore prove more expensive in the long run.

(iv) Superaural (Canal Caps) :

Rubber caps suspended by a spring headband are inserted into the ear canals. Sound attenuation is achieved by sealing the opening of the ear canal- Although size is not a problem here, it is difficult for inspectors to judge whether they are properly worn.

Advantages :

1. They are better accepted for use in hot, humid workshops.
2. Storing and carrying them around is not cumbersome.
3. Less expensive when compared to earmuffs.
4. They donot interfere with the wearing of glasses, hats etc.
5. Keeping them clean is not a problem.
6. Wearing them would not hinder work where the head must be manoeuvred at close quarters.

Disadvantages :

1. Premolded plugs require a tight seal of ear canal, in order to be effective.
2. Use of these devices is difficult to monitor by safety personnel.
3. Some amount of manual dexterity is required for insertion.
4. Sizing of each ear is required.
5. If not replaced regularly, they become hard or may shrink.
6. They need to be reseated frequently.

The selection of EPDs is influenced by several parameters. Prime consideration, however, is directed to the aspect of attenuation characteristics. Some of the measurement and rating procedures are discussed here.

Measuring Hearing Protector Attenuation :

Absolute threshold shift procedure : This is the most commonly used method for measuring the attenuation offered by ear protectors. Almost all manufacturers data on such devices is derived by this method. Essentially, the procedure; involves determination of the minimum level of a sound that a listener can hear

TABLE 1

Comparision of various ear protective devices.

	CIRCUM AURAL	PREMOLDED	SELF MOLDED	CUSTOM MOLDED	CANAL CAPS
Attenuation	Good	Fair	Good for nonporous material	Good	Good
Economy	Expensive	Not Expensive	Expensive in the long run	Expensive	Expensive
Operation	Easy to use	Requires dexterity	Requires dexterity	Easy to insert	Easy to use
Durability	Long lasting as parts can be replaced	Hardens & Shrinks	Hardens	May harden	
Monitoring	Easy	Difficult	Difficult	Difficult	Easy
Best spot for use	Where movement of head in close quarters is not required	Any	Steady noise environment	Any	Intermittent low noise levels
Poor choice in	Hot, humid environment		Dirty environment		
Compatibility with other personally worn items	Poor	Good	Good	Good	Fair
Reseating required	No	Yes	No	No	Yes

Without an EPD (Open threshold) and with an EPD in place (Occluded threshold). The difference between the two thresholds is an index of the attenuation provided *by* the protector.

Description of the threshold shift techniques of evaluating EPDs is provided by two American National Standards. Testing of ten subjects, three times each, at nine different frequencies is required by both.

The ANSI (1957) technique was discarded as the impropriety of using pure tone in a directional field was recognized. The later ANSI standard (S3. 19-1974) specified the use of rd octave bands of noise, presented in a uniform diffuse sound field. Such testing was thought to more closely approximate typical industrial noise environment.

Single Number Ratings : Laboratory reports on the attenuation afforded by an EPD provided information pertaining to the mean attenuation and standard deviations at each frequency. While such data does allow comparison between protectors at each frequency, they do not facilitate direct determination of the total effectiveness of one device as compared to another. Reduction of this data to a single number rating therefore could provide a simple and effective means of choosing EPDs and assessing their utility for particular applications.

Many single number descriptors have been proposed over the last decade. The Noise Reduction Rating (NRR) is the current single number rating proposed by the Environmental protection Agency. The NRR is the difference between the overall C-weighted sound level of a pink noise spectrum and the resulting A-weighted noise levels under the protectors. Using data provided by Zwislocki (1957 cited by Berger 1979) on bone conduction thresholds, it was possible to determine that the maximum theoretical NRR possible is 45. The highest NRR ever measured on an EPD is 35.

A laboratory round robin experiment on EPDs organized by the Environmental Protection Agency (cited by Berger 1979) demonstrated significant interlaboratory variation in results of NRR tests of hearing protectors. It was there fore suggested that rank ordering performances of EPDs should not be attempted unless all the data are collected from one laboratory.

Indian Standards :

The Indian Standards (1979) specify that the material used in constructing EPDs should not cause irritation and should be resistant to heat, skin oil and wax. They should be both moisture and cold proof. Further, certain tests are necessary including damp heat, rapid change of temperature test, low air pressure test, low temperature impact test, cleanability test, salt mist test and headband extension test. The acceptable minimum sound attenuation for earmuffs are 25 dB at 500Hz and 35 dB at 1000, 2000, 3000 and 4000 Hz. For plugs, a minimum sound attenuation of 20 dB at 500 Hz and 25 dB at 1000, 2000, 3000 and 4000 Hz is specified. Manufacturers are required to supply information with regard to sound attenuation, test tension, overall mass, temperature range, low pressure sensitivity and instruction for use and cleaning.

The measurement procedure for EPDs as specified by Indian Standards is similar to the ANSI standard described earlier.

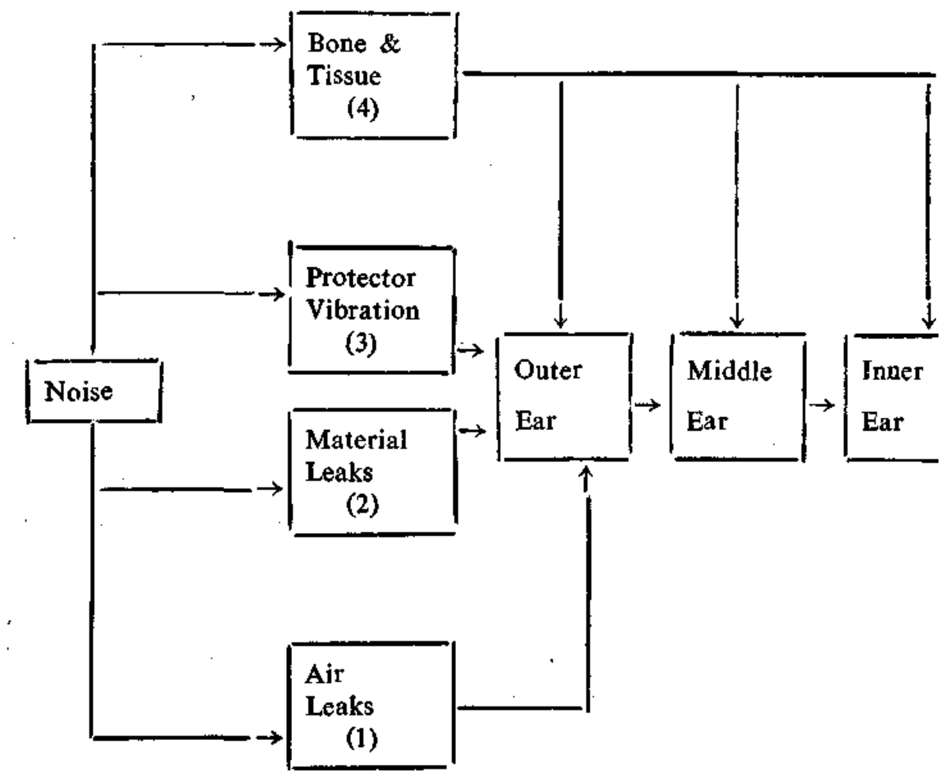

Fig. 1
Noise Pathways to the inner ear (Ref. : Sataloff & Michael, 1973)

Performance of Protective Device in Real World :

Most of the data on EPDs emerged from laboratory studies on well motivated trained subjects using optimal fitting protectors. However, such data obviously do not hold good for individuals working at industrial sites unless modelled after actual usage conditions. An attempt along these lines was made by NAL (cited by Berger 1979a). Their subjects were only provided with the manufacturer's data and very little supervision. The absolute threshold shift procedure (ANSI-24-22) was adopted. Results indicated lower means attenuation values and higher standard deviations than the data supplied by the manufacturers. This contention is further supported by other studies (Edwards et. al., 1978 ; Regan, 1975 ; Padilla, 1976 cited by Berger 1980b) which show that in-field attenuation is only 40-60% of dB values provided by the manufacturers.

When an EPD is carefully fitted and adjusted on a laboratory subject, air leaks will be substantially reduced. Paths 2, 3 and would constitute the primary sound transmitting paths (Fig. 1). In contrast, under actual conditions Path-1 transmission through air leaks, often takes precedence. Air leaks result when plugs do not fit properly or muffs do not seal properly against the head.

Some of the causes of poor EPD sealing are :

1. Comfort and Fit:

Inserts must fit snugly in ear canals and muffs in tight contact with the side of the head. In general, the better the fit, the poorer the comfort. While some individuals adapt, other do not. Therefore, it is important to select several EPDs from the more comfortable ones and to allow the employees to make the final choice.

***2.* Utilization** :

User problems such as discomfort, poor motivation or inadequate training may lead to earplugs not being properly inserted or muffs not being well adjusted.

3. Readjustments :

Ear protectors that work loose or are jarred out of position during work are commonly encountered problems. Employees typically talk, eat and move about actively resulting in jaw motion and perspiration.

4. Compatibility :

The suitability of EPDs vary across different ear canal and head shapes. Some ear canals and head contours defy all attempts to be fitted with EPDs.

5. Deterioration :

EPDs wear out with use. Some may shrink or harden ; flanges can break off and plugs may crack. It must be borne in mind that ear canals too gradually change in shape with time, leading to poor seal. Earmuffs headbands may lose

Research & Development:

Research must be directed to several areas. EPDs suited to specific set ups need to be devised. Manufacturers should be encouraged to develop a variety of EPDs that would cater to the needs of the Indian population. Managements must be made aware of the importance of trying different sizes of inserts for the two ears and of using a combination of EPDs. in certain workspots and of periodic-reissue of EPDs.

To conclude, ear protectors play a pivotal role in hearing conservation.

REFERENCES

1. Berger, E. H. The threshold shift method for measuring hearing protector attenuation. *E. A. R. Log* 1 (1979a)

2. Berger, E. H., Single number measures of hearing protector noise reduction. *E. A. R, Log* 2 (1979b)

3. Berger, E. H., Effects of hearing ptotectors on auditory communication. *E A. R. Log* 3 (1980a)

4. Berger, E. H., The performance of hearing protection in industrial noise environments *E. A. R. Log* 4 (1980b)

5. Berger, E. H., Hearing protector performance : How they work and what goes wrong in the real world. *E. A. R. Log* 5 (1980c)

6. Is 9167-1979. *Specifications for Ear Protectors.* Indian standards institution (1980)

7. Sataloff, J. and Michael, P. *Hearing conservation.* Charles C. Thomas Publishers (1973).

8. Vasallo, L. and Sataloff, J. Procedures in hearing measurements and[3] protection, in D. M. Lipscomb and A. L. Taylor (Ed.) *Noise Control: Handbook of Principles and Practices.* Van Nostrand Reinhold Co. (1978).

REPEATED REFLEX DECAY TESTING*

RAJENDRA KUMAR KOUL *

The present study was designed to find the susceptibility of normal hearing listeners to noise induced hearing loss (permanent threshold shift). This " Repeated reflex decay testing" is among the objective indices of susceptibility to auditory fatigue and can be considered as a more reliable measure than psycho-acoustic tests for susceptibility to noise induced hearing loss.

The present study was designed to investigate whether there is any relationship between the reflex decay for repeated stimulus presentations and magnitude of acoustic reflex.

Also the present study was designed to have information regarding the frequency of the stimulus eliciting the reflex and the decaying process.

This study was carried out in a sound treated room at All India Institute of Speech and Hearing, Mysore. Twenty three (12 females and 11 males) normal hearing subjects were tested. The subjects were divided into four groups to measure their "Repeated Reflex Decay" at four different sensation levels and at four different frequencies. Madson ZO 17 Immittance Audiometer was used. The experimental testing was carried in two stages.

Stage—I : The acoustic reflex thresholds (contralateral stimulation) using T & R setting of the instrument were measured.

Further, "Repeated Reflex Decay" was observed at single frequencies by presenting the acoustic stimulus repeatedly (five presentations). Selection of the frequencies for any experimental session was random. Two frequencies were selected for one experimental session and two for another experimental session. This was done to control the interactive effect of different frequencies so that decaying process at any one frequency does not affect the decay at another frequency.

* An excerpt from the Masters Thesis, University of Mysore, 1986

their tension while the cushions may harden and crack. Therefore, it is important to inspect and reissue EPDs regularly, i.e., 2-12 times/year.

6. Abuses :

Employees have been known to tamper with their EPDs in an attempt to relieve discomfort. Springing headbands to reduce tension, cutting flanges of ear inserts, drilling holes through plugs or muffs are often resorted to at the cost of protection.

7. Speech Communication :

A Common misconception on the part of EPD users is that communication is adversely affected by the use of EPDs. However, research in this area demonstrates that this contention may hold good only at low levels. At moderately high levels EPDs do not have a significant effect on speech discrimination. Further, at high levels—exceeding 85 dBA—EPDs actually improve speech discrimination for normal hearing individuals. As use of EPDs is usually prescribed only when noise levels exceed 85 dB, the wearer should not have difficulty in listening to speech.

These problems explain why the real world attenuation of EPDs is much lower than laboratory data would indicate. As such lapses could result in heavy repurcussions on the health and safety of personnel, it is obvious that avenues must be sought to encourage employees to utilize their EPDs effectively.

Motivating Employees :

Educating employees on the importance of protecting their ears could be achieved through films, pamphlets, posters, slogans and lectures. Compulsory training in proper insertion and maintenance of ear protectors could be prescribed for all new recruits. The management could mark off ' danger zones ' prominently making it mandatory that EPDs be worn in such areas. Surprise checks by safety personnel would be a good tactic. Punitive measures, in steps, may be introduced when rules are flouted—first a verbal warning, followed by a written warning, then a brief suspension with loss of pay, etc., At the time of annual or biannual hearing evaluation, those employees whose EPDs are in good condition and whose hearing thresholds have remained in the same range should be given incentives. Installation of self-monitored listening devices at the entrance to the workspot would serve as another motivational technique. Employees should be encouraged to subject themselves to the test in the morning prior to work and in the evening before leaving. The tone which was audible in the morning but not after provides evidence that the day's noise exposure has taken its toll.

Stage—II: **It** consisted of procedure to determine the average magnitude of the acoustic reflex at 2 KHz in subjects selected from 15 dBSL and 20 dBSL groups.

The following conclusions have been drawn :

1) The subjects who showed " Repeated Reflex Decay " also showed greater magnitude of acoustic reflex and the subjects who did not show reflex decay showed less magnitude of acoustic reflex.

2) Anne Zachariah (1980) concluded that subjects who show greater magnitude of reflex are susceptible to noise induced hearing loss. Since the subjects who show greater magnitude of reflex also show decay for repeated reflex decay test, it may be concluded that the subjects who show decay for repeated test can be considered susceptible to noise induced hearing loss.

3) Repeated reflex decay is greater at high frequencies that at low frequencies, indicating that reflex decay is a frequency dependent phenomenon.

4) Greater amount of " Repeated Reflex Decay " is obtained at higher sensation level than at lower sensation levels.

COMMUNICATIVE DISORDERS IN SOME MINORITY PRESCHOOL AND SCHOOL-AGE CHILDREN IN U. S. A.

JAMES MONROB STEWART*

ABSRACT

The specific purposes of this study were to survey and to determine the number and prevalence of communicative disorders in a metropolitan, minority-based, comprehensive health-care facility. The rationales were •developed from the limited and/or lack of accurate data on medical facilities, language disorders, and preschool children. The methodology included surveying the records for children referred Jor speech-language and audiological evaluations during the five-year calendar period 1973 through 1977. The results revealed that 3,827 children were seen for evaluation ; of this number 38'5% were diagnosed with communicative disorders. The distribution of the hearing, speech, language and learning disabilities was 63'6, 21-9, 10-9 and 4-3% respectively ; the population prevalences were 4-88, 1-63, 0-84 and 0-33% respectively, totaling 7-7%. The distribution for the preschool, elementary and Junior-Senior high groups was 39'2, 38-9 and 21-9% respectively; the population prevalence were 3'02, 3'00 and 1'68% respectively. The male-female ratios in the population and for the disorders were both 1'2: 1, indicating no differences Other specific results and implications were discussed.

The present study reports on a survey of the types and prevalences of communicative disorders seen at a comprehensive health-care facility. The rationales for the study lie in the renewed professional interest in prevalence estimates referred to by Bensburg and Sigelman (1976) and in the need for more current and accurate data. In addition, data on communicative disorders in health-care facilities are more than difficult to obtain, more so than from other sources such as federal, state, local or others. This is due, in part, to public Law 93-308 {Family Educational Rights and Privacy Act of 1974 and its predecessors). It is 4ue, more generally, to the related or divisional status of speech-language pathology and audiology services within the health-care setting. Seldom, if ever, does a patient

* Department of English, Tennessee Technological University.

report to seek these services directly. Generally, the services are sought as a-consequence of medical interventions, management or referral: therefore, records are kept accordingly. This, additionally, compounds another problem, which has. been ignored in the profession of speech-language pathology and audiology. This problem involves whether or not communicative disorders are related or primary-handicaps. This problem is not germane to the present study, but it is germane to prevalence estimates in general.

ASHA (1977) identified four areas in which data on communicative disorders were lacking. These areas included (a) language impairments (b) disorders categorized by etiology and age of onset, and (c) disorders in treated versus un-treated populations. Ol the above, Healey et. al., (1981), advocating ASHA's more current position, found data not available in (a), (b) and (c). Their summation was based on what they cited as "..a comprehensive review and critique of the literature regarding the prevalence of communicative disorders and related disabilities.." (p. 1). A third source, which also reflected on the status of prevalence estimates, was Leske (1981a, b.). Her position was supportive of the other sources. She stated that " Despite the magnitude and socioeconomic impact of the communicative disorder, epidemiologic data on these disorders are limited and often of poor quality " (p. 217). More to the point, Leske further stated that " Valid estimates of prevalence, or number of persons affected at a point in time, are difficult to obtain " (p. 217)

In reviewing the work of Healey et. al., (1981), one finds the report lacking in several critical areas. They do not discuss important topics such as minorities-(Taylor, 1980; Fay, et. al., 1970; Head Start Bureau, 1979, 1980, 1981 : Stewart, 1981); communicative disorders in medical or health care-facilities (Bunch, 1931;. Bunch and Raiford, 1931 ; Haller and Thompson, 1975 ; Stewart Martin, and Brady, 1979; see also Ciocco and Palmer, 1941 ; Watson and Tolson, 1977); and preschool children (Head Start Bureau, 1979, 1980, 1981). This latter area impacts-clearly treated versus untreated populations. In addition, they overlooked studies which would have yielded some data on language impairments (DesRoches, 1976; Stewart et. al., 1979; Head Start Bureau, 1979, 1980, 1981).

Within the context of the foregone discussion, the specific purpose of ther present study is to determine the number of communicative disorders in a major metropolitan, minority-based, comprehensive health-care facility by types of disorder and sex. The survey comes from the unspecified prevalence data originally developed by Stewart et. al., (1979), The terms unspecified prevalence is synonomous with the number of cases seen. Its usage better addresses the problem associated with hospital prevalences. The study is intended to add depth to-areas considered deficient in the profession of speech-language pathology and audiology and to issues not covered by Stewart et. al.,

The study meets a number of professional needs. First, it presents an update and reevaluation of the data from a medical center. Although the data covers the years 1973-1977, they are the most currently available. Second, this study ensures the preservation of data, which may not be retrievable in the future, because the data source is sensitive to the availability of federal funding. In part, a major reason that more timely data are not available. Third, the data reflect communicative disorders in a minority population. Fourth, it reports, in part, data on preschool children, which is most limited in the literature.

METHODOLOGY AND PROCEDURES

Specific details of data collection, methodology and procedures were described in an earlier study (Stewart et. al., 1979). The present study was a demographic study of the children diagnosed with communicative disorders from this earlier survey. Research issues germane to the study are discussed subsequently.

The General Population :

According to the Population Division of the U. S. Bureau of the Census, Davidson County, including Nashville, had a total population of 447, 877 persons in 1970. Of this number, 80-1, 19-6 and 0-3% were whites, blacks and others, respectively. The 1980 census revealed that the country had increased its population to 477,111. The racial composition from this was 76-8, 22-3 and 0-9% for Whites, blacks and others, respectively.

The health-care facility : The childern and Youth Program at Hubbard Hospital, affiliated with Meharry Medical College iu Nashville, Tennessee, has two major goals. One of its goals was to educate and to provide information on health-related topics. Its other goal was to deliver medical, follow-up, and related services to the indigenous, lower socio-economic communities surrounding Nash-Ville. In part, these communities comprised the 19.6 to 22.3% of the blacks in the population.

It was one of two centers in the State of Tennessee which provided services to children from birth through 18 years. The service included both general and specialized medical, dental, psychological, social, nutritional and speech-language and audiological. The target population was accepted according to the guidelines set by the Department of Human Services for the State. Audiological and speech-language services were provided by certified personnel on a routine, evaluative basis.

Data Solicitation:

The records utilized in this survey were for the five-year period dating January 1, 1973 through December 31, 1977. Individuals patient files and speech-language and hearing records were reviewed for specific information.

All children who had been evaluated for speech, language, and hearing disorders were included. Basic demographic data on preschool and school-age children, between the ages 3 through 18 years, were obtained. Based upon previous studies and considering the potential impact on learning, the ranges were partitioned into three groups. These included the age ranges : 3-5 years (preschool), 6-12 years (elementary, and 13-18 years (Junior-seinor high).

Identification of Disorders :

Speech-language : Children with normal speech and language were categorised under a specific age group by sex. Similarly, children diagnosed with communicative problems were classified and tallied appropriately. In addition, a learning-disabilities category was included.

Instruments for the evaluation of speech included the *Goldman-Fristoe **Test** of Articulation* (1969) and spontaneous connected speech samples. *The Preschool Language Scale* by Zimmerman, Siteiner and Evatt (1969) and *The Utah Test of Languages Development* by Mecbam, Jex, and Jones (1973) were the two evaluative measures for language. Although articulation and language scores were derived-by following the design of the tests, they were adjusted after considering cultural differences"

Audiology : Normal hearing children were categorized according to a specific age group by sex. Children were classified under this category if auditory thresholds appeared within normal limits (0-25 dB, re : ISO 1964) bilaterally. Hearing-impaired children were classified according to Martin (1976) under specific type of loss by age group and sex.

Hearing levels were assessed in a sound-treated room. Each ear was tested at the octave frequencies between 250 through 8,000 Hz. Midfrequencies were tested in cases of precipitious, high-frequency losses. Pure-tone and speech measurements were assessed on a Beltone 200C audiometer. A second audiometer, Beltone 10D, was utilized to test children requiring play audiometry. Calibration standards were ISO 1964.

Analysis :

The analysis involved five categories for speech-language. These included normal speech-language, deviant articulation, deviant language, other speech, and learning disabilities; each was divided by sex. They were further evaluted by age; the age range were preschool, elementary and junior-senior high school. These five divisions were mutually exclusive in this study. In the event of multiple speech-language disorders, the children were placed in the more debilitating disorder, that is, the primary disorder.

Hearing, like speech-language, disorders were divided in five categories. These were normal, conductive, sensorineural, noise-induced, and mixed. They were also separated by sex and the three age ranges. Children with speech-language disorders were not excluded from inclusion with the hearing disordered. Thus, within the five categories, one could find those children who also had a speech-language disorder, including learning disabilities.

Race was a factor to the extent that this study surveyed the records of a health-care institution which catered to minorities, blacks, primarily. Other groups were not excluded from the use of this facility. The records indicated that only blacks were seen for evaluation of communicative disorders during the five-year period under study. It is 1.7 : 1 for elementary school children and 1.4:1 across the three groups. The preschoolers appear more equivalent.

Other Speech : These disorders account for 4.7% of the distribution, and are more closely associated with preschool and elementary than junior-senior high school children. Unlike articulation, the male-female ratio is more extreme, overall 1 • 8 : 1. Specifically, for the three groups they are 1.6 :, 2.1 : and 2.0 : 1 for the preschool, elementary, and junior-senior high school children respectively. This general category represents the smallest number of speech-language disorders.

Language : At 30.0%, language disorders reflect the second largest parcentage of communicative disorders. Like other speech disorders, language disorders are seen more often in preschool and elementary than junior-senior high school children. The elementary school children reflect the highest male-female ratio at 1-6 : 1. These Ratio at 1.2 : and 1.3:1 for the preschool and junior-senior high children are close to equivalent. The overall sex ratio of 1.4 : 1, across the three groups, is equivalent to the one found for articulation disorders.

Learning disabilities : Table 1 shows that learning disabilities reflect 11. 8% of the distribution. Of the four categories it ranks third in prevalance. Males are not seen in the preschool groups. The elementary and junior-senior high groups reveal sex ratios of 1.8: and 2.4 : 1, respectively. Across the three groups, it is 1.8 : 1 ; however, excluding preschoolers, it is 2.1: 1. With the exception of the two females in the preschool group, the learning disabilities are seen exclusively in the other two groups.

TABLE 1

Classification and distribution of children by sex across three age groups for speech and language disorders (N=536) found in 1,638 diagnostic evaluations during 1973 through 1977.

Disorders Sex	Perschool (3-5 Years)		Elementary (6-12 Years)		Jr./Sr. High (13-18 years)		Total (3-18 years)	
	N	%	N	%	N	%	N	%
Articulation								
Males	107	20.0	50	9.3	8	1.5	165	30.8
Females	90	16.8	30	5.6	2	0.4	122	22.8
Total	197	26.8	80	14.9	10	1.9	287	53.5
Other Speech								
Males	8	1.5	6	1.1	2	0.4	16	3.0
Females	5	0.9	3	0.6	1	0.2	9	1.7
Total	13	2.4	9	1.7	3	0.6	25	4.7
Language								
Males	46	8.6	38	7.1	9	1.7	93	17.4
Females	37	6.9	24	4.5	7	1.3	68	12.7
Total	83	15.5	62	11.6	16	3.0	161	30.0
Learning Disabilities								
Males	0	0.0	24	4.5	17	3.2	41	7.6
Females	2	0.4	13	2.4	7	1.3	22	4.1
Total	2	0.4	37	6.9	24	4.5	65	11.8
Grand Total	161	30.0	118	22.0	36	6.7	315	58.8
Males	134	25.0	70	13.1	17	3.2	221	41.2
Females	295	55.0	188	35.1	53	9.9	536	100.0

Speech-language summary : Table 1 reveals that articulation disorders for the preschool group dominate the speech-language categories. They actually account for 68.6% of the disorders across the three age groups and for 66.8% with in the preschool group. Articulation disorders are diagnosed in 27.9% of the elementary school groups. These two groups account for 95.6% of the articulation disorders. Language is the second most diagnosed disorders for the preschool and elementary school group ; but, it is second to learning disorders for the junior-senior high school group.

Across the age groups the preschoolers account for 55% of the speech-language disorders. Elementary school children account for 35.1%. Thus, these two groups account for slightly more than 90% of the speech-language disorders.

Hearing Disorders :

During the five-year period, there are 2,189 children referred for audiological evaluation. This total comprises, 1,171 males and 1,018 females. From these figures males are referred 1.2 times more often than females.

The data indicate that 57.2% of the total are normal within limits bilaterally. The remaining 45.8% are classified in the four adiological disorders. For conductive, sensorineural, noise-induced, and mixed hearing losses, the population figures are 12.1, 5.9, 2.9 and 1.4%, respectively. Across the four disorders the sex ratio of 1.1:1 indicates that females are seen slightly more often than males.

TABLE 2

Classification and distribution of children by sex across three age groups for hearing disorders (N=B936) found in 2,189 diagnostic evaluations during 1973 through 1977.

.Disorders sex	Age Groups							
	Preschool (3-5 Years)		Elementary (6-12! Years)		Jr./Sr. High (13-18 Years)		Total (3-18 Years)	
	N	%	N	%	N	%	N	%
Conductive								
Males	150	16.0	88	9.4	27	2.9	265	28.3
Females	102	10.9	91	9.7	46	4.9	239	25.5
Total	252	26.9	179	19.1	73	7.8	504	53.8
Sensorineural								
Males	12	1.3	79	8.4	38	4.1	129	13.8
Females	12	1.3	87	9.3	51	5.4	150	16.0
Total	24	2.6	166	17.7	89	9.5	279	29.8
Noise-Induced								
Males	0	—	12	1.3	52	5.6	64	6.8
Females	0	—	6	0.6	36	3.8	42	4.5
Total	0	—	18	1.9	88	9.4	106	11.3
Mixed								
Males	5	0.5	15	1.6	10	1.1	30	3.2
Females	1	0.1	8	0.9	8	0.9	17	1.8
Total	6	0.6	23	2.5	18	1.9	47	5.0
Grand Total								
Males	167	17.8	194	20.7	127	13.6	488	52.1
Females	115	12.3	192	20.5	141	15.1	448	47.9
Total	282	30.1	386	41.2	268	28.6	936	100.0

Tables 2 elucidates the findings and distribution for the 936 children or 42.8% diagnosed with hearing losses, including where applicable, those children reflected in Table 1. The table reveals that 30.1, 41.2 and 28.6 are preschool, elementary, and junior-senior high school children, respectively. By further delineating these groups by sex, the male-female ratios are 1.5:, 1.0: respectively. The ratios for the two latter groups indicate that females are seen more often than males: this finding is not seen in the speech-language disorders.

Conductive : Table 2 reveals that 53.8% of the hearing disorders are conductive. Preschoolers account for 50% of these disorders, followed by elementary School children with slightly more than one-third of the remainder. Together, these two groups account for 85.5% of the conductive losses.

The preschool, elementary, and junior-senior high school ratios for sex are 1.5 :, 1.0 : and 0.6: 1, respectively. Except for the preschoolers, the other two groups reveal ratios which indicate more females than males.

Sensorineural : The table reveals that 29-8% of the hearing losses are sensorineural. Nearly 60% of these disorders are seen in the elementary school group. One of the more salient findings herein is the propensity of females to have this disorder. Across each group, this fact is clear. The overall male-female ratio is 0.9 : 1, again, indicating a higher number of females than males. The individuals ratios are 1.0 :, 0.9 :, and 0.7 : 1 for the preschool, elementary, and junior-senior high groups, respectively.

Noise-induced : The hearing losses in this category reflect 11.3% of the distribution. Although this disorder is third in prevalence, it occurs approximately *2½* times less often than the sensorineural disorders. The junior-senior high group accounts for 83% of these disorders. The remaining 17% occurs in the elementary school group; no disorders are seen in the preschool group. The sex ratios indicate that males are seen more often than females. The largest ratio is seen in the elementary school group at 2.0 : 1, it is 1.4:1 for the junior-senior high group.

Mixed : The disorder accounts for the smallest number of cases at 5%. Most of the disorders are seen in the elementary school group, followed by the junior-senior high group. The male-females ratio is 1.8:1 across the groups, it is 1.9 : and 1.3:1 in the elementary and junior-senior groups, respectively. The sex ratio in the preschoolers is much higher than in the elementary group ; it can be seen, however, that the general occurrences in this group are small.

Audiological Summary: In overviewing Table 2, some other observations are obvious. Preschool children are diagnosed most often with conductive losses. These disorders, for them, dominate all others. Elementary school children are diagnosed with conductive and sensorineural losses. Junior-senior high children are diagnosed rather equitably across conductive, sensorineural, and noise-induced losses. They do, however, dominate the noise-induced disorders. The mixed losses. are rather close in their occurences for the elementary and junior-senior high groups.

As a variable sex is important. Earlier, it is noted that the male-female referral ratio is 1-2 : 1. The overall sex ratio with hearing losses is 1.1 : 1. These two ratios indicate a slightly higher propensity for females with hearing disorders than males. Additionally, Table 2 reveals that females have a higher propensity

TABLE 3

Classification and distribution of children by sex across three age groups for all communicative disorders (N= 1,472) for the five-year calender period 1973-77.

Disorders Sex	Preschool (3-5 Years)		Elementary 16-12*I* Years)		Jr./Sr. High (13-18 Years)		Total (3-18 Years)	
	N	%	N	%	N	%	N	%
Hearing								
Males	167	11.4	194	13.2	127	8.6	488	33.2
Females	115	7.8	192	13.0	141	9.6	448	30.4
Total	282	19.2	386	26.2	268	18.2	936	63.6
Speech								
Males	115	7.8	56	3.8	10	0.7	181	12.3
Females	95	6.5	33	2.2	3	0.2	131	8.9
Total	219	14.3	89	6.0	13	0.9	312	21.2
Language								
Males	46	3.1	38	2.6	9	0.6	93	6.3
Females	37	2.5	24	1.6	7	0.5	68	4.6
Total	83	5.6	62	4.2	16	1.1	161	10.9
Learning Disabilities								
Males	0	0.0	24	1.6	17	1.2	41	2.8
Females	2	0.1	13	0.9	7	0.5	22	1.5
Total	2	0.1	37	2.5	24	1.7	63	4.3
Grand Total								
Males	328	22.3	312	21.2	163	11.1	803	54.6
Females	249	16.9	262	17.8	158	10.7	669	45.5
Total	577	39.2	574	39.0	321	21.8	1472	100.1

for certain types of hearing losses. This can be seen generally with sensorineural losses and specifically with conductive losses in the junior-senior high group. The conductive and mixed losses suggest equivalence for sex in the elementary school and junior-senior high groups, respectively.

The age groups are revealing. The elementary school group, at 41.2% reflects the largest number of hearing losses ; as noted previously, conductive and sensorineural losses are roughly equivalent and dominate this age group. The preschool and junior-senior high group are eomewhat equivalent with respects to their percentages of hearing losses ; however, they differ in type. For the preschool group, better than 89% of their disorders are conductive losses. Except for mixed losses, the junior-senior high group has a rather equitable distribution across the other categories of loss. This is only true with the conductive and mixed losses for the elementary school group.

Communicative Disorders-Overview :

Table 3 serves to overview the communicative disorders presented in Tables 1 and 2. In doing so, they are combined in order to reveal a different perspective on speech-language and hearing disorders.

The table shows that 1,472 children are diagnosed with communicative disorders across the three age groups. This figure shows that hearing disorders are diagnosed at the rate of 63.6%. Speech, which includes articulation and other speech, language disorders, and learning disabilities follow at the rates 21.2, 10.9 and 4.3%, respectively. This indicates that hearing disorders are seen 3 times more often than speech disorders. In turn speech disorders are diagnosed twice as often as language disorders. These findings cannot be discerned from Tables 1 and 2, individually.

The percentages on the totals for sex indicate a male-females ratio of 1 .2 : 1. For the total number of children evaluated, 3,827, the ratio is also 1.2:1. This fact indicates that males and females are diagnosed equally as often, in both the normal and disordered populations, since the individual disorders are at variance. The sex ratio for hearing is 1.1 : 1, which indicates a slight propensity for females to be diagnosed this, some children are counted twice. This factor is inflationary. The prevalence figures can, therefore be considered maximums.

Discussion

The purpose of this study was to determine the types and prevalence of communicative disorders found in a comprehensive health-care facility. The study was intended to add depth and new information to the limited data available on communicative disorders in medical environments and to issues not developed by Stewart et., al. (1979).

The rationales for the study were developed. They included issues considered important, but lacking, by ASHA (1977), Healey et., al. (1981) Bensberg and Sigelman(1976), and Leske (1981 a, b). In considering'the issues relative to rationales, the area overlooked or not considered were addressed in this study. With special emphasis on Healey et., al. the areas or topics were minorities and data from medical facilities. In addition, it was generally acknowledged that data on language disorders were needed. The present study addressed these three areas.

The methodology included a survey of the records of the Children and Youth Program at Hubbard Hospital for the calendar years 1973 through 1977 and data undeveloped by Stewart et., al. (1979). The data were analyzed in terms of frequency of diagnosis and percentage. The variables included disorders, age, and sex ; race was a variable only to the extent that a minority, blacks, utilized the health-care facility.

The survey revealed a number of findings. First, the results indicated that the majority of children referred for speech-language and hearing evaluations were normal. The percentages for the communicatively handicapped were 32.7 and 42.8% for speech-language and hearing disorders, respectively. Second, the referral race was higher for males than females, but the same for those children with communicative disorders; this ratio was 1.2:1. This indicated no difference on sex for the population and handicapped children. This generalization was true relative to communicative disorders in general. Generally, the results indicated that males were seen more often than females for speech-language disorders and females more often than males for hearing disorders. Practically, sex ratios differed, -depending on the specific type of communicative disorder.

Third, the data indicated that the biggest problem in the referrals was hearing disorders. Hearing disorders accounted for 63.6% of all communicative disorders. They were diagnosed 3 and nearly 6 times more often than speech and language disorders, respectively. Fourth, within the hearing disorders 53.8% were conductive and 41.1% were sensorineural,including noise-induced. Sensorineural losses were diagnosed more in the other groups. Noise-induced losses were diagnosed most in the junior-senior high group; they occurred nearly 5 times more often in this .group than in the elementary group.

Fifth the preschool and elementary groups were equivalent with respects to the percentage of communicative impairments. This equivalence was accounted for by the number of hearing losses, primarily conductive, and speech disorders in the preschool group and the number of hearing disorders in elementary school group. Sixth, the distribution by age group was in close agreement between the population and the communicatively handicapped. Although these two findings were general frue, they must be considered with reference to the specific types of disorders.

Seventh, based on the population across the five years the average prevalence of communicative disorders was 7.7%. Of this percentum hearing, speech, language, and learning disabilities accounted for 4.89, 1.63, 0.84 and 0.33%, respectively. This finding was important not only because it provided specific prevalence figures, but because it yielded a prevalence rate for language disorders independent of speech. This percentage was 0.84%.

The validity and reliability associated with this study were both problematic to varying degrees, but affected the results, herein, minimally. Validity was an issue in terms of both general and specific assessment for communicative disorders. For example, Taylor (1980) noted that " there is an international standard for measuring hearing " (p. 68). In this study hearing was measured in reference to the international standard ; there was no issue here. This was not the case with speech-language disorders.

There were no valid norms for cultural minorities. This issue was applicable in this study. Speech-language was measured with evaluative tools normalized on white, middle-class children. In this study, children were evaluated as per the standard Instructions; afterwards, where applicable, adjustments for cultural differences were made. In addition, during this five-year period, the speech-language pathologists and audiologist were members of the same cultural minority as the populations ; their academic training in cultural differences were minimal. However, they were able to recognize the dialectal variations of the community.

There were strengths and weaknesses associated with the reliability of the data. The major strength lay in the availability of statistics which reflect current, realistic prevalence estimates. And, in doing so, these statistics were derived with considerations for the problems outlined earlier by ASHA (1977), Healey, et., al. (1981), Leske (1981a), and others. There were also several important weaknesses. First, the 7.7% prevalence estimate contained a duplicated count for hearing dirorders ; some of the children had multiple problems, which were included under speech-language. The investigator had not considered this important enough initialy to code this data. This point was not inteded to imply that there were many cases herein, just important data could have been obtained and utilized. Although this data could not be retrieved because of administrative reasons, the duplicated count was felt to be negligible. This was based on the findings of Stewart and Spells (1982) who found 0.1% of the public school population in Nashville with communicative disorders as related handicaps for communicative disorders. The broader, more comprehensive issues on duplicated versus unduplicated counts were presented by McDermott (1981).

A Second problem with the reliability of the data lay in its possible statistical redundancy. Many, if not most, of the children were eligible for services for the communicatively handicapped in their local schools, whether public or private, or other agencies such as Head Start Programs or day care facilities. Children; identified and receiving these services or even referred from other agencies could! not be ascertained. Thus, in the broader perspective on prevalence estimates, it was possible that some of these children were already indentified as communicatively impaired. This meant that they have been statistically acounted for and, therefore, would create an inflated estimate in the general population. This issue was related, but different from the issue on duplicated versus unduplicated counts

The more serious problem with reliability was the uncertainty associated with the total number of children seen by all of the referral units within the hospital. From this perspective it appears that the prevalence estimates would be less, since many children were not referred for evaluation and/or over looked. How much less was at issue. This problem indicated that the prevalence estimate in this study was at a maximum. The problem with realiability was also a strength in the study from another perspective ; by its nature, it established an upper limit as a prevalence estimate on commnnicative disorders. This upper limit had not been established previously.

Although prevalence estimates at hospital facilities and on minorities are most limited, there were some studies available for comparison. One of these studies was Haller and Thompson (1975). They evaluated the prevalence of commuicative disorders at the Harlem Hospital Center in New York City. They found in their screening of children 3 through 17 years a prevalence of 9.1% in the 979 children screened for speech and 17.7% in the 990 children screened for hearing. The combined prevalence was 13.4%. The prevalence of communicative disorders in their study was much higher than the 7.7% in this study.

Their specific findings were also at variance with this study. They found that : (a) communicative disorders were not less common with age, (b) the male-female ratios were 7.0 : 1 and 2.0 : 1 for speech-language and hearing disorders, respectively, (c) articulation, other speech and language disorders accounted for 62.9, 27.8 and 2.9% of the distribution, respectively; and (d) their multiple disorders accounted for 6.3%. The limited areas of agreement between this and the present study were general in nature. They were that hearing disorders had a prevalence than speech disorders and articulation was more prevalent than other speech-language disorders.

There were appropriate reasons for the differing results between the Haller and Thompson study and this one. First, their results were an artifact ; their study operated for 5 months. This study operated over a five year period and conducted full evaluations rather than screenings. With specific reference to hearing criteria were more conservative than the evaluation criteria in this, meaning a higher failure rate. Based on these facts, it appears that their results would have been more in alignment with this study had they used "The full range of hospital facilities .. in the comprehensive evaluation,." (p. 299).

Because Taylor (1980) attached major significance to the world wide status to communicative disorders in blanks, one other study is worth mentioning. Lumba, Oduori and Singh (1977) evaluated speech-language disorders at Kenyatta National Hospital in the East African Nation of Kenya. They evaluated 320 children between the ages of 2 through 15 years, during the two-year period 1974-1976. Each of these children had some type of communicative disorder. Since there was no population referent, this study cannot be evaluated with this one. Its value lay in its availability for consideration and in its relating communicative disorders to other factors such as mental and physical handicaps.

Another study which is valuable for comparision was Fay et,, al. (1970). They found hearing impairments in 19.8% of the 461 "extremely disadvantage inner-city population" remanded to the care of The New York City Department of Social Services Children's Center. These children ranged in age from 2 through 16 years. Like Haller and Thompson (1975), these children were screened for hearing. Their figure was slightly higher than Haller and Thompson's 17.7%, but their findings to a limited extent were consistent on age. By comparison this study was at variance, like Haller and Thompson, with Fay et., al. In speculation Haller and Thompson (1975) and Fay et., al. (1970) were studies conducted in New York City ; it may stem from the different geographical areas and noise levels. On the other hand, the present studs' found equivalency for the preschool and elementary school groups. Because of the greater numbers in these groups than the junior-senior high group, the generalization on age would be true for communication disorders, but the trends with age must consider the specific disorders.

Practically, the major reason for the discrepancy between these two studies and the present one was in screenings for the former and complete diagnostic evaluations in the latter. The diagnostics yielded more accurate data. An excellent example of this consideration was Melnick, Eagles, and Levine (1964). They showed that 29% of children failing on the initial screenings passed the threshold test. This reduction of false positives changed the failure rate downward from 20 to 14%. The 19-8% prevalence found by Fay et., al. (1970) was the adjusted estimate after the false positivse.

The present study can also be evaluated against somewhat current national and local prevalence studies. In a national speech and hearing survey Hull, Mielke, Willeford, and Timmons (1976) found a prevalence for speech disorders at 5.7% in 38,802 school-age children in grades 1 through 12 and a prvealence of 2.60% for hearing disorders in 38,568 of these childern. The combined prevalence was8.3 %. This percentum was only slightly higher than the 7.7% in the present study. It must be noted that they did not evaluate language and also did not consider multiple handicaps. Taken together, however, the 8.3% appears accurate.

In terms of specific findings, some other observations were important. Hull et., al. also found speech and hearing disorders decreased with grade. The agreement between their study and this one was clear, indicating some additional variable operating on the children seen by Haller and Thompson (1975) and Fay et., al. (1970), With specific reference to hearing disorders the present study was in agreement with the later studies in that hearing disorders were much more problematic than speech-language disorders. In spectulating then, it would appear that minorities have a greater problem with hearing disorders than speech disorders or, minimally, culturally deprived, that is, lower socioeconomic minorities have more problems with hearing than speech. This speculative ascertion appears reasonable when considering some local studies on the public school system of Nashville.

Stewart (1981) found a prevalence of 4.02% for primary and related communicative disorders in school-age children in Nashville for the academic year 1978-1979. Of the primary disorders hearing, speech, and language accounted for 0.14, 2.48 and 0.26%, respectively. Later during the academic year 1979-1980, Stewart and Spells (1982) found a prevalence of 4.01%. Of the primary handicaps hearing, speech and language accounted for 0.18, 2.35 and 0.30%, respectively.

In both studies, even with the inclusion of related handicaps, the prevalence in this study was higher than the interracial population of the public school system. The hearing disorders were much greater and language disorders were approximately 3 times greater in this study than in the two just cited. On the other hand the public schools reflected a larger number of speech disorders. With specific reference to the black population within the school system, language disorders were 2 times greater in this study than they occurred in the school system.

One last source of data for comparison was the Head Start Bureau (1981) For their full-year 1979-1980 they diagnosed a total of 7.85% of the 364,400 children enrolled ; these children were preschoolers, ranging in age from 3 through 5 years. Of the percentum hearing, speech and language disorders accounted for 0.47, 3.70 and 3.00%, respectively. The overall percentum was in good agreement with the present study, the specific disorders varied greatly. The age ranges were very much different, howevr. Since the children in the Head Start Programs received full diagnostic evaluations, there was credence to the factor of socioeconomic status affecting the prevalence of communicative disorders. Given the validity of this assertion. The Head Start data and the present study were in agreement.

In general the results of the present study were compatible with other studies considered related and relevant. Variances between studies were generally explainable. For example, in methodology, screenings versus diagnostics indicated gross differences in prevalence estimates or differences in criteria. More importantly, the results indicated the importance of studying the medical population relative to other reported data sources. Although the populations were different, the 8.3 and 7.85% found by Haller and Thompson ;1975) and The Head Start Bureau (1981), respectively, approximated the 7.7% in this study. The specific types of disdorders which reflected these statistics manifested themselves in different proportions ; this is yet to be explained, possibly socioeconomic factors. The results indicated further that Healey et., al. (1981) were not a thorough as they indicated.

The prevalence of communicative disorders was 7.7%; the male-female ratio was 1.2 : 1. The hearing, speech and learning disabilities manifested in the population 4.89, 1.63 and 0.33%, respectively. The population percentage for preschool, elementary, and junior-senior high school children were 3.02, 3.00 and 1.56% respectively. Language disorders in this population occurred 2 times more often than in the public schools ; they occurred 3.6 times in The Head Start population, which can be attributed, in part, to age and socioeconomic considerations. Considering this fact, the general and specific purposes of this survey were accomplished.

ACKNOWLEDGMENTS

The author acknowledges the co-operation of the Children and Youth Program at Hubbard Hospital—Meharry Medical College. This article is based, in part, on a related paper appearing in an earlier volume of this Journal; the author expresses his appreciation to M. E. Martin and G. M. Brady for theif initial work. Any opinion, findings, conclusions, or recommendations expressed herein are those of the author and do not necessarily reflect the views of others. James Monroe Stewart is currently a Post Doctoral Fellow, Department of English Tennesee Technological University, Cookeville, TN. 38505.

REFERENCES

American Speech and Hearing Association. (1977). *Speech pathology and audiology : Manpower resources and needs* Bethesda (MD) : National Institute of Neurological and Communicative Disorders and Stroke (NIH).

Bensberg, G. J., and Sigelman, C. K. (1976). Definition and prevalence. In L. L. Lloyd (Ed.), *Communication assessment and intervention strategies*. Baltimore : University Park Press.

Bunch, C. C, and Raiford, T. S. (1931). Race and sex variations in auditory acuity. *Arch. Otolaryngology*. 13 : 423-434.

Ciocco, A., and Palmer, C. E. (1941). *The hearing of school children: A statistical study of audiometric and clinical records.* Washington, D. C. : Society for Reasearch in Child Development '(National Research Council).

DesRoches, C. P., (1976). Speech Therapy services in a large school system : A six-year overview. *Language. Speech, Heating Services Schools,* 7 :207-249.

Family Education Rights and Privacy Act of 1974. (40 Federal Register, 24670-24675).

Fay, T. H., Hochberg, I., Smith, C. R., Reese, N. S., and Halpern, H. (1970). Audiologic and otologic screening of disadvantaged children. *Arch. Otolaryngology,* 91 : 366-370.

Goldman, R., and Fristoe, M. (1969). *Goldman-Fristoe test of articulation.* Circle Pines (MN) : American Guidance Service.

Haller, R. M., and Thompson, E. A. (1975). Prevalence of Speech, language and Hearing Disorders among Harlem children J. *National Medical Association,* 67 : 298-301, 325,

Head Start Bureau (1979, 1980, 1981). *The status of handicapped children in Head Start Programs.* (Sixth, Seventh & Eighth Annual Report of the U. S. Department of Health and Human Services to the Congress of the United States, on Services Provided to Handicapped Children in Project Head Start). Washington, D. C. U. S. Health and human Services, Office of Human Development Services, Administration of Children, Youth and Families.

Healey, W. C, Ackerman, B. L., Chappell, C. R., Perrin, I. L., and Sterner, J, (1981). *The prevalence of Communicative disorders : A review of the literature.* Rockville (MD) : American Speech-Language-Hearing Association.

Hull, F. M., Mileke Jr., P. W., Willeford, J. A., and Timmons, R. J. (1976). *National speech and hearing survey : Final Report.* Washington, D. C. : U. S. Health, Education and Welfare, Office of Education, Bureau Education Handicapped. (ERIC Document Report Service No. 129 045).

Leske, M. C, (1981a). Prevalence estimates of communicative disorders, in the U. S. ; Speech disorders, *Asha, 23 :* 217-225.

Leske, M. C, (1981). Prevalence estimates of communicative disorders in the U. S. -Language, hearing and vestibular disorders. *Asha, 23 :* 229-237.

Lumba, M., Oduori, M. S., and Singh, S, (1977), Speech defects as seen at Kenyatta National Hospital. *East African Medical J, 54* : 539-547.

Martin, F. N. (1976). *Introduction to audiology.* Englewood Cliffs (NJ): Prentice Hall Inc.

McDermott, L. D. (1981). The effect of duplicated and unduplicated child count on prevalence of speech-impaired children. *Language, Speech and Hearing Services Schools,* 72:115-119.

Mecham, M J.; Jex, J. L., and Jones, J. D, (1973). *Utah test of language development,* Salt Lake City : Communication Research Associates.

Melnick, W., Eagles, E. L., and Levine, H- S. (1964). Evaluation of a recommended program of identification audiometry with school-age children, *J. Speech Hearing Disorders, 20* : 3-13.

Stewart, J. M., (1981). Multidimensional Scaling analysis of communicative disorder by race and sex in a rnid-south public school system. *J. Communication Disorders,* 74:467-483.

Stewart, J. M., Martin, M.,E.. and Brady, G. M. (1979). Cammunicatiye disorders at health-care center. J. *Communication Disorders, 12 :* 349-359.

Stewart, J. M., and Spells, V. R. (1982), Current trends of communicative disorders in a public school system. *Australian J. Human Communication Disorders, 10* : 33-57.

Taylor, O. L., (1980). Communication disorders in blacks. In B. E. Williams and O L. Taylor (Eds.), *Working papers,—The Rockefeller Foundation : International conference on black communication.* New York : The Rockefeller Foundation.

Watson, L. A., and Tolan, T. (1967). *Hearing tests and hearing tests* New York : Hafner Publishing Co.,

Zimmerman, I. L., Sitenrner, V. G., and Evatt, R. L. (1969). *Preschool language scale.* Columbus: Merrill Publishing.

DISTINCTIVE FEATURES OF KANNADA ALPHABET

G. PURUSHOTHAMA *
A. JAGADISH
P. J. KUMAR

ABSTRACT

Kannada alphabet letters were partially exposed to be predicted by 31 subjects. The confusions found were systematic. A list of Distinctive Features was drawn based on a confusion Matrix. In a sorting task of various CV and CCV letters it was found that even people unfamiliar to, could perceive the minimal pairs of the vowel allographs. The allographs can also be reduced to various distinctive features.

Reading is the process of extracting information from printed text. The meaningful units of print are words. It is still not clearly known as to how these units are processed to derive information. The views on this vary very much. At one extreme it is thought that letters are processed one by one and then words are perceived (Gough 1972.) At the other extreme the thinking is that not only the words are perceived as wholes but that the words can be expected even before they are actually seen. (Smith 1971). Both views have been supported, though not fully.

A similar problem seems to exist with the perception of. letters too. A simpler view is that there may be prototypes of letters in mind that are matched to the printed ones in the process of identification. But it has also been possible to explain the identification of letters on the basis of feature recognition (Spoehr and Lehmuhkle 1984.) Similar to the description of phonemes based on distinctive features, features of English letters have been described (Gibson 1969). There is reason to believe that the letters are perceived not as whole units but from parts thereof. Huey (1908) observed that a passage could have been read better when the bottom halves of the letters were removed than when the top halves of letters were removed. Massaro, et al. (1980) found that the legibility of English letters differ depending on the nature of their form.

* AIISH, Mysore-6

It is necessarry to understand the preceving of letters before the nature of reading is understood. The intent of this study was to find the features of Kannada letters that contribute to their recognition. A brief description of Kannada letters is in order. Kannada has a phonetically regular syllabic script. Whereas the English letters represent phonemes, Kannad letters represent syllables. Kannada has an alphabet of 50 letters. The following are the letters classified for the present purpose.

Kannada Vowels :

Short Vowels : ಅ ಇ ಉ ಋ ಎ ಒ

Long Vowels : ಆ ಈ ಊ ೠ ಏ ಓ

Dipthongs : ಐ ಔ

It may be observed that many of he Iong vowels are related to short vowels in their form. All the consonants in the alphabet are written with the vowel [a] Whereas most of them are written with ;he along graph — for the vowel [a] others have a zero allograph.

Consonants with the allograph :

ಕ ಘ ಗ ಚ ಛ ಝ ಠ ಡ ಢ
ತ ಥ ದ ಧ ನ ಪ ಫ ಭ ಮ
ಯ ರ ಶ ವ ಷ ಸ ಹ ಳ

Consonants with the Zero allograph:

ಖ ಙ ಜ ಞ ಟ ಣ ಲ ಬ

It may be noted that unlike the English, letters Kannada letters have round envelope. More than half the number of the letters have an allograph ligatured at their top. Thus it was interesting to see as to which part of the letters are important for their identification.

EXPERIMENT I :

Subject : There were 31 subjects of age range 17-30 years. The subjects had practiced reading Kannada for 12 years in school and were adept in reading Kannada print.

Procedure : One way of finding the features is to find the confusions in reading the letters. Confusions can be brought about by the degradation of the print or by inappropriate exposure. As the invent was also to find the parts right, left, top and bottom of the letters contributing to the identification the task of reading with partial exposure was used. Letters were printed in the centre on cards of size 13 cm by 16 cm. The subjects were instructed that they would see parts of letters and were required to predict and name them. The letters were shown through an opening in a screen so that only half of a letter was exhibited at a time. Each letter was exhibited until a response was made and then removed. The responses were recorded. Fortyeight letters of the alphabet was presented in a random order. All the halves of letters ; right, left, top and bottom were shown to each subject.

Results : Different halves of letters exposed ; right, left, top and bottom, were treated as four attempts at reading a particular letter. Thus each letter had partial exposures for 124 times. It can be seen from the confusion matrix in Table 1 that letters have been confused to those which look similar and also to those with common features. For example the letter ಅ [a] has been confused to ರ [ra] and ತ [ta] as well as ಆ [a:] which looks similar. It can be seen that it is the curve at the bottom part of these letters that has caused the confusions. The matrix presents such widespread confusions. The letters having similar features in the same part have been confused. In Table 2 it can be observed that the confusions of the different parts of letters have been systematic. The confusions of different halves of letters are given separately in columns. In each row the numbers in front of letters present the number of confusions (maximum 31) of letters printed next to them. It was observed that the bottom parts of the letters were most confused. Least number of confusions were observed in the top halves of letters. This observation was inspite of the repeated occurrence of the feature '—' on a large number of letters. The features on the left half and right half of the letters were also confused.

The legibility of Kannada letters is also rank ordered in the Table 2. The number preceding each letter in the first column is the number of correct identifica. tion of letters out of 124 partial exposures. For example the letter ಈ [i :] was identified 119 times correctly and no part of it was confused with any other letter of alphabet. Even though the subjects were informed that the task was of identifying letters of the alphabet, sometimes the letters were misidentified as letters other than those of the alphabet i.e., blended with allographs of other letters.

On the basis of confusions observed a list of distinctive features of Kannada alphabet was made (Table 3). The list of confused letters based on different features is given in Table 4.

Discussion : The bottom halves of letters are more confusable than their top halves. It is interesting to note that, like in English as Huey (1908) had

Table 2. Confusions of different letter parts

NO. OF CORRECT IDENTIFICATION OUT OF 124 PARTIAL EXPOSURES	No. OF CONFUSIONS TO DIFFERENT SIDES of LETTERS			
	RIGHT	LEFT	TOP	BOTTOM
119 ಈ				
110 ಗ			4ಠ 2ಕ	
109 ಸ				
108 ಳ				
107 ಝು		2ಯ		
106 ಣ	2ಉ 2ಊ 2ಪ			
104 ಉ				
102 ಟ				3ಎ 2ಛ
100 ಇ		4ಈ 2ಐ 2ಠ		7ಈ
99 ಊ	4ಋ	11ಉ		
98 ಹ				4ದ 3ಬ 2ಓಋ
97 ಕ				13ಳ
92 ಜ				9ಒ 4ಉಓ 3ಔ
91 ತ	9ಢ 2ಕ			9ಲ 3ಗ
89 ಡ		14ಪ 8ಫ 2ಘ		3ಹ 2ಘ
89 ಋ		15ಖ		
87 ಠ		2ವ	5ಥ 4ದ 2ಯ	4 ರತ
87 ಖ				
85 ಸ	12ದ 2ವ		6ಮ 3ಠ	10ಸ
85 ಔ	2ಔ			12ಒ 7ಜ 2ಔ
83 ರ	5ದ 2ಫ		3ಗ 2ಠ	4ತ 2ಕಳ
82 ಕ	21ರ			3ಳ 2ರ
81 ಫ		21ಫ		7ಫ 4ಟ 3ಒ
81 ಔ	2ಔಟ			26ಜ
80 ಖ	2ಮಯ	10ಋ 6ಖ		
79 ಢ		26ಧ 2ಢ		7ವ 2ಧ
78 ಚ	16ಕ 2ತ			6ದಬ 3ಜಓ 2ಒ
77 ಥ	4ಡ	5ಥ 2ಡಧ		14ಧ 3ಫಭರ
75 ದ	4ವ 3ಜ 2ಧನ	4ಧ 2ರ	5ದ 2ಜ	4ಒ 3ಜ 2ಓಬ
75 ಲ	3ಉ	6ಅ		8ರ 6ತ 2ಅ
74 ಅ		12ಅ		14ತ 5ರ 2ಛ
73 ಎ	7ದ 4ಏ 3ನ			9ವ 4ಏಐ 2ಧ
72 ಧ	2ವ 2ಭ		18ದ 2ಥಅ	2ಛಧಧರ
72 ಬ	16ಎ 3ನ 2ಯ	5ಛ		14ದ
72 ಐ	6ಜ			9ವ 6ಏ 5ಎ 2ಪಟ
71 ಮ	11ಯ 3ಖ 2ಖ	14ವ		
68 ಅ		19ಆ 2ಠ		15ರ 5ತ 3ಲ
67 ಓ	21ಒ 2ಜ			6ಜಒ 5ಜ
65 ಈ		9ಇ 5ಜ 2ಕಖ		26ಇ
64 ಯ	10ಮ			8ಮ
63 ಒ	12ಓ 3ಇ 9ಎದ 3ವ 2ಬ	11ಬ 4ಛ 2ಜ		8ಜ 5ಒ 2ಔಳ 10ವ 3ಐಎ 2ಬದಟಶ
61 ಏಫ	3ಥ 2ಫ 11ಛ 3ಧ			18ಛ 3ಫ
60 ಛ	19ದ 3ಥ 2ಫ	4ಒ 2ಬ		6ಧ 4ಥ 2ಬ ಹ ಛ

Table 3a. Distinctive features of Kannada alphabet

L/F	‿	(	)	⌐	O	I	—	ω	∽	~	⌒	ಎ	3	ә	·	ε		
ಅ	+	+	+	+	+													
ಆ	+	+	+		+		+											
ಇ			+						+	+								
ಈ	+	+	+	+	+	+	+				+							
ಉ	+	+	+		+						+							•
ಊ	+	+	+		+						+							•
ಋ			+	+				+						+				
ೠ			+	+				+						+				
ಎ			+		+			+			+							
ಏ			+		+	+		+			+							
ಐ			+		+			+	+									
ಒ		+			+			+										
ಓ		+			+	+		+										
ಔ		+		+	+	+	+	+										•
ಅಂ	+	+	+	+	+													•
ಅಃ	+	+	+	+	+													•

Table 3b. Distinctive features of Kannada alphabet (Continued)

L/F	◡	(	)	⌣	O	!	–	ω	ო	ɑ	∩	∾	ɜ	9	.	ε	
ಕ	◆	◆	◆	◆	◆		◆				◆						
ಖ			◆					◆						◆			
ಗ		◆	◆	◆							◆						
ಘ				◆	◆	◆	◆	◆									■
ಙ		◆			◆			◆			◆				◆		
ಚ		◆		◆	◆		◆	◆									■
ಛ		◆	◆	◆	◆			◆									
ಜ	◆	◆			◆			◆									
ಝ	◆	◆	◆	◆	◆	◆		◆			◆						■
ಞ			◆						◆	◆	◆						
ಟ								◆					◆			◆	
ಠ	◆	◆	◆	◆						◆					◆		
ಡ		◆		◆				◆			◆		◆				
ಢ		◆		◆		◆		◆			◆		◆				
ಣ			◆		◆				◆							◆	
ತ	◆			◆									◆				
ಥ		◆	◆	◆		◆		◆			◆				◆		
ದ		◆	◆	◆				◆			◆						
ಧ		◆	◆	◆		◆		◆			◆						
ನ			◆	◆								◆					
ಪ			◆	◆	◆			◆									■
ಫ			◆	◆	◆	◆		◆									■
ಬ		◆	◆		◆			◆									
ಭ		◆	◆	◆	◆	◆		◆									
ಮ			◆	◆	◆			◆									■
ಯ	◆	◆	◆	◆				◆			◆						■
ರ	◆	◆	◆	◆							◆						
ಲ	◆	◆	◆		◆												
ವ			◆	◆	◆			◆									
ಶ	◆	◆	◆	◆	◆												
ಷ			◆	◆	◆	◆		◆									■
ಸ			◆	◆	◆							◆					
ಹ		◆	◆	◆				◆									
ಳ	◆	◆	◆	◆	◆	●				–	◆		◆				■

Table 4. List of confused letters based on the distinctive features

[illegible]	ಲ ಠ ರ ತ ಕ ಳ ಆ ಅ ಶ
[illegible]	ದ ಬ ಹ ಜ ಒ ಓ ಉ ಷ ಫ ಘ ಛ ಧ ಥ ಭ ಢ ವ ಐ ಏ ಙ ಔ ಟ ಮ
[illegible]	ಝ ಯ ಡ ಧ ಢ ಅ ಆ
[illegible]	ಣ ಉ ಊ ಪ ಋ ದ ವ ಫ ಠ ಯ ಮ ವ ನ ಎ ಏ ಖ ಬ ಹ
[illegible]	ನ ಸ
[illegible]	ಡ ಶ ತ ಚ ಕ ಢ
[illegible]	ಞ ಇ ಐ
[illegible]	ಛ ಢ ಥ ಫ
[illegible]	ರ ಗ ಕ ದ ಡ ಠ ಥ
[illegible]	ಇ ಞ

noted, when the lower halves are covered Kannada letters can be read easily than when their upper halves are covered. The top halves seem to have important features which are less confusing. The confusability of right and left halves seem equal. As mentioned earlier, the Kannada letters have round envelopes and the bottom halves are formed of either one curve or two curves with an occasional conditional marker. Similarly, curves on right and left sides have also caused confusions. In addition to the smaller and bigger curves there are many other features which are noted including the position and direction of curves and gaps. The task of partial exposure was useful in determining the features in the respective parts of the letters.

Kannada script is syllabic. The consonant letters of alphabet are modified by ligaturing the Vowel Allographs to form syllables. Thus reading Kannada involves not only perceiving the alphabet letters but also other allographs of them Ligatering rules for the allographs are fairly regular.

The following is an example of consonant ರ [ra] with various vowels.

ರ ರಾ ರಿ ರೀ ರು ರೂ ರೆ ರೇ ರೊ ರೋ ರೌ

And the following are examples of different geminated consonants.

ರ್ರ ಡ್ಢ ಡ್ಡ ತ್ತ

It was needed to see if the vowel allograph could be perceived independent of the consonant, based on their forms. As the script is phonetically regular it might be expected that even the subjects not exposed to Kannada will be able to find the differences precisely among allographs and set them into minimal pairs. Another experiment was carried out for this purpose.

EXPERIMENT II

Subjects : There were eight subjects of age range 17-32 years. The subjects were American nationals who were not exposed to Kannada script any time. The subjects volunteered to undergo the experiment.

Materials : Various ligatured consonants were printed on cards 7 cm. by 12 cm. which were handy for sorting. There were three consonant letters (ಗ, ಮ, ಜ. with various vowels (CVs) and 15 geminated consonants written on the centre of cards. Altogether there were 48 letters used in the experiment.

Procedure : **A** task of sorting was used for classifying the letters based on their forms. The set of cards of randomly ordered letters was given to each subject and the subject was asked to group the similar looking letters in to as many groups as they found appropriate.

Generally, the subjects sorted them into atleast six groups. The groups mainly included the letter combination of the three consonants. The subjects were asked to further sort two of the bigger groups into as many groups as possible.

Results : The outcome of sorting tasks were interesting. The subjects sorted the different CV letters (ಗ, ಮ, ಡ, with various vowels) into individual groups. The geminated letters were put into other three or more groups. The grouping of the geminated letters were dependent on the features similar among them. The following are some of the pairs.

ನ್ಕ ಜ್ಜ ಞ್ಞ ರ್ರ ಪ್ಪ
ಸ್ನ ಖ್ಖ ಟ್ಟ ಠ್ಠ ವ್ವ

In the sec.nd round of sorting two of the CV letter groups were given for sorting. The subjects consistently grouped the CV letters which can be considered as minimal pairs together which differed by single features. There were few exceptions which included pairing of CCV with a similar looking CV. The following is an example of the grouping.

a	b	c	d	e	f
ಮೀ	ಮಿ	ಮು	ಮೂ	ಮೋ†	ಪ್ಪ*
ಮೇ	ಮ	ಮೃ	ಮೊ	ಮೌ	ಮ್ಮ

a	b	c	d	e	f
ಡು	ಡೆ	ಡೀ	ಡೂ	ಡ	ಡೋ*
ಡಾ	ಡೌ	ಡೇ	ಡೊ	ಡಿ	ಡ್ಡ

It was clear from the sorting tasks that one can perceive the allographs in minimal pairs very well even without knowing the orthography. It can be seen from the examples of sorting that they could sort the pairs of letters with only one feature difference. The only exceptions have been CV and CCV pairs which were probably inevitable.

Discussion : The sorting tasks revealed that perception of the Kannada vowel allographs has been possible depending on the distinctive features of the allographs It can be noted that all the vowel allographs can be reduced, to the different features shown in Table 3.

General Discussion : Owing to their form, the bottom halves of Kannada letters are more confusing. Even English letters when printed in lower case letters

---

• Different CV pairs

t Pairs differing by more than one feature.

generally having round envelopes, have more information in their top halves. Depending on the confusions that have been observed among different halves of Kannada letters the distinctive features have been delineated. It should be noted that some Kannada letters have features repeating within them (Table 3).

Vowel allographs of Kannada letters were also seen as combination of distinctive features. It was observed that the same list of features can serve for the allographs too. The sorting task showed that even people unfamiliar with Kannada script could arrange the minimal pairs. The list of distinctive features of Kannada alphabet can be thought as a useful meterial in the related works to come on Kannada reading.

Acknowledgement : We thank our Kannada friends and the non-Kannada American friends who volunteered to be the subjects for the study.

BIBLIOGRAPHY

Gough, P. B. (1972). One second of Reading. In Kavanagh and Mattingly (ed) Language by Ear and by Eye. Cambridge, MIT Press.

Smith, F. (1978). Understanding Reading, New York : Holt Rinehart and Winston.

Spoehr, K. T. and Lehmuhkle, S. W. (1982) Visual Information Processing, Sanfrancisco, W. H. Freeman and Company.

Gibson, E. J. (1969), Principles of perceptual learning and development. New York ; Appleton Century Crofts.

Huey, E. B. (1908). The Psychology and Pedagogy of Reading, New York: Macmillan.

Massaro, D. W, Taylor, G. A. Venezky, R. L. Jastrzembski, J. J. and Lucas, P. A. (1980). Letter and word preception. Advances in Psychology. New York: North Holland Publishing Co.

IMPEDANCE AUDIOMETRIC RESULTS FOR THE DIFFERENT PROBE TONES*

K. SRIDHARAN

Impedance Audiometry yields information quickly and it does not require judgements by the patient. Low frequency probe tones are insensititive to identify .and differentially diagnose few pathological conditions. High-frequency probe-tones provide additional information and help us to indentify those pathological conditions which do not always yield pathognomonic patterns with conventional tympanometry (which use low-frequency probe-tones). Hence diagnostic findings for the different probe-tones need to be compared. Present study is carried out to compare the results obtained using the high frequency probe tones and low frequency probe-tones.

Aim of the study was to establish normative data for the different probe-tone frequencies (i.e. 226Hz, 660Hz and 1KHz). Study was carried out on normals as well as on few pathological subjects also. Hence, comparison between normals and clinical population was possible.

Totally 15 normal hearing subjects (20 dBHL, ANSI 1969) were selected .(8 females and 7 males) with age ranging from 16 years to 24 years (Mean age 20 years). None of them had any middle ear pathology. Further, 6 pathological -subjects were selected. Two of them had moderate sensori-neural hearing loss, three had mixed hearing loss (Otosclerosis) and one had conductive hearing loss (Otosclerosis).

ZO 174 Immittance Audiometer was calibrated and used for testing the subjects. The testing was done in a sound treated room.

Data were obtained and analyzed using appropriate statistical procedures. Means and Standard Deviations were obtained. Significant difference between the mean values for the different probe-tone frequencies were found out. The following results were obtained in normal subjects.

---

* An excerpt from the Master's Thesis. University of Mysore, 1986.

1) There was significant difference between static compliance values obtained-using 226 Hz and 660 Hz (P<0-01) and 226 Hz and 1 KHz (P<0-05) probe-tone-frequencies (when the probe was in right ear).

There was significant difference between Static Compliance values obtained using 226 Hz and 660 Hz (P<0-01) and 226 Hz and 1 KHz (P<0-01) probe-tone frequencies (when the probe was in the left ear).

2) There was significant difference between compliance (PVT) values obtained using 226 Hz and 660 Hz (P<0-01) 660 Hz and 1 KHz (P<0-01) and 226 Hz and 1 KHz (P<0.01) probe tone frequencies

3) There was significant difference between middle ear pressure values obtained using 226 Hz and 660 Hz (P<0-02) and 226 Hz and 1 KHz (P<0-01) probe tone frequencies (when the probe was in the right ear).

There was significant difference between middle ear pressure values obtained using 226 Hz and 660 Hz (P<0-01) and 226 Hz and 1 KHz (P< 0-01) probe tone frequencies (when the probe was in the left ear).

4) There was significant difference between Gradient values obtained using 660 Hz and 1 KHz (P<:0-01) probe tone frequencies.

5) There was significant difference between contra reflex threshold values obtained using 226 Hz and 660 Hz (P<0-01) 660 Hz and 1 KHz (P<0-01) and 226 Hz and 1 KHz (P<0-01) probe tone frequencies.

In case of subjects with moderate sensori-neural hearing loss, there was significant difference between compliance (PVT) values obtained using 226 Hz and 660 Hz (P<0-01) 660 Hz and 1 KHz (P<0-01) and 226 Hz and 1 KHz and 1 KHz (P<0-0l) probe tone frequencies. Also there was significant difference between - contra reflex threshold values obtained using 226 Hz and 660 Hz (P<001) 660 Hz and 1 KHz (P<0-0l) and 226 Hz and 1 KHz (P<0-01) probe tone frequencies.

In case of subjects with Otosclerosis, there was significant difference between compliance (PVT) values obtained using 226 Hz and 660 Hz (P<0-01), 660 Hz and 1KHz (P<0-01) and 226Hz and 1 KHz (P<0-01) probe tone frequencies, Also static compliance values increased progressively from low frequency probe tone (i. e. 226 Hz) to high frequency probe tone (i. e. 1 KHz).

In other words, the type of tympanogram obtained using 226 Hz probe-tone frequency was different from the type of tympanogram obtained using 1 KHz probe tone frequency. For example, 2 subjects with Otosclerosis exhibited, As type tympanogram when tested using 226 Hz probe tone frequency. The same-subjects showed B type tympanogram when tested using 660 Hz and 1 KHz probe tone frequencies.

Further, other two subjects with Otosclerosis exhibited As type tympanogram when tested 226 Hz and 660 Hz probe tone frequencies. The same subjects showed, A type tympanogram when tested using 1 KHz probe tone frequency.

From the above results, the following conclusion can be drawn.

1) Static Compliance, Middle Ear Pressure, Gradient, Compliance (PVT) and Contra Reflex Threshold Values are influenced by the different probe-tone frequencies (i. e. 226 Hz, 660 Hz and 1 KHz).

2) Probe tone frequency has an effect on Impedance Audiometric Measurement in normals as well as Clinical population.

3) Low frequency probe-tone (226 Hz) provides useful clinical information in terms of diagnosis of many pathological conditions of the middle ear. However, high frequency probe-tone are more sensitive to a few specific lesions that affect ossicular chain and ear-drum pathology.