TIMBRE STUDY ON NASALICS

PART III—STUDY ON PATTERN DIFFERENCE OF SEVERAL VOCALICS ATTRIBUTABLE TO CHANGES IN NASAL-CAVITY CONDITIONS

YOSHIYUKI OCHIAI and TERUO FUKUMURA

Department of Electrical Engineering

(Received October 31, 1957)

CONTENTS

Introduction

Considered from the viewpoint of studying nasality as a contrast to orality, it is very important, first, to look into the influences upon timbre patterns of both orals and nasals affected by changes in nasal-cavity conditions and, next, to observe similar influences produced by changes in buccal-cavity conditions. It goes without saying here that we must simultaneously study both orals and nasals, not confining ourselves in such a way as to concentrate only on orals to check the result of changing nasal conditions and, in the same manner, not to concentrate only on nasals for proof of the effect of changing buccal conditions. For direct and immediate comparison between "orality" and "nasality" and for unfailing detection of delicate differences between them, we are obliged to follow this obviously over-meticulous and time-taking way. For the same reason we must examine all conceivable vocalics for both orals and nasals. As for the selection of pitches, we employed only three, not six as previously used. We restricted the number of oscillograms needed for determination of timbre patterns to three this time because, after finishing the trial test on deviation in patterns described in Part II, we were able to find what we thought to be the most suitable and economical number of oscillograms for each pitch. The number, of course, might depend upon the time allowed the subject for calling practice to insure indisputable determination of the mean pattern form. Amplification in our present experimental set is not weighted for the reason that we wanted to get a faithful representation of timbre patterns.

Characteristic of Output-Level *versus* Pitch

We show in Fig. 1 the characteristic of output-level *vs.* pitch of nasal $/\tilde{V}/$ obtained through the varying pitches of notes uttered in a *mezzo-forte* voice under

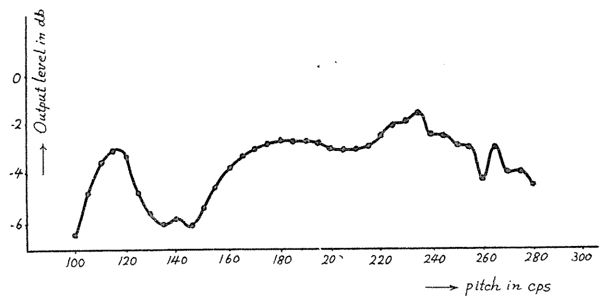

FIG. 1. Characteristic of output-level of nasal /Ṽ/ against its uttering pitch in the normal healthy condition of calling subject TF.

constant strain. In contrast to our previous experience with the same subject where the oral output-characteristic was slow and changed gradually, the nasal output-characteristic this time showed in the narrow region of 130 to 150 c.p.s. a very marked tendency—notwithstanding the subject's effort to keep a constant intensity of voice—toward a rapid and abrupt output decreasing, giving thereby an anti-resonance-like curve form. In addition to this antiresonance-like tendency, we can find some resonance-like tendency at the two pitch points of 120 c.p.s. and 240 c.p.s. (having a mutual relation on one octave), resulting thereby in a relatively large output production in spite of the skill of the subject and his effort to maintain level-constancy. These are the nasal tendencies of output-characteristic which are worth remembering. What should not mislead us here is that the resonance-like or antiresonance-like tendencies do not always mean, in the exact sense, the resonance or antiresonance of pitch itself. What is meant is that there is present a powerful resonance or an effective absorption in some certain higher components of the timbre patterns in question. This presence of output-willing or output-reluctant pitch is of significance when it is considered as reflecting some abrupt changes in mode of voice-production during the process of gradual pitch change.

In Fig. 2 we give the same output-level characteristics of nasal /Ṽ/ when the same caller is in a condition of nasal cold. We see there that the resonance-like and antiresonance-like characters are almost lost and result in a somewhat flattened monotonous characteristic.

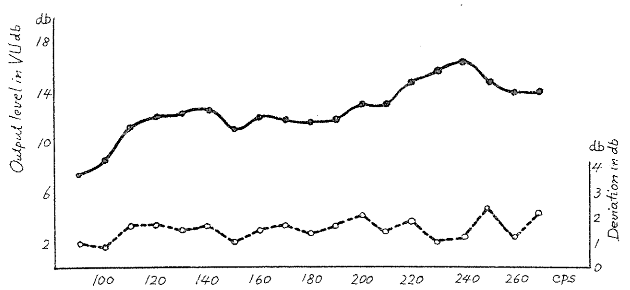

FIG. 2. Characteristic of output-level of nasal /Ṽ/ against its uttering pitch in the nasal-cold condition of calling subject TF.

Research Aims

To obtain from our pattern study of nasalic sounds a sure and progressive approach to transmission performance of biological bifurcated circuit inherently difficult to observe and to regulate, we must consider and utilize all conceivable conditions and circumstances. For this reason our researches find merit in the study of the following items:

(1) Nasalization and denasalization.
(2) Artificial vocalics with blocked nose and those with mouth closed.
(3) Vocalics passing through nose and vocalics blocked in nose.
(4) Head-cold voice.

We now take up each heading in that order.

Nasalization and Denasalization

The brightest prospects for tracing an immediate and important clue to the difference between "nasality" and "orality" is in the field of discriminative studies of the phenomena of "nasalization" and "denasalization." The study of nasalization, *i.e.*, nasalized vowels, can be attributed to the study of the performance of nasal-cavity circuit which is excited by the breath puff, leaving the buccal-cavity circuit as an open by-path. Meanwhile in the course of study of denasalization, *i.e.*, vowels reduced from the state of nasalization to their original state, the mechanism of "oralization" is grasped by illuminating the preformance of buccal-cavity circuit when it is excited by a puff of breath coming through the glottis, leaving the nasal-cavity circuit as an open by-path. In short, to look at the nasal problem from the angle of a discrimination between nasalization and denasalization is to consider the mechanism of nasalizing and denasalizing (*i.e.*, oralizing), by referring to the transmission role of the bifurcated circuit. Along this line we can duly ask the following question: In the bifurcated circuit composed of nasal and buccal circuits, what effect is to be considered in transmitting the sounds in question? More precisely, in nasalization, for example, is the resonance of nasal cavity in fact the main and only effect or is there any noticeable effect due to buccal cavity? In denasalization phenomena, is the resonance of buccal cavity in fact the only effect, or in addition to it is there any considerable effect due to nasal cavity? The question of discrimination is the core of the problem because in any interpretation of the timbre-patterns of nasals and orals, we are necessarily confronted with this vital point.

*Artificial Vocalics with Blocked Nose and Those with Mouth Closed**

Considered merely from the viewpoint of subsidiary circuit as compared to main circuit, subsidiary circuits in nasalization and denasalization correspond to an open by-path composed of either mouth-cavity or nose-cavity. In addition to a study on the open by-path, for the purpose of gaining a complete understanding of the performance of the bifurcated circuit, it is also indispensable to refer to a study of a closed condition of the same by-paths. Following along this line of thinking, it is well-timed to broaden and generalize the conception of "vocalics" by establishing as two distinct vocalics, those issued through the mouth with the

* As to this subject, we shall publish a full report in the near future.

nostrils closed and those issued through the nose with the lips closed. A systematic comparison of one with the other is absolutely necessary because an isolated and segmentary study restricted only to natural real nasal-vocalics could conceivably lead us to shortcomings in our conclusions on the difference between orality and nasality due, in part, to a subject too narrow in scope and too limitted in meaning and, in part, to an unsystematic and unspecialized approach to most complicated phenomena. It is, therefore, not as a dilettante and from mere curiosity that we institute this inquiry on artificially pronounced vocalics (nasals and orals in an enlarged sense) which may seem to be nonsense from a phonological aspect.

Next we shall make another comparison, laying stress on the importance of artificial vocalics presented in the following section.

Vocalics Passing through Nose and Vocalics Blocked in Nose

Here we deal with the nasalizaed vowels produced by voice passing through the nose, and further, with such vowels when pronounced in the mouth like ordinary orals but with the nostrils blocked, *i.e.*, vocalics produced by a voice which has no means of making way through the nose. Explained in another way: For nasalized vowels we can study the voice passing easily through the nose, and for vowels with blocked nasal passage we can study the voice which has no passage through the nose. In ordinary conversation in daily life, one can easily find many cases where the voice has too large a passage through the nose, and other cases where the voice has too small a passage through the nose. Neither of these voices is agreeable to the ear. Although we cannot find the reason for this unpleasantness, we are induced to think that this cannot remain irrelevant to the phenomena of personal vocal nuance. In order to fully understand that even the same caller can easily change his voice quality without influencing his phonemic quality simply by either making way for the voice through the nose or by blocking the way through the nose, our present study serves to demonstrate how this can be done.

Here for the sake of simplicity we propose terminology for the two kinds of nasals: Nasals produced by artificially blocking the nose we term "blocked nasals"; nasalized vowel-sounds which are issued through the open nose we term "ordinary nasals." This designation is adequate because the sounds obtained from blocked nose and through open nose undergo equally some nasalizing effects. In the degree of nasalization, of course, the two nasals, blocked and ordinary, differ, as we prove later, based upon our experimental data.

Too important to be overlooked is still another reason for adopting the so-called "blocked nasals." This is the convenience they afford during experiments with the closed by-path as related to the utterance of the artificial sounds. By introducing the performance of the closed pipes as by-path to the main circuit of the blocked nasals, we can quickly realize that such a condition gives rise to unerring repeated and periodical recurrence of movement in the fine structure of the considered patterns which otherwise are far too complicated and divergent. This evidence of recurrency in pattern forms might come into being as a result of two conditions, (1) certain violent repressions due to the closed pipes in the by-path circuit, and (2) certain additional repeated reinforcements because of some particular cavities in the main circuit. Even when the recurrency is consciously evoked for a purpose, it none-the-less is of great service to an interpretation of timbre patterns in general.

Head-Cold Voice

For the same purpose of comparison, we used a subject with a head-cold for our study material.* It is important to recognize that both ordinary orals and nasals pronounced in the usual way are greatly influenced by the state of the nasal cavity, reflecting and even evidencing some mutual relevancy between the performance of nasal- and buccal-cavity circuits. It is, of course, necessary to prove this relevancy by producing real data on the fine structure of timbre patterns. The study of a head-cold voice is most useful to elucidate the fact that the timbre structure which marks and characterizes the personal voice-nuance depends in some subtle way on the state of the nasal cavity. It goes without saying that as we proceed to face this situation of voice altered by a head-cold, we must return in more detail to the fine structure of voice from the viewpoint of *harmonic-structure* of timbre-pattern from which we are apt to be distracted in our pattern studies looking at the fine structure of pattern from the viewpoint of *frequency-structure* exclusively.

The order of these study-headings does not necessarily imply the order of their importance.

Results of Studies on Vocalics Which Do or Do Not Pass through the Nose

We describe results of our experiments carried out in 1954, first, on voices sounded through the nose, such as uttered in ordinary nasalized vowels, and, then, on voices sounded in the nose as given by the blocked nose.

For this purpose we utilize the representation of five vowels given in Fig. 3, to show two types of nasally modulated voices; one by the open nose, and the other by the blocked nose, both given for three pitches, *viz.*, 120 c.p.s. as resonance-like output-willing pitch; 160 c.p.s. as pitch nearest to antiresonance-like output re-

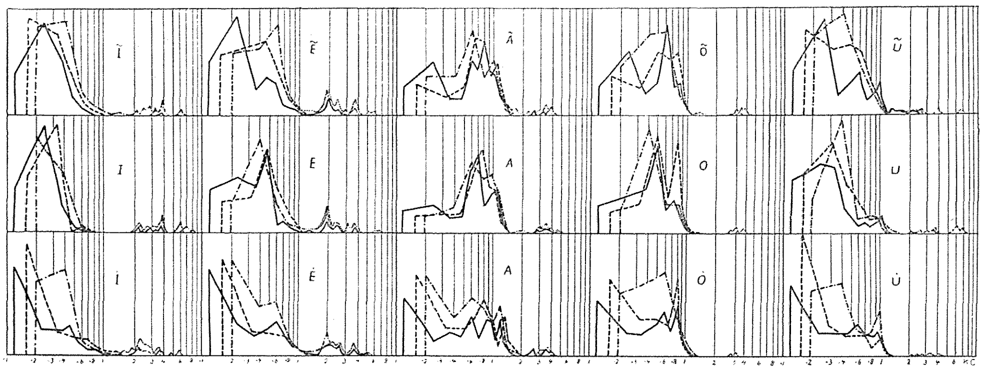

FIG. 3. Pattern comparison of ordinary nasals ($\tilde{V}$), normal orals (V) and blocked nasals ($\dot{V}$) of every five vowels represented for every three pitches.

* In the winter of 1954, during the long course of pattern study with our male calling subject, in the very midst of the experiment with artificial sounds, it happened that he caught cold in his head and his voice became muffled. We, of course, did not fail to make use of this opportunity to thoroughly study the nature of so-called head-cold muffled voice, by bringing it into detailed comparison with the normal voice taken immediately before and after the head-cold condition.

luctant; 200 c.p.s. as giving a pitch intermediate between two resonance-like pitches. All pitches are selected for their own inherent characters. For basis of comparison, five oral vowels are used here as reference. The patterns corresponding to such characteristic pitches change as the pitch changes. Such changes appear even in the same category of sound. By means of the representation in Fig. 3, we can examine pattern-forms from any one of the following parameters, *i.e.*, the category of sound ($\tilde{V}$, V, $\underset{\sim}{\vec{V}}$ or $\dot{V}$), the difference in vowels (I, E, A, O, U), and the difference in pitches (120, 160, 200 c.p.s.). From these parameters, we can carry out a comparison study of the most comprehensive kind and of the most detailed nature. We begin by presenting the over-all observation. In spite of the seeming considerable variation in patterns among the three different sounds, the most important elements, *i.e.*, the most essential from the phonemical aspect, never seem to be lost in their own patterns. It is possible that in certain cases some of these elements may, to some extent, undergo a diminishing. We can easily see that in nasalized vowels the position of vocal peaks differ from peaks in oral vowels, undergoing a slight shifting of position in frequency range either a little to the upper or a little to the lower, or simultaneously shifting to both upper and lower positions. Vocal peaks of nose-blocked vowels are seemingly rounded as the result of considerable shifting of the highest peak downward to the fundamental pitch region. At first sight such phenomena may mean that there has been some additions of coloring formant to the original phonemic element still in part retained. To such seeming additional coloring element we can apply the term "Phonemic Color" because ordinary nasalization can have a phonemic meaning, while nose-blocked nasalization has no meaning in phonemic aspect which we term "Vocal Color."

For a specialized demonstration, the white-phone representation given in Fig. 4 is more suitable. Here are represented three integrated over-all patterns of the oral white-phone, the nasal white-phone and the nose-blocked white-phone. In-so-far as the lower patterns are concerned, the nasal white-phone pattern has a dome-like form and the nose-blocked white-phone has a gradually decreasing form in contrast to the oral white-phone which has a form

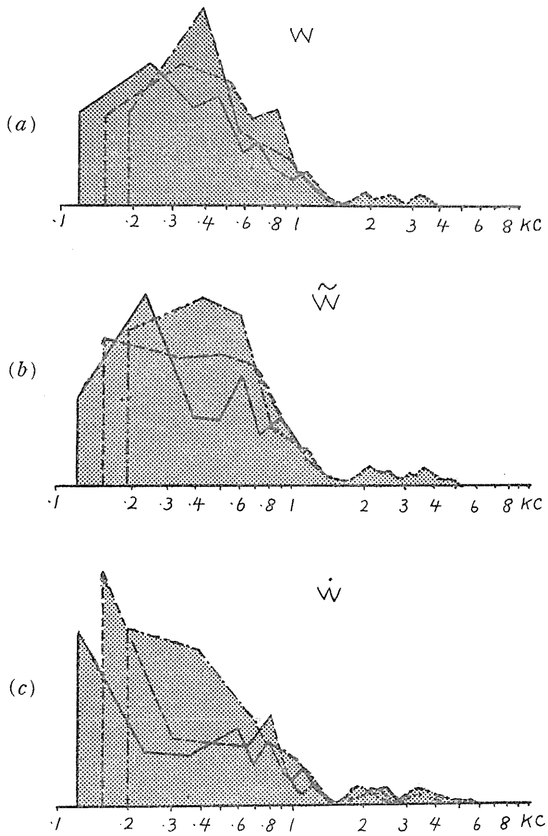

FIG. 4. Representation of timbre pattern of several white-phones in normal voice: (*a*) oral white-phone (W), (*b*) nasal white-phone (W̃), (*c*) nose-blocked white-phone (Ẇ).

something like a pinnacle. It goes without saying that all these forms cover every conceivable form for all possible pitches. As for concrete patterns for each actual pitch, there are more serious differences in pattern because of the pitch in voices with ordinary and blocked nasalization where the nose cavity takes a more positive and sensitive part in utterance activities than with orals where the nose cavity participates only negatively.

Next, we present our more detailed and specialized observation. The essential characteristic differences in pattern-form due to differences in kinds of sound, $/V/$, $/\tilde{V}/$, $/\underset{\sim}{\vec{V}}/$, are those which depend on the kinds of vowels. For example, in vowels "I", "E", their most reinforced parts in orals $/V/$, clearly correspond to the most repressed parts in blocked nasals. A similar tendency seems to be found between orals and ordinary nasals but in a less marked way. Meanwhile, when we keep an eye on the pattern of vowels "A", "O", we note that the most reinforced parts in orals correspond exactly to the most reinforced parts in both ordinary nasals $/\tilde{V}/$ and blocked nasals $/\underset{\sim}{\vec{V}}/$ thus in this case resulting in a smooth meshing (in-phase relation) of individual reinforced maximum parts in the two patterns. With regard to vowel "U", it has remained impossible to make a clear decision as to the tendency (meshing or interlacement) this sound responds to because of the complicated nature of its pattern form.

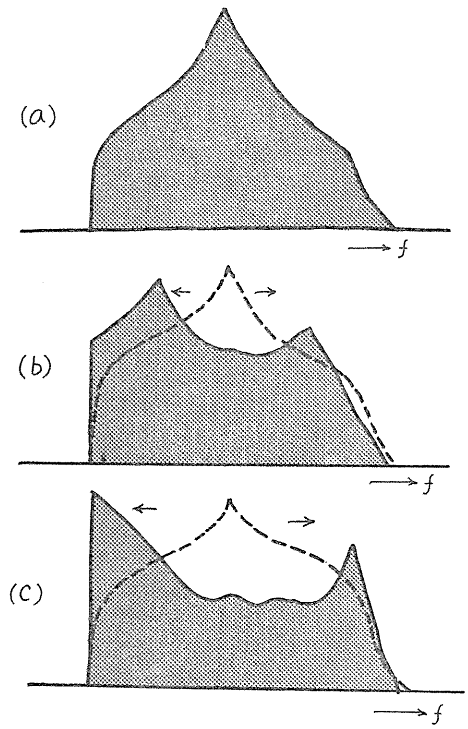

FIG. 5. Schematic explanation of pattern changes among normal orals (a), ordinary nasals (b) and blocked nasals (c).

Speaking in a more integrated and somewhat idealized way, we can venture to interpret the pattern change as follows: By the process of ordinary (not blocked) nasalization, the so-called formant regions of ordinary orals are nearly always shifted a little to the upper as well as a little to the lower in frequency range, as schematically illustrated in Fig. 5. Here is also given an idealized pattern of blocked nasalization where the upper and lower shiftings are rather apart and are so spurred on that there is the greatest predominancy of the fundamental pitch-amplitude as the termination of the shifting to the lowest pitch frequency position, on one hand, and, on the other, there is some reinforced component in the position closest to the oral glen appearing as the termination of the shifting to the upper frequency range. As proof of this latter kind of shifting, we can point to the patterns of vowels "A", "O" and "U". The extension of the lower pattern in "A" is clearly found as a marked component in 1.2 kc region, and in "O" and "U", the upper boundary part of the lower pattern is clearly revealed as the steepest cliff which extends over the so-called oral glen point.

To make some observations on the so-called NOTCHED FORMANT, *i.e.*, double-peak formant, is here interesting as well as important. The phenomena of notched formant are most clearly evident in oral vowel "A" especially for a pitch of 120 c.p.s. They are less clearly evident for pitches 160 and 200 c.p.s. of oral vowel "A", wherein notched formant, *i.e.*, double-peak formant, disappears to give way to a nearly single-peak formant. As for oral vowel "O", notched formant phenomena almost completely vanish for pitches 120 and 200 c.p.s. The finding of this relationship in the nasalization processes would indeed be of considerable significance. But for the present we refrain from going into a more lengthy description of this only, because now we must take the step to a direct and immediate comparison of nasals and orals without the intermediary of any other sounds.

Detailed Observation on Difference between Orality and Nasality Viewed from Harmonic Structure

In Part II of this series report, we have already discussed this difference problem, taking two kinds of nasals issued entirely through the nose and contrasting them with ordinary oral vowels.

A more direct comparison can be obtained through the comparison of ordinary oral vowels with nasalized vowels issued partially through the nose. We show in Fig. 6 the patterns of nasalized vowels compared directly with those of oral vowels for all three pitches. In this case, the observation of pattern changes through changing pitches is particularly necessary. By virtue of the representation in Fig. 6, we are well aware of the fact that the difference between orality and nasality is indisputably displayed by the difference in phases, so to speak, in the whole pattern forms. In the majority of cases we can trace this difference not only in lower pattern but also in upper pattern. It is, of course, obvious that such difference consisting only in a one-directional shift, toward either lower or upper position of a segmentary part of the most conspicuous formant in the pattern in question, is not sufficient. Rather the difference between orality and nasality must be understood as an over-all change in the whole pattern. The seeming difference in phase of indentation in pattern is most reasonably reducible to the difference in harmonic-structure of pattern.

As the best example for our explanation we discuss here patterns for 120 c.p.s. pitch. Here we see the self-evident discrepancies of pattern forms between nasals and orals as revealing a tendency toward zigzag interlacement of two pattern forms, nasal and oral. This tendency toward interlacement of patterns is seen most clearly in the four vowels "E", "A", "O", "U" and least clearly in the extreme front "I". After a closer inspection of the dissimilarities in the four vowels "E", "A", "O", "U", we can well consider the following pattern features from the harmonic-structure viewpoint: In orals, we can find an essential and inherent tendency which prevails exclusively to regulate the predominancy of even-number harmonic components and thereby represses odd-number harmonic components, and the relative weakness of the component of harmonic II (240 c.p.s.) is the only exception because its position is immediately outside the so-called formant region of vowels "E", "A", "O" particularly. In nasals, on the contrary, the essential and inherent tendency toward the usual pattern formation lies in the predominancy of odd-number harmonic components and thereby represses even-number harmonic components, and the vital strength of 240 c.p.s. component as the second harmonic is the only exception the

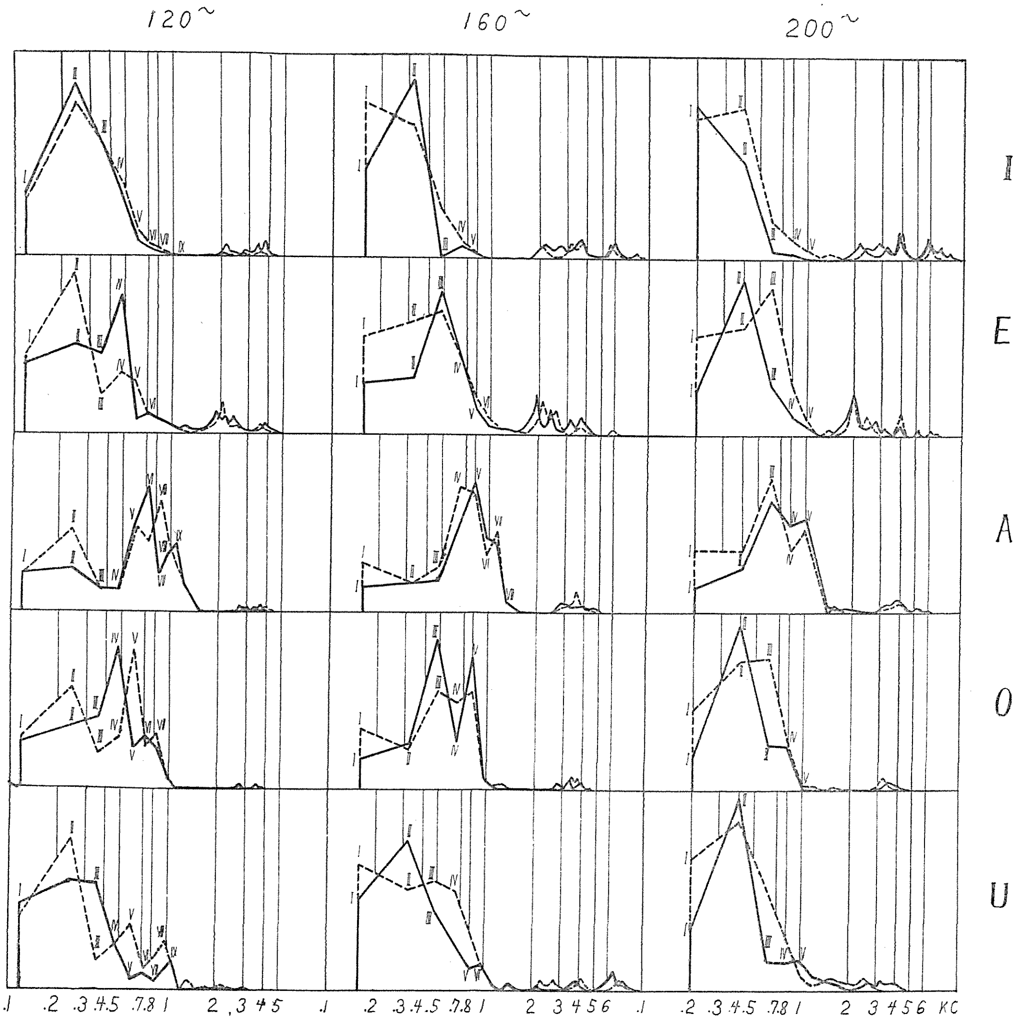

FIG. 6. Pattern difference between vocalics, oral and nasalized, in normal healthy voice, where full line indicate oral and dotted line nasalized.

reason for which seems to be that incidentally this cycle-component coincides with the resonance-like pitch of nasal utterance.

In short, by putting aside the first and second components, we can find the change in timbre construction, *i.e.*, we can find that the even-harmonic predominant structure in orals is replaced by odd-harmonic predominant structure in nasals. In orals, we can easily find the predominancy of IV, VI and VIII components at least; on the contrary, in nasals, the predominancy of V, VII, IX components at least are most clearly seen. The dissimilarity in patterns which comes from such a difference in harmonic-structure, gives rise to apparent meshing of one pattern with another. In the patterns for antiresonance-like pitch 160 c.p.s., where the influence of nasal cavity is seemingly least, the pattern dissimilarity between nasals and orals is almost entirely negative; for example, in vowels "A" and "O" the patterns of both nasals and orals undergo an in-phase relation change. The patterns for 200 c.p.s. pitch seem to undergo an out-of-phase relation change. Here particularly, the replacement of component I in orals by component III in nasals is conspicuously seen. Later, we shall re-examine the problem of harmonic-structure and formulate our description more definitely when we treat white-phone patterns in a more integrated manner.

Experimental Study on Head-Cold Voice

As to the head-cold voice, in 1954 we studied the subject's oral and nasal vocalics, selecting in every case three pitches, 120~, 160~, 200~. We shall describe in due order the details of patterns of his muffled voice because of a head-cold, stressing particularly the departure from his normal healthy voice.

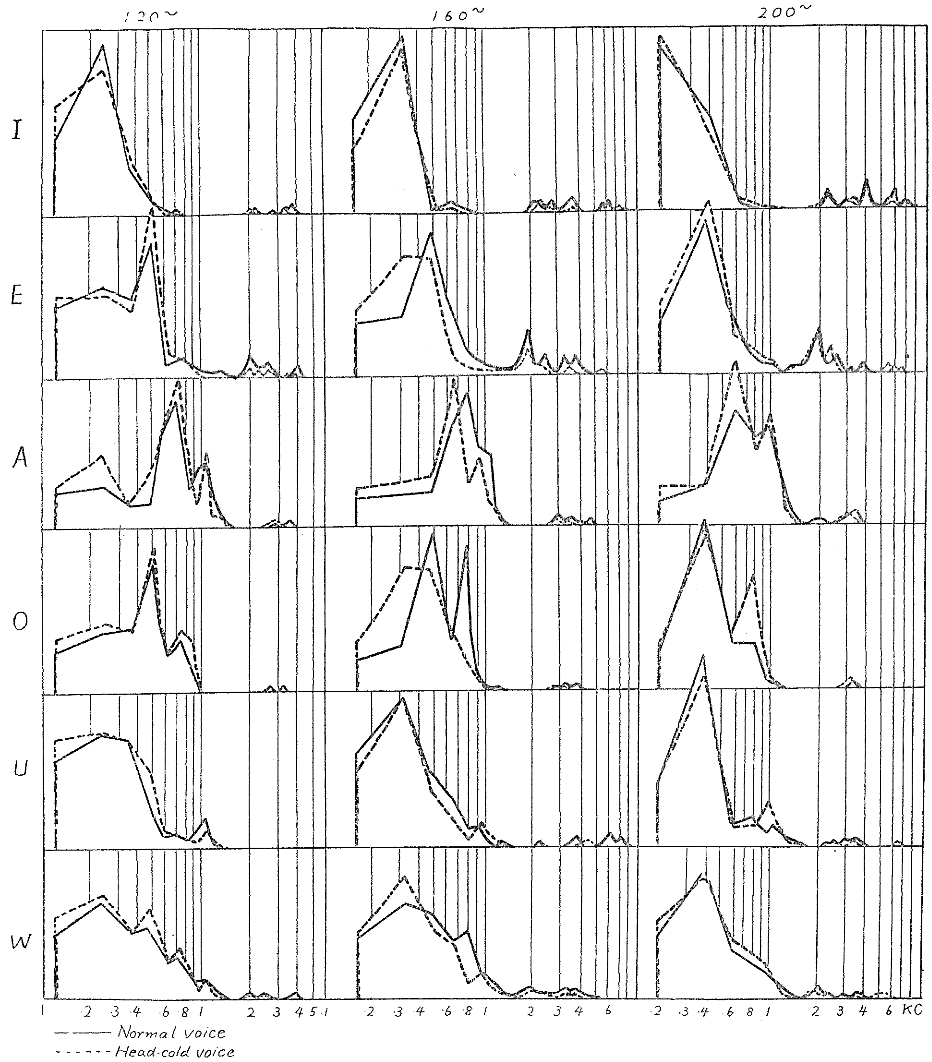

FIG. 7. Pattern difference between muffled orals and normal orals.

Muffled Orals and Normal Orals

We show in Fig. 7 the difference between a normal vocalic and a muffled vocalic, first employing five oral vowels "I", "E", "A", "O", "U" and, finally, white-voice "W", uttered on three pitches, 120~, 160~, 200~. A glance at the graphs composing Fig. 7 leads us to the following interesting observation. The feature which marks the muffled vocalic is that the pattern part below the so-called vocal glen has several sharp indentations in zigzag form, whereas in the normal vocalic the indentations are relatively blunt and inconspicuous. This difference in indentation is obviously related not only to the patterns of five vowels but also to the white-voice pattern. It is particularly informative for us here that these indentations reveal themselves most clearly in the region of the second formant peak as unmistakable "notched formant." As to the pattern part beyond the vocal glen, the normal vocalic pattern seems to show rather sharper indentations than the muffled vocalic; the tendency in the higher pattern is not so clear as in the lower pattern because of the slight amplitude in the higher pattern. The relatively clear tendency found in the lower pattern of white-voice is of importance for the simple reason that the white-voice represents the over-all pattern of all possible vocalics.

Muffled Nasals and Normal Nasals

Because of the nature of the only partially blocked nose during a head-cold, there has remained some route for breath passage through the nose. We can, therefore, examine the nasalized vowel as it passes through the congested nose by comparing it with the nasalized vowel as it passes through the nose in a normal healthy state. In conformity with the same representation as in orals, we show in Fig. 8 nasal patterns of muffled voice in comparison with those of normal voice, giving every timbre pattern in five nasalized phonemes and one in nasalized white-voice for every three pitches. After closely examining the difference between two kinds of nasals, we can easily come to the following conclusions. In spite of having the same nasal phonemes, there is a difference between patterns of muffled and of normal voices to the same extent as is found between orals and nasals in normal healthy voice. What should be noted here is that in normal nasals there appears a tendency toward odd-predominancy restricted to some partial region only, leaving other parts of pattern as even-predominant regions, whereas in muffled nasals there is found the even-predominant tendency only throughout the whole pattern. As a result of this fact, we are led to the final important observation that the oral (phonemic) formants are still clearly seen in the nasalized vowel in muffled voice. This means that oral formants still maintained as reinforced components in nasalized vowels in normal state are nearly lost, repressed by being absorbed by nasalized vowels in a partially blocked nose. In other words, considered from the harmonic quality aspect, muffled nasals seem to lose some or all of their most important phonemic entities in a partially blocked nose. When we consider other detailed points of difference, we can point out the following facts, *viz.*, that in normal state of voice the pattern usually forms the sharp edge of a precipice, dropping from its peak toward vocal glen, and that meanwhile in muffled state of voice the pattern falls in a gradual slope and occasionally there can be found something like a small projection exactly in the very midst of vocal-glen region.

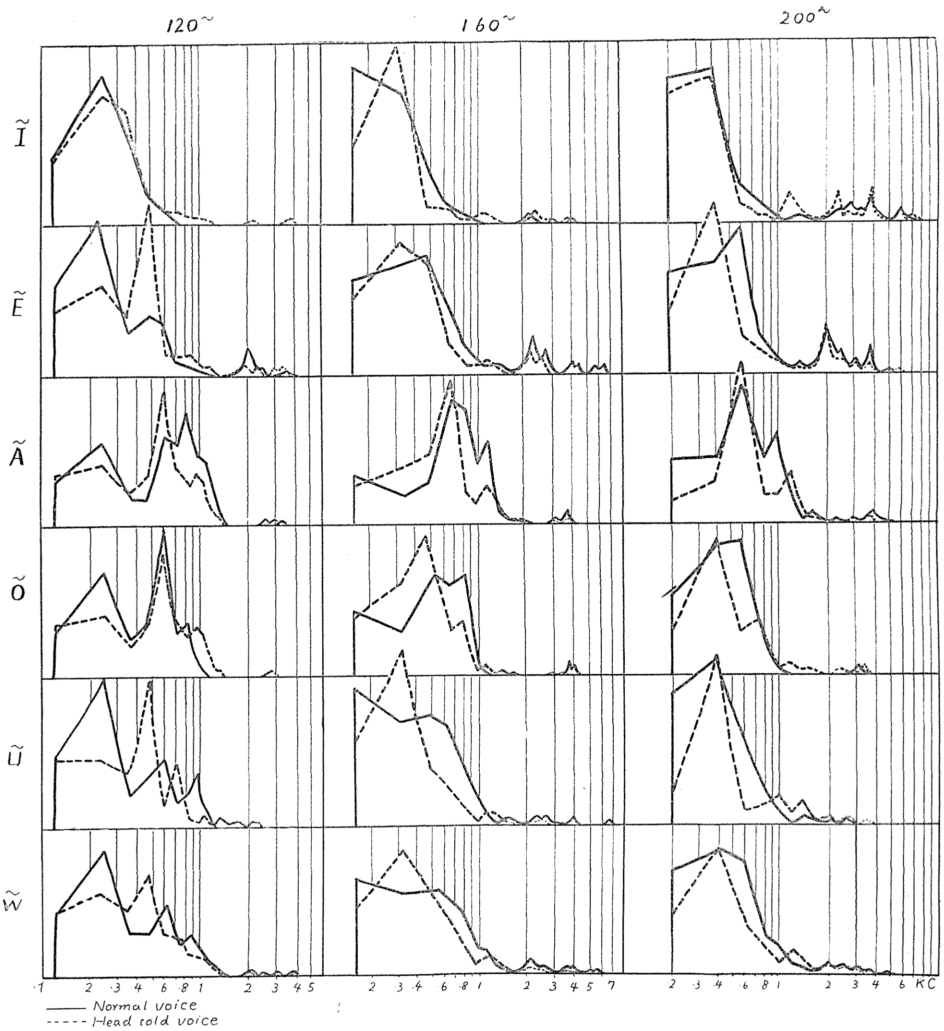

FIG. 8. Pattern difference between muffled nasals and normal nasals.

Over-all Inspection of Muffled and Normal Voices

After finishing the course of study on head-cold voice, it is most necessary that we return to the problem of nasality and orality. To lead most prudently to an unerring conclusion on the essential nature of nasality contrasted with orality, it is indispensable that we take into consideration a more general situation by carrying out comparative studies on nasals and orals not only in the ordinary conditions of open nose but also in the out-of-ordinary conditions of congested nose caused by a head-cold. This latter condition is surely serviceable as a preliminary stage to the study of conditions which lie between a completely free-passage nose and a completely blocked nose which can be managed artificially.

As a summarized study of normal voice and head-cold voice for discriminative observation between nasality and orality, we give the representation of Fig. 9 where individual white voice patterns for both orals and nasals are separately shown for all three pitches. In the normal voice, the marked feature which characterizes the difference between nasality and orality is clearly seen in an interlacement of zigzag forms of both patterns. To our surprise, this unmistakable feature is almost completely lost in head-cold voice where the two patterns stand in nearly equal phase. Closer inspection shows that the out-of-phase relation in normal voice and the in-phase relation in head-cold voice are both most conspicuous for the output-willing pitch 120 c.p.s., and become less conspicuous for pitches 160 and 200 c.p.s.

As we have pointed out in the foregoing, muffled orals are not far distant from muffled nasals. This is reasonable because of the fact that the nasals issued through the partially blocked nose cannot appear as perfect nasals, *viz.*, they cannot show sufficient peak-rounding effect because of the nose condition and, further, because in a head-cold state the orals themselves cannot appear as perfect orals, *viz.*, they cannot give sufficient peak-sharpening action because of blocked nose. As to the peak-scraping action of blocked nose, this white-voice pattern in both normal and muffled voices represents the so-called even-predominant type of pattern which is an essential character of this caller's own voice. Closer inspection shows that the tendency of even-predominancy is more marked in muffled voice than in normal voice. This fact is no more than another expression of more conspicuous indentation of muffled voice pattern. These observations easily lead us to the following infer-

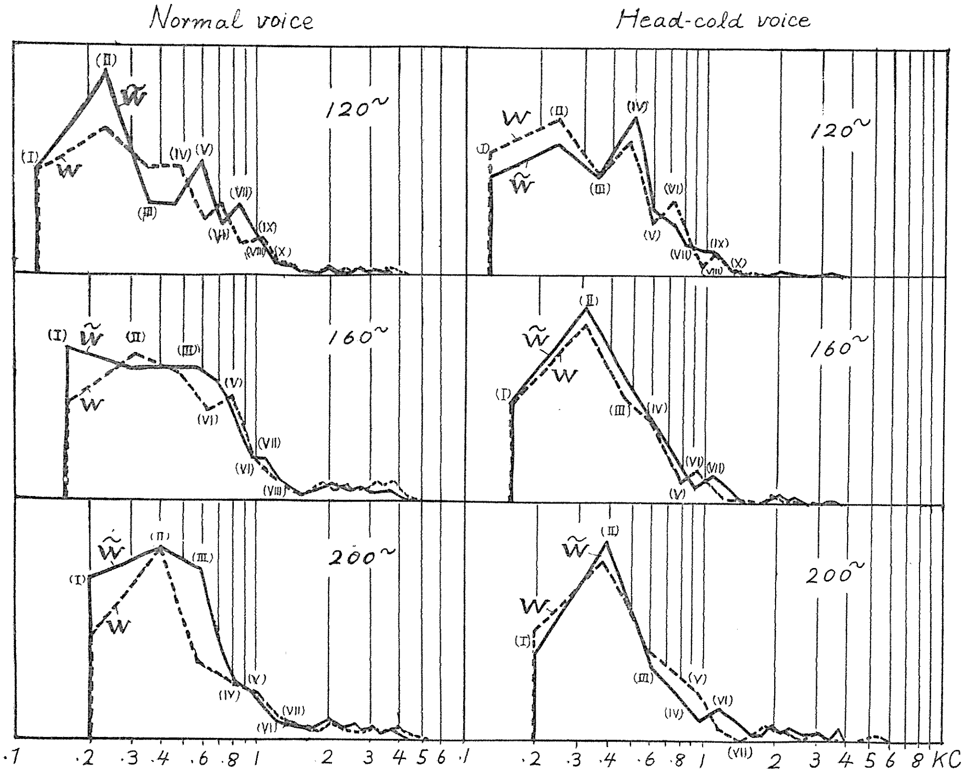

FIG. 9. White-voice pattern difference between orals (W) and nasals (W̃) in both normal voice condition and in head-cold muffled voice condition.

ence. In the idealized pure orals which might be obtained through perfect exclusion of nasal-cavity, the timbre pattern might be entirely composed of clearly reinforced even-number harmonics, that is, speaking in reversed way, might be composed almost entirely of clearly repressed odd-number harmonics. The influence of open by-path of nasal-cavity upon such idealized pattern might reveal itself as a somewhat mitigated even-predominant harmonic type as the result of even-repressing and odd-reinforcing effect of the open nose. What should be noted here is that the effect of the open nose upon orals is not revealed by *uniform damping* but by *recurrent damping, i.e.*, damping activated in such a way as to repress even-harmonics only, thus apparently resulting in reinforcement of odd-number harmonics. Through the partial congestion of the nose during a head-cold, this even-repressing selective transmission effect is mitigated so that we can more clearly see the indented even-predominant type of pattern somewhat similar to the idealized pattern.

Discussion

In nasalized vowels, the position of vocal peaks differs from peaks in oral vowels. By nasalizing process the vocal peak in orals undergoes a slight shift in position in frequency range, either a little upward or a little downward, or a simultaneous shifting to both upper and lower positions. This is what we can comment on the difference between nasality and orality as viewed from frequency structure of pattern. Our view of this difference is not far distant from, for example, that of M. Joos. His idea* was: Between the first and the second vowel formant there appears in the nasal vowels an additional formant with concomitant weakening in the intensity of the former two. As a second quotation, according to P. Delattre,† who observed particularly the difference between oral "a" and nasal "a": "The first factor of the nasalized vocalic is the extreme weakness of the first oral formant; the second factor is the appearing of the so-called first nasal formant in the region of about 240 c.p.s.; the third factor is the second nasal formant of about 2,000 c.p.s." Further, as a remarkable feature, he added: "The second oral formant does not change its position in nasal vocalic, but the third formant in oral shifts upward a little in nasal, and the fourth formant in oral, on the contrary, shifts a little downward in nasal."

It is not sufficient, however, to describe the change in pattern only from the standpoint of frequency structure. It is necessary to consider and refer to harmonic structure of timbre pattern as well, and then the difference between orality and nasality becomes decidedly more clear, because the tendency toward even-predominancy in harmonic structure of orals is in fine contrast to the tendency toward odd-predominant harmonic structure in nasalization.

To elucidate the performance of nasal cavity, the study of muffled voice due to nasal cold is full of suggestions. It was interesting and informative to come to the point that in contrast to the conspicuous difference between nasality and orality in healthy normal voice condition, there is relatively slight difference between them in unhealthy nasal-cold voice condition. It is also worthy of note that there

---

* Taken from "Preliminaries to Speech Analysis" by R. Jakobson *et al.*, Technical Report No. 13, MIT, May, 1952.

† Translated from "Les attributs acoustiques de la nasalité vocalique et consonantique" par P. Dellatre. Tirage à part des STUDIA LINGUISTICA.

is a great difference between muffled nasals and normal nasals and that there is a relatively small difference between muffled orals and normal orals. These differences between muffled and normal vocalics in timbre pattern are, however, sufficient to show us that even the partially blocked nasal-cavity condition can alter the voice quality in vocalics, which is a significant point.

Conclusion

When we consider the basic difference between orality and nasality not only from frequency-structure but from harmonic-structure viewpoint (by studying *ordinary orals* and *ordinary nasals* defined above), we come to an observation a little different from those of authors quoted in our "Discussion." The comments of these authors on nasalization may be true insofar as their concern was with a description of actual nasals only. It seems to us, however, that they are somewhat too faithful to what appeared to them to be phonological phenomena, and consequently they seem to refrain from stepping into a more comprehensive and far-reaching interpretation. We, too, are not in a position to present our final conclusion on this problem because we still have not finished the second half of the study on artificial vocalics, *viz.* on vocalics produced by changing buccal-cavity condition. It might be safe, therefore, to suggest here our temporal interpretation, which, nontheless, is firmly supported by our already finished experiments.

A statement of the most natural outcome of our investigations can be made in the following simple form: Longer constituents in orals appear shorter in nasals and shorter ones in orals become longer in nasals. In more detail, the stronger parts of the oral pattern become weaker in the nasal pattern and the weaker ones of the oral pattern become stronger in the nasal pattern. This may seemingly be vague but it is doubtless more comprehensive insofar as it refers only to the basic difference in the core part of lower patterns. When we return to the use of our original terminology, we can express this point more definitively. As to phase relation between timbre-pattern silhouettes of orals and nasals, we can make use of so-called *interlacement* and *meshing*. Now, the phase relation found in interlacement between patterns can be changed to the phase relation found in meshing (*i.e.* to the reversed relation in phase) by introducing the most simple process of turning the pattern of any one of the two compared upside-down and placing it in a position parallel to the pattern of the other.

This description naturally leads us to the next suggestion. Is it not indeed possible to introduce some practical way to derive one pattern from the other? Let us, for example, draw a pattern-diagram of any one oral on a piece of paper, and then cut out the given oral pattern along its silhouette. Now by picking up the pattern which is outlined on the cut edge of the remaining paper and by turning it upside-down, we get what is approximately the wanted pattern of the nasal just corresponding to the given oral. Of course there may be some way to correct the pattern details, for example, in the region of vocal glen and some other places. At any rate, by this simple method, at least the most essential part in lower pattern can be derived to an approximate degree.

In our "Memoirs on Nasalics" we stated that orals focus their image on the "sunny side" and nasals meanwhile focus their image on the "shadowy side." This figurative description was based upon the impression of French nasality and now, with some scientific validity, it might be referred to again.