TIMBRE STUDY ON NASALICS

PART II. PRELIMINARY EXPERIMENTAL REPRESENTATION OF TIMBRE-PATTERNS OF SUSTAINED NASALS

SECTION B—SPECIALIZED OBSERVATION

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In the foregoing, we have observed the general trends of two nasals, critical $/\tilde{V}/$ and typical $/\tilde{O}/$, by examining the so-called white-phone patterns and by comparing them with the oral phone. We have further discussed pattern differences as to peak and glen. To better detect the detailed difference between two nasals, it is preferable to refer to a comparative study of both patterns for each individual pitch. We now focus our attention on that study.

Pitch Effect upon Timbre Construction of Nasals

After concluding our fundamental discussion on the essential difference between orals and nasals, we now, in due order, pass on the next step of observation, *i.e.*, to more detailed discussions on the finer differences between critical and typical nasals. For the purpose of such a detailed study, we continue with more careful and specialized observations by taking separate timbre patterns for individual pitches and by ceasing to refer to the ultimately integrated over-all patterns of the so-called white-phone. This is because nasal timbres are influenced particularly by the kind of pitch used. Nasals are outstanding examples in this respect. We must, of course, accept that even in orals there are some influences upon timbre patterns due to pitch change. Such influences on orals, however, are not vital because they are so regular and predictable. On the contrary, these influences are the most serious in nasals and, moreover, are seemingly quite irregular. We illustrate these facts by presenting some characteristic features in Figs. 9, 10, 11. In Figs. 9 and 10 the construction changes in the upper patterns due to pitch changes are shown separately for nasals $/\tilde{V}/$ and $/\tilde{O}/$. In Fig. 11 we show jointly the construction changes in lower patterns for both nasals. After carefully inspecting these figures, we can point out the following facts. In lower patterns of nasals, especially in $/\tilde{V}/$, the change in timbre construction is very small. In nasal $/\tilde{O}/$, there is some discernible change where condition of resonance seems to be altered by pitch change and where condition of absorption is not thus altered. In other words, the position of absorption is not altered by pitch change but the position of maximum resonance as well as the sharpness of resonance are changed by pitch change. These changes in lower patterns, however, are not so great as in upper patterns. Briefly, we might say that the following two facts are important for a description of upper-pattern changes. (1) In both nasals, the principal change of timbre-pattern is found mainly in the region of from 1 to 3.5 kc and (2) the pattern-

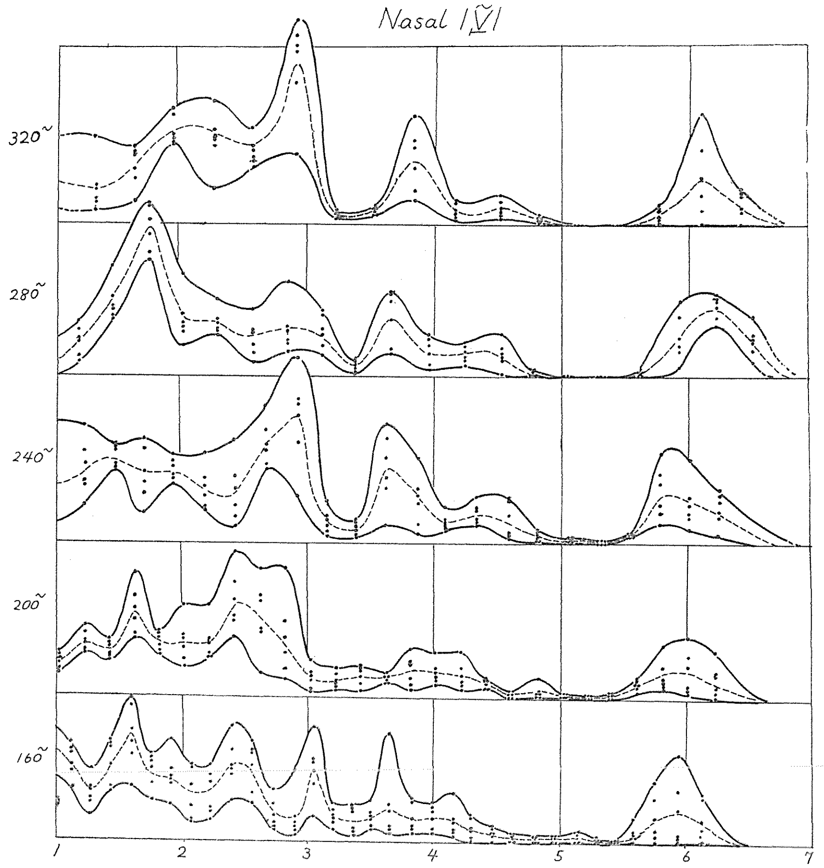

FIG. 9. Upper timbre-patterns of nasal /Ṽ̰/ for individual five pitches.

difference between two nasals appears most conspicuously in the pitch of 160 c.p.s. and least in the pitch of 240 c.p.s. In other words, the timbre patterns of /Ṽ̰/ and /Ǫ̃/ differ most widely in 160 c.p.s. pitch and to only a slight degree in 240 c.p.s. pitch so that this difference drops to practically zero. This last fact is clearly illustrated in Fig. 12 (*a*). We want to present (2) in another way which is of great importance because it reveals hidden features, as shown in Fig. 12 (*b*). By aid of this presentation, we can find without much difficulty that there exist two modes of periodicity in the fluctuation-envelope of pattern which reveal themselves most typically in the patterns of two different pitches, *viz.*, 160 and 240 c.p.s. A glance at the pattern of 160 c.p.s. pitch, leads us naturally to general trends of pattern-form consisting, first, in a considerably repressed amplitude and, next, in a finely fluctuating envelope of the pattern. By inspecting this pattern more closely and looking at it from the viewpoint of a fine rhythm of repression, we reach a position where we can discover that there is a quite regular pulsating periodicity of about 500–600 c.p.s. which governs the rhythm of the pattern-envelope and which almost corresponds to the frequency of the primary position of main absorption found in the transitory part of pattern. Meanwhile in the pattern of 240 c.p.s. pitch we

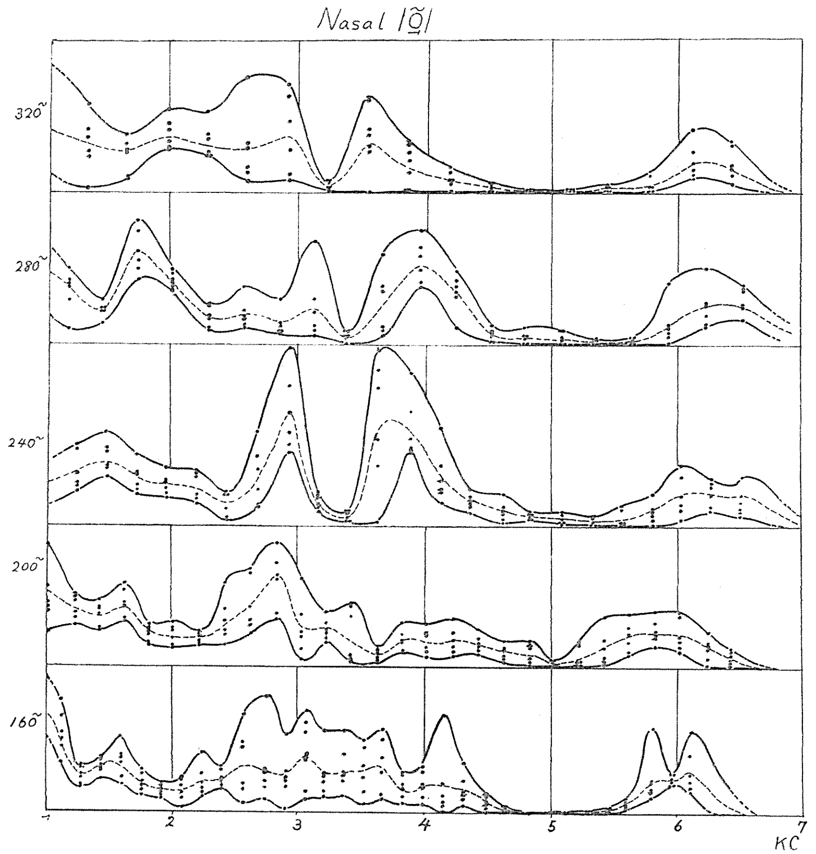

FIG. 10. Upper timbre-patterns of nasal /Õ/ for individual five pitches.

find an equally regular and constant periodicity of about 800–900 c.p.s. which regulates the pulsation of fine reinforcement of the pattern-envelope and which almost corresponds to the frequency of main resonance of nasal /Õ/ found in its transitory part of pattern. In patterns for pitches other than these two, there seem to prevail somewhat confused modes of periodicity which evoke a complicated pattern-form. In contrast to the fact that there is only a slight difference in modes in voice production in the case of orals, in nasals there is a great difference. By means of the experiment on the output level of nasal /Ṽ/, we proved by this same subject-voice that there was quite a sensitive response of level characteristics to the change of pitch, as shown in Fig. 13. As clearly revealed in this figure, there exists a definite pitch point of *output-reluctance* found in a very narrow region having 140 c.p.s. as its center. Further, there are two different pitch points of *output-willingness*, one showing a relatively sharp resonance-like form in the region of about 120 c.p.s., and the other showing an almost flat resonance-like form in the neighborhood of 240 c.p.s., the latter surely having a high octave relation with the former. These tendencies of level characteristic, however, depend upon the state of the nasal passage, and it is reasonable to assume that in the nasal passage of our subject who was catching cold, for example, the trend of level characteristic becomes greatly

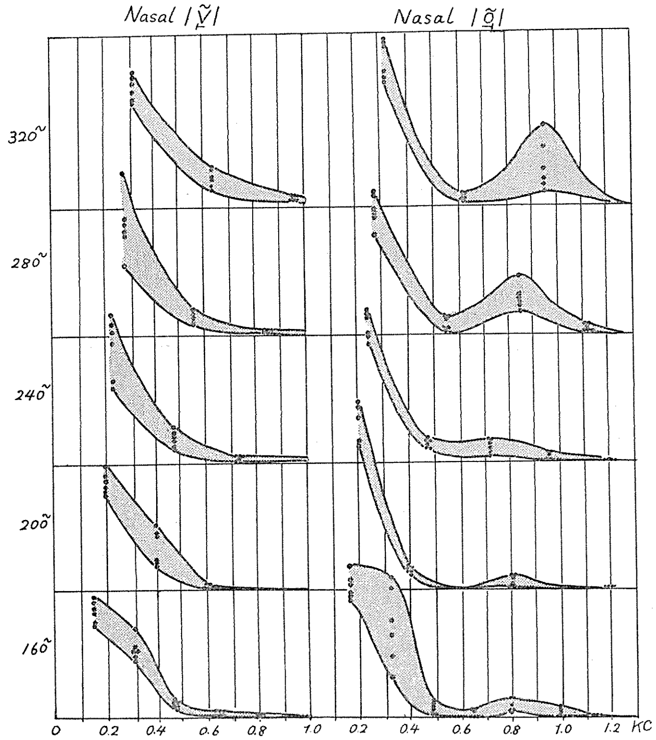

FIG. 11. Lower timbre-patterns of nasals /Ṽ/ and /Õ/ for individual five pitches.

changed; the selectivity of both resonance-like and antiresonance-like forms is greatly changed and even the position of both forms is subject to a slight change. By keeping this point in mind, we can possibly better understand the fact that in the representation of Fig. 12 (*a*), the pitch of 240 c.p.s. coincides exactly with one of the pitches of output-willingness, and that the pitch of 160 c.p.s. stands for the one which is nearest to the pitch of output-reluctancy.

Discussion

This first experiment is no more than a preliminary study attempted for the purpose of scenting some essential difficulties inherent in the nasal problem and, further, for illuminating experimental conditions and uttering circumstances which are really necessary for more certain solution of this problem.

We, of course, did our best to exactly and precisely describe our first experiment; but we do not expect widespread recognition of the merit of the present study. For example, from our present experiment we cannot decide what is the most accurate and over-all conclusion on the difference between "orality" and "nasality" and which conclusion is more likely to be universally accepted. This is because we treat with here only two kinds of nasals both of which are obtained by being issued through the nose entirely. There are other kinds of nasals which are obtained by being only partly issued through the nose, as, for instance, some

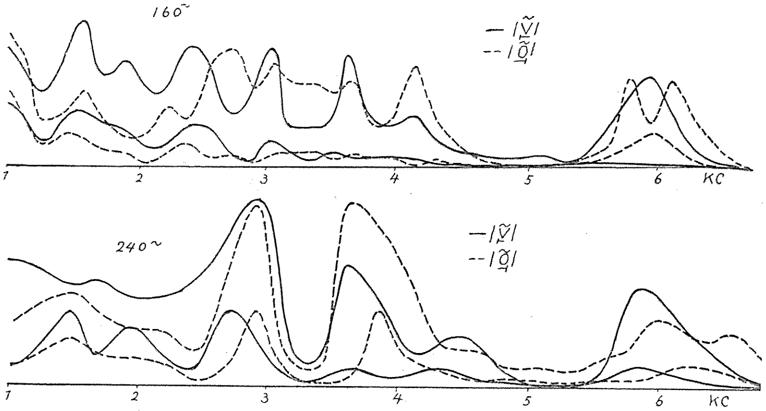

FIG. 12 (*a*). Pattern comparison of two nasals. Upper: Dissimilarity between patterns of nasals /Ṽ/ and /Õ/ for 160~ pitch. Lower: Similarity between patterns of nasals /Ṽ/ and /Õ/ for 240~ pitch.

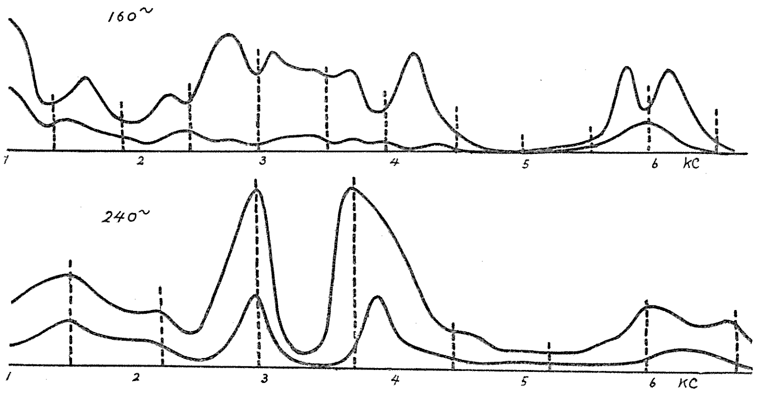

FIG. 12 (*b*). Characteristic of periodicities found in upper patterns of typical nasal /Õ/.

kinds of French nasalized vowels. In other words, there remains a field of nasal problems: *Nasalization* and *denasalization* (that is *oralization*). Until we complete our studies in this remaining field, we cannot make our final conclusion on the difference between "orality" and "nasality." In-so-far as the critical and typical nasals are concerned, both nasals are issued completely through the nose-cavity. By restricting ourselves to only these nasals, we can indicate the differences between nasals and orals by pointing out the position of the so-called peaks and glens as described in this report. After reviewing all details of our description, we must accept one important fact still undetermined, which is that the nasal glen corresponding to the oral glen of 1.3 kc ultimately failed to localize. This failure may be related to something in our experimental process of filtering down the patterns at the frequency point of 1.0 kc. This failure can be explained as follows. It is reasonable to surmise that there exists a nasal glen in the region joining the two groups of structure, *i.e.*, lower pattern of great intensity and upper pattern of small intensity. Even in the display of general patterns of /Ṽ/ and /Õ/ as shown in

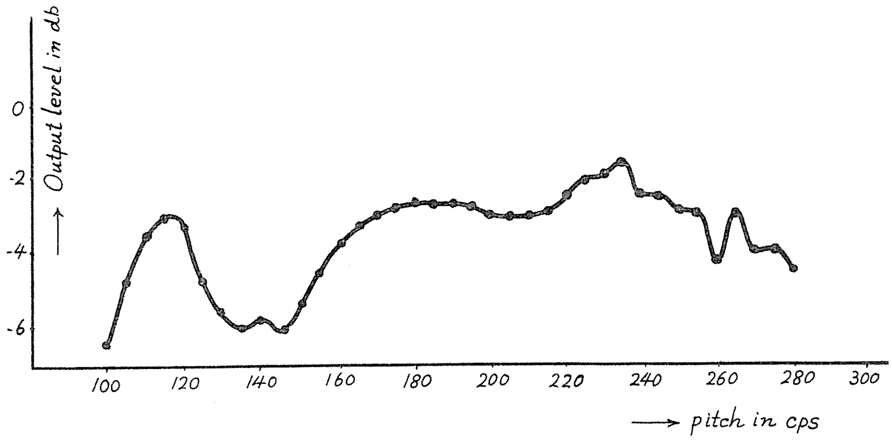

FIG. 13. Characteristic of output-level of critical nasal /Ṽ/ *versus* uttering pitch.

Figs. 3 and 4 in Section A, we can find some glen-like position in their connecting region. For more exact detection we used the so-called closed-up method of upper patterns. But by virtue of our unfortunate selection of the high-pass filter cut-off frequency too near this anticipated nasal-glen point, we failed to detect the correct position of nasal glen.

It seems important to point out that there exist two kinds of periodicity in the fluctuation-envelope of upper patterns. Closer inspection leads us to more concrete observation: In the pattern of nasal /Õ/ uttered by the pitch which corresponds to or is nearest to the output-reluctant pitch, further influences of the primary absorption (500–600 c.p.s.) in the transitory part become so predominant that a quite regular periodicity can easily be found when we look at the repetition of ebbing components in pattern. This predominancy thus gives rise to a suppressing effect on upper pattern as a whole; meanwhile in the pattern for the pitch of output-willingness of nasal /Õ/, further influences of primary resonance (800–900 c.p.s.) in the transitory part become so conspicuous that the upper pattern as a whole is apt to increase and we are able to find the periodicity when we count the repetition of the raised components in pattern.

Finally, we add our opinion on timbre-pattern displays. For better representation of fine structure, the frequency-axis must be measured in linear scale. This expression is better fitted for representation of harmonic-structure, while the logarithmic or mel scales are suitable for quality-characteristic display.

Summary

After reviewing and summarizing our experimental results already presented, we can focus on the following points of great importance as the general attitude to be taken in nasal study:

(1) In the selection of pitches for uttering nasals, particular care is necessary. Because of the definite and sensitive existence of both output-willing and output-reluctant phenomena due to pitch, we must be sufficiently prudent in pitch-selection.

(2) It is consequently needful to be more careful in finer adjustment of level-matching of nasals than of orals.

(3) Particularly for the investigation of the fine structure of timbre-pattern of

nasals, a detailed study of individual timbre-patterns for every possible pitch is vitally needed.

For the most reasonable interpretation of our experimental data concerning timbre pattern of nasals, one, the critical nasal /$\tilde{\underline{V}}$/ and the other the typical nasal /$\tilde{\underline{O}}$/, we can throw the searchlight on the following points:

(4) The common trend of nasals is in the lower patterns of particularly great intensity (including that part of fundamental pitch) as well as in the upper patterns of very small intensity.

(5) The characteristic trend which classifies and specifies nasals themselves is priorily found in (a) the transitory part which connects the upper and lower patterns, and (b) in the fine structure of upper pattern.

(6) For nasal with buccal trap, for instance, there is found in the transitory part, a sharp absorption determined mainly by the form of the mouth. This absorption is nearly independent of the kind of pitch used, and there is found, further, a somewhat resonance-like phenomena, the position and selectivity of which seemingly depend on the nasal pitch, thus finally giving to the transitory part an oscillatory pulsating appearance of one-cyclic alternation of reinforcement and repression.

(7) Another example of critical nasal of nearly single tract is one where we find a gradually and linearly decaying transitory part which makes a sort of low-pass filter of decidedly blunt character.

(8) The upper invariant of nasals is found to be almost the same as that of orals in the region of 3.6 to 3.8 kc. The other higher invariant seems to be found equally in nasals and orals.

(9) As for the lower invariant, we cannot clearly determine it because of the pre-eminency of lower-pattern amplitude which characterizes the nasal quality in general.

(10) In nasals, the position of oral glen of 1.3 kc is not found to be a complete vacuum. The nasal glen cannot be found exactly to the same degree in the place where the oral glen is found, *i.e.*, in the region of 1.3 kc. This point must be checked in more detail in future studies.

(11) The clearest nasal glen is to be first found in the vicinity of 5 kc (4.6–5.4 kc), and the sub-glen is found in the region of 3.3 kc which is nearly the same as for orals.

(12) The feature which characterizes the minute difference between nasals seems to be emphasized particularly in the pitch of output-reluctancy. Meanwhile for the utterance of nasals in the pitch of output-willingness the distinguishing feature rather tends to disappear, in-so-far as the upper pattern is concerned.

References

1) S. Horiguchi: Die experimentelle Forschung über die Resonanz der Nasenlautansatzrohren. Japanische Zeitschrift für Oto-Rhino- und Laryngologie, Bd. XXXXIX, Ht. 6, 1943.

2) A. S. House and K. N. Stevens: Analog Study of the Nasalization of Vowels. Journal of Speech and Hearing Disorders, Vol. **21**, No. 2, 1956.

3) R. Husson: Facteurs Acoustiques des Voyelles Humaines Nasalisées et Genèse Physiologique de ces Facteurs. Comptes Rendus, **246**, 1957.