TIMBRE STUDY ON NASALICS

PART I—SYMBOLIC DESCRIPTION OF TIMBRE-PATTERNS OF GENERALIZED VOCALICS

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Foreword

In our paper titled "Memoirs on Nasalics," we have already discussed the problem of nasals from various points of view. From our standpoint of speech-communication, we look at this problem having in mind the following three objectives. (1) To clarify the role of nasal-cavity system in formation of oral vocalics. (2) To obtain the timbre structure of nasal sounds of various kinds, interpreting thereby the role of buccal-cavity system on the nasal cavity performance. (3) To coordinate the timbre axis of nasality in genealogic display of timbre in general.

The distinguishing mark of our study on nasals is that we present a joint study of (1) and (2). For this purpose we had to ultimately deal with the characteristic circuit performance of bifurcated nature as well as with actual nasal phonemes in the phonological sense.

Sound-Signature Symbols

In order to study the transmission performance of bifurcated circuit of speech organs, and to attain a more reasonable interpretation of our oral and nasal sounds, we must probably touch upon some sounds which are utterable by our articulatory organs but which cannot be represented by any existing symbols. For such practical and utterable but phonetically indescribable sounds by which we must be confronted in our present course of timbre study, we must prepare some descriptive symbols. In thinking this out we must not overlook the following two parameters: Path parameter and breath-distribution parameter. In sound phenomena where utterances in buccal-cavity and nasal-cavity systems might come into play simultaneously, it is advantageous and even important to differentiate between path parameter and breath parameter. We propose the bar symbol — for the path sign and the wave symbol ~ for the breath sign. Further, we can describe the path stoppage as well by a perpendicular line inscribed on the path sign, thereby indicating the place of stoppage. Conforming to this descriptive method, we can express the ordinary oral vowel by $\overline{\underline{V}}$ or, more simply, by $\underline{V}$, and the ordinary nasal vowel by $\tilde{\underline{V}}$ or, more simply, by $\tilde{V}$. Here upper-bar means upper path, *i.e.*, nasal path; under-bar means lower path, *i.e.*, buccal path. In the same way, upper-wave means breath passage in nasal circuit, and under-wave means breath passage in buccal circuit.

It is indeed for the following cases that this symbolic method becomes most desirable. For the vowels issued through the mouth with the shunted nose which is

stopped up by the closing of nostrils by outside pressure or with some filling, we use the symbol $\underset{\sim}{\overrightarrow{V}}$ or $\overrightarrow{V}$; for the sounds issued through the nose with the shunted mouth which is closed by the lips or by the hand wearing a rubber glove, we use the symbol $\underset{\sim}{\widetilde{V}}$ or $\underline{V}$. The former corresponds to the oral vocalic sound with the nose stopped up, and the latter to the nasal vocalic sound with the mouth closed. Very useful and important data will be furnished by the following cases as examples of some critical conditions of utterance. For the sound kept out of the mouth by being sent through the nose when the tongue is forced against the palate, we use $\underset{\sim}{\widetilde{V}}$ or $\underline{V}$; for the sound kept out of the nose and forced into the mouth by entirely filling the whole cavity of nasal passage with a tampon, we use $\underset{\sim}{\overrightarrow{V}}$ or $\overrightarrow{V}$. The former gives an idealized and pure nasal, a timbre of which there is only one, and shows the kind of nasal possible when the whole mouth cavity is completely excluded. The latter gives an ideal and perfectly critical oral when the whole nasal cavity is completely excluded. As such a critical oral, there might be listed five timbres in accordance with the number of ordinary oral vowels as, for instance, in the Japanese language. Let us now consider a common daily experience with nasality. When one is catching cold, his nose tends to be stopped up and his voice becomes muffled, then the symbol for such an oral vowel can be $\underset{\sim}{\overrightarrow{V}}$ and for the nasal $\overrightarrow{\widetilde{V}}$; it is most reasonable that $\overrightarrow{\widetilde{V}}$ is nearly equal to $\underset{\sim}{\overrightarrow{V}}$ when the voice is in a muffled state by reason of nose stoppage because of a head-cold.

White Voice and White Phone

We have previously employed WHITE VOICE and defined it as a useful representation of vocalic sounds, and further, have used WHITE PHONE (VOWEL) defining it as a pertinent expression of vowel-phone as a whole from a phonemic aspect. Of course, our definitions took into consideration only oral vowels and oral voices. Now we must widen our scope to include other sounds, by going further into our subject which takes us beyond oral sounds. This means a generalization of vocalic sounds by artificial means, which we have already considered, and by doing so we will, in a sense of timbre quality, be able to find some relationship among our certain groupings of timbre.

Under Sound Signature Symbols we have in a generalized sense introduced four sets of vocalic sounds $\underset{\sim}{\overrightarrow{V}}$, $\underset{\sim}{\widetilde{V}}$, $\overrightarrow{V}$, $\underline{\widetilde{V}}$. For convenience, we use more simplified forms $\underset{\sim}{V}$, $\widetilde{V}$, $\dot{V}$, $\underline{V}$, indicating respectively, $\underset{\sim}{V}$ for oral, $\widetilde{V}$ for nasal, V for oral with nose stopped up, and $\underline{V}$ for nasal with mouth closed.

We now venture to illustrate by using these symbols in some experimental processes carried out after level- and pitch-matchings: We denote superposition process $+$, and juxtaposition process $\cdot$; superposition sum by $\sum_{(s)}$ and juxtaposition sum by $\sum_{(j)}$. By aid of these symbols we can indicate white voices for four sets of sounds, describing all processes needed for timbre treatment in the following way.

For oral white-voice

$$\underset{\sim}{\mathrm{w}}(p) = \underset{\sim}{\mathrm{A}}(p) + \underset{\sim}{\mathrm{E}}(p) + \underset{\sim}{\mathrm{I}}(p) + \underset{\sim}{\mathrm{O}}(p) + \underset{\sim}{\mathrm{U}}(p) + \ldots = \sum_{\underset{\sim}{V}}{}_{(s)}\, \underset{\sim}{V}(p).$$

For nasal white-voice

$$\widetilde{\mathrm{w}}(p) = \widetilde{\mathrm{A}}(p) + \widetilde{\mathrm{E}}(p) + \widetilde{\mathrm{I}}(p) + \widetilde{\mathrm{O}}(p) + \widetilde{\mathrm{U}}(p) + \ldots = \sum_{\widetilde{V}}{}_{(s)}\, \widetilde{V}(p).$$

For white-voice of oral with stopped-up nose

$$\dot{\mathrm{w}}(p) = \dot{\mathrm{A}}(p) + \dot{\mathrm{E}}(p) + \dot{\mathrm{I}}(p) + \dot{\mathrm{O}}(p) + \dot{\mathrm{U}}(p) + \ldots = \sum_{\dot{V}}^{(s)} \dot{V}(p).$$

For white-voice of nasal with closed mouth

$$\dot{\underset{\sim}{\mathrm{w}}}(p) = \dot{\underset{\sim}{\mathrm{A}}}(p) + \dot{\underset{\sim}{\mathrm{E}}}(p) + \dot{\underset{\sim}{\mathrm{I}}}(p) + \dot{\underset{\sim}{\mathrm{O}}}(p) + \dot{\underset{\sim}{\mathrm{U}}}(p) + \ldots = \sum_{\dot{V}}^{(s)} \dot{\underset{\sim}{V}}(p).$$

Thus, continuing in the same way, we can easily indicate white phones for four sets of sounds as:
For oral white-phone

$$\underset{\sim}{\mathrm{W}} = \underset{\sim}{\mathrm{w}}(p_1) \cdot\!:\!\cdot \underset{\sim}{\mathrm{w}}(p_2) \cdot\!:\!\cdot \underset{\sim}{\mathrm{w}}(p_3) \cdot\!:\!\cdot \ldots = \sum_{p}^{(j)} \underset{\sim}{\mathrm{w}}(p).$$

For nasal white-phone

$$\widetilde{\mathrm{W}} = \widetilde{\mathrm{w}}(p_1) \cdot\!:\!\cdot \widetilde{\mathrm{w}}(p_2) \cdot\!:\!\cdot \widetilde{\mathrm{w}}(p_3) \cdot\!:\!\cdot \ldots = \sum_{p}^{(j)} \widetilde{\mathrm{w}}(p).$$

For white-phone of oral with stopped-up nose

$$\dot{\mathrm{W}} = \dot{\mathrm{w}}(p_1) \cdot\!:\!\cdot \dot{\mathrm{w}}(p_2) \cdot\!:\!\cdot \dot{\mathrm{w}}(p_3) \cdot\!:\!\cdot \ldots = \sum_{p}^{(j)} \dot{\mathrm{w}}(p).$$

For white-phone of nasal with closed mouth

$$\dot{\underset{\sim}{\mathrm{W}}} = \dot{\underset{\sim}{\mathrm{w}}}(p_1) \cdot\!:\!\cdot \dot{\underset{\sim}{\mathrm{w}}}(p_2) \cdot\!:\!\cdot \dot{\underset{\sim}{\mathrm{w}}}(p_3) \cdot\!:\!\cdot \ldots = \sum_{p}^{(j)} \dot{\underset{\sim}{\mathrm{w}}}(p).$$

As we have mentioned above, the timbre-pattern-obtaining procedures having been carried out after completion of two kinds of matching with regard to volume and pitch, all timbres $V(p_1)$, $V(p_2)$, $V(p_3)$, ... are subject to matching sufficient for their volume level despite their pitch changes, and in the same manner all timbres $V_1(p)$, $V_2(p)$, $V_3(p)$, ... receive level-matching notwithstanding their vowel change.

Now, denoting the phoneme entities of oral vowels $\underset{\sim}{\mathrm{A}}$, $\underset{\sim}{\mathrm{I}}$, $\underset{\sim}{\mathrm{U}}$, $\underset{\sim}{\mathrm{E}}$, $\underset{\sim}{\mathrm{O}}$, ... by $\underset{\sim}{\mathrm{a}}$, $\underset{\sim}{\mathrm{i}}$, $\underset{\sim}{\mathrm{u}}$, $\underset{\sim}{\mathrm{e}}$, $\underset{\sim}{\mathrm{o}}$, ... and the phoneme entities of nasal vowels $\widetilde{\mathrm{A}}$, $\widetilde{\mathrm{I}}$, $\widetilde{\mathrm{U}}$, $\widetilde{\mathrm{E}}$, $\widetilde{\mathrm{O}}$, ... by $\widetilde{\mathrm{a}}$, $\widetilde{\mathrm{i}}$, $\widetilde{\mathrm{u}}$, $\widetilde{\mathrm{e}}$, $\widetilde{\mathrm{o}}$, ..., we can present the following formulations:

$$\underset{\sim}{\mathrm{a}} = \underset{\sim}{\mathrm{A}}(p_1) \cdot\!:\!\cdot \underset{\sim}{\mathrm{A}}(p_2) \cdot\!:\!\cdot \underset{\sim}{\mathrm{A}}(p_3) \cdot\!:\!\cdot \ldots = \sum_{p}^{(j)} \underset{\sim}{\mathrm{A}}(p)$$

$$\underset{\sim}{\mathrm{i}} = \underset{\sim}{\mathrm{I}}(p_1) \cdot\!:\!\cdot \underset{\sim}{\mathrm{I}}(p_2) \cdot\!:\!\cdot \underset{\sim}{\mathrm{I}}(p_3) \cdot\!:\!\cdot \ldots = \sum_{p}^{(j)} \underset{\sim}{\mathrm{I}}(p)$$

$$\underset{\sim}{\mathrm{u}} = \underset{\sim}{\mathrm{U}}(p_1) \cdot\!:\!\cdot \underset{\sim}{\mathrm{U}}(p_2) \cdot\!:\!\cdot \underset{\sim}{\mathrm{U}}(p_3) \cdot\!:\!\cdot \ldots = \sum_{p}^{(j)} \underset{\sim}{\mathrm{U}}(p)$$

$$\underset{\sim}{\mathrm{e}} = \underset{\sim}{\mathrm{E}}(p_1) \cdot\!:\!\cdot \underset{\sim}{\mathrm{E}}(p_2) \cdot\!:\!\cdot \underset{\sim}{\mathrm{E}}(p_3) \cdot\!:\!\cdot \ldots = \sum_{p}^{(j)} \underset{\sim}{\mathrm{E}}(p)$$

$$\underset{\sim}{\mathrm{o}} = \underset{\sim}{\mathrm{O}}(p_1) \cdot\!:\!\cdot \underset{\sim}{\mathrm{O}}(p_2) \cdot\!:\!\cdot \underset{\sim}{\mathrm{O}}(p_3) \cdot\!:\!\cdot \ldots = \sum_{p}^{(j)} \underset{\sim}{\mathrm{O}}(p)$$

$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots,$$

and

$$\widetilde{\mathrm{a}} = \widetilde{\mathrm{A}}(p_1) \cdot\!:\!\cdot \widetilde{\mathrm{A}}(p_2) \cdot\!:\!\cdot \widetilde{\mathrm{A}}(p_3) \cdot\!:\!\cdot \ldots = \sum_{p}^{(j)} \widetilde{\mathrm{A}}(p)$$

$$\widetilde{\mathrm{i}} = \widetilde{\mathrm{I}}(p_1) \cdot\!:\!\cdot \widetilde{\mathrm{I}}(p_2) \cdot\!:\!\cdot \widetilde{\mathrm{I}}(p_3) \cdot\!:\!\cdot \ldots = \sum_{p}^{(j)} \widetilde{\mathrm{I}}(p)$$

$$\widetilde{\mathrm{u}} = \widetilde{\mathrm{U}}(p_1) \cdot\!:\!\cdot \widetilde{\mathrm{U}}(p_2) \cdot\!:\!\cdot \widetilde{\mathrm{U}}(p_3) \cdot\!:\!\cdot \ldots = \sum_{p}^{(j)} \widetilde{\mathrm{U}}(p)$$

$$\tilde{e} = \tilde{E}(p_1) \dot{:}\dot{:} \tilde{E}(p_2) \dot{:}\dot{:} \tilde{E}(p_3) \dot{:}\dot{:} \ldots = \sum_{p}^{(j)} \tilde{E}(p)$$
$$\tilde{o} = \tilde{O}(p_1) \dot{:}\dot{:} \tilde{O}(p_2) \dot{:}\dot{:} \tilde{O}(p_3) \dot{:}\dot{:} \ldots = \sum_{p}^{(j)} \tilde{O}(p)$$
$$\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots$$

Further, in the same manner we can go on by indicating the entities of oral vowels with stopped-up nose and those of nasal vowels with closed mouth, the descriptions of which we will omit here for brevity.

It is self-evident that for every set of sounds each white-phone pattern can be obtained in one way by juxtaposition of white-voice, and in another way by superposition of phoneme entities in corresponding set, as given here for oral case only by the expressions

$$\underset{\sim}{W} = \underset{\sim}{w}(p_1) \dot{:}\dot{:} \underset{\sim}{w}(p_2) \dot{:}\dot{:} \underset{\sim}{w}(p_3) \dot{:}\dot{:} \ldots$$
$$\underset{\sim}{W} = \underset{\sim}{a} + \underset{\sim}{i} + \underset{\sim}{u} + \underset{\sim}{e} + \underset{\sim}{o} + \ldots$$

We want to make one remark as to why we introduce into our study white-phone and white-voice representations. We have a positive reason for this introduction. Such integration of various kinds is an indispensable basis for interpretation of articulation and naturalness of vocalic sounds. For instance, we can trace the relation between white-phone pattern and vowel-articulation on one hand, and the relation between white-voice pattern and voice-naturalness on the other hand. But to go into more detail, we must refer to individual phoneme patterns and individual voice patterns by comparing them with individual vowel-articulation and individual voice-naturalness.

Schedule of Experiments on Nasality

We have dealt with the problem of nasality from timbre aspect, having spent no less than five years in its study. This problem has been treated phonetically by many authors who brought to light some features of nasality. The reason for our spending so many years on only the problem of nasality is because the way of thinking which conceives that the best clue for interpretation of fine structure in the timbre pattern of oral vocalic sounds can be found nowhere else than in this nasality aspect because the nasal passage is not irrelevant to oral utterance, but indeed has a very close connection with it. A verification of this needs most prudent experimentation processes. One is apt to believe that oral vowels are produced only through buccal passage, and that nasal passage is thereby completely shut off due to backward movement of velum and its attachment to the posterior wall of pharynx. The search must be carried out from the standpoint of timbre aspect because examinations of fine structure in the timbre pattern are also to be done from timbre aspect. These considerations forced us to carry on our studies for many years. This does not mean for us to take a spear to kill a fly. Nasality is just as vital as orality. We show in the following tables our schedule of experiments already made during five years.

TABLE I

Data on 1953 Experiment (120 Graphs in Total)

Sound→ / Pitch↓	Critical nasal /$\underset{\sim}{\tilde{V}}$/		Typical nasal /$\underset{\sim}{\tilde{O}}$/	
	For complete pattern	For upper pattern only	For complete pattern	For upper pattern only
160~	6	6	6	6
200~	6	6	6	6
240~	6	6	6	6
280~	6	6	6	6
320~	6	6	6	6

TABLE II

Data on 1954 Experiment (270 Graphs in Total)

Sound→ / Pitch↓	Normal voice										Headcold voice									
	$\underset{\sim}{\text{I}}$	$\underset{\sim}{\text{E}}$	$\underset{\sim}{\text{A}}$	$\underset{\sim}{\text{O}}$	$\underset{\sim}{\text{U}}$	$\dot{\text{I}}$	$\dot{\text{E}}$	$\dot{\text{A}}$	$\dot{\text{O}}$	$\dot{\text{U}}$	$\tilde{\text{I}}$	$\tilde{\text{E}}$	$\tilde{\text{A}}$	$\tilde{\text{O}}$	$\tilde{\text{U}}$	$\underset{\sim}{\text{I}}$	$\underset{\sim}{\text{E}}$	$\underset{\sim}{\text{A}}$	$\underset{\sim}{\text{O}}$	$\underset{\sim}{\text{U}}$	$\dot{\text{I}}$	$\dot{\text{E}}$	$\dot{\text{A}}$	$\dot{\text{O}}$	$\dot{\text{U}}$	$\tilde{\text{I}}$	$\tilde{\text{E}}$	$\tilde{\text{A}}$	$\tilde{\text{O}}$	$\tilde{\text{U}}$
120~	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
160~	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
300~	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

TABLE III

Data on 1955-I-Experiment (60 Graphs in Total)

Sound→ / Pitch↓	$\dot{\text{I}}$	$\dot{\text{E}}$	$\dot{\text{A}}$	$\dot{\text{O}}$	$\dot{\text{U}}$	$\underset{\cdot}{\text{I}}$	$\underset{\cdot}{\text{E}}$	$\underset{\cdot}{\text{A}}$	$\underset{\cdot}{\text{O}}$	$\underset{\cdot}{\text{U}}$
120~	2	2	2	2	2	2	2	2	2	2
240~	2	2	2	2	2	2	2	2	2	2
320~	2	2	2	2	2	2	2	2	2	2

TABLE IV

Data on 1955-II-Experiment (90 Graphs in Total)

Sound→ / Pitch↓	/$\underset{\sim}{\tilde{O}}$/	/$\underset{\sim}{\tilde{U}}$/	/$\underset{\sim}{\tilde{V}}$/	$U_{(f)}$*	$U_{(p)}$†
100~	3	3	3	3	3
120~	3	3	3	3	3
160~	3	3	3	3	3
200~	3	3	3	3	3
240~	3	3	3	3	3
280~	3	3	3	3	3

* $U_{(f)}$: Oral vowel *U* in *forte* voicing.

† $U_{(p)}$: Oral vowel *U* in *piano* voicing.

TABLE V
Data on 1956 Experiment (405 Graphs in Total)

Sound→ Pitch↓	I̲	E̲	A̲	O̲	U̲	Ị	Ẹ	Ạ	Ọ	Ụ	İ	Ė	Ȧ	Ȯ	U̇	Ĩ	Ẽ	Ã	Õ	Ũ	M	N	Ng	Ũ̲	Ū̲	Ũ	Ũ̲
110~	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
120~	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
130~	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
150~	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
170~	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

In addition to the detailed studies as shown in Tables I, II, III, IV, V on timbre patterns of nasalics, we further carried out a subjective study on nasalics in 1955 which gave a number of results worthy of note.

Discussion and Conclusion

The study of the so-called "nasals" is important for its own sake, of course, but we think that it is far more important in a sense that this study must furnish some vital clue by giving physical meaning to the timbre structure of the so-called "orals." We feel an immense responsibility to make a comparative study of nasals and orals, considering only their essentials, *i.e.*, placing the basic pattern structure of orality in direct contrast to the basic structure of nasality.

Nasals and orals have been further studied for the purpose of getting some important information on the influences of a stopped nasal passage and closed mouth, that is, the influences of a closed shunt-circuit upon an open main circuit where the main path and by-path come to be altered in turn. Studies on ideal nasals caused by perfect exclusion of buccal-cavity and ideal orals caused by perfect exclusion of nasal-cavity are important to explain the performance of bifurcated circuit. Pathological studies of abnormal nasals (so-called "näseln") are also important. Studies on "Rhinolalia Aperta" and "Rhinolalia Clausa" never fail to furnish important data on the workings of nasal cavity system. We do not touch upon these problems at the present stage of our study. We do, however, call this series of sounds "nasalics." "Nasalics" is wider in meaning than "nasals" and more essential than any actual "nasals."

At the present stage of our study our aim is an analysis of circuit performance of bifurcated passage, considering only air-transmission path in biological system. If influences of the bone-conduction passage superpose themselves on the result of air-transmission path, the immediate analyses might become too difficult to make.

Postscript

We have used the nasal study as a touchstone for our timbre theory because nasal phenomena are more unstable and capricious than oral phenomena and therefore their timbre treatment must be more unfailing and unrivaled in precision. We finally ask ourselves if our refined timbre-treating method is capable of examining this most subtle problem of an inextricable nature.