ACOUSTIC BASE OF BIHAR URDU PHONOLOGY

In this chapter, we limit ourselves to providing acoustic rationale for the establishment of the Phonological Grid of Bihar Urdu (Diagram I-1), presented in Chapter I. However, it must be pointed out at the outset here that our justification of Bihar Urdu Phonological Grid in terms of acoustics is based on received knowledge only. For, experimental research for the acoustic base is beyond the scope of the present study.

We present the various aspects of Bihar Urdu Phonological Grid in terms of acoustic medium in three sections. In Section-A, we deal with the acoustic divisions of the apertures into constriction and opening. Section-B emphasizes the acoustic requirement of labio-dorsality for the back vowels. The chapter ends with concluding remarks in Section-C.

Section-A: Constriction versus Opening

As pointed out in Diagram I-1 the apertures can be divided into two basic categories, namely, constriction and opening, in view of their differing physiologico-acoustic characteristics (cf. INTRODUCTION: Section-B1(a)(ii)). The apertures known as constriction (Ø through 2) are the smaller
apertures and the units produced at these apertures are called obstruents (stops and fricatives). The apertures known as opening (3 through 8), on the other hand, are large apertures and the units articulated at these apertures are called non-obstruents (liquids and vowels).

The phonological units formed at constriction (0 through 2) are characterized by the noise activated by the close contact of the articulator and the point of articulation. In contrast, the units that materialize at the apertures of opening (3 through 8) are marked by resonance, there being no close contact or stoppage.

For the apertures of constriction the contact between the articulator and the associative point of articulation is so close and the distances between the degrees of aperture is so narrow that they can be measured in absolute terms.

Inasmuch as the pertinent supraglottal articulator, in combination with the apertures of constriction, can both shape and excite the vocal cavity in the production of phonological units at these small apertures, there is no obligatory
requirement to utilize an extra articulator, such as larynx. Thus, voicelessness becomes the simplest phenomenon in the production of units at apertures of constriction. To be sure, the phonological units with both voicing and aspiration are formed at constriction. But, these units are physiologically more complex, as they require the use of larynx as an extra articulator.

In contradistinction to the small and absolutely-defined apertures of constriction, the apertures of opening are large and their position vis-a-vis each other can only be defined in relative terms.

As the local supraglottal articulator, in combination with the apertures of opening, cannot excite the cavity in the production of phonological units at the larger apertures, the excitation is brought about by introducing the vibration of the glottis and the local articulator merely shapes the cavity. It is possible to excite the cavity at these larger openings without the vibration of the glottis; but this requires a great expenditure of the air supply.

Parenthetically, it may be pointed out here that the nasals which have been placed at one of the
constriction apertures, have acoustic feature similar
to that of the units at larger apertures. In the
articulation of nasals, in spite of the closure in the
mouth, the air stream is free to move through the
nose. Hence, the nasals have been linked with capital
N of aperture-3.

Section-B: Labio-dorsal Units (Apertures-3 through 6)

The Grid (Diagram I-1) shows that in the makeup of
the semi-vowel \( \tilde{w} \) and the vowels \( \tilde{u}: u: \tilde{u}: o: \tilde{o}: \) and \( o \) falling on the intersections of back-dorsum and
apertures-3 through 6, labium combines with back-
dorsum and makes these units rounded (cf. CHAPTER I:
Section-A1(b)(v)).

<table>
<thead>
<tr>
<th>Articulators</th>
<th>Labium Medium Front Back Dorsum Dorsum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apertures</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>( \tilde{w} )</td>
</tr>
<tr>
<td>4</td>
<td>( i: i: ) ( u: u: ) ( u: u: ) ( u: u: )</td>
</tr>
<tr>
<td>5</td>
<td>Interaction with Back Dorsum</td>
</tr>
<tr>
<td>6</td>
<td>( e: (e) ) ( o: ) ( o: )</td>
</tr>
<tr>
<td>7</td>
<td>( \tilde{a}: \tilde{a}: ) ( a: a: )</td>
</tr>
<tr>
<td>8</td>
<td></td>
</tr>
</tbody>
</table>
Thus, in Bihar Urdu all back dorsal vowels plus the semi-vowel ʍ (apertures 3 through 6) are rounded in nature involving lip rounding in their articulation and are known as labio—dorsal vowels. The medial and front-dorsal vowels (apertures 4 through 8), on the other hand, are unrounded vowels and they don't involve lip rounding in their articulation. There is definite physiologico-acoustic rationale for the use of labium in the rounding of back dorsal vowels.

In the production of the vowels at apertures—4 through 8, where the relative height of tongue is taken into account, the size of resonance chamber matters greatly. The size of chamber for medial vowels is bigger in length and breadth than that for the back-dorsal vowels due to asymmetry of the vocal tract. The vertical space between medium and hard palate is much greater than the vertical space between dorsum and velum. Furthermore, as the resonance chamber for the vowels extends from the larynx to the lingual articulator, this chamber is much larger in the case of the medial vowels (larynx to medium) as compared to the chamber for the back dorsal vowels (larynx to dorsum). Thus, for medial vowels, the resonance chamber is big enough to keep the vowels
distinguished acoustically. In case of back-dorsal vowels, the chamber is very small. So, we need to increase the resonance chamber for back dorsal vowels with the help of certain device. This device is rounding of the lips. By lip rounding two chambers are formed. One from the larynx to the dorsum-velum and the other from dorsum-velum to the lips. The second chamber (from dorsum-velum to the lips) acts as an amplifier for the vowels produced at the back and makes the vowels distinct clearly from one another at the back. As a consequence of this, lip rounding becomes essential for them.

Formant frequencies: The acoustic need of lip rounding for back-dorsal vowels discussed above can be explained more clearly in terms of formant frequencies. Units produced can be recorded by a spectograph and the sound waves of units can be obtained by sound spectogram. Vowels (aperture 4 through most open) are characterized by the formants. Three formants are generally provided, but for our purpose, two formants would be sufficient. So we limit our discussion to only two formants, namely, F1 and F2. Characteristics of F1 is determined by resonant cavity which is behind the tongue. It also characterizes tongue height. Characteristics of F2,
on the other hand, is determined by resonant cavity in the front of the tongue.

Although the vowel system of Bihar Urdu (with diphthongs) is slightly different than that of Mewati Urdu* (with open vowels in place of diphthongs), we are reasonably sure that the frequencies of comparable vowels in both dialects is the same; for they are pronounced alike. With that assumption, we produce below the formant frequencies of the common Urdu vowels in Table IV-1.

<table>
<thead>
<tr>
<th>Vowels</th>
<th>F₁</th>
<th>F₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>i:</td>
<td>250</td>
<td>1950</td>
</tr>
<tr>
<td>e:</td>
<td>300</td>
<td>1800</td>
</tr>
<tr>
<td>a:</td>
<td>700</td>
<td>1100</td>
</tr>
<tr>
<td>o:</td>
<td>400</td>
<td>850</td>
</tr>
<tr>
<td>u:</td>
<td>250</td>
<td>800</td>
</tr>
<tr>
<td>I</td>
<td>200</td>
<td>1800</td>
</tr>
<tr>
<td>a</td>
<td>300</td>
<td>950</td>
</tr>
<tr>
<td>U</td>
<td>260</td>
<td>600</td>
</tr>
</tbody>
</table>

Table IV-1: Formant Frequencies of Common Urdu Vowels

*Ftn. After Fatihi, 1987
Diagram IV-2: Location of Formants
for i: e: a: o: u:
in terms of F1 and F2 can be shown diagrammatically also. Thus, we present Diagram IV-2 dealing with the location of formants for long vowels only.

Comments

(i) Diagram IV-2 shows the relative position of the first and second acoustic formants on a scale of acoustic frequency for only five vowels (i: u: e: o: a:) of the eight common Urdu vowels presented in Table IV-1.

(ii) F1 frequency of the vowels i: (250 Hz) and u: (250 Hz) is the lowest whereas that of a: (700 Hz) is the highest. And the frequency of e: (300 Hz) and o: (400 Hz) is in between. Given these frequencies, it would not be possible to distinguish the vowel i: from u: and the vowel e: and o:. It means that the cues of F1 alone will not be of much use for us in distinguishing the vowels produced in the front from those being produced at the back.

(iii) When we examine the frequencies of F2 for the five vowels under discussion, we find that there is a steady fall of frequencies from i: to u:. The frequency of the vowel i: is the highest and that of its counterpart u: is the lowest. So, the two vowels in terms of their F2 frequencies are poles apart. The
vowels e: and o: are also distant apart in terms of their F2 cues. Therefore, there is no problem of distinguishing the vowels produced at the back from those being produced in the front. This acoustic distinction is achieved by driving the F2 frequency of the back-dorsal vowels down and it is made possible by labio-dorsal phenomenon; in that the second chamber produced by the lip rounding drives the frequency of the second formant of o: and u: down. Without lip rounding and the addition of second chamber, the frequency of second formant of the unrounded counterpart of o: and u: will go up and it will be very difficult to distinguish the vowel e: from the vowel o: which will have similar frequencies. Likewise, it will be very difficult to distinguish between i: and u: vowels which will both have the highest frequency at second formant. To avoid this, lip rounding is essential.

(iv) We know fewer articulators are preferred over more articulators in terms of human behaviour. The labio-dorsality involving an extra articulator goes against this and yet the acoustic desirability dictates the use of an extra articulator for greater clarity of the sounds that must be discriminated by the human ear.
Section-C: Summary and Conclusions

The present chapter is restricted to the justification of Bihar Urdu Phonological Grid in terms of acoustic medium.

In Section-A, we postulated a broad division of Bihar Urdu phonological units with reference to the degrees of aperture into constriction (Ø through 2) including all the stops and fricatives of Bihar Urdu versus opening (3 through most open) involving vowels, liquids, nasals.

In Section-B, devoted to the labio-dorsality of Bihar Urdu phonological units, we presented acoustic rationale for lip rounding of the back dorsal vowels in terms of the formant frequencies.

To conclude: (1) The degrees of aperture can be divided acoustically in terms of constriction versus opening, (2) The smaller apertures (Ø through 2) can be absolutely defined and are known as constriction. The traditional 'stops' and 'fricatives' are produced at constriction apertures. The larger apertures (3 through 8), on the other hand, are relative and are known as opening. The opening apertures are associated with the production of 'vowels' and
'liquids'. (3) For the production of phonological units at constriction apertures, voicelessness is preferred over voicing. But voicing becomes most desirable in the production of phonological units at opening. (4) Due to asymmetry of the vocal tract, the size of the resonance chamber is not the same vertically. Moreover, unlike the front part of the chamber (extending from larynx to the velum), the back part (extending from larynx to the dorsum) is too small to keep the acoustic distinctions apart among the various vowels. As a consequence of this, lip rounding is required for back vowels which forms a second chamber (from dorsum to lips) acting as an amplifier and makes the vowels at the back distinctive acoustically. (5) The spectographic analysis of the vowels show that the acoustic distinction between the vowels is achieved by driving down the F2 frequencies of the back-dorsal vowels and it is made possible by labio-dorsal phenomenon. (6) Labio-dorsality, that is, the use of labium along with the dorsum of the tongue emphasizes the primacy of acoustics over human behaviour which disfavours use of an extra articulator.