DIADOCHOKINETIC RATE IN THE SPEECH OF HEARING IMPAIRED

REGISTER NO.M8905

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"BAPU"

&

"AAI"

MY BELOVED PARENTS - TO WHOM

I OWE MY EVERYTHING ....

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C E R T I F I C A T E

This is to certify that this Dissertation entitled: "Diadochokinetic rate in the speech of hearing impaired" is the bonafide work, done in part fulfilment for Final M.Sc., (Speech and Hearing) of the student with Register No.M8905

Mysore

1991

Director
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C_E_R_T_I_F_I_C A_T_E

This is to certify that the Dissertation entitled: "Diadochokinetic Rate in the Speech of Hearing Impaired" has been prepared under my supervision and guidance.

Mysore
1991.

Dr.Ravishankar Shukla
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DECLARATION

This Dissertation entitled: "Diadochokinetic Rate in the Speech of Hearing Impaired" is the result of my own study undertaken under the guidance of Dr.Ravishankar Shukla, Lecturer, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier at any University for any other Diploma or Degree.

Mysore
1991.

Register No.M8905

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INTRODUCTION

Speech is highly integrated physiological act characterized by a series of complex motions executed in kinetic chains which is monitored by audition (Fletcher, 1972). Over the past 5-6 decades considerable research effort has been directed towards an understanding of organization and control of the process by which humans produce speech. Such research has evolved observations of aerodynamic and acoustic characteristics of speech, movement of anatomic structures, activity in related musculature and so on.

One of the major constraints imposed upon speech is the motor aspect of speech in that, it is the muscle motility that governs the rate with which any set of utterances can be accomplished, for example the speech output. The measurement of maximum speech output contains a greater amount of information about the physical and motorical system.

Diadochokinetic rate measurement is one of such measures and so diadochokineticrate measurement becomes important and it helps us to know the efficacy of the speech motor system.

Diadochokinesis has been defined as, the ability to perform rapid alternating and repetitive bodily movements auch as opening and closing of the jaw or lips, raising or lowering the eyebrows or tapping the fingers (Wood, 1971). Diadochokinetic rate is number of such movements per minute. And oral diadochokinetic rate refers to such rapid, repetitive and alternating movements of the lips, tongue and other articulators.

In 1929, West postulated a close relationship between the oral diadochokinetic rate and the ability to articulate rapidly. The relationship may be justified by the logic that diadochokinetic syllable repetition requires rapid motion superimposed by balanced equilibrium of the oral structures along with the intact hearing ability. Hence, studying of oral diadochokinesis in hearing impaired children throws light on the role of hearing in diadochokinesis.

Although, speech motor control has been studied intensively in normals less research has been conducted on the neurophysiological intactness of the hearing impaired. The information presently available on the speech of the hearing impaired based on acoustical, phonological and physiological evidence is relatively greater and little is known of the underlying speech and motor coordination skills of hearing impaired speakers specifically as they relate it to the speech sound production and degree of hearing loss.

There are various methods to assess the intactnesa of the motor speech system and one known method of indirectly measuring coordination of speech motor mechanism is through the use of diadochokinetic rate production.

When we talk about speech production then speech intelligibility also becomes one of the important issues to be discussed.

Speech intelligibility is defined as, a measure indicating how well the speaker could make himself/herself understood to a group of listeners.(Cited by Ravishankar, 1985).

Speech intelligibility may be affected through any wide range of disorders and one such disorders is hearing loss and therefore it is important to study relationship between speech intelligibility, hearing loss and oral diadochokinesis.

The purpose of the present study is to examine, by means of selected speech timing task, the speech motor control abilities in a group of hearing impaired subjects. Specifically, the present study aims to answer the following questions:

1. Is there a significant difference between normal hearing and hearing impaired subjects with respect to the oral diadochokinetic syllable production?
2. Is there a relationship between degree of hearing loss and the ability to perform oral diadochokinesis?
3. Is there a relationship between oral diadochokinesia and speech intelligibility?

REVIEW OF LITERATURE

The production of speech demands the use of muscles, group of muscles and organs the basic function of which are not to produce speech. The overlaid function, that is, the production of articulated speech makes certain demands that individual system eventhough biologically and physically normal not be able to meet.

The speech production demands manipulative movements of the jaw, lips and tongue that are much faster than those demanded by the basic functions of chewing, sucking and swallowing.

Professionals in the field have taken differing positions concerning the performance of the parson with speech defects and a positive relationship has been indicated between motor ability and speech. In the past few years, the investigators in the field of speech rehabilitation as well as psychology and medicine have sought to maketheir observation of motor abilities in various ways and reported that the measurement of diadochokinesis is the best tool to measure the motor abilities of speech production.

Diadochokinesis is defined as the performance of rapid alternating and repetitive bodily movements such as opening and closing of the jaws and lips and raising and lowering the eyebrows or tapping the finger (Wood, 1971).

Measuring diadochokinetic rate is very essential in knowing the maximum output of speech rate which in turn gives good amount of information concerning the physical system? that is the information on the neurophysiological coordination*

There are three approaches to measure the diadochokinetic rate? they are -

i) Typical/traditional approach,

ii) Time by count procedure,

iii) Instrumental method such as oscillograph, spectrograph etc.

The typical/traditional approach to the measurement of diadochokinetic syllable rate has been to count the number of syllables uttered in given period of time (Prins, 1962; Mixon and Hardy, 1964). This involves two steps:-

1. To establish the time limit,
2. The another step is to establish thenumber of syllables uttered within the time limit.

Therefore, the examiner is required to divide his attention between watching the stop watch and counting the syllables being uttered. Data obtained through such a procedure would be of questionable validity.

In view of this, a modification of this procedure was provided by Fletcher (1972). In the modified procedure number of syllables rather than the time intervals were pre-established which eliminated the over-lapping of attentional requirements. In the modified procedure, the stop watch is started when the speaker begins to utter the syllables. The examiner's full attention is then directed to the syllable count until the measured number of repetition are uttered. The watch is then turned off. The elapsed time indicated on the stop watch is then recorded at the convenience of the examiner. This method is known as "time by count method".

The third approach is to measure the diadochokinetic rate with the help of an instrument. In this approach, for example spectrogram of a given speech sample is obtained, i.e. wide band bar spectrogram of initial segment of 2.5 seconds (pa, ta, ka) utterances are taken. Then, number of syllables on spectrograph are counted to calculate the diadochokinetic rate per minute (Shukla,1988).

The best approach in all the three above approaches is the time by count measurement. Here in this, the clinician's attention is not divided into two tasks as in the tranditional approach. Also it does not require a costly instrument such as a spectrograph or an oscilloscope to obtain diadochokinetic rate as in the third approach.

Diadochokinetic ability varies from an individual to individual. Even in a given individual this ability does not remain static. Pettit and Schalanger (1960) reported that diadochokinetic rate increases as chronological age increases until about the age of eighteen.

Jenkin Rusell (1941) reported a study based on the rate of diadochokinetic movements of the jaw at the ages from seven to maturity. The subjects selected were twenty-one normal males, eighteen normal females, eighteen male stutteres and eighteen female stutterers. He concluded that -

1) There seems to be an increase in the rate of diadochokinesis of the jaw from the age of seven to eighteen.
2) Statistically speaking, the rate of diadochokinetic movement does not closely correlate with the age.
3) There seems to be greater probability that there is a difference in speed of this movement for successive ages than there is a difference in speed between the sexes of the same age.
4) There seems to be no correlation with age after seventeen.
5) The female norm established in this study is greater than the male norm for diadochokinesis.
6) Male diadochokinetic rate corrected to compensate for greater females development at the various ages seem to exceed the female diadochokinetic rates.

7) The speed of the diadodhokinetic rate seems to vary during the different hours of the day the maximum rate being at 4 p.m.

8) The individual male diadochokinetic rates seems to vary more widely from established male mean than to the female diadochokinetic rates vary from the established female mean.

9) Practically, all subjects seem to produce the maximum rate for the diadochokinetic [movement during the first ten seconds.

10) Stutterers seem to show a slower rate of diadochokinesis of the jaw than normal position.

Lundeen Dale (1950), did a study to know whether or not diadochokinesis changes from one consonant to other and to know whether there is any sex difference existed in diadochokinesis. They selected 40 subjects and included the following 10 consonants such as, /p//t//b//d//k/, /g//f//v//s//z/.

The results indicated the significant 'differences in diadochokineticrate. The average of the means of the 10 syllables was 34.9 for the male and 31.7 for the female group.

Thus, the males were on the average faster than that of females by 3.2 syllables. Though the males proved to have faster diadochokinesis, there was no overt sex difference in variability. Both male and female groups had mean standard deviations of 3.7 in the group.

The syllables which included the consonants /d/ /t/ /b/ and /p/ were most rapidly produced in the diadochokinetic rate than the others. This is because these are among the earliest to be mastered by the children. The /f/ and /v/ occur approximately in the middle, both developmentally and diadochokinetically. The /a/ and /z/ are among the last consonants to be mastered and were also slowest in diadochokinesis.

Fletcher (1972) measured diadochokinetic rate using time by count procedure in 384 school aged children and reported that the two methods of measurements, that is the traditional method and time by count procedure produce equivalent data. He concluded that the time-by-count procedure can produce accurate estimates of diadochokinetic syllables production in a simpler way.

Oliver, Jones, Smith and Newcombe (1985) studied oral stereognosis and diadochokinesis in children and young adults and reported that the mean time for different age groups for diadochokinetic tests show an improvement with age.

However, two aspects are important here, first over the age groups studied there does not appear to be a threshold age above which further improvement of the performance does not occur, secondly, the female sample gave a slower time than a male sample. Also it is reported that for certain diadochokinetic tests there is marked improvement in performance of repeated testing over two days.

Diadochokinetic rate has been measured in clinical population such as on parkinsonism, stuttering, misarticulation and hearing impaired population.

Kreul Jame (1972) studied oral diadochokinesis, sustained phonation and reading rate in parkinsonism. He recorded it in 3 sets of subjects and those 3 sets were healthy young normal adults, healthy elderly adults and patients with parkinsonism. Results indicated that reduced ability to prolong vowels and reading rapidly is associated both with advanced age and parkinsonism. The study also revealed that the syllable diadochokinetic rate fails to differentiate between normal subjects and subjects with parkin sonism.

Canter (l950) reported a study and he contradicted the above finding. He studied the relationship between the diadochokinesis and articulation in parkinsonism and the relationship of both to the overall speech adequacy. The results of the study are as follows:

i) The parkinsonian group showed impaired ability to perform rapid movements of the tongue tip, back of the tongue, lips and vocal folds.

ii) All measures of articulatory diadochokinesis (movements of tongue tip, back of the tongue, lips and vocal folds) were found to be correlated with clarity of articulation. The strongest of these relationships was between articulation and rates of tongue movements.

iii) Of the 4 indices of physiological support for speech (maximum pitch range, maximum intensity range, maximum phonation duration and diadochokinetic rate), it was found that articulatory diadochokinesis had the strongest relationship with overall speech adequacy.

Dworkin and Culatta (1985) studied neuromuscular and structural characteristics in children with normal and disordered articulation. They selected two control groups in which 20 girls (mean age 7.7 years) and 14 boys (mean age 8.1 years) were included. These control subjects did not show any history of unimpaired speech and language disorder. The other group included 6 girls (mean age 7.8 years) and 18 boys (7.7 mean age) These subjects had been diagnosed as functional articulation disorder.

They administered articulation test, measured diadochokinetic rate and examined oral mechanism. Results revealed no significant difference on diadochokinesls between these two groups. Comparisons of diadochokinetic rate data demonstrated that there were no significant differences between the boys and girls in either group or between the control and articulation disordered subjects. The tongue strength, diadochokinetic rate and oral, structural and neuromuscular characteristic of these children were not significantly different from those group of normally articulating children.

McNutt (1977) and Dworkin (1978) examined diadochokinetic rate of those individuals with specific misarticulations and of their normal speaking peers. McNutt examined the rate of alternating syllable productions such as /dʌg / in children with / s / misarticulation and children with / r / misarticulation. Both groups of children misarticulations were noted to be slower than normal speakers in syllable production rates. Dworkin examined lingual diadochokinetic rates for the syllables /tʌ/, /dʌ/,/kʌ/, /gʌ/ in normal and frontal lisping speakers aged 7 to 12 years. The mean rate of utterance of the syllables tested was significantly lower in the disordered group.

Winitz (1956) reported a study in which the report was on five children and 2 adults. The five studied children included a collective total of 16 diadochokinetic tasks. Differences were nonsignificant on 11 of the 18 tasks. All seven tasks showed significant differences between children with articulation problems and children with normal speech were performed better by the controls. These seven tasks were tongue extension, lip rounding, teeth to lip movement production of /pʌ/, of /pʌtʌ/ and of /pʌtʌkʌ/ and elevation of the tongue tip.

The studies reported in the literature reviewed the weak correlation between articulatory proficiency and rapidity of repeated movements of muscles of articulation.

Shukla (1988), studied the diadochokinetic rate in 30 hearing impaired children. The mean age of the subject was 15.67 years, the age range being 11 to 28 years. The hearing impaired individuals selected had congenital bilateral hearing loss (pure tone average greater than 70 dB). The children did not have additional handicap other than that directly related to the hearing impairment. Thirty normally hearing subjects were selected to serve as controls.

Each subject was instructed to utter /pa/ /ta/ /ka/ syllables as fast as he/she could and recordings of the same were made. A sound spectrograph was used to make spectrogram of the speech.Sample recorded was the wide band bar spectrogram of the initial segments of 2.5 seconds of /pa/ /ta/ /ka/ utterances were taken. Then the number of syllables on the spectrograms were counted to calculate the diadochokinetic rate/minute for all the subjects.

The study revealed that the mean diadochokinetic rate for normally hearing subjects was 155.73/minute. The hearing impaired subjects performed poorly on diadochokinetic when compared to the normally hearing speakers. Thus, on the average hearing impaired individuals uttered /pa, ta, ka/ much slower than the normally hearing children. The t-test revealed a statistically significant (0.01 level) difference in the ability to produce rapid and repetitive movements between the two groups.

An analysis of the spectrograms showed two probable reasons,at least at the acoustic level, for this reduction in the diadochokinetic rate in the speech of hearing impaired. They are-

i) Hearing impaired speakers have shown a longer time lapse between the syllable of /pa, ta, ka/ that is inter syllable gap was longer in the utterances of the hearing impaired than those of the normally hearing individuals. This observation indicates that the hearing impaired individuals seemed to have difficulty in translating their articulators of speech rapidly from one artlcu-lator to another.

ii) Hearing impaired individuals while uttering /pa, ta, ka/ syllables had prolonged the vowels whereas the normal had not done so.

Using the time by count procedure, Robb, Hughes and Frese (1985) measured the oral diadochokinetic rate in the hearing impaired children. Along with this they measured the speech intelligibility of the hearing impaired speakers.

The study included 30 prelingually hearing impaired high school students in the age range of 15 years 1 month to 18 years 9 months. The students with abnormal results on the speech mechanism were not considered for the study. Subject inclusion for the study was based on the hearing impaired students demonstrated ability to produce /pa, ta, ka/ consistently as evaluated by one of the investigators. The subjects selected had a pure tone audiometric average of 58.0 dB HL or greater, unaided in better ear, 7 were from moderately severe group, 13 were from severe group, and 10 were from profoundly hearing loss group. The intelligibility of speech sound production was assessed using Arizona Articulation Proficiency scale. Time by count method was used to elicit the diadochokinetic rate.

The results indicated that the mean total time and Standard deviation values appear to increase relative to hearing loss severity. The hearing impaired subjects produced diadochokinetic rate. Slower than normal hearing peers. When oral diadochokinesis was analyzed as a function of hearing loss, a consistent trend was observed. The speed in the production of the diadochokinetic rate was closely related to degree of hearing loss for each child. The profoundly hearing impaired subgroup was considerably slower than the less severely hearing impaired subgroup.

The study also revealed that in general, Arizona Articulation Proficiency Scale was not related to oral diadochokinesis, subsequently the rate of speech production was decreased by hearing impaired individuals. It was reported that this decreased rate was the subject's attempt to ensure speech intelligibility. Thus finally they concluded that exposure to auditory stimulation would very well be the primary factor to the development of coordination within the speech motor mechanism. Thus it is logical to suggest that,hearing impaired speakers will vary their speech motor skills on the basis of perception to auditory stimuli. The natural timing of speech seems to represent a combination of neurological, physiological and biochemical adjustments on one hand and auditory based perception of rhythm and rate on the other hand.

METHODOLOGY

The aim of the study was to measure the diadochokinetic rate in the hearing impaired individuals and to find out the relationships between degree of hearing loss and diadochokinetic rate and speech intelligibility.

The study included 20 hearing impaired children which included 12 males and 8 females. The age range of the subjects was between 9 years 1 month to 12 years 11 months. Each subject was required to satisfy the following criteria, before he/she was included for the study.

1) Each subject should have pure tone average of 55 dB HL or more sensori-neural hearing loss in the better ear.
2) Should have no abnormal oral structures and no neurologic abnormality.
3) Should have normal Intelligence
4) Should have the ability to read simple bisyllabic and trisyllabic words.

Depending upon the severity of the hearing loss, the subjects were divided into 3 groups as shown in Table-1.

Table-2 shows, age, sex and pure tone average of 0.5, 1 and 2 KHz for all the 20 hearing impaired subject.

Table-1: Showing the distribution of the cases on the basis of number, severity of hearing loss and pure tone average

S.No.	No.of cases	Pure tone average	Severity of hearing loss
1	5	58-70	Moderately severe hearing loss
2	8	73-85	Severe hearing loss
3	7	90-98	Profound hearing loss

Table-2: Showing age. sex, pure tone average of 0.5 Khz, 1 KHz & 2 KHz for each subject.

S.No.	Age Year/month	Sex	Pure tone average (Better ear)	
			dB	severity
1.	10*01	M	62	Moderately severe hearing loss
2.	12-8	M	58	Moderately severe hearing loss
3.	12-10	M	60	Moderately severe hearing loss
4.	11-0	F	70	Moderately severe hearing loss
5.	9-5	F	60	Moderately severe hearing loss
6.	12-9	F	75	Severe hearing loss
7.	11-1	M	80	Severe hearing loss
8.	12-2	F	72	Severe hearing loss
9.	10-0	M	75	Severe hearing loss
10.	12-0	M	81	Severe hearing loss
11.	9-2	M	73	Severe hearing loss
12.	10-5	M	80	Severe hearing loss
13.	9-10	M	85	Severe hearing loss
14.	11-0	F	95	Profound heating lass
15.	9-9	M	95	Profound hearing loss
16.	12-10	M	97	Profound hearing loss
17.	11-0	F	97	Profound hearing loss
18.	12-0	F	90	Profound hearing loss
19.	9-1	M	98	Profound hearing loss
20.	11-0	F	99	Profound hearing loss

Speech Sample and Recording Procedure:

Diadochokinetic rate:

Speech sample selected for the diadochokinetic rate assessment was utterance of /pa/, /ta/, and /ka/ syllables because, utterance of /pa, /ta/, /ka/ has been widely used to assess diadochokinetic rate production probably because these sounds are acquired early in the childhood and cover different places of articulation in the speech mechanism.

Each subject was seated in a chair comfortably in a quiet environment. And prior to actual recording of the speech task, each subject was given simultaneous signed and spoken instructions plus each syllable repetition was first demonstrated at a rapid rate.

Then subjects were given an opportunity to practice the syllables rapidly and continuously. Finally each subject was instructed to utter the syllables as quickly as possible until he/she was stopped and the same was recorded using Philips AM-125-Tape recorder and Coney 90-SQ cassette. Bach subject was required to perform the task 3 times.

Before recording the speech task, each subject was given the following instructions:
"I want you to say some sounds for me. They are no words just sounds. I will show you how to make them first. Then you can say them with me. Then you try it yourself as fast as you can".

Speech_intelligibility:

To assess the speech intelligibility 30 words containing both disyllabic and trisyllabic words were used. The words selected were simple to read. These words were in the vocabulary of the hearing impaired children. The word list is provided in the Table-3. The picture cards of the 30 words were prepared for eliciting correct responses from the subjects.

Table-3:Showlng 30 words used for eliciting response for speech intelligibility.

ಬಾಲು : [ba:lu].	ಚಂದ್ರ : [cʰand̪ra]
ಮಂಚ : [man̪cʰa]	ಲೋಟ : [loṭa]
ಪೆನ್ನು : [pen̪n̪u]	ಪೈಸೆ : [paise]
ಬಸ್ಸು : [bas̪s̪u]	ನಾಯಿ : [na:i]
ಕಾಗೆ : [ka:ge]	ಚೀಲ : [cʰi:la]
ಬೀಗ : [bi:ga]	ಆನೆ : [a:n̪e]
ತಟ್ಟೆ : [t̪aṭṭe]	ಸೂರ್ಯ : [su:rya]
ಕಾಲು : [ka:lu]	ಬ್ಯಾಟು : [bæ:ṭu]
ಕಿವಿ : [kivi]	ಸೇಬು : [se:bu]
ಮೀನು : [mi:nu]	ಹಾಲು : [ha:lu]
ಬಳೆ : [baḷe]	ಮಗು : [magu]
ಅನ್ನ : [an̪n̪a]	ಮನೆ : [mane]
ಬೆಕ್ಕು : [bekku]	ಮರ : [mara]
ಫ್ಯಾನು : [fænu]	ಬೂಟು : [bu:ṭu]
ದೋಣಿ : [d̪oṇi].	ಕೆಂಪು : [kempu].

Before recording, each subject was instructed as follows:

"Now I will show you some picture cards: You have to read or identify what is written on the card or identify the picture and say it loudly after carefully looking at them".

For every subject, the list was presented three times in different order. The gap of about 10 seconds was given between the two picture cards. Recording was done using Philips AM-125 tape recorder and Coney 90 SO cassette.

Measurement procedure:

Diadochokinetic rate:

To measure the diadochokinetic rate time by count procedure was adopted. This included the following steps.

1. The best of the three trials was selected.
2. Variable speed tape recorder was set to the lowes. speed and 10 /pa,ta,ka/ utterances were counted and at the end of the 10th utterance the word stop waa recorded to aid in marking the end point of the sample.
3. Tape recorder was rewinaed to start position of the sample.
4. Then variable speed tape recorder was set to the "normal speed level" and played again, simultaneously switching on the stop watch. The stop watch was on till the investigator heard the word stop.

5. Time elapsed on the stop watch gave the time taken to utter 10 /pa, ta, ka/ utterances.

The tape recorder used for this was Philips N 2210 which has the facility for varying the play speed.

Speech intelligibility:

Speech intelligibility was assessed with the help of 3 experienced listeners (judges). The 60 lists obtained from all the subjects were randomized and re-recorded to rule out order effect.

These lists were played for all the 3 judges at the same time and they were requested to write down what they perceived from the recorded sample.

When the judge correctly identified the whole word whether bisyllabic or trisyllabic then, only it was considered as correct response. The number of correct responses were converted into percentages. Then the scores of all three listeners were averaged for each subject because intra judge reliability was high.

Statistical analysis:

Pearson product moment coefficient of correlations were computed to examine the relationship between:

1. Pure tone average and oral diadochokinesis and hearing loss.
2. Pure tone average and speech intelligibility scores.
3. Diadochokinetic rate and speech intelligibility scores.

ANOVA was not used to find out the intra group differences because of small sample in each group and high correlation obtained between the two variables.

RESULTS AND DISCUSSION

Speech of the deaf children differs from that normals in all regards. In all studies, of speech of hearing impaired attention is drawn to the fact that to a greater or lesser degree hearing impaired do not produce speech as well as those who hear (Monsen, 1974.

Considering the information presently available about the speech motor skills of hearing impaired speech, very little is known about it. The present study has been undertaken to find out the speech motor skills of the hearing impaired subjects by assessing diadochokinetic rate. The study also aimed at finding out the relationship between the diadochokinetic rate and degree of hearing loss and disdochokinetic rate and speech intelligibility.

The diadochokinetic rate was measured using time by count procedure and speech intelligibility was measured using experienced listeners as judges.

1. Diadochokinetic rate:

Diadochokinesis is defined as, the performance of rapid alternating and repetitive bodily movements such as opening and closing of the jaws and lips and raising and lowering the eyebrows or tapping the finger (Wood, 1971).

In the present study diadochokinetic rate was defined as time taken in teams of seconds to utter /pa, ta, ka/ 10 times.

The results obtained are shown in Table-4

Table-4: Shows the diadochokinetic rate for ail the 20 hearing impaired subjects.

S.No.	Age year/ month	Sex	Puretone average(better ear)		Diadochokinetic rate	
			dB	Severity	Time taken for 10 utterances (in second	sylla-bles utteera within 10 sec.
1	10-1	M	62	Mod.sev.hearing loss	5.4	18.3
2	12-8	M	58	Mod.sev.hearing loss	5.2	19.0
3	12-10	M	60	Mod.sev.hearing loss	5.3	18.6
4	11-0	F	70	Mod.sev.hearing loss	5.7	17.3
5	9-5	F	60	Mod sev.hearing loss	5.4	18.3
6	12-9	F	75	Severe hearing loss	6.4	15.6
7	11-1	M	80	§evere hearing loss	6.6	15.0
8	12-2	F	72	Severe hearing loss	6.1	16.3
9	10-0	M	75	Severe hearing loss	6.2	16.0
10	12-0	M	81	Severe hearing loss	6.8	14.6
11	9-2	M	73	Severe hearing loss	6.2	16.0
12	10-5	M	80	Severe hearing loss	6.8	14.6
13	9-10	M	85	Severe hearing loss	7.1	14.0
14	11-0	F	95	Profound hearing loss	10.9	9.1
15	9-9	M	95	Profound hearing loss	11.1	9.0
16	12-10	M	97	Profound hearing loss	12.0	8.3
17	11-0	F	97	Profound hearing loss	12.5	8*0
16	12-0	F	90	Profound hearing loss	10.2	9.8
19	9-01	M	98	Profound hearing loss	13.6	7.3
20	11*0	F	99	Profound hearing loss	14.2	7.0

It may be observed from the table-4 that the hearing impaired subjects on the average had taken 8.2 seconds for 10 utterances of /pa,ta,ka/, when we calculte the number of syllables uttered per minute it comes to 80 utterances of /pa* ta, ka/ per minute.

Shukla (1980) reported that the oral diadochokinesis for normal speaker as 155 utterances per minute and 90.00 utterances/minute for hearing impaired speakers and the difference was statistically significant.

The diadochokinetic rate obtained for the hearing impaired subjects of the present study agree with the finding reported by Shukla (1988); this confirms that the hearing impaired subjects perform very poorly on the oral diadochokinesis when compared to normal hearing subjects.

Shukla (1988) after the acoustic analysis of /pa, ta, ka/ utterances attributed this slower performance of the hearing impaired subjects to the fact that -

i) The hearing impaired speakers showed a longer time lapse between the syllable of /pa, ta, ka/ that is longer inter syllable gap in the utterance of the hearing impaired individuals, which shows that hearing impaired individuals have problems in translating their articulators of speech from one position to other rapidly.

ii) Hearing impaired individuals while uttering /pa, ta, ka/ significantly prolonged the vowels which was not a feature in the utterance of normal hearing subjects.

2. Effect of hearing loss on diadochokinetic rate:

Table-5 shows time taken (in terms of seconds) to complete 10 utterances of /pa, ta, ka/ among moderately severe, severe and profound hearing loss cases. The table also shows number of syllables uttered by each group within 10 seconds.

Table-5: Showing the diadochokinetic rate among 3 categories of healing impaired subjects.

S.No.	Severity of hearing loss	No.of cases	Time taken for 10 utterances (in seconds)	/pa,ta,ka/ uttered within 10 seconds.
1	Moderately severe hearing loss	5	5.4	18.3
2	Severe hearing loss	8	6.6	15.2
3	Profound hearing loss	7	12.0	8.3

From the above table it may be observed that the time taken to utter 10 /pa, ta, ka/ utterances increases as the severity of hearing loss increases. However, the difference between moderately severe and severe hearing loss is not much but there is significant difference between severe and profound hearing loss group.

Robb, Hughes and Frese (1985) also reported no significant difference between the moderately severe and severe hearing impaired group but they reported a significant difference in the diadochokinetic rate between severely hearing impaired group and profoundly hearing impaired group.

To examine the relatipnship between the degree of hearing loss and ability to perform rapid and alternating movements; Pearson's product moment correlation was applied between pure tone average of 0.5, 1 and 2 KHz of each subject and their diadochokinetic rate. The analysis revealed the correlation coefficient of f = -0.97 which was significant at 0.01 level which confirms that as the hearing loss increases the diadochokinetic rate decreases. Since the correlation was very high the statistical procedure to test the group difference was not suggested.

From these results we can infer that the auditory feedback plays a vital role in oral diadochokinesis, as the severity of hearing loss increases ability of the articulatory system to perform rapid alternating and repetitive movements of the articulators to produce speech decreases*

Also, because of the hearing loss the hearing impaired subjects rely on visual clues to learn articulation. Because they learn to articulate through visual observation of the articulatory movements of the other speakers, the fine rapid movements of the articulators are difficult to observe this probably resulting in poor performance in rapid and alternating movements.

However, it is known that tactile and kinesthetic feedback aid in monitoring the ongoing articulatory activity. If this was the case then hearing impaired speakers would have achieved better diadochokinetic rates since it is not, so it could probably imply the importance of a multisensory feedback and more so the auditory feedback.

It is also well known that the feedback is vital to bring about the coarticulatory effects during speech production. Thus it could be contended that the "cause and effect" constitute a chain reaction wherein hearing loss leads to poor articulation which in turn causes decreased diadochokinetic scores.

2. **Speech intelligibility:**

In the present study speech intelligibility was defined as a measure indicating how well the speaker could make himself/herself understood to a group of listeners.

To assess the speech intelligibility 30 commonly used disyllabic and trisyllabic Kannada words were used and the relationship between the hearing loss and speech intelligibility was found.

The results obtained are shown in the Table-6.

Table-6: Showing the distribution of the cases in terms of age, sex hearing loss with their speech intelligibility scores in percentage.

S.No.	Age year/month	Sex	Pure tone average(better ear) dB	Severity	Speech intelligibility scores in percentage.
1	10-1	M	62	Mod.sev.hearing loss	90
2	i2-e	M	58	Mod.sev.hearing loss	97
3	12-10	M	60	Mod.sev. hearing loss	91
4	11-0	F	70	Mod.sev.Hearing loss	85
5	9-5	F	60	Mod.sev.hearing loss	90
6	12-9	F	75	Severe hearing loss	79
7	11-1	M	80	Severe hearing loss	75
8	12-2	F	72	Severe hearing loss	80
9	10-0	M	75	Severe hearing loss	77
10	12-0	M	81	Severe hearing loss	75
11	9-2	M	73	Severe hearing loss	82
12	10-8	M	80	Severe hearing loss	78
13	9-10	M	85	Severe hearing loss	70
14	11-0	F	95	Profound hearing loss	61
15	9-9	M	95	Profound hearing loss	60
16	12-10	M	97	Profound hearing loss	55
17	11-0	F	97	Profound hearing loss	51
18	12-0	F	90	Profound hearing loss	68
19	9-1	M	98	Profound hearing loss	51
20	11-0	F	99	Profound hearing loss	50

Mod - Moderately? Sev-severely

Table-7 shows the relationship between the severity of hearing loss and speech intelligibility.scores in percentage

S.No.	Severity of hearing loss	No.of cases	Speech intelligibility scores in %
1	Moderately severe hearing loss	5	90.6
2	Severe hearing loss	8	77.0
3	Profound hearing loss	7	56.57

The Pearson's product moment coefficient of correlation was applied to find out the relationship between pure tone average and speech intelligibility. The correlation obtained between the two variables was r=-0.98 which was significant at 0.01 level indicating that, as the hearing loss increased the speech intelligibility scores decreased.

The above findings agreed with the findings reported by Robb, Hughes and Frese (1985) and Ravishankar (1985). They also reported that as the hearing loss increased and the speech intelligibility scores decreased and the lowest score was seen in profoundly hearing impaired subjects.

Speech production requires constant efficient monitoring of the articulatory movements. Over-shooting or under-shooting of the coarticulatory gestures leads to imprecise production which in turn results in poor speech intelligibility. This happens mainly because they rely on visual clues because they learn to articulate through visual observation of the articulatory movements of the other speakers. Consequently it follows that the fine rapid movements and those articulatory gestures produced in the back oral cavity become difficult to observe hence what is available to the hearing impaired children is probably just the gross nature of articulatory movements thus resulting in poor production and hence poor intelligibility. This could also be due to failure to coordinate certain biochemical functions necessary for speech production, for example in-coordination between respiratory, phonatory and resonatory system or as whitehead and Barefoot (1983) have suggested failure tin phonatory aerodynamics.

3.Diadochokinesis and speech intelligibility:

Table-8 shows the diadochokinetic rates and speech intelligibility scores for all the 3 groups.

Table-8: Shoving diadochokinetic rates and speech intelligibility scores in terms of percentage for the 3 groups of hearing impaired subjects.

S.No.	Severity of hearing loss	Diadochokinetic rate (time taken for 10 utterances in seconds)	Speech intelligibility scores in percentage
1.	Moderately severe hearing loss	5.4	90.60
2.	Severe hearing loss	6.6	77.0
3.	Profound hearing loss	12.0	56.57

Pearson's product moment coefficient of correlation was applied to find out the relationship between diadochokinetic rate and speech inteiligibility. Correlation obtained was r = + 0.98 which was significant at 0.01 level.

This shows as the diadochokinetic rate increased the speech intelligibility increased. This relation between higher diadochokinetic rates and better speech intelligibility is not a causal one, instead, it simply means that those who can produce diadochokinetic rate at the faster rate which require better motor control (neurophysiological intactness) can also produce many other aspects of speech in a normal manner which results in better speech intelligibility. Meaning that the individuals who had higher diadochokineticrate had higher speech intelligibility scores.

SUMMARY AND CONCLUSIONS

The study was aimed at measuring oral diadochokinesis in hearing impaired subjects and to find out the relationship between, the following:

- Degree of hearing loss and diadochokinetic rate.
- Diadochokinetic rate and speech intelligibility.
- Speech intelligibility and degree of hearing loss.

Diadochokinesis was defined as the time taken by the individual to produce 10 utterances of /pa, ta, ka/ or/as the number of /pa, ta, ka/ utterances produced by an individual within 10 seconds.

Speech intelligibility was defined as, a measure indicating how well the speaker could make himself/herself understood by a group of listeners.

Specifically the study aimed at answering the following questions.

1) Is there a significant difference between normal hearing and hearing impaired subjects with respect to the oral diadochokinetic syllable production?
2) Is there a relationship between degree of hearing loss and the ability to perform oral diadochokinesis?
3) Is there a relationship between oral diadochokinesis and speech Intelligibility?

The study included 20 congenitally hearing impaired children in the age range of 9 years 1 month to 12 years 11 months. The subjects had a wide range of sensorineural hearing loss.

The oral diadochokinesis was measured using /pa* ta,ka/ utterances by"time by count" procedure. To assess speech intelligibility 30 words (bisyllabic and trisyllabic' Kannada words)were used, speech intelligibility was assessed with the help of experienced listeners. Appropriate statistical procedures were applied.

The study revealed the following:

1. The hearing impaired subjects had poor oral diadochokinesis (slower rate) as compared to normals.
2. The diadochokinetic rate showed a high negative correlation with hearing loss, indicating that a good pure tone average is associated with better oral diadochokinesis and hence better motor control abilities.
3. The speech intelligibility scores showed good negative correlation with hearing loss that is as hearing loss increased speech intelligibility decreased.
4. A high positive correlation was obtainedbetween oral diadochokinesis and speech intelligibility scores indicating that children who had higher diadochokinetic rate - also had better speech intelligibility.

Based on the results of the study the following conclusions were drawn:

- Abnormal hearing affects the individuals ability to perform rapid and alternate oral movements.

- The ability to perform oral diadohhokinesis decreases with the increase in severity of the hearing loss. Good positive correlation between the speech intelligibility and oral diadochokinesis hint that speech therapy should also aim at improving the diadochokinetic syllable production rate of the hearing impaired speakers. Articulation drills which facilitate motor coordination and speed may help the hearing impaired speakers to increase their diadochokinetic rate, plus the abberant speech respiratory patterns present if any in the speech of the hearing impaired should be modified to improve the oral diadochokinesis.

Suggestion for further research:

1. Due to time constraints only a small number of subjects were considered in the study. A similar study on a larger sample would be beneficial in strengthening the results of the current study.
2. Little is known concerning the significance of oral diadochokinesis inrelation with various kinds of articulatory disorders so more research of this kind will be helpful.

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