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Reference vs. Preference: The "Surround" of Surround Sound

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ABSTRACT

Surround sound provided by stereo and 5.1 systems may not be satisfying all its listeners. Whether in the automobile or in the home, customers complain of "nothing from the rear speakers", or about the sound "not filing the room", etc.

While 5.1 systems promise more surround, the economics of music production and concerns of music professionals are likely causing stereo to dominate production resources and causing 5.1 mixes to miss their full potential. The author believes that post-processing electronic and acoustic manipulation can produce sound that customers will prefer.

A controlled experiment was performed which compared reference stereo and surround systems to ones augmented by extra surround equipment.

This paper:

1. Discusses a very brief history of stereo and surround sound
2. Describes an experiment used to test listener preference,
3. Details experimental results when comparing reference-like music presentation with envelopment enhancing sound processing using both stereo and 5.1 recorded music.

INTRODUCTION

Typical stereo and 5.1 multichannel listening systems do not provide a strong sense of surround or envelopment when playing much of today's music.

Many in the audio industry argue that the objective of a reproduction system is to replicate to the greatest extent possible the sound that was produced in the mixing studio. The "correct" listener envelopment is the envelopment intended by well-paid professionals involved in the production process. The sound of the studio is the reference that home and automobile audio systems should emulate. Also, why wouldn't these professionals add more envelopment to their mix if people really liked it?

Others in our industry believe that to maximize the listening experience, the listener must sense a reasonably high level of envelopment. After all, better concert halls and similar venues are designed to, among other goals, provide pleasing levels of listener envelopment.

This latter group also believes that most music, as recorded and played in a typical manner, has insufficient envelopment. These people want to make up for this insufficiency by adding more envelopment to the reproduction process.

The author falls into the latter category and believes that most naive and even many trained listeners will prefer higher than "reference" envelopment. The results of the experiments discussed in this paper strongly support this position.

BACKGROUND

In the early days of high fidelity, monaural audio was offered and customer interest in home and automobile music reproduction systems grew. In the automobile, a single dash-mounted speaker, often integrated with the AM radio, provided a pleasing modest fidelity experience.

When home stereo was developed and accepted, customers were given width, imaging and staging. And the listener's sense of envelopment, especially in reflective rooms, was significantly enhanced.

In automobiles, the earliest FM stereo offerings featured front and rear stereo using dash and package tray locations. The listener had little staging, but the sense of

envelopment in this otherwise non-reflective space was increased.

Eight-track tapes, cassettes and CDs found their way from home to vehicle. Four speakers were designed into automobiles, with small speakers in each corner of the dash and larger bass-producing speakers on the package tray. Staging and a strong sense of envelopment could be obtained using the balance and fader controls. “Crossfire” stereo, where the rear speaker staging was reversed, was offered, and this may or may not have been an improvement.

Later, front door installations with coaxial speakers or midrange-tweeter setups began to provide better fidelity and more up-front bass.

Recently, vehicles have been fitted with speakers in many different locations, and with the advent of premium equalized systems, response and spatial fidelity were now very close to that of better home systems. Envelopment could be adjusted to user taste, and the center fade position generally supported high envelopment.

But then along came the requirement that the sound should be good for all four seating positions.

> Although not supporting blasting the rear passenger with loud sounds, the author has not seen any evidence of cars moving down the highway with four critical listeners enjoying the music. Almost certainly this listening situation does not commonly occur in smaller cars.

But to satisfy this perceived four-position requirement, rear speakers were moved from the package tray or other rear locations into the lower part of rear doors or rear quarter panels. These speakers were approximately the same distance from the front seat occupants as the front speakers.

In lower-cost systems without time delay, rear speakers located about the same distance from the listener as the front speakers contribute nothing to the sense of envelopment. The rearmost half of the “sphere of envelopment” was lost. In the author’s opinion, this has been a significant step backwards for the driver and front passenger.

Multichannel 5.1 and 7.1 systems are now offered in automobiles, and it is the author’s observation that envelopment is source dependent and not always guaranteed by even the most sophisticated home or automotive “surround” systems.

THE VALUE OF ENVELOPMENT

Envelopment’s value is seen in the design of better concert venues and listening rooms. In outdoor venues, reflecting panels add envelopment and thus add to the audience’s enjoyment. The perhaps outdated “live end dead end” listening rooms were designed to suppress response-damaging early reflections while maintaining a live back wall to raise envelopment.

The author’s personal experience has added to his belief that envelopment is worthy of design resources. These three observations help support my belief:

1. My wife walks into our listening area and notes that despite the presence of a 5.1 system, the furniture-damped room is not “filled with sound” (certainly not with stereo source material). And she’s right. Only the front wall seems so “filled”.

2. Our ballroom dance club’s attendance was growing when our venue had four overhead “crossfire” stereo speakers that filled the room with sound. The club has recently moved into another venue with “one-sided” sound and the attendance is smaller. The lack of envelopment may (or may not) be part of the reason for this. I personally find this system unpleasant.

3. I have driven automobiles with only two full range speakers mounted in the kick panels, and after a time, had to turn the system off. I now own a Pontiac Vibe with rear door speakers and with almost no sense of envelopment. For this, and admittedly some frequency response reasons, I strongly dislike the system and mostly listen to talk radio on AM.

One can look at the large number of available surround processors and at the advent of 5.1 and 7.1 multichannel systems and suspect that consumers are asking and expecting to be surrounded, perhaps enveloped by their music.

The author does not fault professional mixers for failing to include higher levels of envelopment in their productions. For example, two-channels of stereo music can only contain just so much reverberant information before intimacy is compromised. It is in the reproduction process that additional speakers and processing can “complete the other half space” with a minimal sacrifice of intimacy.

Even in 5.1, the surround information of the type described herein is not well managed by speakers in the classic 110-degree position. This latter opinion is further discussed in the experimental design and setup sections of this paper.

HYPOTHESES OF ENVELOPMENT

The author hypothesizes that:

1. Most listeners prize envelopment more than automotive system designers seem to value it. Ambience, which is a category on automotive audio rating forms, is rated highest when it matches that of a reference listening room. Additional ambience would generate lower scores. I believe listeners want more envelopment than a typical “reference” room provides.

2. While reflective listening rooms may provide an improved sense of envelopment, the much deader automobiles must depend on, and should have, electro-acoustical enhancement.

3. Going one step further: the typical naive listener prefers more envelopment than even a reflective listening room typically provides.

Evaluating listener preference for hypothesis 3 is potentially quite difficult. When the listener first perceives the surrounding ambience, this may evoke a positive response that may not reflect a longer-term preference. Added envelopment is potentially the “More”, described in one of the author’s earlier paper[1] as something added to “sweeten” the choice process.

In the first place, “More” means not adding “X” (e.g. bass) when you’re trying to test “Y” (envelopment). That is why volume and perceived frequency response is matched in this experiment.[2] Further, delay is used to prevent rear speaker localization. Finally, test elements are faded in and out to minimize sound level memory effects.

AN EXPERIMENT TO EVALUATE LISTENER ENVELOPMENT PREFERENCE

An experiment was designed to evaluate the envelopment preferences of both naïve and trained subjects. The experimental design is now discussed.

HARDWARE AND ROOM SETUP

1. Music used was from five stereo and two multichannel sources, with short segments recorded into Ableton Live for further processing opportunities (fig 1). Analog audio came from a MOTU 828 eight-channel firewire interface device (fig 2).

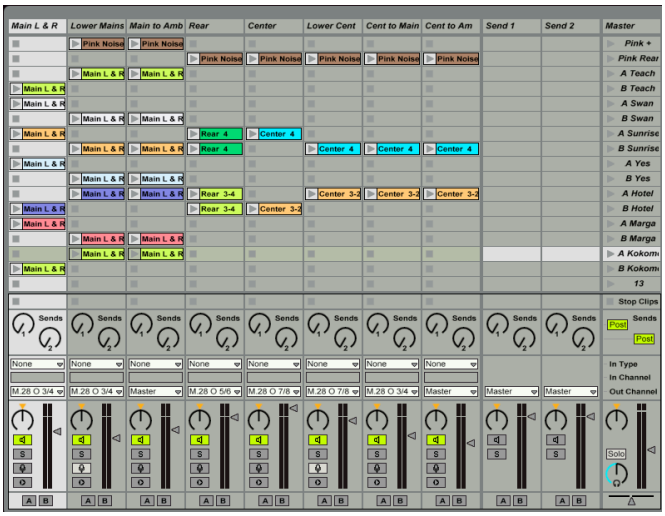

Figure 1. Ableton Live® Screen Shot

Figure 2. MOTU 828® Audio Interface

2. Amplification was provided by two amplifiers:

   a. A five-channel home amplifier that has been adjusted to minimal processing and equal delay.

   b. A two-channel stereo amplifier for the surround-producing rearmost pair of speakers.

3. Five of the seven speakers were laid out on a six-foot circle around the listener In classic ITU-R BS.775-1 configuration (albeit smaller due to room constraints). Additionally, there were two hidden speakers along the rear wall that were eight and nine feet away from the listener (see figs 3 & 4).

4. Two Acoustic Research AR 3a speakers provided stereo imaging and bass. A Lineam speaker provided the center sounds for multichannel and two Bose Model 101 Music Monitor speakers provided classic 5.1 rear sound. Equalization was used to make the response of these speakers similar in the 200Hz+ range. The hidden two speakers were tiny Boston Acoustics speakers aimed upward at approximately 45 degrees from horizontal. These speakers were delayed 5 mS and were equalized with treble rolloff to minimize rear localization.

   Originally, the extra “surround” information was just routed to the normal surround speakers. This did not

work well. The treble boost caused by the head-related transfer function at 110 degrees required that treble information be suppressed by equalization. This and the speaker's directional properties virtually eliminated potentially beneficial effects from room reflections.

5. All tests were conducted in a home listening space. This space is reflective in the rear and much less so in the front (fig 3).

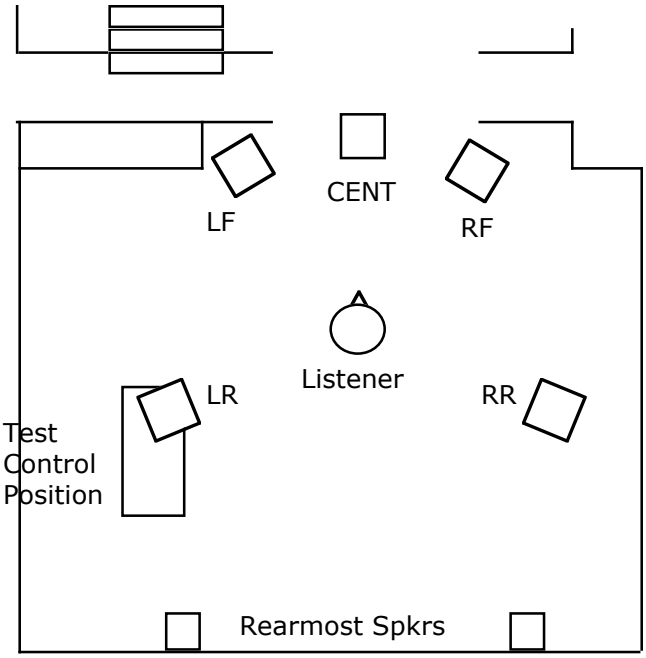

Figure 3. Experiment Listening Room

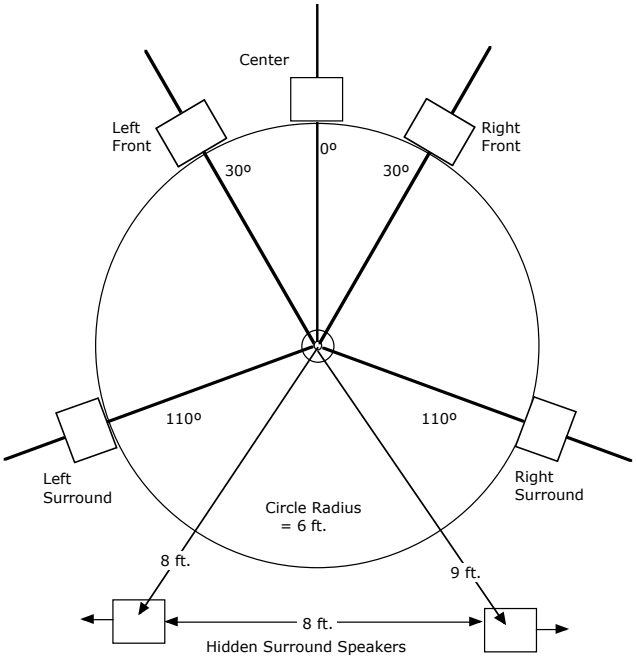

Figure 4. Experiment Speaker Placement

6. The rearmost surround-producing speakers were hidden to eliminate expectation of "something coming from the rear speakers". During testing, no subject discerned the presence of these speakers.

7. Sound levels for comparison testing were made uniform in level by A and C weighted measurement in the listening position. The musical segment levels started at –5dB below a later sustained level. The sound was also faded out at the end of the selection.

8. Sounds routed to the rearmost speakers were derived from signals going to the corresponding front speakers, and from the center speaker. Frequency response rolloff and simple 5 mS time delay were used to prevent rear speaker localization. These are the only processing features used for the rearmost speakers. This minimized mix changes, which are generally perceived as negative.

   Please note that a recent Audio Engineering Society Paper[3] discusses LEV as a measure of listening envelopment. This paper proposes looking at late arriving, more reverberant sounds. However, electronically adding reverberant effects like this to the rearmost speakers would have significantly changed the mix, and signals like this were not used.

   For the two surround recordings, an additional signal rerouting was implemented. The center speaker's signal was shared between itself and the two left and right main speakers. This was to broaden the very hard center of the "Sunrise" piece. A 2mS delay was added in L and R to minimize loss of "sweet spot".

9. The level of sound going to the rear speaker and all adjustments were set to my own preference. My adjustment criteria included maximum envelopment with minimum rear localization.

10. The test is single-blind, but during the tests, the test controller is silent and out of sight (unless something is obviously out of sync). Suitable randomization and other experimental controls are in place.

11. Originally, the mostly naive listeners were given no indication about what sound aspect was changing. This lead to confusion and wasted time. It was decided to provide guidance to focus the listener's energy toward spatial properties. The following was included in the listener instructions:

    > "This experiment has to do with the size and space of the sound (its "spatial" properties). Each of the sounds, both A and B are adjusted to provide a certain kind of space, large or small, thick or thin, frontal or surrounding, etc. You job is to listen for a

difference in these qualities, then decide which sound treatment you like and mark how much you prefer it on the A-B line."

The "A-B line" is discussed in the next section.

The brief verbal instructions re-emphasized that the listener's preference was being sought and that there were no "right" answers.

EXPERIMENTAL PROCEDURES

The experiment lasted from approximately 10 to 20 minutes, depending on the listener. Music was played in seven pairs, with each pair containing both the "reference" setup, and the setup with the front information being also fed to rearmost speakers. Five of the seven music pairs are stereo recordings and two are 5.1 multichannel. Sources are:

1. "Teach Your Children", Crosby, Stills, Nash & Young
2. "Swan Lake", New Symphony Orchestra of London
3. "Sunrise", Nora Jones and the Handsome Band (Dolby Digital® 5.1)
4. "Just Say Yes", Highway 101
5. "Hotel California", Eagles (DTS®)
6. "Margaritaville", Jimmy Buffet
7. "Kokomo", Beach Boys

Note: The 5.1 sources above show substantial activity in center and rear channels. Selection 5's applause is suitably in the rear, but selection 3's applause seems to come from the front. Two other so-called "surround" recordings I purchased had nothing on either center or rear channels.

The subject is asked to indicate a preference for each paired comparison along a line from A to B (fig 5). The subject marks the line to indicate both preference and a relative amount of listener preference. The vertical line in the center is "no opinion".

The A-B line is used to allow further (future) data processing to determine "how much" in addition to "which one". The author believes that this technique minimizes test pressure and delivers better data.

A----------|----------B

Figure 5. A-B Preference Line.

After the song scoring was completed, the subjects were asked to describe, in their own words, the differences they were hearing.

To my own ears, most of the selections sounded "flat" in the "reference" mode and spacious in the "preference" mode. But I had some difficulty deciding a preference because of imaging issues on "Swan Lake" and surround audibility in the already surround-rich "Hotel California". My own data was, of course, not included.

RESULTS OF EXPERIMENTS

Thirty-four subjects were tested. Scoring was done two different ways. Note that for this paper, only "A", "B", or "no opinion" (center of line) information was used.

First, a majority "vote" on each scoresheet determined whether the listener preferred the extra surround (the "preference" mode}, or preferred the "reference" mode. Twenty-eight listeners chose the "preference" mode, four chose the "reference" mode, and two person's scores were tied.

Second, a total was made of the raw numbers from each song listed on the scoresheets. The scores were "preference"-157, "reference"-56, a ratio of about 2.8 to 1. The "no opinion" score was 25.

Of the four "reference" listeners, two had solid rationale for their choice, one of the other two admitted to guessing.

All of the three trained listeners scored either 5 of 6, or 5 of 7 in favor of the "preference" mode.

Words used by listeners to describe differences include "fuller", "surrounding", "fills the room", "more spread out", etc. Even one of the "reference" persons indicated a desire for fuller sound.

CONCLUSIONS

This experiment showed a strong preference by listeners for envelopment as generated by the simple act of putting delayed and tone shaped front sounds in an extra pair of rear-mounted speakers.

It is possible that long-term exposure to envelopment as tested would reduce preference scoring. The author doubts this, as his personal experience and past observations suggest otherwise.

It is also possible that a more sophisticated surround-producing setup would generate an even higher scoring for the “preference” mode.

Even if this paper is faulted for its experimental methods or its short-term testing, there has been shown at least the possibility that real listeners want higher levels of envelopment than two-speaker stereo and five-speaker surround can and/or typically does provide. The author believes that automobile audio designers should take note and make envelopment a higher priority for sound system design.

ACKNOWLEDGMENTS

I would like to acknowledge the “reference” crowd that energizes the author to try and prove “reference” wrong. I would also like to thank the many volunteer listeners and my wife Doll Stroud for her entertainment of the listener queue.

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