A NEW PARADIGM IN PSYCHOACOUSTICS, PART TWO

By Steven Orfield

In Part one of this series, the concept of sound quality was discussed, along with myriad applications. In Part Two, we will take a more in-depth look at the issues of sound quality research and testing, with an eye toward the types of systems and procedures which are used, and the process which is undertaken. As we look deeper into the sound quality process, it is important to keep the intent of its typical range of background questions in mind:

- How pleasant does the product sound?
- Does the sound suggest power?
- Does the sound seem appropriate for the product?
- Does the product sound expensive?
- Does the product sound annoying or peculiar?
- Should the sound quality vary over time?
- How many "listeners" (groups/types) are to be considered?
- Among multiple "listeners," which is more important?
- Can the near field and far field sound be controlled separately?
- Does the product have an environmental acoustical impact?
- Is there an advantage to "adjustable" sound quality?
- Is there an "ideal" sound quality which cannot be provided by the product naturally and may need to be synthesized?
- Are the demographics of the users similar or contradictory?

Further, it is important to understand that sound quality is not dependent upon any technical definitions but is rather investigated most accurately via the use of a non-technical or product consumer audience. Any investigation of sound quality not governed by the listener has no basis for claims of validity.

Therefore, the search for product sound quality is not a measurement and analysis type of process; it is rather a process governed by procedures developed solely to elicit iterative responses from the listener. The elegance of this analysis is in its dependence upon the skill of the investigator to understand a broad range of parameters related to the listener expectations and concerns regarding the performance of the product.

Further, understanding of quantitative jury analysis work is important; current market research suggests the view that while the subject (listener) may respond verbally to many types of inquiries, such as focus group questioning, there is very little validity in assuming that the subject, in fact, has an analytical understanding of his preference or preference behavior. In other words, via the use of poor experimental questions, it is very easy to lead the subject to respond in ways which represent his "opinion" of a product but do not represent his "response" to the product. For example: Will he purchase? Will he feel positively?

Secondly, typical focus group methods of evaluation tend to be skewed by group responses following the most dominant participants or on the expectations of the experimenter. Thus, conventional focus groups are generally not a suitable tool for sound quality work.

THE EXPERIMENTAL PROCESS

The manufacturer of a product is, to some degree, an anecdotal expert on consumer response to his product; he does, in fact, know which products are more successful, and he does have field reports of positive and negative comments regarding his product. He may also have significant market research regarding consumer response to general or specific aspects of his product, such as quality, performance and cost. This is generally a good beginning point in the development of a sound quality program. With this point of reference, it is useful to inventory descriptive terms related to the acoustic performance of the product, and these terms should ideally be bipolar, such as those shown below.

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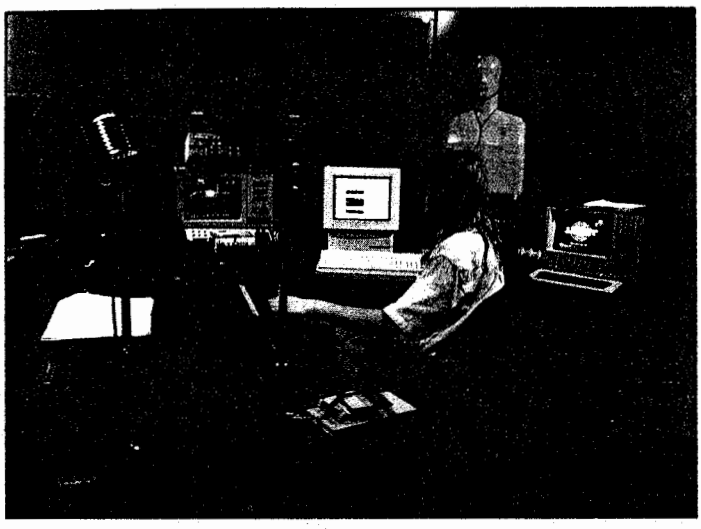
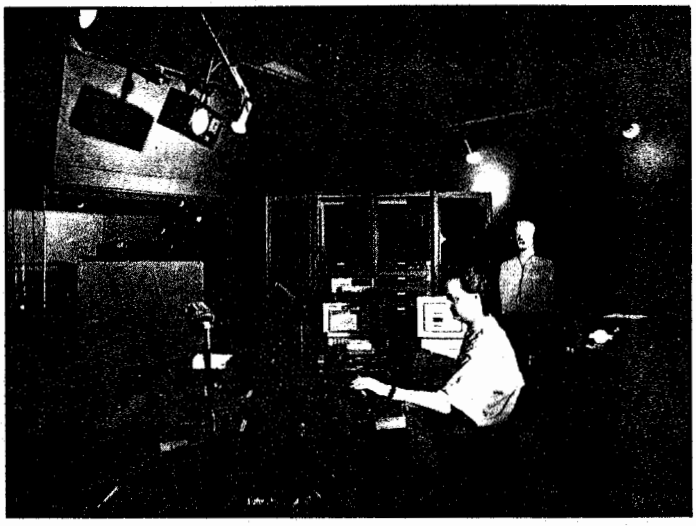


Sound Quality Editing / Analysis System



The Sound Quality Process

Bipolar Sound Quality Parameters

Good — Bad
Loud — Quiet
Harsh — Pleasant
Sharp — Mild
Strong — Weak
Rough — Smooth
Powerful — Gentle

Secondly, it is useful to work with the marketing and engineering staffs of the manufacturer to develop two demographic views of the product; on one hand, the consumer anecdotal responses and market research responses should be assembled. On the other hand, responses from the marketing and technical staffs regarding their own views should be assembled. (The second set of information may assist in understanding the body of long-term market response information which has been inculcated by the firm, possibly without analysis or verbalization.) Once this information is assembled, an initial set of bipolar parameters can be developed; next, these parameters should be presented to both the consumer and staff in the form of semantic differential ratings (1—10, typically) based on listening to the product in question.

AURAL PRESENTATION MATERIAL

In order to present aural information to the listening jury, it is necessary to assemble that information via some type of recording process. The three most common recording types used are monaural, stereo and binaural. The monaural recording, such as a typical acoustical noise recording, has time and frequency content, but provides no directional or localization cues. The stereo recording provides cues across one axis, typically left-to-right for the listener. The binaural recording provides three axes of aural cues for the most accurate source localization of the product under study. (Some products, such as audio stereo system components, will generally find little application for binaural recording.)

The choice of methods relates to the importance of localization in the typical process of listening to the product. For example, a motorcycle rider will find localization very important, as he hears a quite different distribution of sound sitting while riding the bike from that which a pedestrian would experience. On the other hand, a recording of a home food processor may find little benefit in source localization methodology.

Depending on the method of recording, the method of listening will also need to vary, and there are three typical methods. The first method is the presentation via a single loudspeaker, the second via presentation with two loudspeakers, and the third via presentation binaurally via loudspeakers (with cross-cancellation systems) or headphones. There is also a fourth method via the use of an acoustic simulation room (See Sound & Communications, December 1990, March 1991).

A second issue with regard to presentation is background noise and room acous-

tics. Listening to products such as appliances which are typically heard against a spectrum of background noise and room effect is quite different from listening to those products in an anechoic (dead) environment with unnaturally low background noise levels. It is important that aural demonstrations not over emphasize the product noise but rather attempt to recreate it in its natural acoustical environment.

Finally, the ear is very capable of discerning extremely small acoustic differences, but there is a clear inverse relationship between aural acuity and memory of sounds. Thus, sounds presented sequentially may elicit clear negative-to-positive preference responses which may not be elicited by sounds presented independently. The issue of sound quality relates more to the second condition than to the first, due to the poor performance of aural memory. (In sound quality, we are often looking for reponses to the product in the absence of immediate comparisons to other product sound possibilities.)

PREPARATION OF THE AURAL PRESENTATION

The recordings for use by a sound quality jury generally exhibit the following characteristics:

- They are significantly similar to live listening to the product.
- They are recorded at typical listener positions.
- The recordings or their playback include background noise characteristic of their use environment.
- The recordings or their playback include reverberation and time delay characteristics typically found in their use environment.
- The recordings or their playback must not be negatively affected by the listening system or environment.

(It is important to keep in mind that many products have significant perceptual stimulation other than aural; for example, the sights, feel and smell of a vehicle may clearly affect the overall response of the consumer. Thus, other presentation variables, such as video films of product operation, may provide a more valid overall presentation.)

If the recordings are to be made via monaural or stereo methods, it is important to follow the tenets of professional recording with regard to equipment specifications such as frequency response, signal-to-noise ratio, time response and dynamic range. It is imperative that precision microphone systems be used and that the overall recording system can handle the dynamics and range of product acoustical performance. Digital Audio Tape (DAT) recording is the preferred method for this type of recording, due to its accuracy and dynamic range. There are many good recording manuals for the inexperienced technician.

If the recording is to be performed binaurally, it is important to use a validated binaural recording system (See Sound & Communications, September 1990 and October, 1990). The Sound Quality Working Group (SQWG) is using this combination of components for binaural recording:

RECORDING SYSTEM

- Bruel and Kjaer 5930 Recording Torso
- Bruel and Kjaer 4128 Measurement Torso (optional for verification use)
- TEAC RD 120 or 125 T DAT Recorder
- WB 1057 Power Supply (B&K 4128)

After successful recording, there is a need for a capable playback system based on the method of recording and corrections needed. For monaural and stereo recordings, the playback system may be nothing more complex than an accurate sound system and loudspeakers, including equalization methods and measurement systems. For binaural DAT recordings, the more typical case, this playback system becomes increasingly complex, and for this purpose the Sound Quality Working Group is using these components or variations of them:

Playback System

- Bruel and Kjaer 2133 Analyzer
- Bruel and Kjaer 4128 Measurement Torso (optional for verification use)
- TEAC RD 120 or 125 T DAT Recorder
- Yamaha DMP-7 Mixer
- Yamaha DEQ-7 or 5 Digital EQ
- Yamaha D-A DA 202 Converter
- Yamaha P2075 Power Amp
- Yamaha NS-10MC Near Field Monitor
- Sennheiser HD-560 Headphones

The final system in the recording process is the editing and computational analysis system. This system is used for these purposes:

- Correcting inaccuracies in the recording.
- Changing the recording to simulate changes in the product.
- Equalizing the recording for playback.
- Editing the recordings made into a final presentation tape for the jury.
- Providing initial computational analysis of the sound quality of record
  ings in order to consider editing options that suggest a significant possibility of sound quality improvement.

The SQWG analysis and editing system is made up of the following components:

EDITING/ANALYSIS SYSTEM

- Two channel digital editing workstation including MAC and associated electronics (We are currently using Digidesign Sound Tools)
- Bruel and Kjaer 2133 Analyzer
- Bruel and Kjaer 4128 Measurement Torso (optional for verification use)
- TEAC RD 120 or 125 T DAT Recorder
- Yamaha DMP-7 Mixer
- Yamaha DEQ-7 or 5 Digital EQ
- SWSG Sound Quality Software

- IBM Compatible MS-DOS 486 PC with LabWindows program and audio board

These three systems together comprise the basic equipment for gathering the acoustic signal, editing this signal and presenting it, edited and unedited, to the sound quality jury.

PREPARATION OF THE SOUND QUALITY JURY

The sound quality jury is intended to be the final arbiter of decisions on sound quality of the product under investigation; therefore, in significant ways it must represent the consumer group which is either available or targeted for the product. (Both options are suggested, as many products are most popular among a different demographic group than intended in the marketing plan.) Some of the demographics important in typical selection processes are: Age, Sex, Education, Income, Purchasing history, Product use history, Geographic purchasing patterns, Aural, visual and physical impairment.

Ideally, the market research (MR) division of the manufacturer (or their independent MR firm) will provide criteria for current client demographics and desired demographic changes in customer profile.

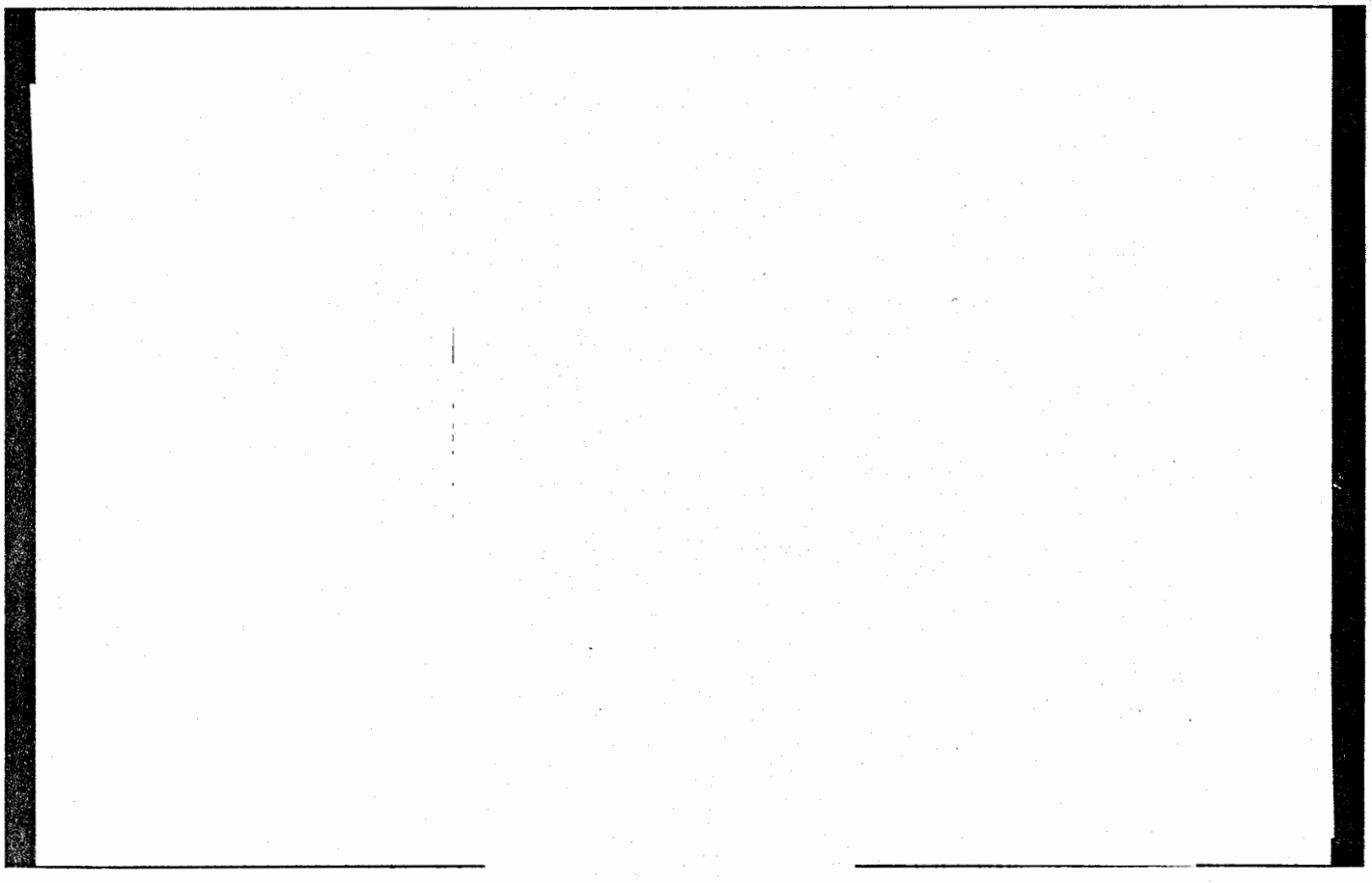
Using the established MR criteria, a jury is then selected, including a statistically relevant sampling of the identified population. This group is then assembled for preliminary testing of hearing (and possibly vision), possible MR interviews are held to verify the sample, and a final jury and alternates are selected for use as the sound quality jury. (Hearing and vision generally verify whether the subject is typical of his/her age group in acuity and other attributes.) With regard to issues of jury statistics, etc., I refer the reader to the marketing research community.

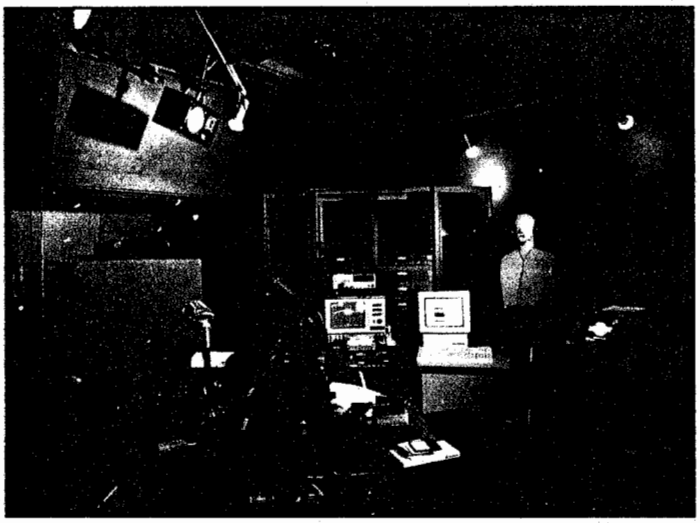
Prior to the presentation of recordings to the sound quality jury, it is important that they be accommodated to the presenation and noise levels; thus, a general introduction to the material over a period of 10-30 minutes is useful for understanding and adaptation to ambient levels of the material.

EDITING THE AURAL PRESENTATION

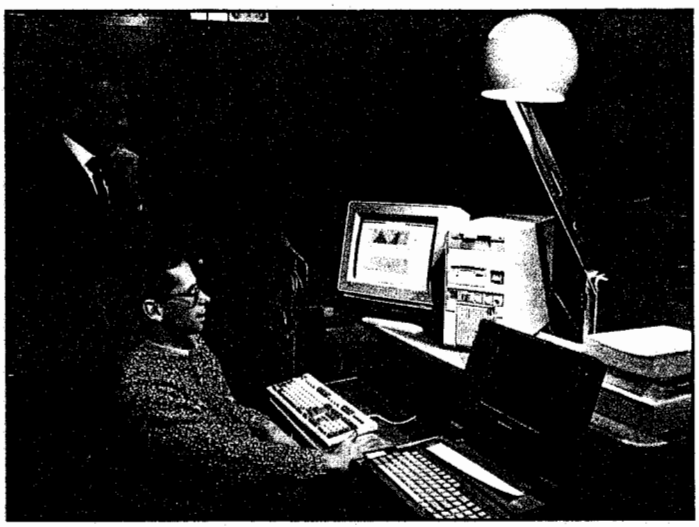
Generally, the aural presentation is intended to perform these tasks:

- Present the sounds of the current product and product line.
- Present adjacent comparisons with competitive products.





Sound Quality Recording System



Sound Quality Recording System

• Present adjacent comparisons with edited recordings which are intended to characterize product improvements. 4. Present non-adjacent recordings of the same phenomenon for absolute rather than comparison ratings.

Normally, the jury is given a scoring sheet (1-10) with bipolar attributes and is asked to circle one attribute position for each presentation (i.e., loud versus quiet). If multiple attributes ratings are desired, the stimulus is presented additional times. In addition to acoustically descriptive attributes, other types of comparisons are often made based on consumer expectations and parameters (i.e., "pleasant," "powerful," "comfortable," "appropriate"). These jury presentations and their responses are generally considered to be building blocks for assembly of additional presentations leading to final jury results.

Editing of original recordings can be used in preparation of these presentations for purposes of these types of changes:

- Frequency response characteristics.
- Time response characteristics.
- Background noise characteristics.
- Positional listening characteristics.

STANDARDS DEVELOPMENT

After sufficient jury testing has been completed and after computer runs on alternate acoustic presentations are performed to determine which sound quality metrics parallel jury responses, intitial standards are created for: noise reduction; frequency response changes; temporal response changes; sound enhancement.

While the majority of these changes will generally be attenuation based (noise reduction) changes, in some cases, acoustic levels may be increased in certain frequency ranges which are considered beneficial to the consumer, and time-based response may also be altered. Once these initial standards are created, additional sound quality jury work is often performed for final verification before these standards become operative. After the standards have been verified and accepted, the next stage of the sound quality process is product noise analysis, and this will be the subject of the next article in this series.

In review, the following is the set of steps typical of sound quality analysis, and the remainder of this series will involve the application of these steps and specific examples of them.

Sound Quality Standards Development

- Product listening and market discussion.
- Market research.
- Binaural Recording of current and competitive products (See Sound & Communications, Sept. and Oct. 1990).
- Playback to a listening jury.
- Calculation of sound quality parameters.
- Editing of sound to reduce annoyance and increase positive sound quality based on jury response and calculations.
- Playback to a listening jury of alternative solutions for validation.

Sound Quality Initial Measurement

- Playback and measurement of above recordings.
- Application of alternative analyses of time and frequency-based components.
- Characterization of acoustical performance at all points of operation (speed, cycles, etc.).

Sound Quality Source Localization Measurement

- Sound Intensity measurement based on measurement findings and targets for reduction in sound components (See Sound & Communications July, Sept. 1989).
- Sound Intensity measurement of components of the product under test, often with product covers removed.
- Sound Intensity mapping of sound power over engineering diagrams of product surfaces.

Sound Quality Modal Measurement

- Modal Analysis measurement based on intensity measurement findings and the analysis of the structural vibration components of the noise.

Sound Quality Prototype Development

- Production of an operational prototype based on sound quality standards and measurements.

Final Sound Quality Jury Presentation

- Presentation of recordings to jury
- Presentation of actual product prototype
- Market research on prototype