# On the Need to Clarify Methods for Assessing the Quality of Sound Paths Through the Use of Psychoacoustic Criteria

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Abstract: Currently, the evaluation of the sound quality of a product or a sound path is usually based on objective physical measurements. Despite this, in real a quality of the sound path is evaluated by human hearing. The listener evaluates the sound quality of the product or sound path using his auditory system, and not a set of physical measuring devices. In this situation, psychoacoustics is a scientific field that allows bridging the gap between physical or objective and subjective assessments. In a number of previous psychoacoustic experiments, some relations were established between the physical representation of the result and the audible perceptual sensation correlated with it. Assessing the quality of audio signals is an important consideration in making high quality sound product and sound paths and various methods have been developed. In this article is review interconnection of electrical indicators of sound quality and subjective psychoacoustic criteria assessment. It is proposed to apply the psychoacoustic assessment criteria because not all qualitative indicators can be measured using objective methods.

## 1 INTRODUCTION

In the modern world, music, speech and other sounds surround us from all sides. Sound paths are found in television and radio broadcast studio hardware complexes, recording and mastering studios, when listening to phonograms through household devices, etc. In other words, any sound that we hear today has indirectly passed through a certain sound path - a set of devices for capturing, amplifying, processing, transmitting and reproducing sound information. It is difficult to find a person who does not appreciate and love pure and high-quality sound reproduction. But today there is no clear understanding of what the quality of sound reproduction depends on [1]-[3].

Many factors are responsible for a pleasant sound signal, but the key and important one today is an objective assessment of the quality of sound paths using standard measurement techniques. However, more and more often, questions arise about the adequacy and comprehensiveness of objective methods for assessing quality, since among professional musicians, sound engineers, music lovers and ordinary listeners, more and more attention is being given to subjective assessment, and the majority are practically not interested in data on technical characteristics.

Subjective assessment includes blind or non-blind listening to the sound path with an assessment of a number of psychoacoustic criteria for the quality of sound reproduction and provides more information about the qualitative properties of the sound path than measuring only electrical characteristics. The principles and criteria of psychoacoustic subjective assessment have been independently formed over the past 40-50 years among quality sound lovers, musicians, sound engineers, audiophiles, etc.

# 2 SYSTEMATIZATION OF OBJECTIVE AND SUBJECTIVE CRITERIA FOR ASSESSING SOUND QUALITY WITH THE ESTABLISHMENT OF RELATIONSHIPS

## 2.1 Quality Assessment Standards System

Any existing objective method for assessing the quality characteristics of analog audio devices [4]-[6] and digital paths [7]-[10] professional and household is implemented using a set of one or more measuring instruments designed to measure electrical quantities.

Summarizing the methods, we can highlight general approaches to objective assessment. Measurements of electrical quantities always affect such characteristics as the operating frequency range, unevenness of the amplitude-frequency response (AFC), non-linear distortion factor (or harmonic distortion factor), intermodulation distortion factor, the nature of the transient process under pulsed action, the signal-to-noise ratio at the output and the maximum level signal or dynamic range, channel separation (in a multi-channel system). However, none of these electrical characteristics are relevant to assessing the listener's perception of the result.

Today there is an absurd situation. Developers, manufacturers and marketers in the audio industry continue to surprise with numbers that speak of the extremely high quality of their devices, and buyers are increasingly leaning towards devices with low quality indicators, “vintage” devices, tube designs and devices without specifying their quality characteristics.

Also, a number of listeners refuse digital media, Internet streaming resources and listen to recordings from magnetic tape, on vinyl discs, although there are some adherents of the seemingly outdated CD format. In [11] it is indicated that sometimes sound engineers often deliberately reduce the quality of the sound signal during processing in order to give a pleasant sound to the created phonogram, radio program, etc.

At the same time, Appendix A of GOST IEC 61606-3-2014 [9] contains an indication of the possibility of using an alternative method for assessing electrical characteristics in order to obtain more information, but does not provide for the possibility of conducting a subjective assessment of sound quality.

## 2.2 Objective and Subjective Assessment Methods

Among sound engineers, music lovers, musicians and audiophiles, sound quality assessment criteria such as audibility, fullness, loudness, warmth or neutrality, timbre, tonal balance, high register, dark background, stage, micro-detail, macro-detail, fatigue or fascination are often used. There are other subjective criteria, but they are either rare or include those mentioned above.

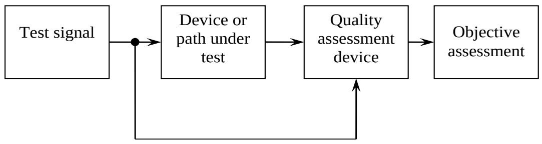


Figure 1: Scheme for objective assessment of the quality of the audio path.

Figure 1 shows a diagram of establishing the relationship between the electrical characteristics of the device and the psychoacoustic evaluation criteria. The complexity of using the scheme lies in the unclear understanding of exactly what electrical characteristics of the device under test need to be measured electrically to combine the result with the psychoacoustic assessment criteria, as well as the formation of an expert group. For this reason, it is possible to introduce new qualitative characteristics for assessing the electrical characteristics of analog audio devices and digital paths that go beyond those specified in [4]-[10]. As experts, it is necessary to involve both professionals who have experience in hearing examination or have the skill of professional assessment in the course of practical work, as well as groups of non-professionals of different age groups, since the properties of human hearing change with age. However, the requirement to divide into age groups is not mandatory. The testing scheme for subjective assessment is shown in Figure 2.

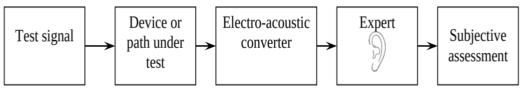


Figure 2: Scheme for subjective assessment of the quality of the audio path.

As it can be seen from Figure 2, in a subjective assessment, human perception takes place, which is based on psychoacoustics. This circuit does not take into account the response of the electrical meter - the evaluation device as in Figure 1, but takes into account the human reaction to the result of the passage of an audio signal through the path or device being evaluated.

# 3 PSYCHOACOUSTIC EVALUATION CRITERIA AND THEIR CONNECTION WITH THE ELECTRICAL PATH

In accordance with the division of objective quality indicators and psychoacoustic criteria, a correspondence diagram has been compiled in Figure 3. The diagram was compiled based on systematization and analysis of information available on the Internet from specialized resources, as well as based on a survey of audio equipment buyers and audio professionals, and does not take into account age groups. Solid lines show established connections, and dotted lines indicate that the relationship is possible, but not obvious.

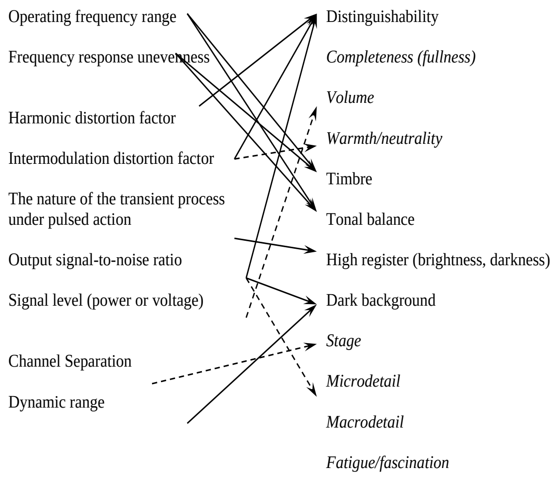


Figure 3: Correspondence of objective indicators for assessing the quality of the sound path to the subjective characteristics of psychoacoustic assessment.

The presence of uncertainties in the diagram in Figure 3 indicates an incomplete assessment of the psychoacoustic properties of sound paths using existing methods for measuring electrical characteristics.

As can be seen from Figure 3, *completeness* (fullness) of the sound picture, *scene*, *micro-detail*, *macro-detail*, *fatigue* or *fascination* are not taken into account in the objective assessment, but are considered important in the subjective assessment.

Thus, the *fullness* indicator may be associated with the effect of compression of the dynamic range when the audio signal is amplified and the effect of variation in the nature of the transient process when the input signal level changes. This assessment is not taken into account in objective electrical indicators; the measurement technique has not been developed.

Although the subjective indicator loudness is related to the signal level (output power or voltage), when listening to different sound systems with the same electrical parameters it gives a different perception.

Loudness is often associated with fatigue or fascination. So a path that sounds exciting makes you want to listen to it at a higher volume, and a path that sounds tiring – at a low volume. The use of *fatigue* and *fascination* indicators makes it even more difficult to establish clear connections with objective characteristics, since no relationship has been established for them. Thus, these criteria are the most complex, since they combine a final assessment of the sound quality of the entire sound path and must be formed based on the analysis of a number of psychoacoustic characteristics.

The subjective indicator of *warmth*/*neutrality* is usually associated with the presence of a certain spectrum of nonlinear distortions and their mutual distribution. Thus, the predominance of the second harmonic and harmonics of even orders is usually assessed as some heat. The predominance of the third harmonic and harmonics of odd orders is assessed as aggressiveness or harshness. The neutral character is usually associated with a rapidly decreasing spectrum of nonlinear distortion products. A number of electrical parameters are measured using standard methods [4]-[10], although the levels of even and odd harmonics are not indicated separately.

Assessing *stage* is quite difficult. One can often find the wording about a close stage or a distant stage. This is probably due to the enlarged presentation of the sound image in the presence of dynamic range compression, due to which quiet sounds become louder and loud sounds quieter.

*Micro-detail* and *macro-detail* refer to the characteristics of reproducing quiet sounds against the background of loud ones and masking quiet sounds with loud sounds. If the wording is similar, small and large sounds are assessed separately, since the effects of psychoacoustic masking of human hearing are involved. The basis of electrical phenomena in sound paths when these indicators change are nonlinearity effects that appear when exposed to signals with a complex spectrum. Standard methods [4]-[10] provide for assessment based on the impact of a pair of stationary signals with different frequencies and a certain level ratio, which has no relation to the real sound signal.

Thus, the presence of many cross-connections between parameters or their absence does not give an exact answer to the question of which electrical parameter needs to be improved to improve sound quality in a subjective assessment.

# 3 USING AN ARTIFICIAL INTELLIGENCE SYSTEM TO ADJUST PSYCHOACOUSTIC EVALUATION CRITERIA

Since recently, artificial intelligence (AI) systems are beginning to be introduced into scientific and educational fields [12], [13]. An interesting possibility is to obtain more information about the evaluation methods being studied based on the analysis of the results of a survey of respondents and the synthesis of simulation models for creating (processing) reference phonograms by modifying the structure of subroutines of sound data processors (chains). The possible structure of the AI system for surveying respondents is shown in Figure 4.

The AI system contains a library of test records that can be processed by distortion chains when generating a test task for a respondent by a test generation machine. The test generation machine is a working area and, based on the initial information received from the respondent through the respondent interface subsystem, generates a test task and transmits it through an electroacoustic transducer to the respondent. The electroacoustic converter must be a reference path consisting of a digital-to-analog converter, an amplification path and stereo headphones or an acoustically prepared room and speaker systems.

During research, the respondent reports to the AI system the results of a subjective assessment of sound quality through the respondent’s interface. The response acceptance subsystem can accept the respondent’s answer or add or change a test task to clarify the survey result.

The knowledge base stores initial information about the research, but in the process of acquiring knowledge, the knowledge base can be changed and supplemented. Thus, it is possible to identify frequently encountered criteria for psychoacoustic assessment and compare them with distortion introduction circuits.

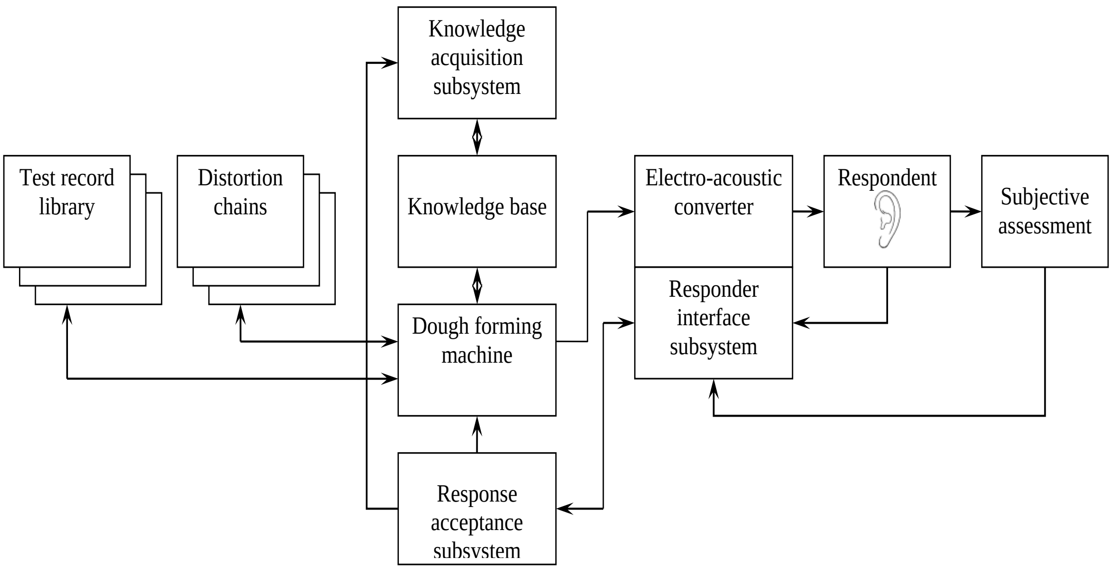


Figure 4: Scheme of using AI to survey respondents in order to clarify the psychoacoustic criteria for assessing the quality of sound paths.

The distortion injection chains can be changed during the test to clarify the degree of influence on the psychoacoustic perception of electrical characteristics.

The database of test records is selected according to the wishes of the respondent based on the respondent's interaction with the AI system. Based on feedback from the respondent, the database of test recordings can be supplemented, since recordings of different styles can change their psychoacoustic properties differently when processing distortion chains.

The result of the work of the AI system should be a knowledge base about the criteria for psychoacoustic assessment and the electrical characteristics that are compared with them.

# 3 CONCLUSIONS

It has become obvious that objective measurement methods [1-7] do not meet the requirements of listeners and the professional community, which requires clarification of existing assessment methods using psychoacoustic criteria.

Clarification of methods for objective assessment of sound paths by taking into account indicators related to psychoacoustic properties will improve their quality characteristics, increase listeners' interest in information, music, and educational programs by achieving a comfortable presentation.

In the audio engineering industry, the construction of sound processing devices based on a psychoacoustic assessment of their sound quality will increase the competitiveness of devices on the market compared to models that have similar functionality, but are built without taking into account psychoacoustic properties.

The use of a system based on AI at the stage of establishing sustainable mutual relations between psychoacoustic and electrical characteristics would make it possible to measure certain sets of sound device physical quantities or sound tract that would not just be numbers, but by those descriptions of the real sound quality with a psychoacoustic perception context.

It is possible that psychoacoustic criteria can be used to deliberately correct the nature of sound materials in advertising campaigns and public speaking, but this possibility requires additional research.

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