ON TIMBRE QUALITY

PART I. INTRODUCTORY CONSIDERATION

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Introduction

How should we study *timbre*? What is a method and a direction of the study of timbre? This is the main subject of our present study. The reason why such a problem is called in question, is: first the studies of sound executed hitherto are chiefly on level and volume; and even studies on pitch are not many; as to timbre, we can find only a few studies; secondly, a fundamental conception of timbre has not been fully established; for instance, an exact notion of timbre discrimination or timbre matching has not been set up; even a clue to it has not been found; thirdly, with all the stages of present study, we are, nevertheless, in an urgent need of knowledge on timbre in the practical treatment of transmission quality. Because, a pivot of transmission-quality problem consists in timbre study. For the articulation and naturalness in speech communication cannot be well studied without refering to timbre.

Timbre being in fact a sort of conception of sound on its totality, and at the same time a conception of quality of the highest class, it will be quite difficult to quantify timbre itself. It will be inadmissible to neglect timbre study in the cause of its extreme difficulties. Let us take a fresh start by beginning with reaffirmation of the difficulty of timbre.

Quality Transmission

In a previous paper entitled "Transmission of Quality" we have studied about various fundamental characteristics of "quality," according to a viewpoint on which we stand. For example: in proceeding with a quality study of pitch and loudness, we have clarified two conceptions of "comparison" and "matching" in connection with either attribute, differentiating one from the other. Problem of quality matching is to be considered firstly as a matching between transmission systems, and secondly as a matching between speech phones. As to timbre quality, we have considered only the conception of timbre comparison. The conception of timbre matching is not fully accessible. Because, we have not yet a concrete process for it; more precisely, we have not yet appropriate means as a referenec for timbre matching. Thus, our discussion is confined to the quality in general. As a timbre study that alone will not be enough. We shall, therefore, try to consider more closely about timbre quality.

Problem of Quality Aspect

It is important at the biginning to make clear the question of aspect we set

out in dealing with sound. In proportion as we take sound for sound, not being content with taking sound to be a mere oscillation or undulation of some media, we take to treat this problem by attaching importance to the fact that sound essentially appeals to our sensation. It is just therefrom that the so-called "quality" comes into existence. There can be two aspects on quality: physical or objective aspect, and psychological or subjective aspect. We must proceed making a fine distinction between these two aspects. As to the former aspect, it cannot carry us very far, notwithstanding a clear methodology led from that aspect in a decided manner. We shall explain more closely: as far as we conform to this physical aspect, we shall come to fall into an impasse with the ultimately acquired idea of "faithful transmission": this idea is but a dry and insipid conception of "physical fidelity" which has played a considerable rôle in giving a temporary canon to classical transmission engineering. But we are not so much interested in it. It looks, to us, too primitive as a quality aspect. It will no more give a very bright prospect in the near future. We now quite rely on subjective aspect, to which our consideration is to be paid preferably.

Lastly we have only one remark to repeat. Quality is but something which is always coming out of subjective affairs in communication, which one cannot precisely define with ease, and which, nevertheless, is of the very essence of communication itself. Quality, therefore, instead of being an accessary, must be the fundamental *sine qua non* in communication. Quality is indeed what counts first and last in communication.

Quality Response

Quality study in subjective phonal aspect is but a study of interpretation of quality considered from the viewpoint which admits the superiority of subjective part of communicatory circumstances. In quality theory of communication, subjective factors must outweigh objective parts of it. But when we say the subjective superiority, we do not mean that physical aspect is utterly to be neglected. We are not in favour to consider such a problem as quality merely from physical aspect. By quoting an actual example, we shall explain it. We have to assess any processes of transmission which we call "quality response" of transmission systems. To study quality response is, in our opinion, to set up a mutual relation between subjective phenomena by transmission and physical phenomena in transmission: speaking more concretely, what is needed is a relation of correspondence between physical data on transmitting condition of transmission system and subjective data on subjective effect produced by transmission system. What is meant by subjective data? We mean scores on subjective phenomena not only as to timbre, but also as to pitch and further as to loudness which must be counted in as phonal attributes. An example of quality response is articulation characteristic which is well known. As quality responses there can be and must be, other various characteristics such as naturalness, pitch, loudness, etc. But let us return to the problem of timbre which is our present subject.

Correlative Conception of "System and Signal" in Communication

We would often treat the signal in communication as being well known or

as being quite given. But what is meant essentially by this statement? We think this depends on the nature of the problem with which one fronts; we shall be able to solve the transmission problem in such a direction as obtaining an unknown form of output signal under the assumption that the input signal is quite given and further under the condition that the transmission function of intervening system is also well known. It is the customary way of the treatment of problem. Consequently the signal may be either electrical or acoustical according as the system concerned is held either as electrical or electroacoustical. In these cases, the signal is anyhow to be proposed as physically given, provided that the system concerned is restrictedly only to physical one. After all, this is only a narrowly restricted form of physical treatment of communication problem. Whereas, physical solution is but a partial solution, as far as communication is concerned. We care for better, more comprehensive solution, that is more reasonable in communication. After seeking and limitting sources of origination from which the subjective phenomenon of communication comes out, we shall try to decide more closely the notion of subjectiveness in communication. As main parts of subjective constituent which forms the communication phenomena together with its objective side, there are two: one is the expression side as *communicant*, the other the impression side as *recipient* in communication; an expression side stands in such a correspondence to an impression side that an expressed intention of a communicant who wishes to be well understood comes and arrives to be impressed upon and absorbed by a recipient who wishes to comprehend; this relation reminds us a sort of closed circuit as to mental intelligence, that is, the information intended to be understood arrives at the understanding: In ordinary manifestation by a form of words, we call it an establishment of the phenomena of communication, or a conclusion of communication phenomena. We have introduced the conception of *speech quality*, as a previous paper has shown. It is very reasonable. Because speech can be speech for no other reason than that speech passes for speech. The conception of speech quality is the very image of speech signal considered as signal to the subjective systems which are not less important than physical systems, and which have been quite neglected hitherto in communication.

Thus we have to enlarge the conception of *system* in communication. We can, and must talk about not only the physical system but also the subjective system which means conclusively both the expression and impression sides of communication. There comes a self-evident axiom: if we extend the meaning of transmission system in communication up to the subjective one (*i.e.* expressive or impressive system), then the speech signal in speech communication must necessarily be considered as being expressed or impressed, instead of being given. This is certainly a flexible, mellifluent idea, really suitable to the most reasonable comprehension and the most proper appreciation of communication phenomena, only through which we can possibly approach a more comprehensive, general solution than ever. As a result, we can say, speech study will be done most reasonably when it is brought into relations with the inmost processes both of expression and impression. This means a new research rooted in a new aspect. "Analysis-for-analysis" principle applied to speech study seems rather an out-of-date study founded on a trite, somewhat petrified viewpoint. For, it deals only with such a speech as is fixedly given. Timbre study of speech vowels, for instance, must be run through by an idea that accords with the conception of speech quality mentioned above.

Classification of Timbre (I)

To treat timbre problem more practically and more concretely, we are in need of some classification of timbre. Because the problem of timbre is of so complicated nature that there are so many ways of study out of which a choice is not always facile. Good classification gives chance to supply us with a good vista in the dark wood filled with difficult problems. We do not care in fact whether it is deduced by intuition or reasoning.

If we refer to the history of telecommunication and technical experiences in it, we shall be able to foresee, without much fault, what quality should be counted heaviest in an assessment. We take first the timbre quality; secondly we take the pitch quality; thirdly and lastly we take the loudness quality. We submit only to the order of high quality. From this standpoint, we proceed to classify timbre. It is very useful and even important to classify timbre by taking into consideration the nature of pitch on which the said sound is based. This means: we classify timbre according as it has pitch or not: pitched timbre and pitchless or unpitched timbre. By pitched timbre we mean the timbre with a definite pitch: by unpitched timbre is meant the timbre without any pitch. Considering more closely, we can probably give these cases: mono-pitched timbre, poly-pitched timbre, unpitched timbre. The ordinary voiced vowel is an example of mono-pitched timbre, and the unvoiced vowel is an example of unpitched timbre. As an example of poly-pitched timbre, we can give the voiced vowel distorted conveniently by carrier synchronous distortion (CSD).

Consideration on Time Element

As to the phonal phenomena, a consideration on time element is quite indispensable. It is because that the time element is almost as important as other three phonal attributes. The meaning and the value of time in phonal phenomena is reasonably appreciated only in the subjective phonal aspect. It means: in our quality theory, the subjective time must play an important part together with the three phonal qualities. As far as only the physical time is concerned, the phonal phenomena are quite the same with any other physical phenomena. Time study of phonal phenomena takes no special significance until we try to look them from the viewpoint of quality aspect. We shall come back again to this point in the next report.

Classification of Timbre (II)

By introducing the time factor in timbre problem, let us proceed further to branch off timbre in another way. We can consider first the *stationary timbre* which does not change its construction notwithstanding the time, and of which an example is given by sustained vowel. In the next place we can consider the *transient timbre* which changes its construction in the course of time, of which an example is illustrated by transient part of diphthong. Into a group of *fluttering timbre* come the sounds such as *vibrato* and *tremolo* that change their constructions nearly periodically. The ordinary lively voice of human conversation that flutters in pitch and level (corresponding perhaps to frequency- and intensity-modulated sounds) notwithstanding the intention of sustaining is called also a sort of fluttering timbre.

Actual Problem of Timbre in Communication

Before entering upon into a logical consideration for the sake of exact definition of timbre, it will be suitable to be aware of what kind of problem, and, what sort of place really comes into our question. To know as clearly as possible about boundary circumstances where the said problems really happen is very useful. For the direction and consequently the method of the treatment of timbre problem is often well determined from precise informations on boundary that encircles the problem. And, what is more important essentially, is; the very development of consideration on some idea in the most abstract way cannot be fully carried out without an exact and minute knowledge of the practical nature of the actual problem. We shall describe some examples of timbre problem with which we meet in speech communication engineering.

Naturalness or natural property of human voices

The most important problem of timbre transmission in speech communication is on naturalness. This is a problem of the most fundamental character concerning the technical aim of transmission-engineering. For, the purpose of ideal transmission (which is well known by name of "high fidelity") in the past consisted in attaining the faithful transmission of the impressed sound-signal. As one index of timbre transmission the so-called articulation was proposed and so many articulation responses were obtained. Here may exist another index of timbre quality by which we are able to forecast the idea of naturalness proposed for the first time. Naturalness can be defined as a sort of timbre which has direct concern with natural property of voices in speech communication.

Timbre distortion

For timbre study an observation of timbre distortion is quite indispensable. For the study of timbre distortion we need distortion systems that affect the timbre factor. As there is some sort of distortion that affects mainly the volume quality, so there will be some appropriate distortion systems that have influences exclusively upon the timbre quality. To find such distortion systems is very profitable to the study of timbre. For that purpose we have made use of CARRIER SYNCHRONOUS DISTORTION (CSD) and also ROTATIONAL SYNCHRONOUS DISTORTION (RSD). We already reported about the quality study of CSD. As to the quality study of RSD, we finished a detailed study, and we shall have chance to publish it. We are interested in these distortions because of their special influences upon timbre. The distortion CSD causes the change of internal structure of harmonic components of vowelic timbre, giving the transitional displacement of "constant difference" to each component and resulting in the degradation of pitch at the same time. The RSD gives the transitional displacement of "constant interval" to each component, resulting in the change of pitch-height but without accompanying any degradation of pitch. The distortion of band-elimination is held as one that can have influences upon timbre as well as loudness. The quality study of the distortion of this kind is also important. For the determination of transmission band-width of speech communication system is seriously important from the practical viewpoint. Non-linear distortion is also useful for the discussion of timbre which we are to study in no distant future.

Mishearing phenomena

The study of timbre distortion of speech sounds may found on the observation of the so-called mishearing or confusion. This phenomenon is worthy of notice, especially in the case of timbre distortion caused by a special distortion system. We have studied on this thesis about the two distortions CSD and RSD, part of the studies was already reported.

Allowance problem

Allowance problem is nothing but the study of the tolerance of distortion. It is practically required to determine to what extent the distortion is to be allowable for communication. We are attracted to this problem for no other reason than that it has some concerns with the problem of timbre discrimination. But the problem here is proposed in a form of determining the limit of the distortion produced by the transmission system, not the limit of the change of timbre construction. Nevertheless this is important and useful for timbre study. We have tried allowance study about CSD and RSD, and other distortions, of which a part also has been reported.

Summary

Starting with a conceptional study of the so-called "transmission quality," we have at last arrived at the notion of "quality transmission." This notion is based on the fundamental standpoint of subjective phonal interpretation. This aspect binds up all three phonal qualities (loudness, pitch, timbre) together with time quality. Merely from such a viewpoint, the quality interpretation can be completed, being related closely to the essence of communication itself. A loyal abiding by this principle will help more surely than any other process of ratiocination in interpreting four qualities: not isolated and unconnected parts of quality but all of quality, brought together and correlated in a synthetic map of communication. These logical considerations will be set down in a next paper. Timbre study becomes a touchstone of our quality study. Whereas, the timbre quality is of the most complicated nature. Consequently we cannot immediately come to the point, as far as timbre is concerned. We have just commenced a preliminary of it. By way of thinking of the phonal coordinates we are going to proceed to the essential problem of vocalic timbre, setting up the phonal quality as well as the vocal quality.

Our aim of this study is to provide not with a map, but with a compass for timbre study.