MEMOIRS ON NASALICS

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(Received May 31, 1957)

Introduction

In the first paper, "Timbre Study of Vocalic Voices," we introduced a method for physical representation of timbre-patterns of sustained vocalic sounds, segregating VOCAL PATTERN from PHONEMIC PATTERN for the purpose of giving basis to the interpretation of the two quality aspects, NATURALNESS and ARTICULATION of vocalic sounds. In the second paper, "Timbre Study of Vocalic Voices Viewed from Subjective Phonal Aspect," we described in more detail ARTICULATION CHARACTERISTICS with reference to the well-defined patterns of timbre-signals (fully studied in the first paper) when these signals are impressed upon well-drilled listening subjects after being transmitted through the distortion of the type of band-elimination. In the third paper under the same title, we stepped further into the realm of the timbre-confusion problem, dealing with subtle points of timbre-discrimination, *viz.*, distinction between VOCAL CONFUSION and PHONEMIC CONFUSION. Of these timbre studies, the first is objective and the other two subjective, but all relate to PITCHED TIMBRE of ORAL VOWELS. In our first consideration of the problem of timbre-quality, we had to restrict our approach to oral vowels, excluding timbres of consonantal sounds entirely. This procedure of restriction is not only useful but may even be indispensable because in the face of such a complicated problem, we must first of all clarify the point at issue to solve it, that is to say, we must discard all non-essentials by focussing our attention on the crux of the problem.

Origin and Significance of Our Nasal Study

During the course of these studies mentioned above, we were duly conscious of some delicate and important effect of nasality upon even the so-called oral timbres of voices uttered in a manner which strictly conformed to phonetic instruction for oral vowels. As will be illustrated later by citing an actual example, the constituents of oral timbres seem not irrelevant to the state of nasal cavity. Is oral-sound timbre undoubtedly and unconditionally determined only by the state and condition of buccal passage? It might seem so if we rely on the implication presented in the so-called vocal tract theory.[1] But as basis for some suspicion we need only recall the case of the common headcold; at that time the oral sounds are considerably changed by the stoppage of the nose. Then, not only the nasal sounds but the oral sounds as well come out quite differently according to the degree that the nose is stopped up. There are some whose nasal passage is completely or partially blocked by a chronic adenoidal growth and doubtless their nasal condition affects the oral vocalic timbre to some extent. Instead of describing the exact nature of this condition, we go direct to the origin of our researches,

begun in 1953, through which we were inevitably to be led into our five-year uninterrupted study of nasals still in progress.

We had already carried out timbre-pattern studies covering a considerable number of voices.* After finishing the work of many years, we became impressed by the vital fact that there are many voices the vocal patterns of which as a whole are almost always characterized by superiority of even-number harmonics, whereas there are others the vocal patterns of which are marked by a preponderance of odd-number harmonics. Although we could not find the reason for it at that time, it was most intriguing. That such a difference in vocal timbres affects the timbre construction of phonemic (phonal) pattern, we thought, may be of some significance. We found evidence of the influence of such difference when we recalled that for some types of vocal quality, the main formant peak, for example, that of vowel "A", is a double-peak with the one exception of the pitch which corresponds to that of output-reluctance where the main formant becomes a single-peak, recalling further that for other types of vocal quality, the situation is reversed, *i.e.*, the main formant is usually formed by a single-peak with the one exception of the pitch which corresponds to that of output-willingness where the main formant changes into a double-peak. We term such a double-peak formant a NOTCHED FORMANT. In our vowels, the so-called notched formant phenomena are most often to be found in the main formants of Japanese vowels "A" and "O". The problem of construction of vocal timbre imposed on us through the notched formant phenomena seems actually to lie in the close relationship of construction and the very subject of nasality.

It is therefore most important for us to study the nature and the cause of nasality before discussing further the individual vocal quality, because in the main problem of individual vocal qualities (oral vocalic qualities) there must be deeply hidden a point of fine distinction, *viz.*, the subject of nasality, the revelation of which will not fail to serve as a practical and partial solution of the main problem. The nasal-sound problem, however, is not a novel one. Many authors have treated this problem in various fields of science and engineering from various standpoints. It is therefore necessary first to glance at the studies already executed. As it is too time-taking to describe in detail all previously published studies, we must be content to show the fields and circles of science brought into contact through this problem.

Study of Various Aspects of Nasal Sounds

Historically and categorically speaking, this nasal problem seems to be found in many fields of inquiry. First we see the wide range of studies concerned with the physico-phonetical aspect, next, we come to the medico-physiological aspect which includes pathological and therapeutical studies on articulatory organs of speech. Here we must bring in a recently developed field coming from transmission engineering in speech communication which we shall discuss in detail later. Finally and of equal importance is the fact that the science and technique of vocal music must necessarily stand in close relationship to the science and practice of phonetics.

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* Except in a few cases, these reports have not yet been completed.

Nasality Viewed from Speech Quality in Speech Communication

In the phonetical meaning, nasal sounds in speech relate to those which have their positions in a somewhat intermediate area between vowels and consonants, as indicated by the fact that they are often termed semi-vowels. With regard to their sonority and pitch nature such a term is logical. Viewed from the standpoint of speech communication, nasal sounds also can with due reason be considered as belonging to a group of semi-vowels because experimental data easily prove that nasal-sound articulation is normally situated midway between vowel-articulation and consonant-articulation. Nasal-sound articulation is usually higher than consonant-articulation and lower than vowel-articulation. As we have already finished a comprehensive study on vowel sounds, it is suitable now for us to keep our eyes on the nasal sounds as preliminary to the study on consonant sounds of purely transient nature.

On French Nasality

While there are no languages which do not contain nasal sounds in their phone-system, there are only a few having nasal sounds in their vowel group. One of these is French. The French nasalized-vowel quality seems to us to be unrivaled for attractiveness. The characteristic nuance of French speech is owing in part to its rich nasal quality. One is attracted by its charm, especially when misty nasals are uttered by a glossy voice, for example, in an alto tone of moderate pitch. In French conversation, and particularly in the prosodical reading of French verse, nasalized vowels appear in sweet relief in the sequential stream of speech waves. This mode of beauty seems to suggest that nasally-modulated vowels are brought into exquisite contrast with oral vowels, thereby giving forth some spell by the pleasing rhythmical alternation of timbres between orals and nasals, thus presenting alternating bright gay lustrous and shadowy gloomy nebulous timbres. This suggestion leads us to the very problem of distinction between orality and nasality in their essential meaning. Figuratively speaking, the timbre pattern of orality focusses images on the sunny side and that of nasality conversely focusses images on the shadowy side.

Timbre Study of Nasal Sounds in Quality Aspect

What, in fact, led us to our inquiry into such a problem of nasal sounds was essentially our broad basic interest in the sharp contrast between so-called nasality and orality. The foundation of our study is, of course, timbre-quality aspect. As we have already specialized in the oral vowels in timbre aspect, so we must follow the same line in the study of nasal sounds. It goes without saying that we do not intend here to obtain the usual spectre-analyses of certain actual nasal vowels uttered at some particular pitch and on some particular level; that is to say, we will not depict some pattern characteristics which are due to some particularity, but we do intend to extract universal and disinterested features of nasality. Not until we reduced the nasal problem to its essentials, and stripped it of all irrelevancies imposed on it by a particular condition of utterance, could we come to any plausible conclusion for the problem. It is for this reason that we keep to our basis of timbre aspect and continue with the various processes which stem from

our original principle.

For example, by the timbre-pattern of speech sounds we mean the timbre-pattern which is responsible for characterization of the speech sounds in question. In order to obtain timbre-pattern in its strictest meaning, we must represent an integrated timbre-pattern by summarizing all possible timbre-patterns given at all possible voicing pitches because even under the condition of constant voicing stress there may be some considerable changes in timbre construction when voicing pitches are changed. To obtain the timbre-patterns of oral sounds, in practice we used five or six pitches by repeating five or more analyses for every pitch because there are deviations in timbre constructions attributable to certain inevitable instabilities in utterance. This integrated pattern-representation is especially needed in the nasal timbre study, because there is an evident tendency to both output-willing (resonant-like) and output-reluctant (antiresonant-like) voicing pitches seemingly due to nasal passage, whereas there is no conspicuous pitch tendency in oral utterance. We must therefore be more prudent in selecting voicing pitches for nasal sounds than for oral sounds. For the very same reason, we must be exceedingly careful for level matchings of nasals, because there may be obvious deviations in output level accordingly to the degrees of output-willingness and output-reluctancy of their pitches employed.

As we have already remarked in the previous paper[2] in which we discussed timbre representation of oral vowel sounds, for determination of timbre-pattern, it is absolutely necessary that we prove not only the existence (presence) of the so-called formants in some certain places of frequency region, but their non-existence (absence) in other certain places, because usually a far more complicated combination of emphasis and de-emphasis governs the details of the shape of the so-called formant structure than that anticipated from an ordinary four-terminal reactance network theory of single tract. For the purpose of further clarifying the condition which causes the most entangled combination of steep reinforcement and abrupt repression in timbre-pattern of the oral sounds in question, we must refer to the special absorption sources due to anti-resonant performance of subsidiary shunt-passage of nasal cavities in addition to the main resonance effects of the buccal passage which is priorily responsible for the utterance of the sounds in question.

As for the interpretation of timbre-pattern of nasal sounds, this situation must be reversed. In this case the performance of the main nasal passage must be modified by subsidiary effects of buccal passage. The relation of reinforcement and repression must be reversed. Keeping this picture in mind, we are necessarily thrust into the study of nasal problem.

Problem of Generalized Nasality

Although the nasal problem will be treated here by first restricting our presentation to the element of the speech-sounds and speech-voices, we must accept the fact that essentially this problem is closely connected with that of general acoustics. Among natural and artificial sounds, there are so many tones that give the impression of so-called nasality. As a well-known example, we can mention the Spanish guitar which usually partakes of soft rich mellow tones with some nasal-like effect except in the very high tones. As another example, we can recall the sounds of some violins[3] or those of the violincello made by famous Amatius

which partakes of some nasal shades in its tone quality.[4] We can further mention that in spite of the shrill chirrup of the common cicada, there are some cicadas in Japan whose chirrup is filled with noisy twang.

In the problem of timbre classification in which we are interested for future presentation, we shall doubtless place considerable weight on a group of nasalic timbres, and in this classification we must then take care of the opponent timbres of nasalic timbres. The subject of timbre classification, *i.e.*, genealogy or lineage of timbres, is very important and useful for timbre study. But what the science of timbre quality needs is scientific genealogy of timbre and that imposes on us a very difficult yet a very interesting task. As it may be, we must in any case differentiate between *nasality* and *impurity*. These two categories of timbre, nasality and impurity, have some similarity in that they both stand on opposite sides of another category of timbre, that is, of *serenity*. There may be some categories of timbre other than these three. What we want to stress here is that for solution of the nasal problem our concerns are not only with a practical description of actual nasal phonemes in certain languages but also with a logical and disinterested interpretation of basic quality of nasality. These naturally include nasal phonemes and nasal voices and, further, nasal-like sounds in general acoustics which serve to contribute to the orientation of scientific lineage of timbre.

Understanding of Nasal Pronunciation by Means of Circuitry Treatment

By returning to our problem on the phenomena of actual nasal speech-phones, we must primarily step into an investigation of the utterance-mechanism and pronouncing processes of human speech organs. In such a stage of consideration, we come easily to see that the transmissional circuit in any biological system which participates in nasal utterances can be considered as a circuit of bifurcated nature. We mean by this that the laryngeal part of the speech organ is divided into buccal passage and nasal passage. Then we come to this question. In our usual speech-phone utterances, which of these two parts does indeed play the leading role? The decision depends upon the circumstances under which the speech-phones are uttered and, in some cases, it may possibly depend on the speech peculiarities of individuals.

For an understanding of circuit performance of phonal utterances there are two points to be noted: The switching action of velum between buccal and nasal circuits, and the distribution of breath stream between these two circuits. A most essential step in such a circuit understanding is to solve our speech-phone phenomena in general, covering both oral and nasal, by means of schema showing transmissional characteristics of forked circuit. In the interpretation of timbre-pattern of nasal phones, is it really necessary to consider the effect of a buccal by-path circuit in addition to the transmission performance of a nasal main path circuit? If it is necessary to do so, then it is also necessary to treat oral utterances in the same manner. In other words, in addition to considering the main transmission performance of the buccal circuit which is primarily responsible for oral utterance, it is necessary to consider the by-path effect of the nasal circuit. In accordance with the Vocal Tract Theory we are persuaded to accept unilateral participation of the buccal-cavity circuit in the mechanism of oral utterance only for

the reason that thereby the nasal cavity is completely shut out from buccal passage by a backward movement of velum. It was proved by Röntgenogram that the contact of velum with the posterior wall of the pharynx is made. Is it possible to conclude easily that thereby the nasal passage is absolutely cut off from the buccal passage merely by reason of Röntgen-proof of velum contact which shows no more than one directional view? Without regard to abnormal cases such as "Rhinolalia Aperta,"[5][6] we raise the question whether the by-path nasal circuit has any influence upon the formation of oral phone in the ordinary pronunciation of normal calling subjects. For exhaustive researches on the effect of by-path nasal circuit, we would need either some special pronunciations not found in ordinary phonetical techniques or some laryngo-otological processes. This consideration leads us to adopt symbolical descriptions of nasalic sounds too diverse and too singular to be covered by ordinary phonetic language signs.

Other Subjects in Timbre-Pattern Study

It is natural to deduce from the combined consideration of the several viewpoints described above that there is one novel and important aspect of timbre-pattern of vocalic sounds, including both nasals and orals, in which we are interested exclusively, and that with the help of this aspect we are aiming to find the structural *recurrency* or *periodicity* of fine structure in timbre patterns. In other words, the aim of our present timbre study is to find the exact principle which, as a radical basis of timbre formation, governs the relations between *vocal glens* or between *vocal peaks* as found in timbre patterns of fine structure. We have already described in our study of oral timbres that there are several sub-glens and sub-peaks in addition to the main glen and main peak. Whether or not such glens or peaks, as the case may be, are produced by several independent absorbing or reinforcing sources is of the greatest importance for an understanding of timbre-patterns.* Confronted with the wisdom of considering structural recurrency or periodicity in timbre pattern, we must be fully conscious of a situation wherein we must face the fine structure of timbre-pattern which can have a serious meaning in the perception of timbre-signal. We would feel disqualified for our researches, if our processes for obtaining timbre-patterns are not sufficiently authenticated because thereby we must deal not only with fine structure in lower pattern but with fine structure in upper pattern where the amplitude is usually too small and weak to be easily detected.

As we have already pointed out, neither the true meaning nor a reasonable definition of the so-called *formant* can be found in any other study than in a subjective quality study. What has been established in experiments on oral vocalics holds good for nasalics also. For this reason we cannot overlook subjective experiments on nasalics. When we reflect upon the nature of nasalics we can easily see that more weight should be placed on a subjective study of nasalics than on orals because, it is indeed here in the nasal study that we must answer the questions: Are the so-called formants which characterize the speech-phones always formed and determined by vocal peaks as *positive formant?* Or are there cases in which the formants can be formed by vocal glens as *negative formant*? From

* This aspect increases in importance when the mechanism of formation of so-called *invariant formants* is considered.

our daily experience we know that nasal quality depends on the nasal pitch. Finally, we add our last motive for our subjective quality experiment: The recurrency or periodicity in structure must be examined from the subjective viewpoint.

Summarization of Points at Issue

As stated in the foregoing section, the aim of our nasal study is not merely to find some certain timbre-pattern of particular nasal speech-sounds, but to get an answer to the question: What, in their essential and abstract meanings, are oral quality and nasal quality? In other words, what is the basic difference between nasality and orality in timbre aspect? It is indeed from the *vocal quality* viewpoint that we raise this question. Undoubtedly there is also the viewpoint of *phonemic quality* in the question as to whether or not there can be found the so-called formant in nasal speech-sounds due to resonances of nasal passage. After summing up all these considerations in the single point at issue, we cannot help thinking that we are finally reduced to a critical line of research in which we are forced to face the most difficult question of all: Is this problem of nasality one from *phonemic* or from *vocal* aspect? In other words, we are compelled to decide whether the so-called nasality is the problem of phoneme or the problem of shading or coloring.[7]

We think it is appropriate now to ask some practical questions from the phonetic side. One example: What are the necessary and sufficient conditions which justify the distinction between (phonemic) formant and the so-called coloring? What examination and proof is necessary to lead to the solid conclusion that some preponderant partials, or bars, can undoubtedly be attributed either to phonemic element or to shading element? Speaking concretely, we have some questions on actual conditions. Do nasalized vowels have any characteristic formant or do they appear as a mere coloring of corresponding oral vowels? Another example: Nasal speech sounds such as [m], [n]. [ng] are capable of having their own formants. It may be true; but how can they have sufficient individualistics to show any personal nuance? It is toward these blind spots and weak points that we are forced to face through our present problem.

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