CHAPTER 4

A SKELETAL STRUCTURE OF THE BENGALI PHONOLOGY

4.0. INTRODUCTION

As discussed previously dysarthria is a neurogenic motor speech disorder where the nerves and the muscles of the speech apparatus get affected resulting in the distorted output of phones. The consonants and the vowels become so imprecise that the speech of the individual becomes unintelligible. Such imprecision during the production of the speech sounds suggests that the speech apparatus has deviated from the precise manner and place of articulation.

In order to know to what extent the dysarthric Bengali speech is getting deviated from the normal Bengali speech and in what manner the sounds are getting imprecise in the speech of the Bengali dysarthrics, it is first essential to describe the articulation of the Bengali speech sounds from the point of view of articulatory and acoustic phonetics.
Further, a brief description of the Bengali phonology is also required. Thus in this chapter the main emphasis has been given on the description of the Bengali vowels and consonants with illustrations of their distributional patterns along with the processes involved in their production.

Moreover, the spectrograms of the vowels and consonants are also included in order to make the study more objective.

The chapter also deals with the Bengali prosodic or suprasegmental features. The Bengali prosodic or suprasegmental features include stress, juncture, clause terminals, pitch and intonation patterns. But since in dysarthric Bengali speech the prosodic features such as stress, clause terminals and pitch are only affected as far as this study is concerned, in this chapter only these three features are dealt with.

4.1. ARTICULATORY DESCRIPTION OF BENGALI VOWELS AND CONSONANTS ALONG WITH THEIR DISTRIBUTION

The Standard Colloquial Bengali (henceforth Bengali) consists of seven vowels along with their nasalised counterparts and thirty consonants.
4.1.1. DESCRIPTION OF THE VOWELS AND THEIR DISTRIBUTION

Bengali has seven vowel sounds and their seven nasalised counterparts. The following table 4.1 presents the articulatory features of the vowel sounds.

Table 4.1: Articulatory Features Of The Vowel Sounds

<table>
<thead>
<tr>
<th></th>
<th>Front unrounded</th>
<th>Central neutral</th>
<th>Back rounded</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>i iM</td>
<td></td>
<td>u uM</td>
</tr>
<tr>
<td>High-Mid</td>
<td>e eM</td>
<td></td>
<td>o oM</td>
</tr>
<tr>
<td>Low-Mid</td>
<td>E EM</td>
<td></td>
<td>O OM</td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td>a aM</td>
<td></td>
</tr>
</tbody>
</table>

The vowels are described below (Bhattacharya, 1988: 8-56):

/ii/ It is a unrounded high front vowel. During its production the front part of the tongue is raised as high as possible towards the hard palate but does not touch it causing any kind of friction. The
lips are spread. The soft palate is raised to close the nasal passage and the vocal folds are vibrated when the air is passed.

**Examples:**

Initial position | itihaS | 'history'
Medial position | tin | 'three'
Final position | chobi | 'picture'

**/ɛ/** It is an unrounded high mid front vowel. The front part of the tongue is raised high towards the hard palate but it is not as high as in /i/. The tongue does not touch the hard palate and cause any friction. The lips are spread. The soft palate is raised and blocks the nasal passage. The vocal folds are in vibration.

**Examples:**

Initial position | ekuS | 'twenty one'
Medial position | deS | 'country'
Final position | dure | 'far'

**/ɛ/** It is an unrounded low mid front vowel. This sound is produced by raising the front part of the tongue slightly above the normal
lowest position that it occupies in the mouth. Lips are spread. The soft palate is raised to block the entry of air into the nasal passage and the vocal folds vibrate.

Examples:

Initial position Ek 'one'
Medial position khEla 'game'
Final position hEM 'yes'

/a/ It is an unrounded central vowel. In the production of this sound the air passes through the center of the tongue and the middle point of the palate. The tongue remains in a relaxed position and remains as low as possible and moves slightly backwards. The lips are spread. The nasal passage is closed and the vocal folds vibrate during its production.

Examples:

Initial position alo 'light'
Medial position pan 'betel leaf'
Final position matha 'head'
/oI/ It is a rounded low mid back vowel. It is produced by raising the 
back of the tongue slightly towards the soft palate but the height 
is a little lower than it is required for /o/ and a little higher than /a/. 
The lips are half rounded. The soft palate is raised with vibrating 
vocal folds.

Examples:
Initial position Onek 'many'
Medial position chOY 'six'
Final position bO 'to carry'

/ol/ It is a rounded high mid back vowel. In the production of this 
sound the back part of the tongue is raised towards the soft 
palate. The degree of rising is a little lower than needed for /u/. 
The lips are rounded. The soft palate is raised and the vocal folds 
are in vibration.

Examples:
Initial position opor 'top'
Medial position khoia 'open'
Final position pujo 'sacred ceremony'
/u/ It is a rounded high back vowel. During its production the back part of the tongue is raised as high as possible towards the soft palate but does not touch it. The lips are rounded. The soft palate is raised and the vocal folds are in vibration.

Examples:
Initial position uniS 'nineteen'
Medial position mukh 'face'
Final position goru 'cow'

/iM, eM, EM, aM, um, oM, OM/

To articulate the nasalised counterparts of the vowels, the speech organs are in the same position as they are in case of the corresponding oral vowels. The only characteristic that differentiates them from the oral vowel is that the soft palate is not raised and thus the nasal passage remains open. And as a result the airstream can pass through both the oral and nasal passages.

/iIM/ Examples:
Initial position iMdur 'mouse'
Medial position piMpRe 'ant'
Final position  jhiM jhiM  'a twinging sensation'

/eM/ Examples:
Initial position  eMcoR  'name of a vegetable'
Medial position  peMpe  'name of a vegetable'
Final position  heM heM  'a kind of laughter'

/EM/ Examples:
Initial position  Emka-bEka  'zig-zag'
Medial position  DhEMRoS  'a name of a vegetable'
Final position  hEM  'yes'

/aM/ Examples:
Initial position  aMcol  'end of a loin-cloth worn by a lady'
Medial position  kaMc  'glass'
Final position  haM  'open mouth'

/OM/ Examples:
Initial position  gOMd  'gum'
Distributional Patterns Of The Vowels

Vowel length is not significant in Bengali. The vowels O and E occur in syllable final position in limited cases only. They are found mainly in monosyllabic words and mostly in repetitions, for example- hEM ‘yes’ or chEchE ‘fie’. The other five vowels namely, i, e, a, o and u occur in the initial, medial and final positions of words. Examples of the occurrences of the vowels in different positions have already been given.

Nasalization is a phonemic feature in Bengali. The vowel /O/ is nasalised rarely. All the other six vowels are usually nasalised.
Generally, the nasal vowels occur in the first syllable of the Bengali words.

In Bengali when two vowels are combined they can either form two different syllables or they can form a single syllable. In the first case both the vowels have the syllabic peak and thus they can form two syllables.

Such vowel sequences are nine in number and are listed below:

1) ie nie 'having taken'
2) io prio 'favourite'
3) ia Tia 'a parrot'
4) ue Sue 'having lain down'
5) ea khea 'ferry boat'
6) Oa hOa 'to become'
7) oa doa 'to milk'
8) uo kuo 'well'
9) ua jua 'gambling'

But in the second case a single syllable can be formed by two vowels as in case of diphthongs, which have been enumerated below.
4.1.2. DIPHTHONGS

According to Bhattacharya (1993: 16), 'when the two vowel cluster forms a single syllable, the four vowels /i, u, e, o/ can only be the last component of the cluster. The last component has either the same height of articulation as the initial component or is higher. The initial component carries the syllabic peak and the last component is a nonsyllabic one without having the syllabic prominence. Phonetically these vowel clusters are called diphthongs'.

Sarkar (1998:15-16) has given a list of seventeen Bengali diphthongs.

These diphthongs are illustrated below:

1) iy  diy  'I give'
2) iw  Siwli  'name of a flower'
3) ey  ney  '(be), (have) not'
4) ew  kew  'anybody'
5) eW  deWghOr  'a place name'
6) EY  bEY  'expenses'
7) EW  SEWiа  'moss'
8) ay  jay  'I go'
The semivowels /y, w, Y, W/ are the non-syllabic variants of the vowels /i, u, e, o/ respectively. They are produced in the similar manners as that of the respective vowels. These sounds always occur as the second element in combination with other vowels. During the production of the semivowels the articulatory organs move rapidly from the previous vowel position to that of the following semivowels.

4.1.3. DESCRIPTION OF THE CONSONANTS AND THEIR DISTRIBUTION

There are thirty consonant sounds in Bengali.
Stops  \( p, ph, b, bh \)
\( t, th, d, dh \)
\( T, Th, D, Dh \)
\( k, kh, g, gh \)

Fricatives  \( S, s, h \) (according to some Bengali phonologists \( s \) is a phoneme. And according to others it is an allophone of \( S \))

Affricates  \( c, ch, j, jh \)

Nasals  \( m, n, N \)

Flaps  \( R, Rh \) (according to some scholars these are phonemic)

Trill  \( r \)

Lateral  \( l \)

The following table shows the manner and place of articulation of the thirty consonants.
Table 4.2: Articulatory Features of the Consonants

<table>
<thead>
<tr>
<th></th>
<th>Bilabial</th>
<th>Dental</th>
<th>Alveolar</th>
<th>Retroflex</th>
<th>Alveopalatal</th>
<th>Velar</th>
<th>Glottal</th>
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<tbody>
<tr>
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<td>vl. vd</td>
<td>vl. vd</td>
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<tr>
<td>unaspirated</td>
<td>p</td>
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<td>T</td>
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<td>th</td>
<td>dh</td>
<td>Th</td>
<td>Dh,Rh</td>
<td>kh</td>
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<td>jh</td>
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<tr>
<td>Nasals</td>
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<td>Trill</td>
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<tr>
<td>Lateral</td>
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</tbody>
</table>

The columns represent manner of articulation and the rows represent points of articulation.

In Bengali there are sixteen stops, three fricatives, four affricates, three nasals, two flaps, one trill, and one lateral. All of them are discussed in the following.
Bilabial Stops /p, ph, b, bh/

The general articulatory feature of producing these stops is that the airstream coming from the lungs is completely blocked by the tight closure of the lips. Then the air is released with an explosion.

These stops are described one after the other in the following:

/p/ It is a voiceless unaspirated bilabial stop. In the production of /p/ the vocal folds do not vibrate. The soft palate is raised to close the nasal passage.

It occurs in all the initial, medial and final positions of words.

Examples:
Initial position pata 'leaf'
Medial position apei 'apple'
Final position Sap 'snake'

/ph/ It is a voiceless aspirated bilabial stop. The vocal folds do not vibrate. During its production a heavy puff of air is released at the time of explosion.
It occurs in all the positions. But in the final position it is weakly aspirated.

Examples:
Initial position  phOi  ‘fruit’
Medial position  Sophor  ‘travel’
Final position  bOroph  ‘ice’

/b/  It is a voiced unaspirated bilabial stop. During its production the vocal folds vibrate.
It occurs in all the positions of words.

Examples:
Initial position  baRi  ‘house’
Medial position  Saban  ‘soap’
Final position  Dab  ‘green coconut’

/bh/  It is a voiced aspirated bilabial stop. The vocal folds vibrate.
There is an extra puff of air during the time of explosion.
It occurs in all the positions of words.
Dental Stops /t, th, d, dh/

During the production of these sounds the air from the lungs is completely blocked by the blade of the tongue against the upper teeth. The soft palate is raised to close the nasal passage.

/t/ It is a voiceless unaspirated dental stop. The vocal folds do not vibrate.

It occurs in all the positions of words.

Examples:

Initial position tala 'lock'
Medial position hati 'elephant'
Final position bhat 'rice'

/th/ It is a voiceless aspirated, dental stop. The vocal folds do not vibrate. There is an extra puff of air during the time of explosion.
It occurs in all the positions of words.

Examples:

Initial position    thala    'plate'
Medial position    kOtha    'words'
Final position    pOth    'road'

/\d/ It is a voiced unaspirated dental stop. During its production the vocal folds vibrate.

It occurs in all positions of the words.

Examples:

Initial position    dOS    'ten'
Medial position    Sada    'white'
Final position    caMd    'moon'

/\dh/ It is a voiced aspirated dental stop. During its production the vocal folds vibrate and there is an extra puff of air during its production.

It occurs in all the positions of words.

Examples:

Initial position    dhan    'grains'
Medial position gadha 'donkey'
Final position oSudh 'medicine'

Retroflex Stops / T, Th, D, Dh/

To produce these sounds the tip of the tongue is raised towards the roof of the mouth and is curled back. The under side of the tongue touches the roof of the mouth and then suddenly it leaves the point of articulation. The soft plate is raised to obstruct the airstream from flowing into the nasal passage.

/T/ It is a voiceless unaspirated retroflex stop. The vocal folds do not vibrate. It occurs in all the positions of words.

Examples:
Initial position Taka 'money'
Medial position choTo 'small'
Final position ThoMT 'lips'
/Th/ It is a voiceless aspirated retroflex stop. The vocal folds vibrate and the sound is produced with an extra puff of air. It occurs in all the positions of words.

Examples:

Initial position Thakur ‘God’
Medial position ciThi ‘letter’
Final position kaTh ‘wood’

/Id/ It is a voiced unaspirated retroflex stop. The vocal folds vibrate. It occurs in the initial and medial positions of the words. But only in a few loan words it occurs in the final position of words.

Examples:

Initial position Dim ‘egg’
Medial position gOnDar ‘rhinoceros’
Final position rOD ‘rod’

/Dh/ It is a voiced aspirated retroflex stop. During its production the vocal folds vibrate along with an extra puff of air. It occurs in the initial and medial positions of words.
Examples:

Initial position Dheu 'wave'
Medial position Odhel 'plentiful'

Velar Stops /k, kh, g, gh/

During the production of these sounds the airstream coming from the lungs is completely blocked by the back of the tongue against the soft palate. Then the air is released with an explosion at the time of sound production.

/k/  It is a voiceless unaspirated velar stop. The vocal folds do not vibrate during its production.

It occurs in all the positions of words.

Examples:

Initial position kOla 'banana'
Medial position akaS 'sky'
Final position lok 'man'
\textit{/kh/} It is a voiceless aspirated velar stop. The vocal folds do notvibrate and the sound is produced with an extra puff of air.

It occurs in all the positions of words.

Examples:

<table>
<thead>
<tr>
<th>Position</th>
<th>Word</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>kham</td>
<td>envelope'</td>
</tr>
<tr>
<td>Medial</td>
<td>pakhi</td>
<td>'bird'</td>
</tr>
<tr>
<td>Final</td>
<td>cokh</td>
<td>'eye'</td>
</tr>
</tbody>
</table>

\textit{/g/} It is a voiced unaspirated velar stop. The vocal folds vibrate during itsproduction.

It occurs in all the positions of words.

Examples:

<table>
<thead>
<tr>
<th>Position</th>
<th>Word</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>gaRi</td>
<td>'car'</td>
</tr>
<tr>
<td>Medial</td>
<td>agun</td>
<td>'fire'</td>
</tr>
<tr>
<td>Final</td>
<td>dag</td>
<td>'stain'</td>
</tr>
</tbody>
</table>

\textit{/gh/} It is a voiced aspirated velar stop. The vocal folds vibrate and the sound is produced with an extra puff of air.

It occurs in all the positions of words.
Examples:

Initial position  ghoRi  'clock'
Medial position  aghat  'injury'
Final position  bagh  'tiger'

Affricates /c, ch, j, jh/

During the production of these sounds the airstream coming from the lungs is blocked by the closure made by the front part of the tongue pressed against the hard palate. Then the blockage is released gradually so that a friction is created. The soft palate is raised to block the entry of the air into the nasal cavity.

\(/c/\) It is a voiceless unaspirated alveo-palatal affricate. The vocal folds do not vibrate at the time of production.

It occurs in all the positions of words.

Examples:

Initial position  cul  'hair'
Medial position  khaMca  'cage'
Final position  nac  'dance'
/ch/  It is a voiceless aspirated alveo-palatal affricate. The vocal folds do not vibrate and the sound is produced with an extra puff of air. It occurs in all the positions of words.

Examples:
Initial position  chata  'umbrella'
Medial position  bichana  'bed'
Final position  gach  'tree'

/j/  It is a voiced unaspirated alveo-palatal affricate. The vocal folds vibrate when the sound is produced.
It occurs in all the positions of words.

Examples:
Initial position  juto  'shoe'
Medial position  hajar  'thousand'
Final position  jahaj  'ship'

/jh/  It is a voiced aspirated alveo-palatal affricate. The vocal folds vibrate and the sound is produced with an extra puff of air.
It occurs in all the positions of words.
Examples:
Initial position  jhiNe  'name of a vegetable'
Medial position  mejhe  'floor'
Final position  saMjh  'evening'

Fricatives /s, s, h/

/s/ It is a voiceless alveo-palatal fricative. The sound is produced by raising the tongue towards the hard palate creating a narrow passage through which the air is squeezed out with friction. The soft palate blocks the nasal passage and the vocal folds do not vibrate. It occurs in all the positions of words.

Examples:
Initial position  Saban  'soap'
Medial position  SOSa  'cucumber'
Final position  ghaS  'grass'

/s/ It is a voiceless dental fricative. To produce this sound the blade of the tongue moves towards the inner side of the upper teeth and the teeth ridge by leaving a narrow passage. Through this
passage the air squeezes out with a friction. The soft palate is raised and the vocal folds do not vibrate. The lips are slightly spread.

According to some phonologists this is an allophone of /S/ since it is contextually predictable. But the other group of phonologists treats it as a phoneme, though the functional load is marginal. It occurs in all the positions of words. Normally word initially and word finally it occurs in loan words.

**Examples:**

<table>
<thead>
<tr>
<th>Position</th>
<th>Word</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial position</td>
<td>sugar</td>
<td>'colloquial name for diabetes'</td>
</tr>
<tr>
<td>Medial position</td>
<td>rasta</td>
<td>'road'</td>
</tr>
<tr>
<td>Final position</td>
<td>bas</td>
<td>'bus'</td>
</tr>
</tbody>
</table>

/h/ It is a voiceless glottal fricative. To produce this sound the glottis remains open and the airstream passes through it with a weak friction. The tip of the tongue loosely touches the gum of the lower teeth. The middle part of the tongue raises towards the hard palate. The soft palate blocks the nasal passage. It occurs in the initial and medial positions of words.
Examples:

Initial position hat 'hand'
Medial position pahar 'hill'

Nasals /m, n, N/

/m/ It is a voiced bilabial nasal. During the production of this sound the lips are tightly pressed together and stop the airstream in the mouth. The soft palate is lowered and the air stream passes through the nasal cavity. The vocal folds are vibrated.

It occurs in all the positions of words.

Examples:

Initial position mach 'fish'
Medial position jama 'cloth'
Final position am 'mango'

/n/ It is a voiced alveolar/post dental nasal. To produce this sound the tip of the tongue is raised towards the backside of the upper teeth to block the air in the mouth cavity. The soft palate is lowered and the air stream passes freely through the nose. The vocal folds vibrate and the lips are kept open.
It occurs in all the positions of words.

Examples:

Initial position  nodi  'river'
Medial position  Onek  'many'
Final position  kan  'ear'

/IN/  It is a voiced velar nasal sound. In the production of this sound the back part of the tongue touches the soft palate and stops the air stream in the mouth. The soft palate is lowered and the air stream escapes through the nasal passage. The vocal folds are in vibration.

It occurs in the medial and the final positions of words.

Examples:

Medial position  aNul  'finger'
Final position  bEN  'frog'

Flaps / R, Rh/

In the production of these sounds the tip of the tongue is raised towards the roof of the mouth and remains slightly curled back by touching it and
thus blocks the airstream. Then the airstream bursts out by throwing the tip of the tongue forward with a sharp thrust with a quality of flapping. The soft palate is raised by closing the nasal passage. The vocal cords are in vibration and the lips are kept slightly open.

/R/ It is a voiced unaspirated retroflex flap. It occurs in the medial and final positions of the words.

Examples:
Medial position beRal ‘cat’
Final position SaMR ‘ox’

/Rh/ It is a voiced aspirated retroflex flap. It occurs in the medial and final position of the words.

Examples:
Medial position gaRho ‘intense’
Final position aSaRh ‘monsoon’

Ferguson and Chowdhury (1960: 22-59) considered [R] as a phoneme and according to them we can treat /R, Rh/ as marginal phonemes.
According to some phonologists /\textipa{R}/ is an allophone of /\textipa{D}/. But Chatterjee (1962) discarded this idea stating that /\textipa{D}/ and /\textipa{R}/ form minimal pairs as in /\textipa{coDde}/ ‘will be angry’ and /\textipa{coRbe}/ ‘will climb’. So phonemic status has to be granted to /\textipa{R}/.

**Trill /\textipa{r}/**

/\textipa{r}/ It is a voiced alveolar trill. This sound is produced by tapping the tip of the tongue against the alveolar ridge two or three times. The air stream passes through the mouth cavity as the soft palate raises itself and blocks the nasal passage. The vocal folds are vibrated and the lips are kept slightly open.

It occurs only in the initial, medial and final positions of words.

**Examples:**

- Initial position: rOkto 'blood'
- Medial position: dOrja 'door'
- Final position: baMdor 'monkey'

**Lateral /\textipa{l}/**

/\textipa{l}/ It is a voiced alveolar lateral. During the production of this sound the tip of the tongue touches the teeth ridge and thus blocks the
air in the middle of the mouth. The air passes by the sides of the tongue. The nasal passage remains closed by the soft palate. The vocal folds are vibrated. It occurs in all the positions of words.

Examples:

Initial position lal 'red'
Medial position kalo 'black'
Final position gol 'round'

4.1.4. CONSONANTS IN SEQUENCE

In SCB consonantal sequences are formed in two forms, in the form of geminate consonants and in the form of consonantal clusters.

GEMINATE CONSONANTS

According to S. K. Chatterji (1928: 20) and Ferguson and Chowdhury (1960: 36) the SCB geminate consonants are phonetically long consonants. But according to Bhattacharya (1993: 23) if we follow the definition of Abercrombie, (1967: 82) "A double consonant is one whose duration extends over two syllables whereas the duration of a long consonant is confined to a single syllable. She further states, 'The SCB consonants are nothing but
double consonants. In SCB the duration of the geminate consonants extends over two syllables' (Bhattacharya, 1993: 23). The first consonant out of the two geminate consonants closes the first syllable thus acting as a coda and the second begins the next syllable acting as an onset. The stress however falls on the first syllable.

In standard colloquial Bengali there are fifteen geminate consonants. They occur word medially and contrast with single consonants (Bhattacharya, 1993: 22- 23).

The geminate consonants are as follows:

1) dhakka  'a push'
2) joggo  'ritual'
3) gOcca  'useless expenditure'
4) pujjo  'honorable'
5) aTTa  'eight'
6) aDDa  'a place of rendezvous'
7) Sotti  'truth'
8) poddo  'poetry'
9) tappi  'patch'
10) kabbo  'prose'
11) SoSSo  'crops'
12) panna  'emerald'
13) kammo  'desired'
CONSONANTAL CLUSTERS

In standard colloquial Bengali consonantal clusters are made up of either two members in the minimum or three in the maximum. There are sixty-six two consonantal clusters out of which eleven occur in the word-initial position (e.g.: pr in *prothom* ‘first’, gr in *gram* ‘village’) and forty-one word medially (pl in *biplob* ‘revolution’). There are however three triconsonantal clusters such as spr, str and skr that occur both word initially and word medially (e.g.: str in *stri* ‘wife’, *ostro* ‘weapon’).

Only the ones used for the purpose of the present study have been mentioned below:

<table>
<thead>
<tr>
<th>Consonantal Cluster</th>
<th>Bengali Word</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>pr</td>
<td>prothom</td>
<td>‘first’</td>
</tr>
<tr>
<td>pl</td>
<td>plastik</td>
<td>‘plastic’</td>
</tr>
<tr>
<td>br</td>
<td>bibbriti</td>
<td>‘statement’</td>
</tr>
<tr>
<td>bhr</td>
<td>bhromon</td>
<td>‘travel’</td>
</tr>
<tr>
<td>bl</td>
<td>bled</td>
<td>‘blade’</td>
</tr>
<tr>
<td>tr</td>
<td>tritio</td>
<td>‘third’</td>
</tr>
<tr>
<td>dr</td>
<td>dirsti</td>
<td>‘sight’</td>
</tr>
<tr>
<td>dhr</td>
<td>dhrubo</td>
<td>‘truth’</td>
</tr>
<tr>
<td>Tr</td>
<td>tram</td>
<td>‘tram’</td>
</tr>
</tbody>
</table>

14) *hOlla* 'hue and cry'
15) *chOrra* 'a small bullet'
4.1.5. SYLLABIC PATTERNS

According to Sarkar (1979: 38-41) there are 16 syllabic structures available in the Bengali language. They are as follows:

<table>
<thead>
<tr>
<th>Dr</th>
<th>Dram</th>
<th>'drum'</th>
</tr>
</thead>
<tbody>
<tr>
<td>kr</td>
<td>kripon</td>
<td>'miser'</td>
</tr>
<tr>
<td>kl</td>
<td>klanto</td>
<td>'tired'</td>
</tr>
<tr>
<td>gr</td>
<td>gram</td>
<td>'village'</td>
</tr>
<tr>
<td>ghr</td>
<td>ghran</td>
<td>'scent'</td>
</tr>
<tr>
<td>gl</td>
<td>glani</td>
<td>'fatigue'</td>
</tr>
<tr>
<td>sl</td>
<td>slok</td>
<td>'a verse'</td>
</tr>
<tr>
<td>sk</td>
<td>skOndho</td>
<td>'neck'</td>
</tr>
<tr>
<td>st</td>
<td>stOr</td>
<td>'layer'</td>
</tr>
<tr>
<td>sp</td>
<td>spOsTo</td>
<td>'clear'</td>
</tr>
<tr>
<td>spr</td>
<td>spriSSo</td>
<td>'touchable'</td>
</tr>
<tr>
<td>sth</td>
<td>sthoirjo</td>
<td>'stability'</td>
</tr>
<tr>
<td>str</td>
<td>stroino</td>
<td>'henpecked'</td>
</tr>
<tr>
<td>skh</td>
<td>skhOlon</td>
<td>'to fall'</td>
</tr>
<tr>
<td>hr</td>
<td>hridOY</td>
<td>'heart'</td>
</tr>
<tr>
<td>jr</td>
<td>bOjjro</td>
<td>'thunder'</td>
</tr>
<tr>
<td>mr</td>
<td>mrittu</td>
<td>'death'</td>
</tr>
<tr>
<td>ml</td>
<td>mlan</td>
<td>'pale'</td>
</tr>
<tr>
<td>nr</td>
<td>nritto</td>
<td>'dance'</td>
</tr>
</tbody>
</table>

According to Sarkar (1979: 38-41) there are 16 syllabic structures available in the Bengali language. They are as follows:
<table>
<thead>
<tr>
<th>Syllabic pattern</th>
<th>example</th>
<th>meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>e</td>
<td>'this'</td>
</tr>
<tr>
<td>CV</td>
<td>na</td>
<td>'no'</td>
</tr>
<tr>
<td>CVC</td>
<td>tin</td>
<td>'three'</td>
</tr>
<tr>
<td>VC</td>
<td>am</td>
<td>'mango'</td>
</tr>
<tr>
<td>CCV</td>
<td>gram</td>
<td>'village'</td>
</tr>
<tr>
<td>CCVC</td>
<td>sriSTi</td>
<td>'creation'</td>
</tr>
<tr>
<td>CCCV</td>
<td>stri</td>
<td>'wife'</td>
</tr>
<tr>
<td>CCCVC</td>
<td>spriSSo</td>
<td>'touchable'</td>
</tr>
<tr>
<td>CVCC</td>
<td>SOnSkrito</td>
<td>'Sanskrit'</td>
</tr>
<tr>
<td>VV</td>
<td>oi¹</td>
<td>'that'</td>
</tr>
<tr>
<td>CVV</td>
<td>dui</td>
<td>'two'</td>
</tr>
<tr>
<td>VVC</td>
<td>oikko</td>
<td>'unity'</td>
</tr>
<tr>
<td>CVVC</td>
<td>dhoirjo</td>
<td>'patience'</td>
</tr>
<tr>
<td>CCVV</td>
<td>prae</td>
<td>'almost'</td>
</tr>
<tr>
<td>CCVVC</td>
<td>sthoirjo</td>
<td>'tranquility'</td>
</tr>
<tr>
<td>CCCVV</td>
<td>stroino</td>
<td>'henpecked'</td>
</tr>
</tbody>
</table>

The CV and CVC syllabic patterns are the most frequent in SCB.

¹ As the second member of the compound nucleus in Bengali is a semivowel, which is functionally an allophone of the corresponding vowel, it has been represented as V in the syllabic patterns.
4.2. ACOUSTIC DESCRIPTION OF BENGALI
VOWELS AND CONSONANTS

According to Fant (1973:4), 'The acoustics of speech includes in a broad sense both the theory of speech as wave motion and how speech waves are produced and heard....With modern sound recording and analysis techniques it is possible to undertake rather complete specifications of the speech wave.' It is needless to say that from the acoustic viewpoint the speech sounds can be studied more objectively. In the present study as already mentioned (see Section 4.0) there is an attempt to present the spectrographic representations of the speech productions of the dysarthric individuals along with the analysis of the speech productions from the perspective of articulatory phonetics. So, it is essential to give a skeletal description of the acoustic characteristics of the relevant speech sounds, which are, of course, phonemic in Bengali (see Section 4.1).

4.2.1. SPEECH SIGNALS

Speech exhibits three basic kinds of signals namely, quasiperiodic, quasirandom and quiescent described below.
Quasiperiodic: A signal where the shapes are repetitive but not exactly. Shapes of consecutive periods may differ slightly in either amplitude or time period or shape itself. For example, all voiced speech signals are Quasiperiodic.

Quasirandom: The signal, which is not perfectly random. For example: the sound of Bengali /h/ as in /ahar/ ‘food’ and English /z/ in ‘zebra’. All fricatives and affricates are quasirandom.

Quiescent: When there is absence of signal. For example: occlusion for unvoiced intermittants and breath pause.

A periodic speech signal can be described in terms of the three following physical parameters namely, amplitude, frequency and complexity.

Amplitude: Difference between the maximum and minimum displacement in a period.

Frequency: Number of repetitions per second usually represented by $F_0$. One may note that pitch period sometimes taken as a parameter may be defined as the inverse of $F_0$. 


Complexity: The way it differs from a sine wave.

 Diagram of a sine wave

The following figure 4.1 presents the schematic description of a speech signal.

Figure 4.1: Schematic Representation Of The Physical Parameters Defining A Signal

4.2.2. ACOUSTIC DESCRIPTION OF VOWELS

Spectral characteristics of the oral vowels are normally characterized by broad resonances known as formants. Pressure waves produced by the
vibration of the vocal folds at the exit of the glottis are modified by the cavity characteristics of supra glottal cavities structured by the position of the articulators. Different structures of the oral tract produce different resonances. Formants are these resonances and have a bandwidth more than 300 Hertz (Hz). These are numbered by the increasing position on the frequency axis. For example, F0 represents the lowest resonance, which coincides with fundamental frequency. The next resonances are numbered as F1, F2, F3 etc (see Figures 4.2 - 4.8). For Bengali the mean and standard deviation of the first four formant frequencies of oral vowels are given in the following table 4.3 (Ganguli et al, 1988: 50-56).

Table 4.3: Formant Frequencies of Oral Vowels

<table>
<thead>
<tr>
<th>All values in cells are in Hz</th>
<th>F1</th>
<th>F2</th>
<th>F3</th>
<th>F4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>i</td>
<td>323</td>
<td>25.7</td>
<td>2296</td>
<td>336.9</td>
</tr>
<tr>
<td>e</td>
<td>399</td>
<td>71.3</td>
<td>2099</td>
<td>279.4</td>
</tr>
<tr>
<td>E</td>
<td>724</td>
<td>72.7</td>
<td>1818</td>
<td>239.5</td>
</tr>
<tr>
<td>a</td>
<td>728</td>
<td>71.7</td>
<td>1427</td>
<td>217.9</td>
</tr>
<tr>
<td>O</td>
<td>650</td>
<td>71.1</td>
<td>1153</td>
<td>115.0</td>
</tr>
<tr>
<td>o</td>
<td>449</td>
<td>85.6</td>
<td>1046</td>
<td>111.6</td>
</tr>
<tr>
<td>u</td>
<td>350</td>
<td>53.0</td>
<td>967</td>
<td>117.0</td>
</tr>
</tbody>
</table>

Abbreviations: SD- Standard Deviation, Hz- Hertz
- represents NOT AVAILABLE
F1 indicates the height of the tongue hump and it increases as the height of the tongue hump decreases. On the other hand F2 indicates the horizontal position of the tongue hump and it increases as the tongue hump moves from the back to the front. F3 and F4 are highly speaker dependent and do not meaningfully reflect the phonetic quality of the vowels.

Nasal vowels are produced by connecting the nasal tract with the oral tract through the opening of velum. This connection produces tale-tell marks on the spectrum of the corresponding sounds. Some new formants as well as antiformants are introduced. Antiformants are zeroes introduced by the resonances of the nasal cavities, which act as shunts and thereby reducing the partials (overtones) in these resonance zones.

Due to the complexity of the nasal cavity new resonances and anti resonances appear. The antiformants sometimes weaken the general vowel formants. The additional nasal formants can sometimes be visible as additional formants or sometimes can enhance the existing oral formants (Fant, 1960). These resonance and anti resonance structures for standard colloquial Bengali has been studied and reported (Datta, 1989 & Datta 1991). The occurrence of nasal anti formants are found to
be speaker dependent. These appear generally in three different regions: 1200-2000 Hz, 2400-3000 Hz, 3100-3400 Hz. However the influence of the antiformant is strongest in the third range (Datta, 1991).

The following figures viz., 4.2, 4.3, 4.4, 4.5, 4.6, 4.7 and 4.8 provide the spectral representations of the seven Bengali oral vowels and their nasalised counterparts.

**Figure 4.2: Spectral representation of [i] and [iM]**

**Figure 4.3: Spectral representation of [e] and [eM]**
Figure 4.4: Spectral representation of [E] and [EM]

Figure 4.5: Spectral representation of [a] and [aM]

Figure 4.6: Spectral representation of [O] and [OM]
4.2.3. ACOUSTIC DESCRIPTION OF CONSONANTS

The figures 4.9 to 4.21 present spectrograms (top section), waveforms (bottom section) and schematic representation of coordination between closures of the articulatory passage and the glottis for the production of different manners of articulation of consonants at the middle section. It
may be noted that a neuromotor disorder may adversely affect this coordination. In the figures black fillings indicates closure. In explaining these coordinations it would be sufficient to consider only one place of articulation for each category of relevant consonants (e.g. velars in the present case for plosives).

Plosives are produced by an obstruction of the vocal tract to increase the pressure of the back cavity followed by the sharp release of the pressure. These sounds are characterized by the place of the obstruction/closure as well as by certain manners of these productions. In case of Bengali the affricates have only one place of articulation. The affricates are characterized by a substantial duration after release of the obstruction during which the tongue is in close proximity with the alveopalatal region and therefore causing some frictional sound.

The place of articulation reveals its acoustic signature in the form of the transition of formants, particularly in connection with the first two formants of the adjoining vowels.

For example, in the $V_1CV_2$ context some of the portions of the vowel contiguous to the consonant exhibit transition of these formants. In case of $V_1C$ context the movement of the tongue is from the stable situation
of vowel $V_1$ to the contact point of the upper articulator of consonant $C$. This is known as the VC transition. In case of $CV_2$ context, the movement of the tongue is from the contact point of the upper fixed articulator of consonant $C$ to the stable situation of the vowel $V_2$. This is known as CV transition. These movements of the tongue leave their corresponding tale-tell marks in the transition of the formants.

In case the tongue hump position for the vowel is almost same as the articulatory position of the consonant, the second formant transition is almost absent. When these two differs, the large transition of the second formant is observed.

One manner of production is caused by the presence/absence of the vocal fold vibration during the closure of the articulators. These vocal fold vibrations are caused by closed glottis as will be indicated in figures 4.9 - 4.16. This manner distinguishes between the voiced and voiceless stops and affricates.

The other manner relates to the aspirated/unaspirated nature of these sounds. After the release of the closure of the articulators, if the voicing starts with an appreciable delay, during this period the glottis as well as the
articulator remain open. Air passing through the glottis produces a turbulence, which can be heard as a /h/ like sound.

VELAR PLOSIVES

Figure 4.9: [OkO]  Figure 4.10: [OkhO]

Figure 4.9: [OgO]  Figure 4.10: [OghO]
While producing [OkO] the glottis is in a closed state and the articulators are open during the production of the initial [O] followed by a long occlusion of the vocal tract from where [k] starts (figure 4.9). This is immediately followed by a burst which releases [k]. The VOT is very short. The glottis closes indicating vibration of the vocal folds for production of the final [O]. While producing [OkhO] (figure 4.10) and [OghO] (figure 4.12) the glottis opens much after the opening of the articulators for the burst allowing enough time for the turbulence of the air streaming through the open glottis to produce a perceptible aspiration. While producing [OgO] or [OghO] the glottis is in a closed state during the occlusion period in contra-distinction to an unvoiced plosive like [k] (figure 4.9) or [kh] (figure 4.10).

AFFRICATES

Figure 4.13: [OcO]  Figure 4.14: [OchO]
Figures 4.13 to 4.16 as given above present the same parameters for the affricates. The explanation of manners like voiced and aspirated remains the same. Ideally, one should observe a burst followed by a frictional segment. However, most of the time they cannot be separated. The note worthy point is that during the period from the opening of the articulators to the closing of glottis the tongue remains very close to the alveo-palatal region (for Bengali) causing a perceptible frictional turbulence of high frequency. In fact, in isolation this segment is heard as a sibilant. The perceptual distinction of these sounds from the corresponding sibilant sound like [S] (figure 4.17) is in the fact that these segments are always preceded by an articulatory closure be it voiced or unvoiced.
Fricatives

Figures 4.17 and 4.18 above represent the sounds [s] and [h] respectively. In case of [S] friction is produced by the tongue forming constriction at some point in the upper part of the oral cavity. In case of [h] the friction is produced at the glottis. The spectral signatures are different. For [h] the front big cavity acts as the resonator causing distinctly different concentration of energy beginning at a comparatively lower level. For [S] the big back cavity acts as a sink producing antiformants and the spectral energy begins at a comparatively higher level. The spectra of sibilant sounds are characterized by a flat top with random variation interspersed by relatively narrow valleys. Sometimes resonance peaks are also visible. The formants and antiformants are indicative of the place of articulation. According to Ganguly, (1993:440)
the formant frequencies of the alveo-palatal [S] are found between 2800-4000 Hz and 5000-6000 Hz. For the glottal [h] the formant frequencies are between 800-1500 Hz and 3500-4500 Hz.

LIQUIDS

Figure 4.19: [OrO]  Figure 4.20: [OIO]

Figures 4.19 and 4.20 as given above present the sounds [r] and [l] respectively. While producing [OrO] the glottis is in a closed state throughout. [r] is produced usually by a single tap by the tongue on the alveolar region. The resulting acoustic pictures therefore show a small break in the pattern. During this break voice bar is present.

While producing [OIO] the glottis is in a closed state throughout. The closure of the articulators in this case is only medial. The passage is
open laterally. Therefore, a lot of energy can pass through. The signature differentiating this with a voice bar, therefore, is the presence of energy in higher frequencies.

'The spectral characteristic of [r] has also formant like structure with periodic interaction of patterns.' (Ganguli et al, 1995:49). One to four such repetitions of periodic patterns have been observed.

The formant frequencies for [r] ranges from 310-422 Hz for first formant, 1214-1410 Hz for second formant, 2132-2418 Hz for third formant, 3246-3484 Hz for fourth formant (Ganguli et al, 1995:53).

According to Fant (1973:27) laterals show vowel like features except for a reduction of either second, third or fourth formant intensity due to the antiformant created by the shunting mouth cavity behind the tongue.

In Bengali the formant frequencies for [l] ranges from 353-484 Hz for the first formant, 1284-1588 Hz for the second formant, 2195-2476 Hz for the third formant and 3160-3484 Hz for the fourth formant (Ganguli et al, 1995:53).
Nasal murmurs are produced when during the articulatory closure the glottis remains closed as well as velum remains open. The above figure 4.21 is the spectrographic representation of the nasal [m].

Because of the occlusive nature of the nasal murmurs some formants are weakened. As already discussed in the context of the nasal vowels (see Section 4.2.2), additional nasal formants and anti formants are found to occur for these sounds. According to the results on acoustic phonetic analyses of Bengali nasal murmurs (Datta, 1991:157-160) the presence of the antiformants and formants are dependent on the adjoining vowels. For [m] and [n] the frequency range of antiformants
are the same as that of the nasal vowels. For [n] antiformant is always present in the range of 1200-2000 Hz and is scarcely seen in the range of 3100-3400 Hz. However for [m] the antiformant appears more conspicuously in the range 2400-3000 Hz than in range 1200-2000 Hz.

4.3. SUPRASEGMENTAL FEATURES

As mentioned earlier (see Section 4.0) though the prosodic features get affected, the present study deals only with the nature of stress, clause terminals and pitch so far as the Bengali dysarthric speech is concerned.

4.3.1. STRESS

Bhattacharya (1988: 54) defines stress as 'the relative greater force exerted in the articulation of a part of an utterance.' According to S.K. Chatterji, (1928: 22-23) 'In the Standard Colloquial (Bengali), stress is dominantly initial in isolated words....Word-stress is always subsidiary to Sentence-stress, and in conversation the Sentence-stress is most commonly on the initial syllable of the first important word in a Sense-group....The stress on individual words disappears in favour of the sentence-stress, since one sense-group has only one dominant stress
at or near the beginning. This is the rule, but the position of the stress may be changed to give emphasis to a particular word.' Stress is however not significant in SCB in isolated words. It is denoted by the symbol ['] before the syllable that bears it.

In contrastive or emphatic stress there is a forceful articulation of the word, which needs to be emphasized. Depending on the degrees of emphasis there is a possibility of infinite levels of loudness as both degrees of emphasis and the levels of loudness are correlated.

Examples:

'/"tumi mach khabe/' 'You (not anyone else) will eat fish.'

'/tumi ' mach khabe/' 'You will eat fish (not anything else).'</p>

4.3.2. CLAUSE TERMINALS

Clause terminals mark a pause, which may be tentative or final in a sentence. Two types of clause terminals, which are significant in Bengali, are sustained clause terminal and final clause terminal.
Sustained clause terminal marks 'the tentative pause at the end of a grammatical clause of a sentence' (Bhattacharya, 1988: 55). The symbol used is [\[\]].

Examples:

/jOkhon amar choTo bhai bagane thake \[ kaThbeRalider Dhil mare/ 'When my little brother is in the garden, he throws stones at the squirrels.'

/bhorbEiaY \[ jOkhon dhiredhire Surjo oThe \[ ami gache jOl diy/ 'At dawn, when the sun rises slowly, I water the plants.'

Final clause terminal signifies the end of a sentence. The symbol used is [\#].

Examples:

/bagane procur kaThbeRali ache \#/ 'There are many squirrels in the garden.'

/baganer paSe ekTa choTo pukur ache \#/ 'There is a small pond beside the garden.'
4.3.3. PITCH

Pitch means the number of times the vocal folds vibrate per second. In Bengali the four significant pitches are as follows:

Extra-high, High, Mid and Low.

Extra-high pitch is identified by the number [4]. It 'occurs before pause to indicate excitement' (Bhattacharya, 1988: 55).

Examples:

2 3 3 4
/tumi eSecho / 'You have come!'

High pitch is identified by the number [3]. It 'occurs before pause to indicate question' (Bhattacharya, 1988: 56).

Examples:

2 3 3
/tumi eSecho / 'Have you come?'

Mid pitch is identified by the number [2]. It 'occurs before pause to indicate continuation of statement' (Bhattacharya, 1988: 55).
Examples:

2 2 2 1
/oy baRiTa amar/ 'That house is mine.'

Low pitch is identified by the number [1]. It 'occurs before pause to indicate a final statement' (Bhattacharya, 1988: 55).

Examples:

2 2 1
/ami bhat khabo/ 'I will eat rice.'

REFERENCES


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Examples:

2 3 3
/tumi eSecho/ ‘Have you come?’

Mid pitch is identified by the number [2]. It 'occurs before pause to indicate continuation of statement' (Bhattacharya, 1988: 55).
Examples:

2 2 2 1
/oy baRiTa amar /
‘That house is mine.’

Low pitch is identified by the number [1]. It ‘occurs before pause to indicate a final statement’ (Bhattacharya, 1988: 55).

Examples:

2 2 1
/ami bhat khabo /
‘I will eat rice.’

REFERENCES


