HARMAN

The Perception and Measurement of Headphone Sound Quality: Do Listeners Agree on What Makes A Headphone Sound Good?

by

Dr. Sean Olive, Todd Welti & Elisabeth McMullin

Harman International

AKG by HARMAN harman/kardon by HARMAN Infinity by HARMAN JBL by HARMAN Lexicon by HARMAN Mark Levinson by HARMAN

presented at the AES PNW Meeting September 18 2014, Seattle, WA

Research Motivation

Lack of meaningful standards for measurement and evaluation of headphone sound quality

No meaningful standard on headphone target response to achieve optimal sound quality (diffuse and free-field calibrations are commonly recommended

Controlled blind listening tests on headphone are challenging and time-consuming

...but they still need to be done to better understand the relationship between the perceived sound quality and measurement of headphones

Research Questions

How can we do controlled, blind headphone listening tests that produce accurate,repeatable and unbiased results?

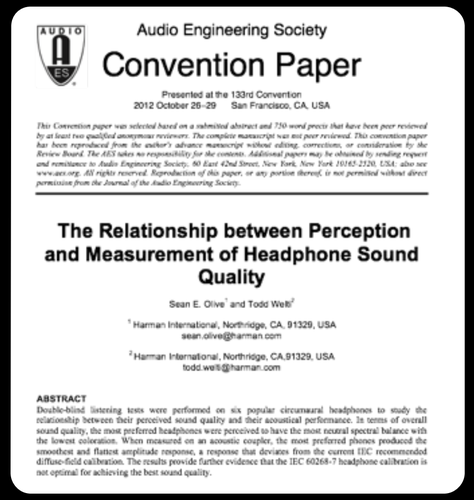
What is the preferred headphone target response?

Is it the same as the preferred in-room loudspeaker response?

Do college kids prefer the same headphone sound quality as adults and trained listeners?

What about the headphone tastes of different cultures?

We've been very busy the past 2 years researching the perception and measurement of headphones



Audio Engineering Society

Convention Paper

Presented at the 133rd Convention
2012 October 26–29 San Francisco, CA, USA

This Convention paper was selected based on a submitted abstract and 750 word precis that have been peer reviewed by at least two qualified anonymous reviewers. The complete manuscript was not peer reviewed. This convention paper has been reproduced from the author's advance manuscript without editing, corrections, or consideration by the Review Board. The AES takes no responsibility for the contents. Additional papers may be obtained by sending request and remittance to Audio Engineering Society, 60 East 42nd Street, New York, New York 10165-2520, USA; also see www.aes.org. All rights reserved. Reproduction of this paper, or any portion thereof, is not permitted without direct permission from the Journal of the Audio Engineering Society.

The Relationship between Perception and Measurement of Headphone Sound Quality

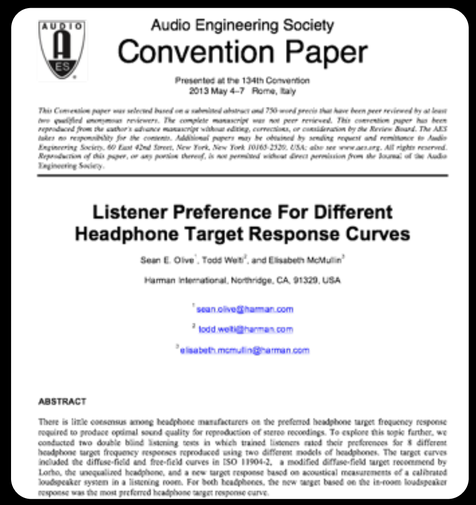
Sean E. Olive[1] and Todd Welti[2]

[1] Harman International, Northridge, CA, 91329, USA
sean.olive@harman.com

[2] Harman International, Northridge, CA,91329, USA
todd.welti@harman.com

ABSTRACT

Double-blind listening tests were performed on six popular circumaural headphones to study the relationship between their perceived sound quality and their acoustical performance. In terms of overall sound quality, the most preferred headphones were perceived to have the most neutral spectral balance with the lowest coloration. When measured on an acoustic coupler, the most preferred phones produced the smoothest and flattest amplitude response, a response that deviates from the current IEC recommended diffuse-field calibration. The results provide further evidence that the IEC 60268-7 headphone calibration is not optimal for achieving the best sound quality.



Audio Engineering Society

Convention Paper

Presented at the 134th Convention
2013 May 4–7 Rome, Italy

This Convention paper was selected based on a submitted abstract and 750 word precis that have been peer reviewed by at least two qualified anonymous reviewers. The complete manuscript was not peer reviewed. This convention paper has been reproduced from the author's advance manuscript without editing, corrections, or consideration by the Review Board. The AES takes no responsibility for the contents. Additional papers may be obtained by sending request and remittance to Audio Engineering Society, 60 East 42nd Street, New York, New York 10165-2520, USA; also see www.aes.org. All rights reserved. Reproduction of this paper, or any portion thereof, is not permitted without direct permission from the Journal of the Audio Engineering Society.

Listener Preference For Different Headphone Target Response Curves

Sean E. Olive[1], Todd Welti[2], and Elisabeth McMullin[3]

Harman International, Northridge, CA, 91329, USA

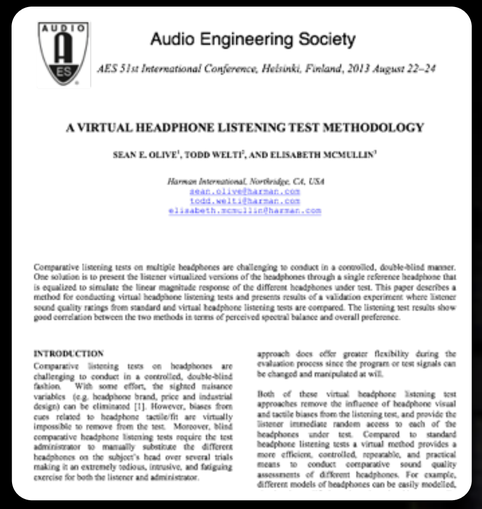
[1] sean.olive@harman.com

[2] todd.welti@harman.com

[3] elisabeth.mcmullin@harman.com

ABSTRACT

There is little consensus among headphone manufacturers on the preferred headphone target frequency response required to produce optimal sound quality for reproduction of stereo recordings. To explore this topic further, we conducted two double blind listening tests in which trained listeners rated their preferences for 8 different headphone target frequency responses reproduced using two different models of headphones. The target curves included the diffuse-field and free-field curves in ISO 11904-2, a modified diffuse-field target recommend by Lorho, the unequalized headphone, and a new target response based on acoustical measurements of a calibrated loudspeaker system in a listening room. For both headphones, the new target based on the in-room loudspeaker response was the most preferred headphone target response curve.



Audio Engineering Society

AES 51st International Conference, Helsinki, Finland, 2013 August 22–24

A VIRTUAL HEADPHONE LISTENING TEST METHODOLOGY

SEAN E. OLIVE[1], TODD WELTI[2], AND ELISABETH MCMULLIN[3]

Harman International, Northridge, CA, USA
sean.olive@harman.com
todd.welti@harman.com
elisabeth.mcmullin@harman.com

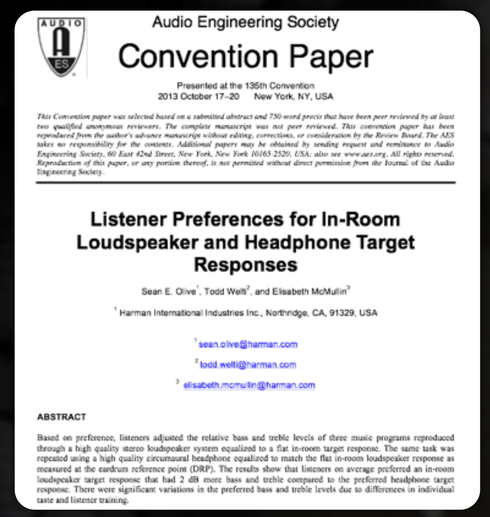
Comparative listening tests on multiple headphones are challenging to conduct in a controlled, double-blind manner. One solution is to present the listener virtualized versions of the headphones through a single reference headphone that is equalized to simulate the linear magnitude response of the different headphones under test. This paper describes a method for conducting virtual headphone listening tests and presents results of a validation experiment where listener sound quality ratings from standard and virtual headphone listening tests are compared. The listening test results show good correlation between the two methods in terms of perceived spectral balance and overall preference.

INTRODUCTION

Comparative listening tests on headphones are challenging to conduct in a controlled, double-blind fashion. With some effort, the sighted nuisance variables (e.g. headphone brand, price and industrial design) can be eliminated [1]. However, biases from cues related to headphone tactile/fit are virtually impossible to remove from the test. Moreover, blind comparative headphone listening tests require the test administrator to manually substitute the different headphones on the subject's head over several trials making it an extremely tedious, intrusive, and fatiguing exercise for both the listener and administrator.

approach does offer greater flexibility during the evaluation process since the program or test signals can be changed and manipulated at will.

Both of these virtual headphone listening test approaches remove the influence of headphone visual and tactile biases from the listening test, and provide the listener immediate random access to each of the headphones under test. Compared to standard headphone listening tests a virtual method provides a more efficient, controlled, repeatable, and practical means to conduct comparative sound quality assessments of different headphones. For example, different models of headphones can be easily modelled,



Audio Engineering Society

Convention Paper

Presented at the 135th Convention
2013 October 17–20 New York, NY, USA

This Convention paper was selected based on a submitted abstract and 750 word precis that have been peer reviewed by at least two qualified anonymous reviewers. The complete manuscript was not peer reviewed. This convention paper has been reproduced from the author's advance manuscript without editing, corrections, or consideration by the Review Board. The AES takes no responsibility for the contents. Additional papers may be obtained by sending request and remittance to Audio Engineering Society, 60 East 42nd Street, New York, New York 10165-2520, USA; also see www.aes.org. All rights reserved. Reproduction of this paper, or any portion thereof, is not permitted without direct permission from the Journal of the Audio Engineering Society.

Listener Preferences for In-Room Loudspeaker and Headphone Target Responses

Sean E. Olive[1], Todd Welti[2], and Elisabeth McMullin[3]

[1] Harman International Industries Inc., Northridge, CA, 91329, USA

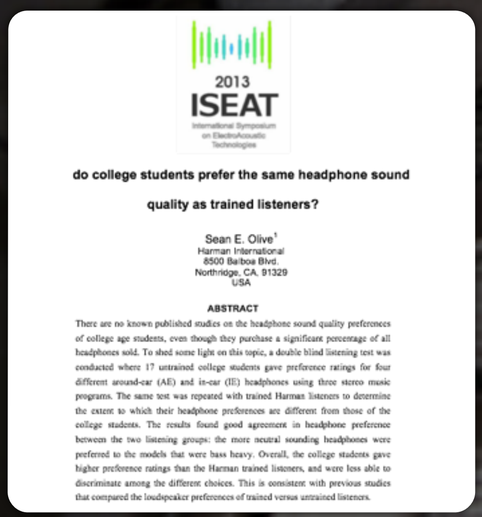
[1] sean.olive@harman.com

[2] todd.welti@harman.com

[3] elisabeth.mcmullin@harman.com

ABSTRACT

Based on preference, listeners adjusted the relative bass and treble levels of three music programs reproduced through a high quality stereo loudspeaker system equalized to a flat in-room target response. The same task was repeated using a high quality circumaural headphone equalized to match the flat in-room loudspeaker response as measured at the eardrum reference point (DRP). The results show that listeners on average preferred an in-room loudspeaker target response that had 2 dB more bass and treble compared to the preferred headphone target response. There were significant variations in the preferred bass and treble levels due to differences in individual taste and listener training.



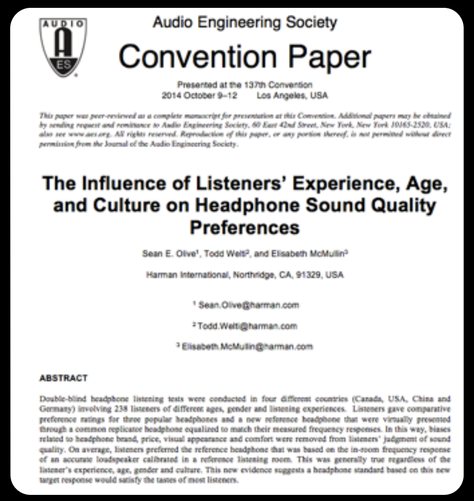
2013
ISEAT
International Symposium on Electroacoustic Technologies

do college students prefer the same headphone sound quality as trained listeners?

Sean E. Olive[1]
Harman International
8500 Balboa Blvd.
Northridge, CA, 91329
USA

ABSTRACT

There are no known published studies on the headphone sound quality preferences of college age students, even though they purchase a significant percentage of all headphones sold. To shed some light on this topic, a double blind listening test was conducted where 17 untrained college students gave preference ratings for four different around-ear (AE) and in-ear (IE) headphones using three stereo music programs. The same test was repeated with trained Harman listeners to determine the extent to which their headphone preferences are different from those of the college students. The results found good agreement in headphone preference between the two listening groups: the more neutral sounding headphones were preferred to the models that were bass heavy. Overall, the college students gave higher preference ratings than the Harman trained listeners, and were less able to discriminate among the different choices. This is consistent with previous studies that compared the loudspeaker preferences of trained versus untrained listeners.



Audio Engineering Society

Convention Paper

Presented at the 137th Convention
2014 October 9–12 Los Angeles, USA

This paper was peer-reviewed as a complete manuscript for presentation at this Convention. Additional papers may be obtained by sending request and remittance to Audio Engineering Society, 60 East 42nd Street, New York, New York 10165-2520, USA; also see www.aes.org. All rights reserved. Reproduction of this paper, or any portion thereof, is not permitted without direct permission from the Journal of the Audio Engineering Society.

The Influence of Listeners' Experience, Age, and Culture on Headphone Sound Quality Preferences

Sean E. Olive[1], Todd Welti[2], and Elisabeth McMullin[3]

Harman International, Northridge, CA, 91329, USA

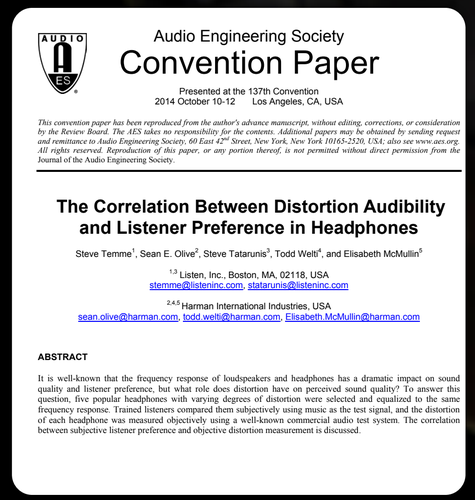
[1] Sean.Olive@harman.com

[2] Todd.Welti@harman.com

[3] Elisabeth.McMullin@harman.com

ABSTRACT

Double-blind headphone listening tests were conducted in four different countries (Canada, USA, China and Germany) involving 238 listeners of different ages, gender and listening experiences. Listeners gave comparative preference ratings for three popular headphones and a new reference headphone that were virtually presented through a common replicator headphone equalized to match their measured frequency responses. In this way, biases related to headphone brand, price, visual appearance and comfort were removed from listeners' judgment of sound quality. On average, listeners preferred the reference headphone that was based on the in-room frequency response of an accurate loudspeaker calibrated in a reference listening room. This was generally true regardless of the listener's experience, age, gender and culture. This new evidence suggests a headphone standard based on this new target response would satisfy the tastes of most listeners.



Audio Engineering Society

Convention Paper

Presented at the 137th Convention
2014 October 10-12 Los Angeles, CA, USA

This convention paper has been reproduced from the author's advance manuscript, without editing, corrections, or consideration by the Review Board. The AES takes no responsibility for the contents. Additional papers may be obtained by sending request and remittance to Audio Engineering Society, 60 East 42nd Street, New York, New York 10165-2520, USA; also see www.aes.org. All rights reserved. Reproduction of this paper, or any portion thereof, is not permitted without direct permission from the Journal of the Audio Engineering Society.

The Correlation Between Distortion Audibility and Listener Preference in Headphones

Steve Temme[1], Sean E. Olive[2], Steve Tatarunis[3], Todd Welti[4], and Elisabeth McMullin[5]

[1,3] Listen, Inc., Boston, MA, 02118, USA
stemme@listeninc.com, statarunis@listeninc.com

[2,4,5] Harman International Industries, USA
sean.olive@harman.com, todd.welti@harman.com, Elisabeth.McMullin@harman.com

ABSTRACT

It is well-known that the frequency response of loudspeakers and headphones has a dramatic impact on sound quality and listener preference, but what role does distortion have on perceived sound quality? To answer this question, five popular headphones with varying degrees of distortion were selected and equalized to the same frequency response. Trained listeners compared them subjectively using music as the test signal, and the distortion of each headphone was measured objectively using a well-known commercial audio test system. The correlation between subjective listener preference and objective distortion measurement is discussed.

Audio Engineering Society

Convention Paper

Presented at the 133rd Convention
2012 October 26–29 San Francisco, CA, USA

The Relationship between Perception and Measurement of Headphone Sound Quality

Sean E. Olive[1] and Todd Welti[2]

[1] Harman International, Northridge, CA, 91329, USA
sean.olive@harman.com

[2] Harman International, Northridge, CA,91329, USA
todd.welti@harman.com

ABSTRACT

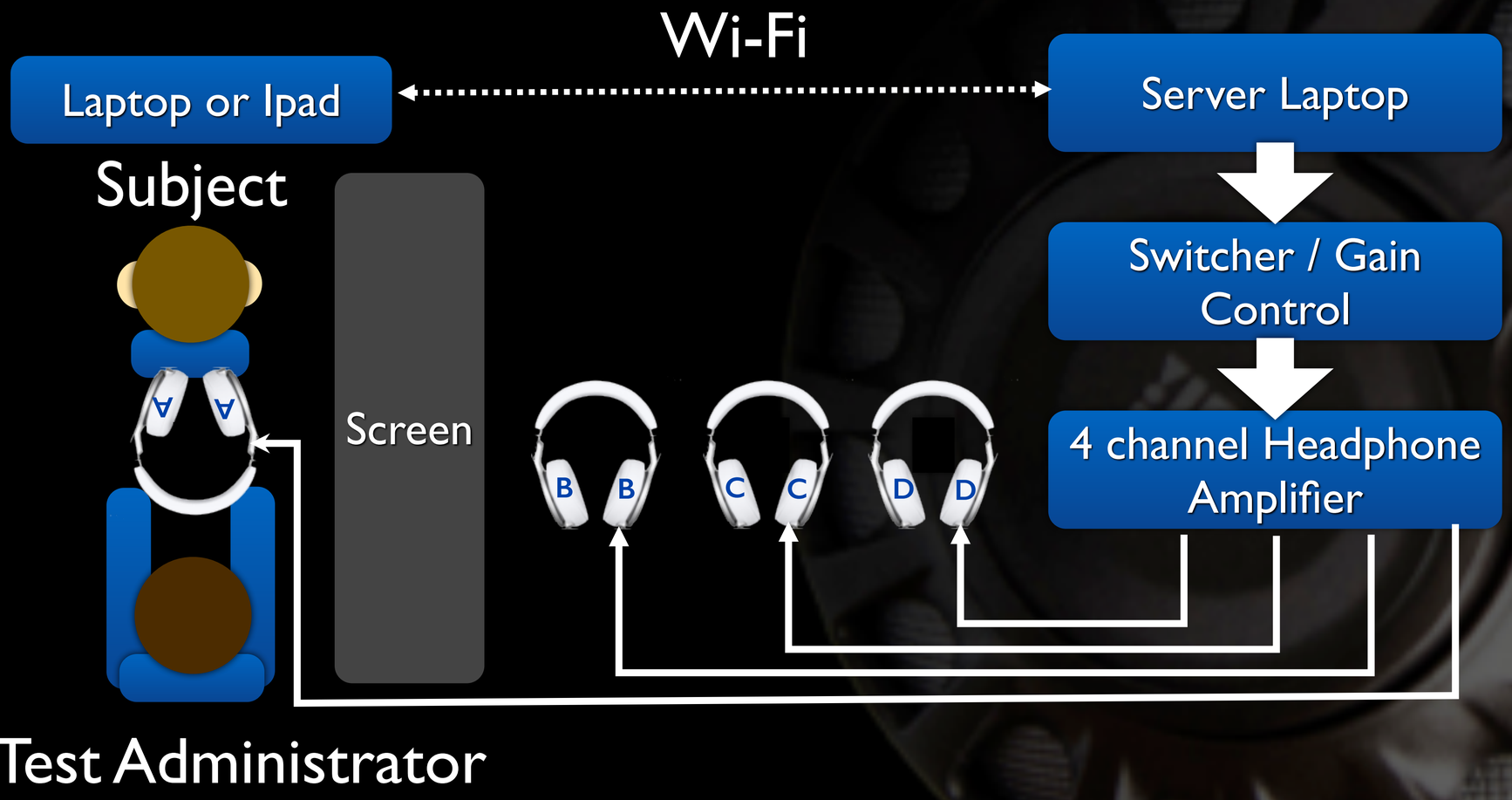
Double-blind listening tests were performed on six popular circumaural headphones to study the relationship between their perceived sound quality and their acoustical performance. In terms of overall sound quality, the most preferred headphones were perceived to have the most neutral spectral balance with the lowest coloration. When measured on an acoustic coupler, the most preferred phones produced the smoothest and flattest amplitude response, a response that deviates from the current IEC recommended diffuse-field calibration. The results provide further evidence that the IEC 60268-7 headphone calibration is not optimal for achieving the best sound quality.

Do trained listeners agree on what makes a headphone sound good?

Headphones Tested

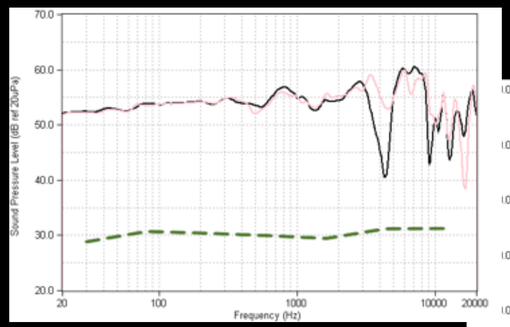
Brand / Model		Price
AKG K701		$278
AKG K550		$245
Audeze LCD2 (rev 2)		$995
Beats by Dre Studio Limited Edition		$270
Bose Quiet Comfort 15		$299
V-Moda Crossfade LP		$115

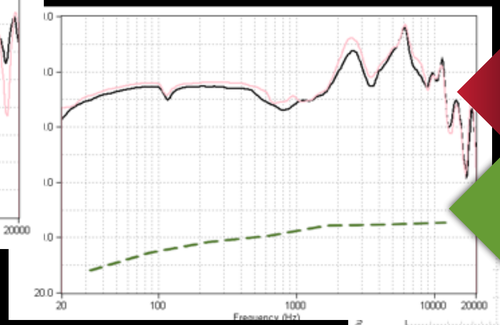
Double-Blind Test Method



The influence of visual & psychological biases (e.g. brand, price, appearance and celebrity endorsement) were removed from listeners' judgement of sound quality

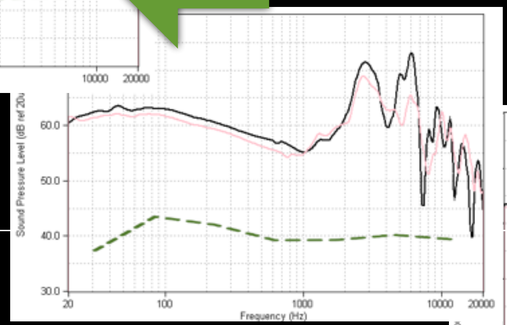
Even the most popular headphones are quite different in terms of their measured and perceived spectral balance

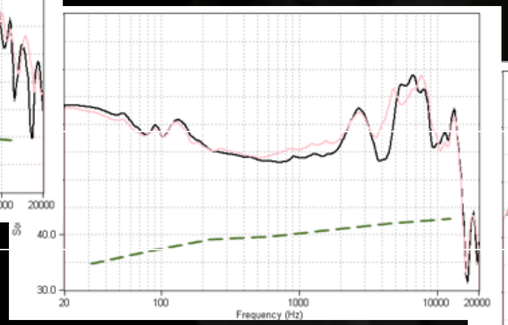


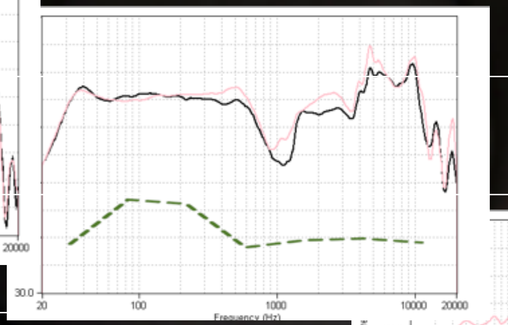


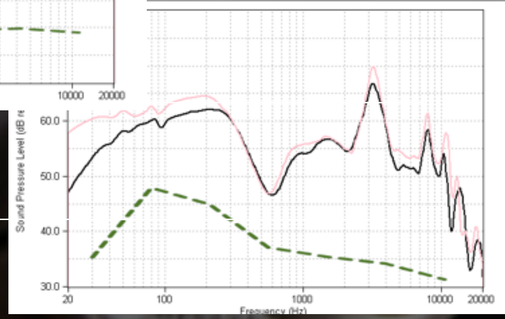
measured response in GRAS ear simulator

perceived spectral balance by trained listeners









Conclusions

Good agreement among listeners on headphone preferences

Listeners preferred the headphones with the most neutral and balanced sound

Strong correlation between headphones' measured frequency response and it's perceived spectral balance and preference rating

The fit (bass leakage) of the headphone on individual listeners affected the perceived bass/spectral balance and preference rating

Audio Engineering Society

Convention Paper

Presented at the 134th Convention
2013 May 4–7 Rome, Italy

Listener Preference For Different Headphone Target Response Curves

Sean E. Olive[1], Todd Welti[2], and Elisabeth McMullin[3]

Harman International, Northridge, CA, 91329, USA

[1] sean.olive@harman.com

[2] todd.welti@harman.com

[3] elisabeth.mcmullin@harman.com

ABSTRACT

There is little consensus among headphone manufacturers on the preferred headphone target frequency response required to produce optimal sound quality for reproduction of stereo recordings. To explore this topic further, we conducted two double blind listening tests in which trained listeners rated their preferences for 8 different headphone target frequency responses reproduced using two different models of headphones. The target curves included the diffuse-field and free-field curves in ISO 11904-2, a modified diffuse-field target recommend by Lorho, the unequalized headphone, and a new target response based on acoustical measurements of a calibrated loudspeaker system in a listening room. For both headphones, the new target based on the in-room loudspeaker response was the most preferred headphone target response curve.

Is there a better sounding headphone target response curve than the current recommended standards?

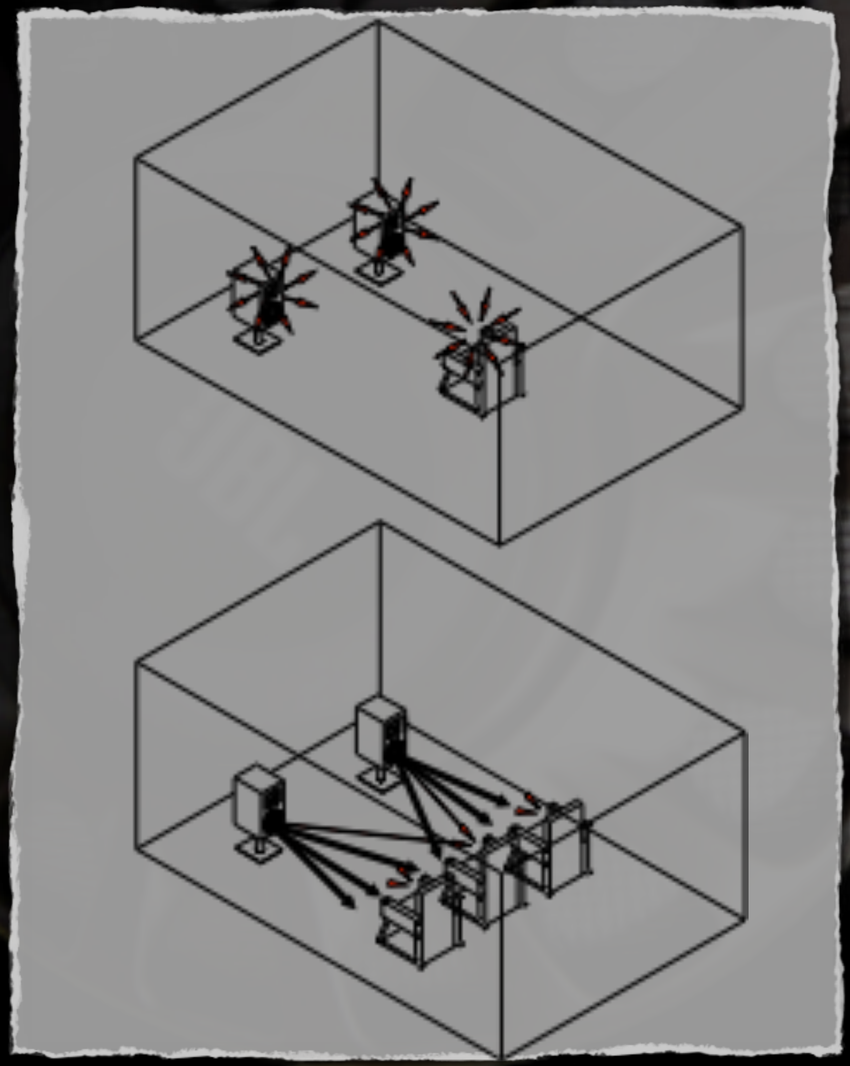
Current Popular Headphone Target Responses

Diffuse Field Calibration

Based on the premise that the headphone should produce the same acoustic response at the ear drum as a loudspeaker in a diffuse sound field

Free-field Calibration

Based on the premise that the headphone should produce the same acoustic response at the ear drum as a loudspeaker in a free field (e.g. anechoic chamber)

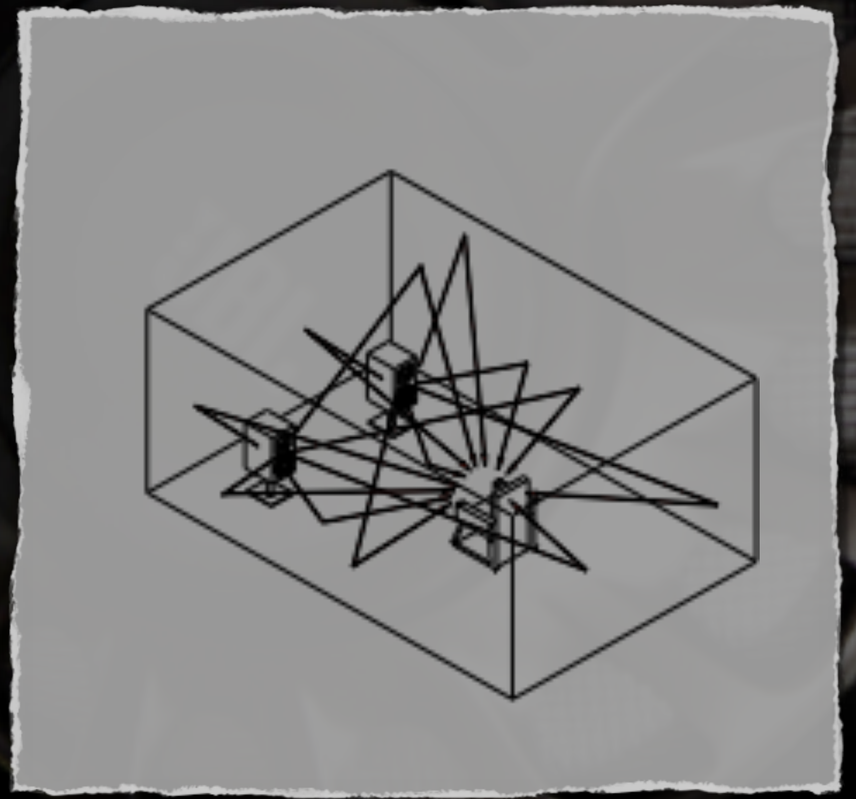


Current Headphone Target Responses Are Based on a Flawed Premise

Typical listening rooms are *neither* diffuse nor free field but somewhere in between, containing both direct, early and late reflected sounds

Listening rooms provide bass reinforcement from standing waves and boundaries effects that are not accounted for in the diffuse and free-field target responses

Therefore, headphones calibrated to DF and FF target responses will sound too bright and too thin in the bass



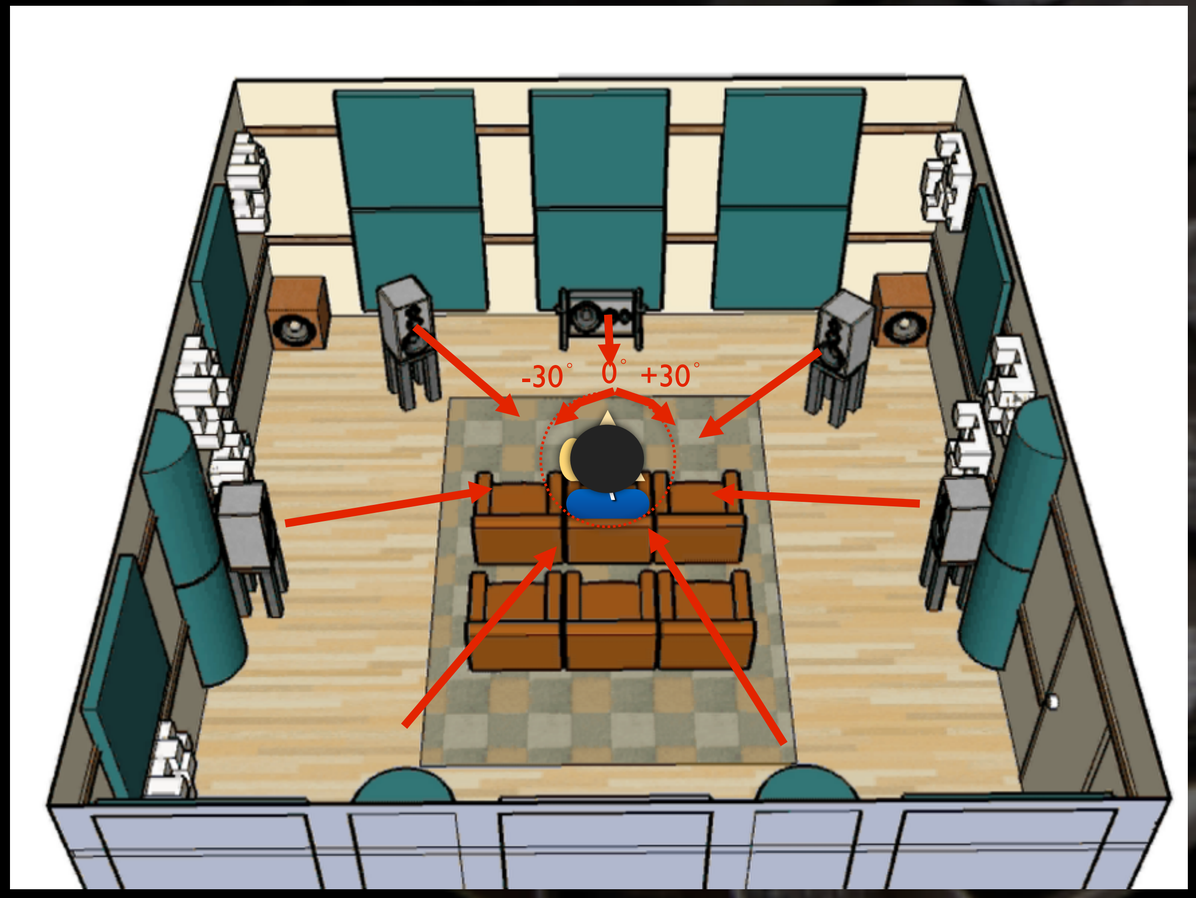
Our Hypothesis: A Headphone's Target Response Should Ideally Approximate an Accurate Loudspeaker in a Reference Listening Room

Our simple logic is as follows:

Since stereo recordings are optimized to sound best through loudspeakers in rooms...

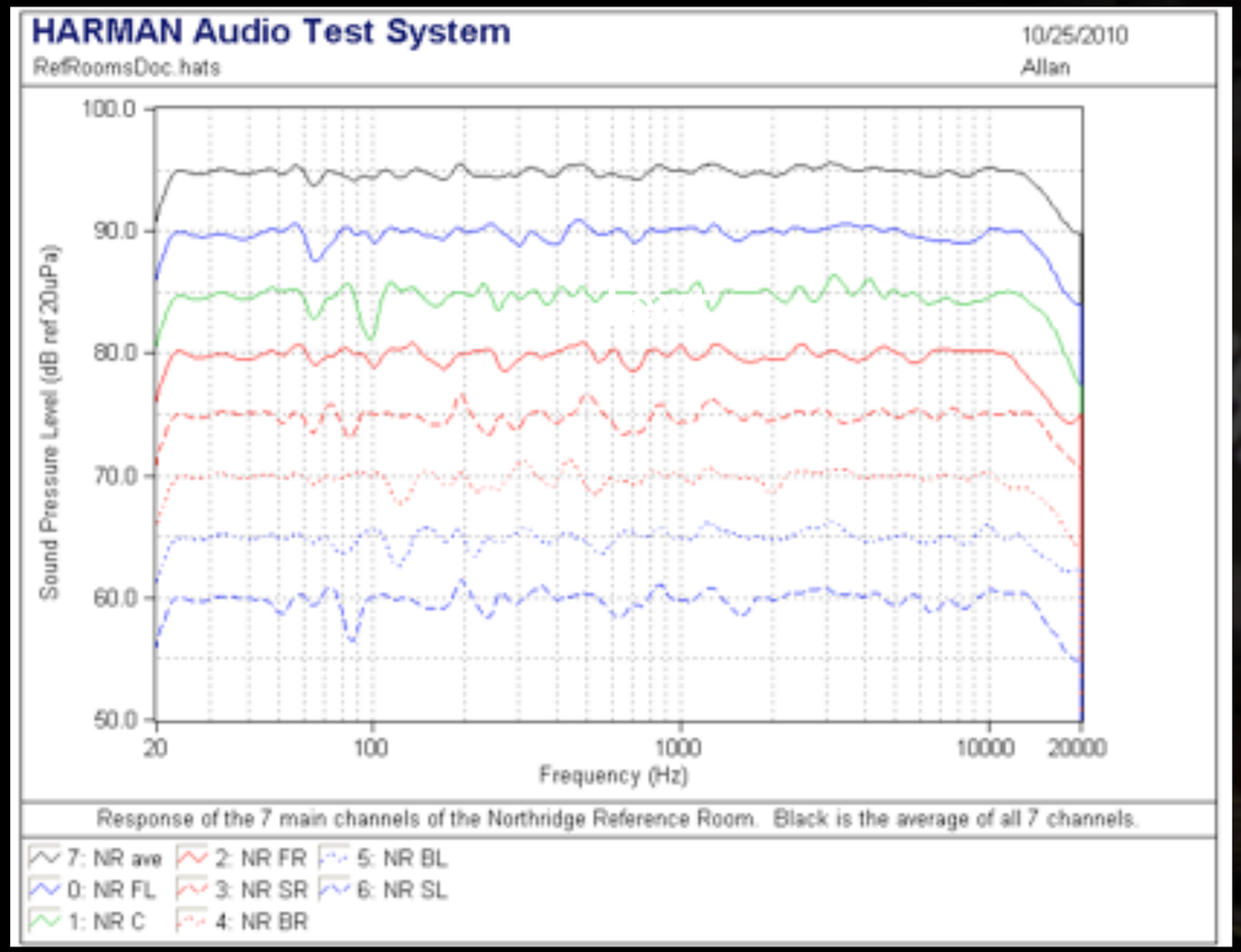
.. stereo recordings will sound best when reproduced through headphones that simulate the in-room response of a well-designed loudspeaker system calibrated in a reference listening room

Harman Reference Listening Room



Measuring the in-room loudspeaker response

Response For 7 Channels Averaged Across 6 seats <u>Before</u> Target Curve EQ Are Applied



avg. 7 channels

L

C

R

LS

RR

RL

RS

Headphone Target Curves Tested

Equalization	Description
No EQ	Headphone with no EQ
DF_MH	Diffuse-field target based on Hammershöi & Möller [7]
DF_M	Diffuse-field target response based on Möller [8]
DL_L	A modified diffuse-field calibration based on Lorho [4]
FF	A free-field calibration based on Hammershöi & Möller [7]
JBL Target 1	Based on measurements of JBL Pro LSR loudspeakers in Harman Reference Room
JBL Target 2	Same as above with modified in-room target curve with slightly less bass and treble

JBL by HARMAN

Listening Test Design

Sennheiser HD 518 ($120)

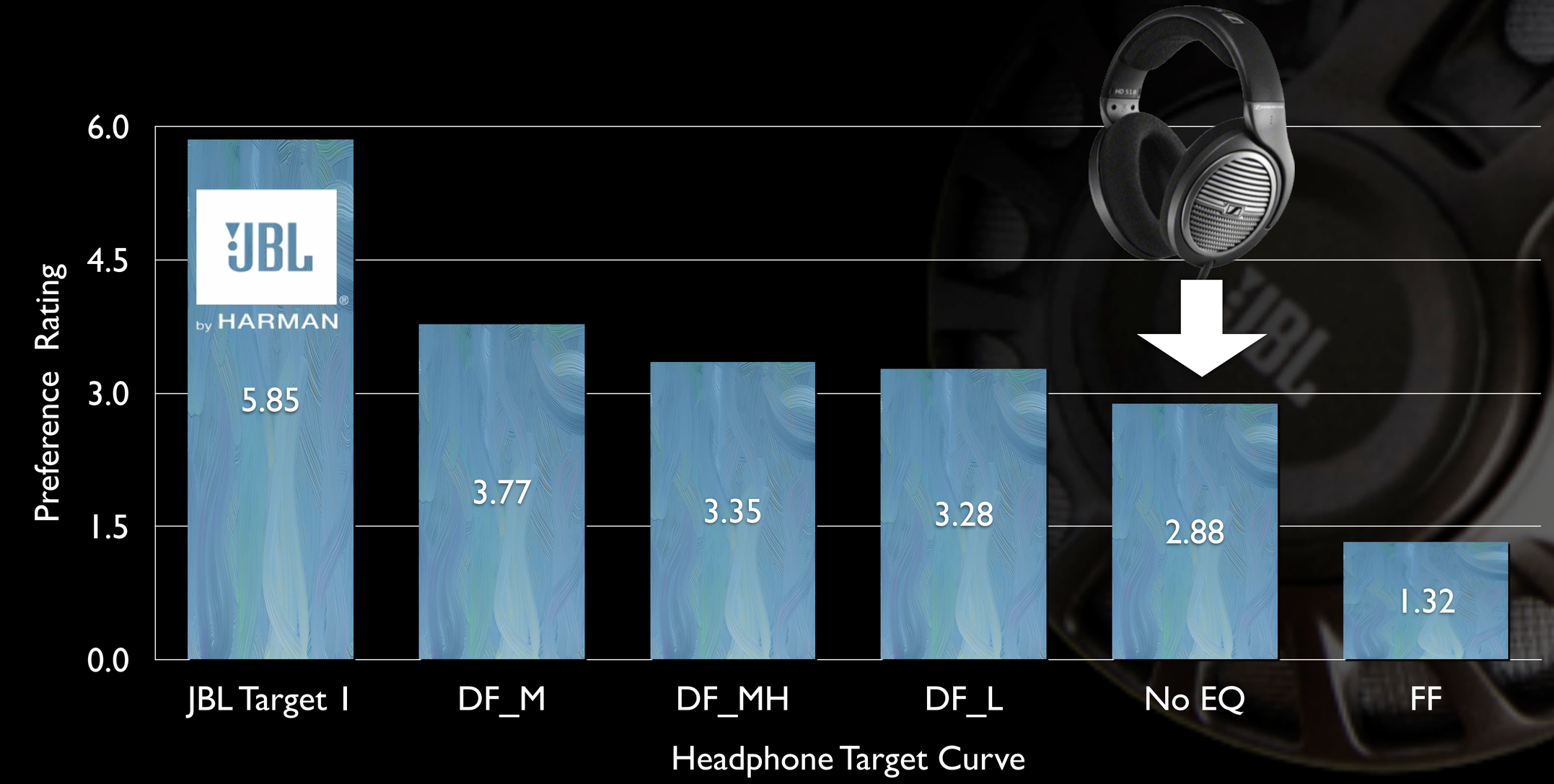
Audeze LCD2 ($995)

Each target curve was rated by trained listeners based on preference using three music programs with one repeat

The test was repeated using two different headphones equalized to the different target responses

Results

Preferred Headphone Target Response



Preferred Headphone Target Response

Conclusions

The new Harman headphone target response based on an accurate loudspeaker in our reference listening room was *strongly preferred* to both diffuse and free-field target responses, and the unequalized headphones (Sennheiser and Audeze).

Listeners reported that the new target response had the most neutral and balanced sound with natural bass that was not boomy or muddy

Audio Engineering Society

Convention Paper

Presented at the 135th Convention
2013 October 17–20 New York, NY, USA

Listener Preferences for In-Room Loudspeaker and Headphone Target Responses

Sean E. Olive[1], Todd Welti[2], and Elisabeth McMullin[3]

[1] Harman International Industries Inc., Northridge, CA, 91329, USA

[1] sean.olive@harman.com

[2] todd.welti@harman.com

[3] elisabeth.mcmullin@harman.com

ABSTRACT

Based on preference, listeners adjusted the relative bass and treble levels of three music programs reproduced through a high quality stereo loudspeaker system equalized to a flat in-room target response. The same task was repeated using a high quality circumaural headphone equalized to match the flat in-room loudspeaker response as measured at the eardrum reference point (DRP). The results show that listeners on average preferred an in-room loudspeaker target response that had 2 dB more bass and treble compared to the preferred headphone target response. There were significant variations in the preferred bass and treble levels due to differences in individual taste and listener training.

Do listeners agree on the preferred in-room loudspeaker and headphone target responses?

Are they the same?

Methodology

Preferred In-Room Loudspeaker Target Response

Choose an accurate loudspeaker and equalize it to a flat in-room response in a refernece listening room

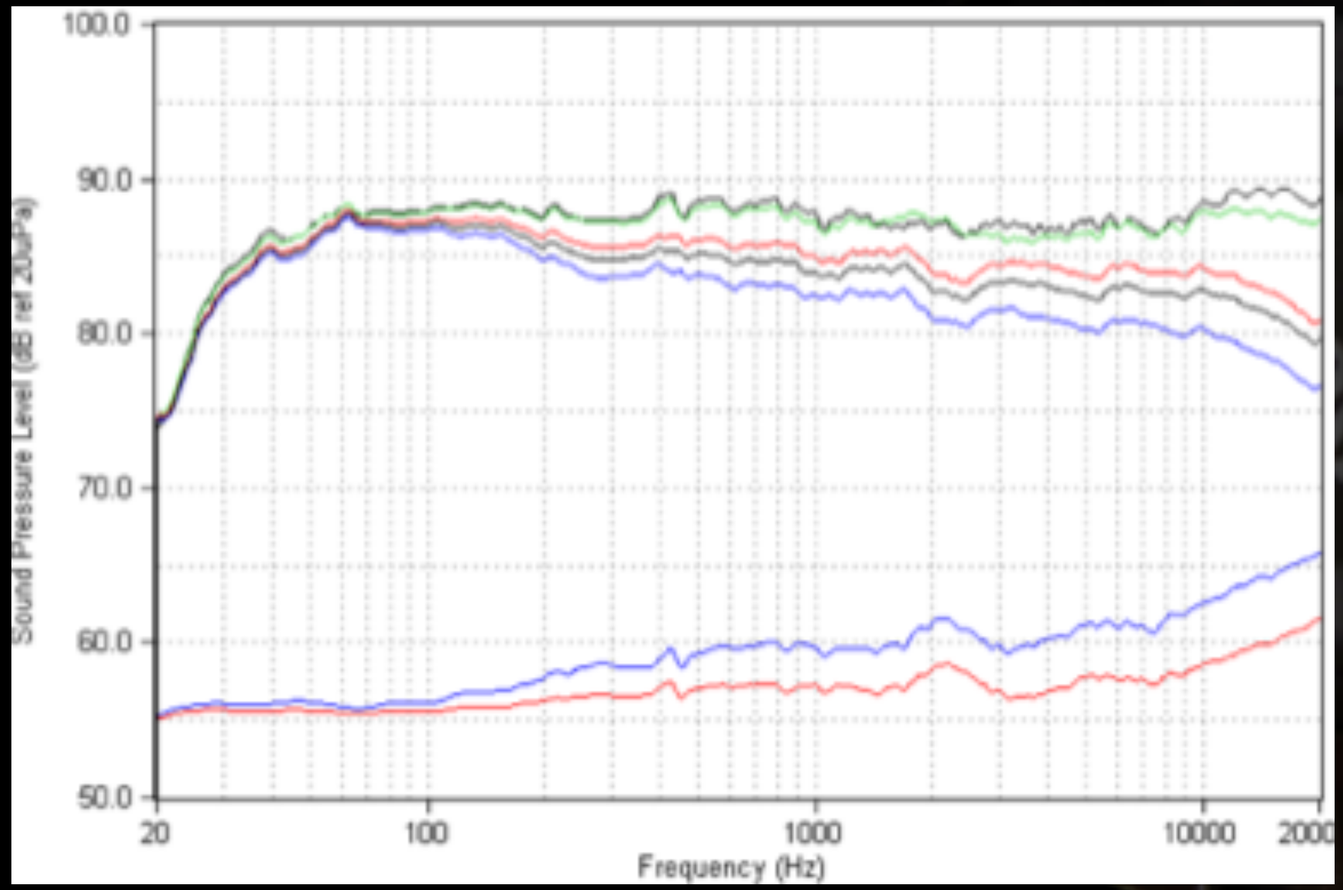
Listeners adjust the bass and treble levels to their preferred level (single versus two parameters)

Preferred In-Room Headphone Target Response

Equalize an accurate headphone to the same flat response as loudspeaker at Ear Drum Reference point (EDR)

Listeners adjust the bass and treble levels to their preferred level (single versus two parameters)

Loudspeaker: Revel F208

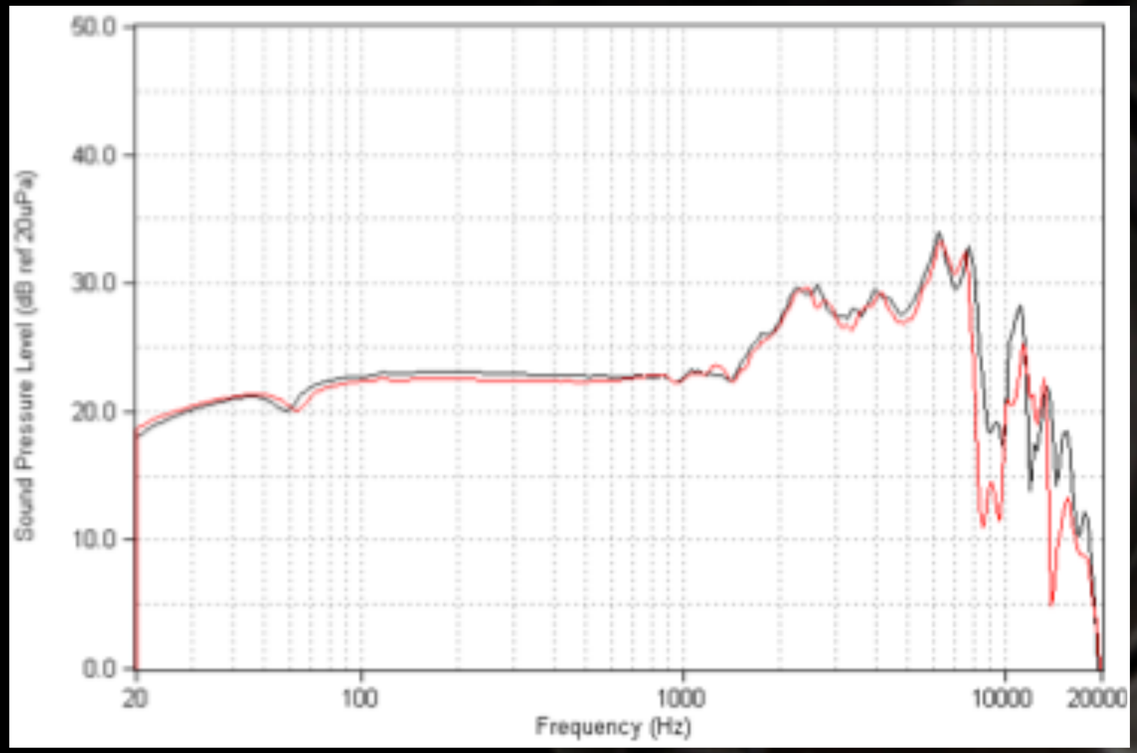


Listening Window
First Reflections

Sound power

Sound Power DI
First Reflections DI

Headphone: Sennheiser HD800



Measured on a GRAS 45 CA Test Fixture with IEC 60711 simulator and KB0071 pinnae

Harman Reference Room

Standardized room for listener training, research and product evaluation

Quiet with adjustable acoustics

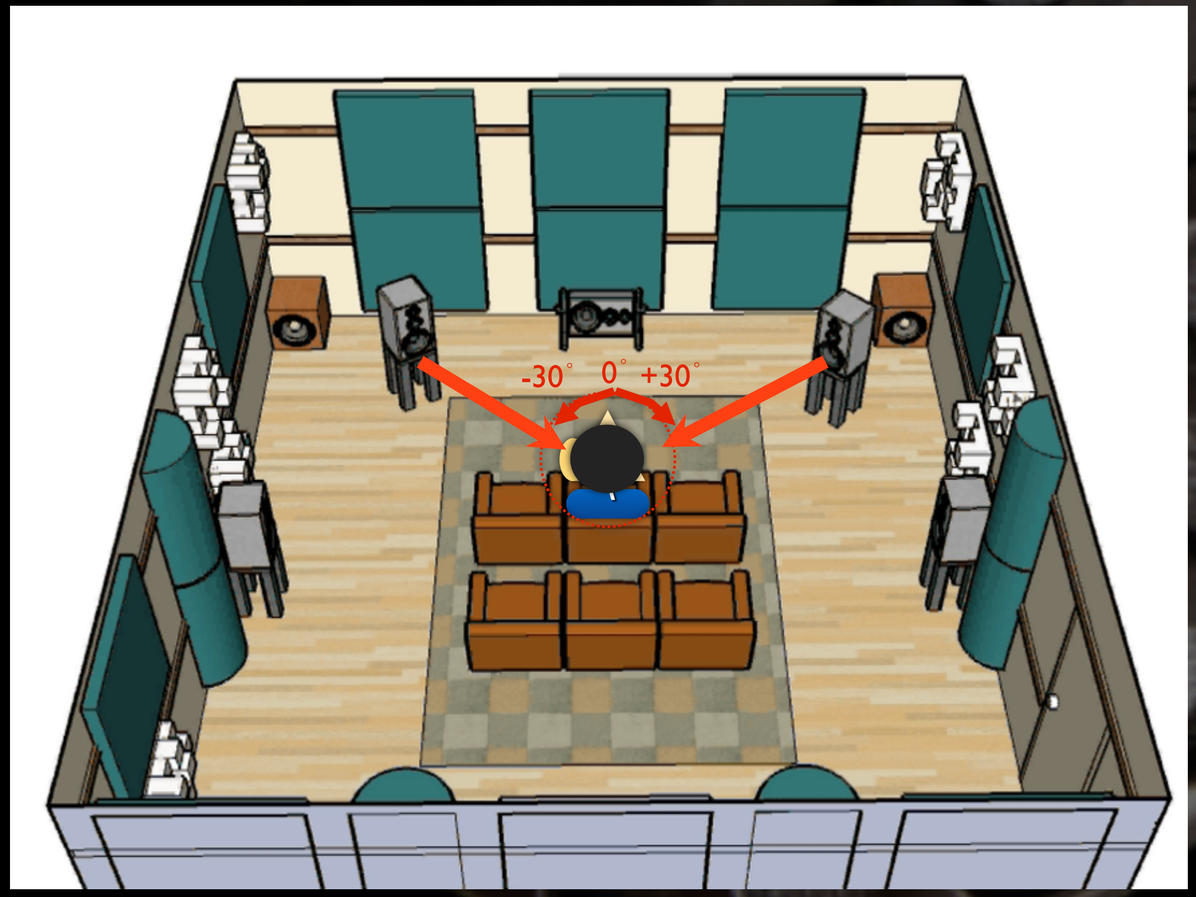
Semi-reflective with average RT60 of 0.4 s

Automated speaker mover integrated into wall

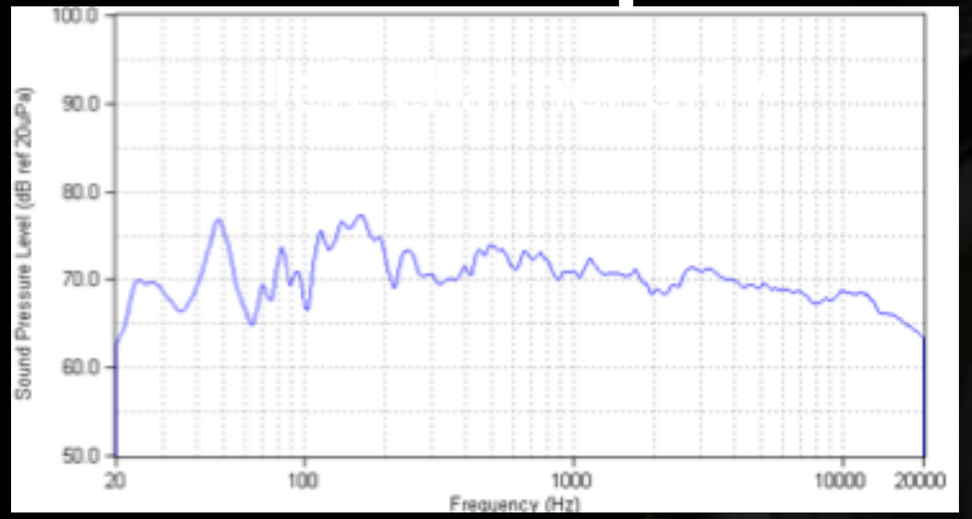
Equalizing The In-Room Loudspeaker Response

Stereo loudspeakers were each measured at the primary listening seat using a 3 x 3 array of microphones to provide spatial-averaging

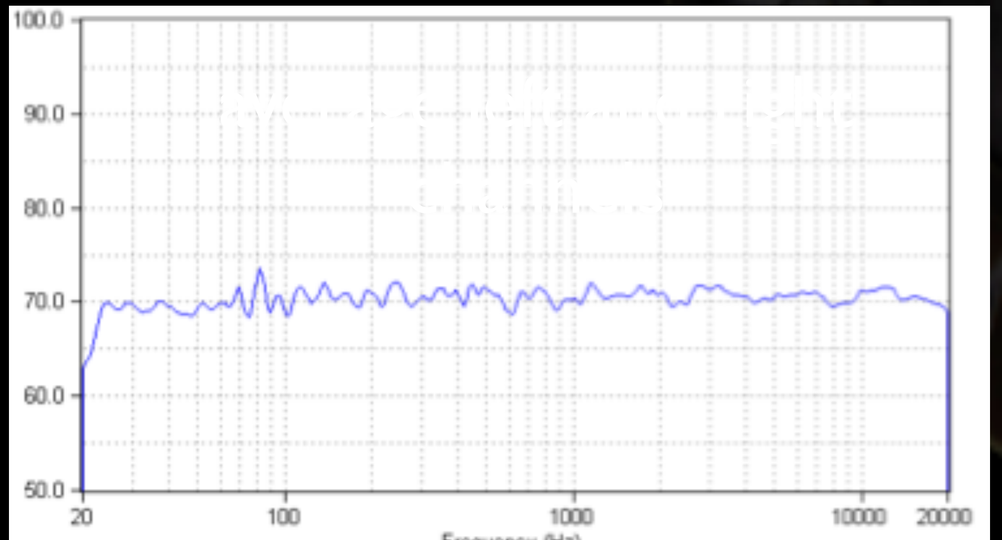
Equalized to a flat in-room response using the HATS auto-EQ



Equalizing the In-Room Loudspeaker Response to Flat

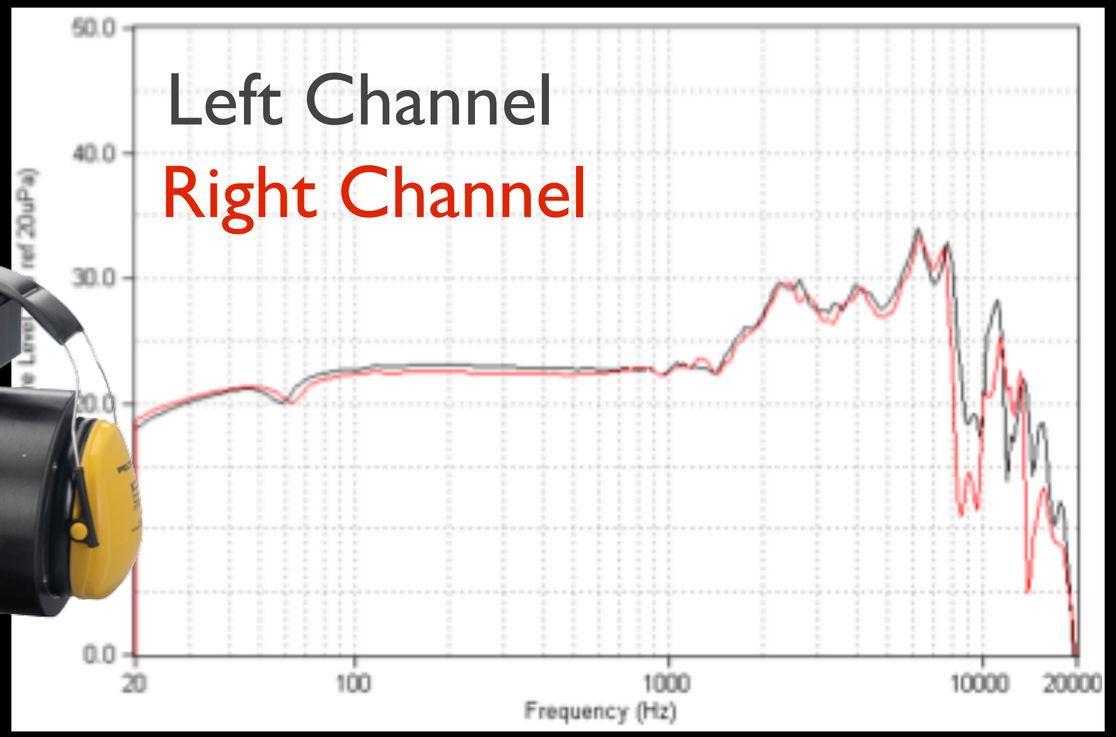


Before EQ

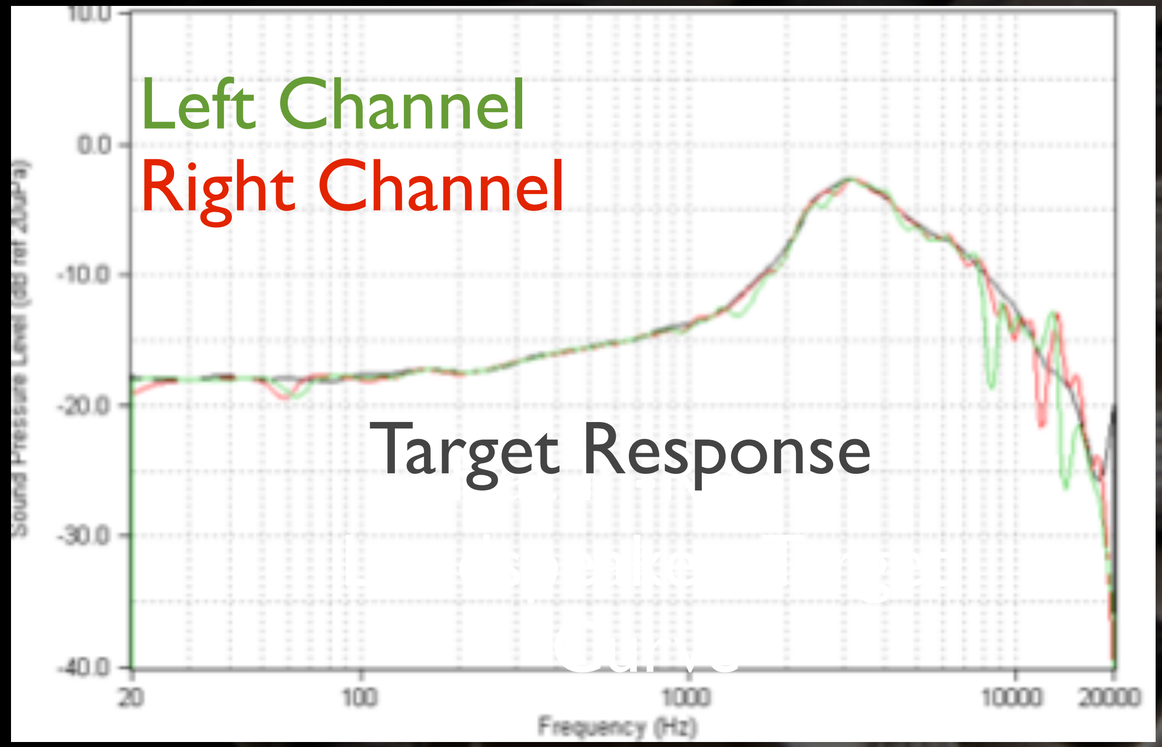


After EQ

Equalizing the Headphone to the In-Room Loudspeaker

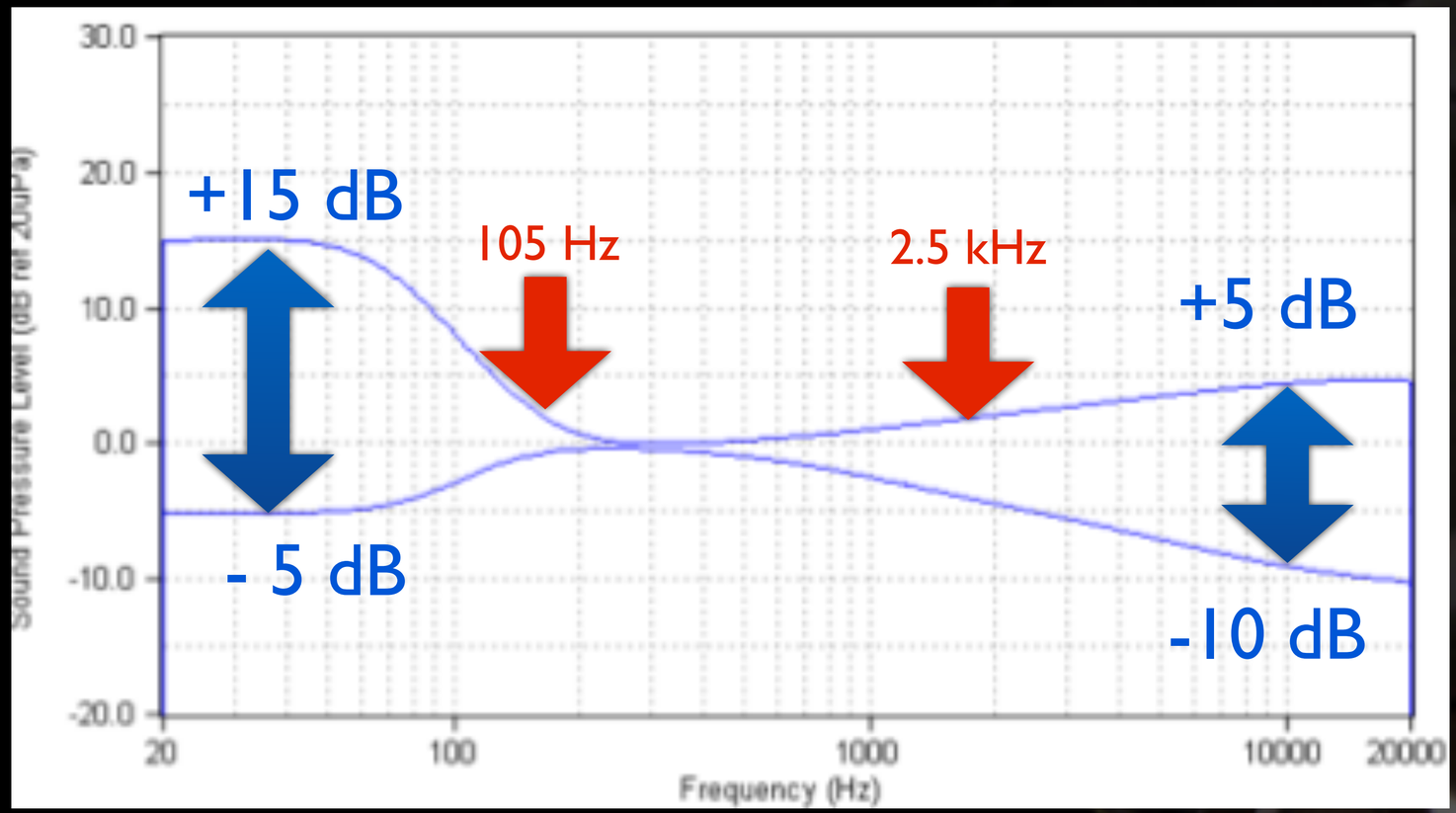


Before EQ



After EQ

Range of Bass and Treble Adjustments

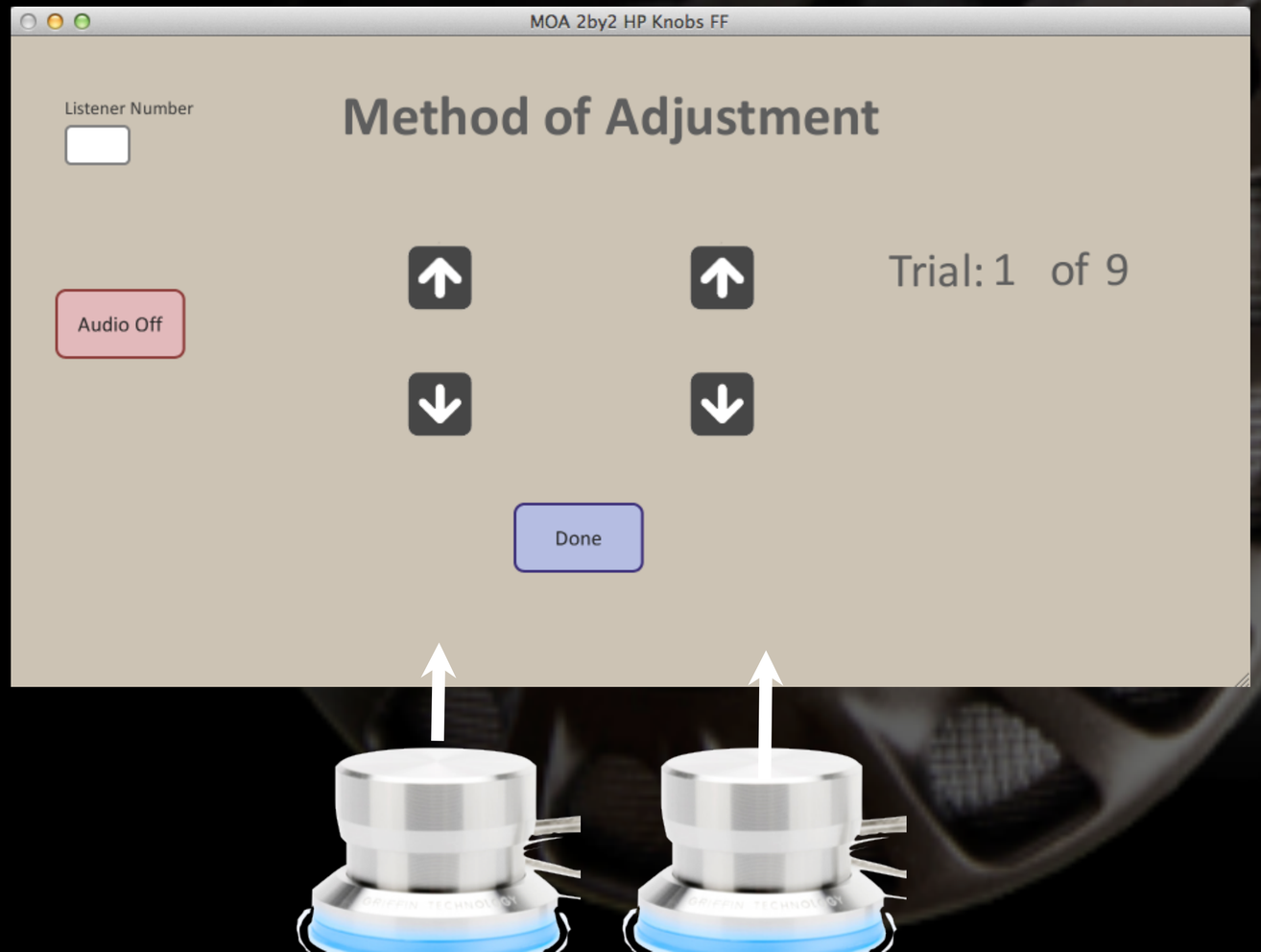


Adjustments made in 0.25 dB increments

MOA Listening Test Software

Custom software app written in Max to control listening experiments, adjust bass/treble filters based on user input

Stores all responses in mySQL database



USB Controller For Method of Adjustments

Griffin PowerMate USB assignable controller

Eliminates response biases related to position of volume control since volume has no detents and is endlessly rotatable

Software employs random-sized buffer when extreme values are reached

Two Powermates were used for two parameter MOA tests (bass + treble)

Listeners

11 listeners (8 males, 3 females)

Median age = 34 years; SD = 10 years

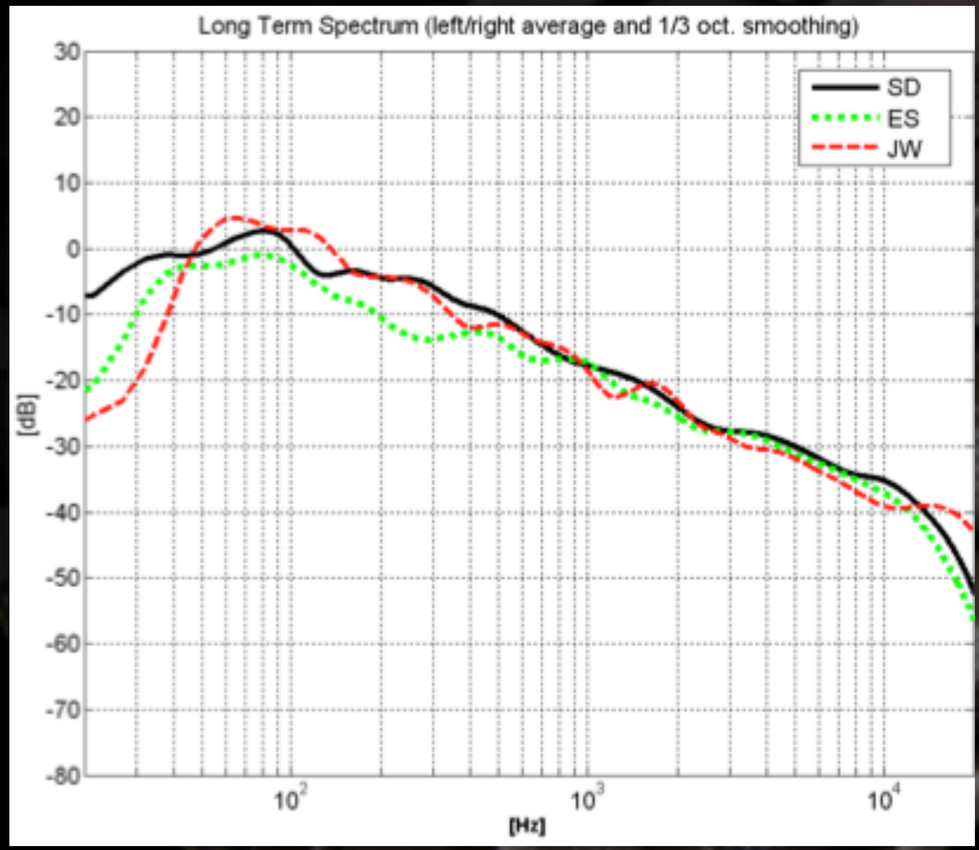
audiometric normal

Trained Listeners = 8 Harman employees

Untrained Listeners = 3 (one bass player; all under 30 years)

Programs

Program	Artist / Song / Album
JW	Jennifer Warnes / Bird on a Wire / BMG Records, 1989, B00000DN6J Female Pop Vocal
SD	Steely Dan / Cousin Dupree/ Two Against Nature / Giant Records/WEA, 2000, B00004GOXS
ES	Estelle w. Kayne West / American Boy Shine/ Atlantic Records, 2008, B00142Q7H8 Male / Female Hip Hop



Listening Test Procedure

Each subject completed 27 trials for each task

3 programs x 9 repeats = 27 trials

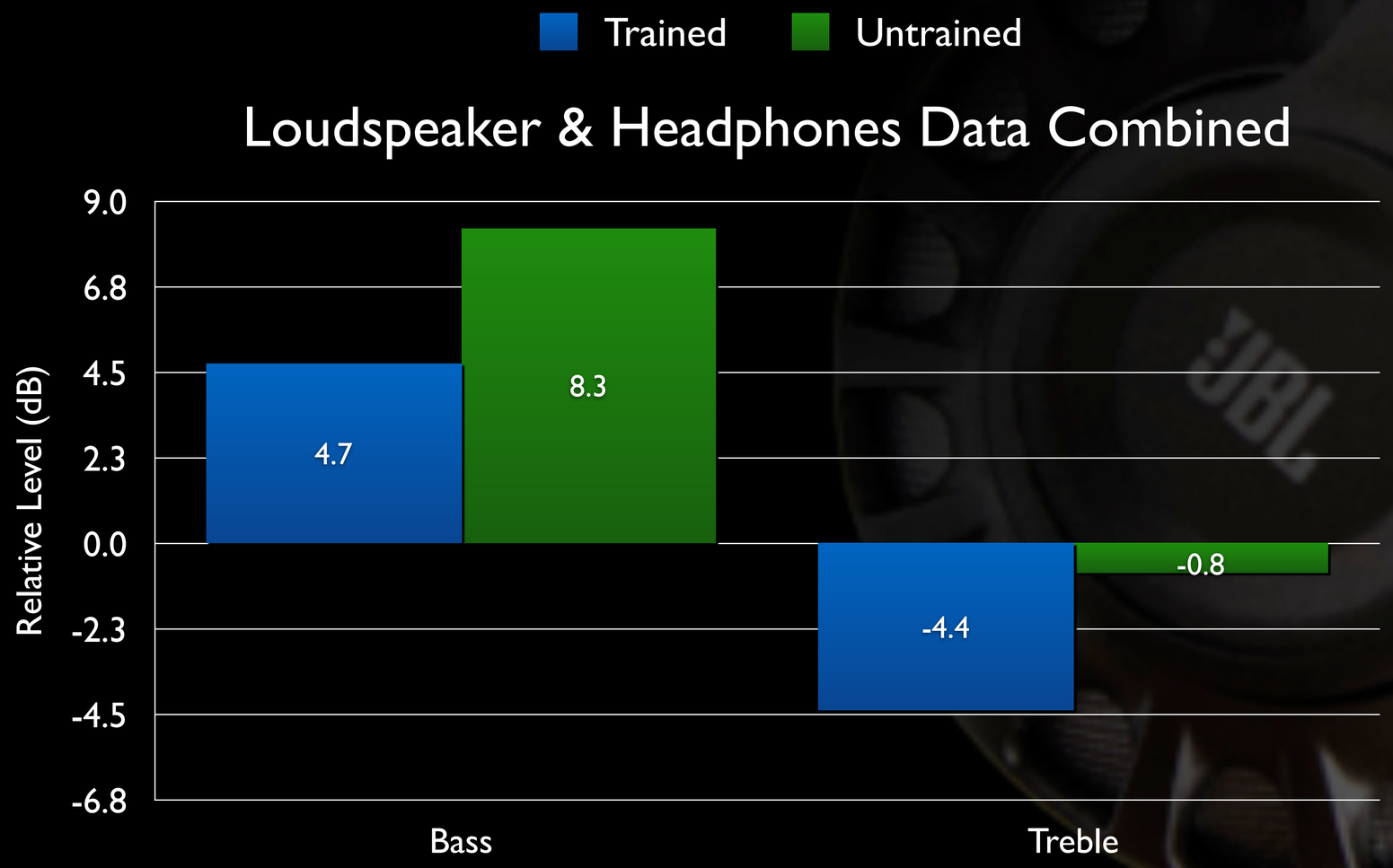
The mean preferred level is the average of 9 trials for each program

Approximately half the subjects did the loudspeaker task first and the other half headphones task first

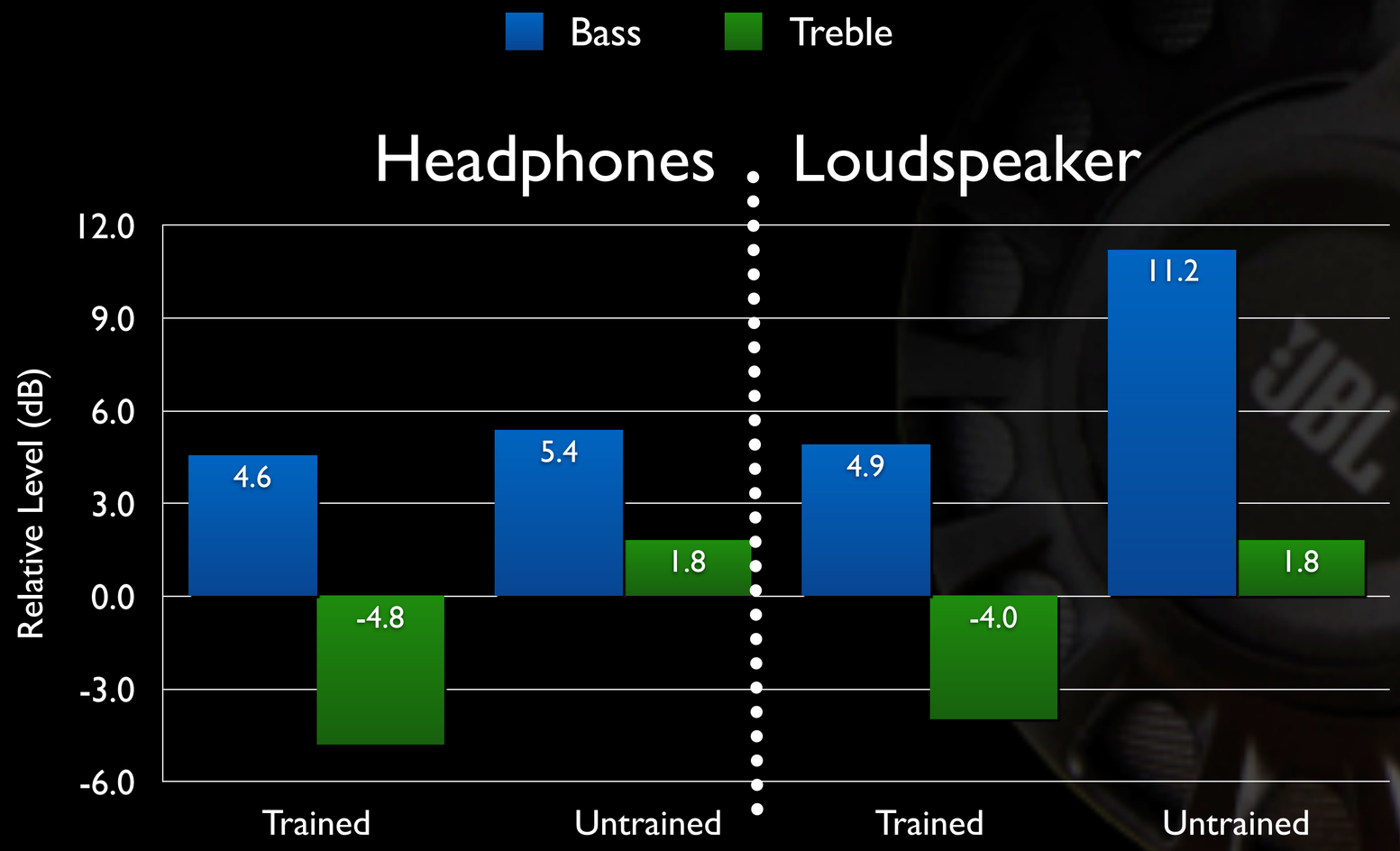
Order of tasks (single and two parameter tasks randomized)

Results for Two Parameter MOA Tests

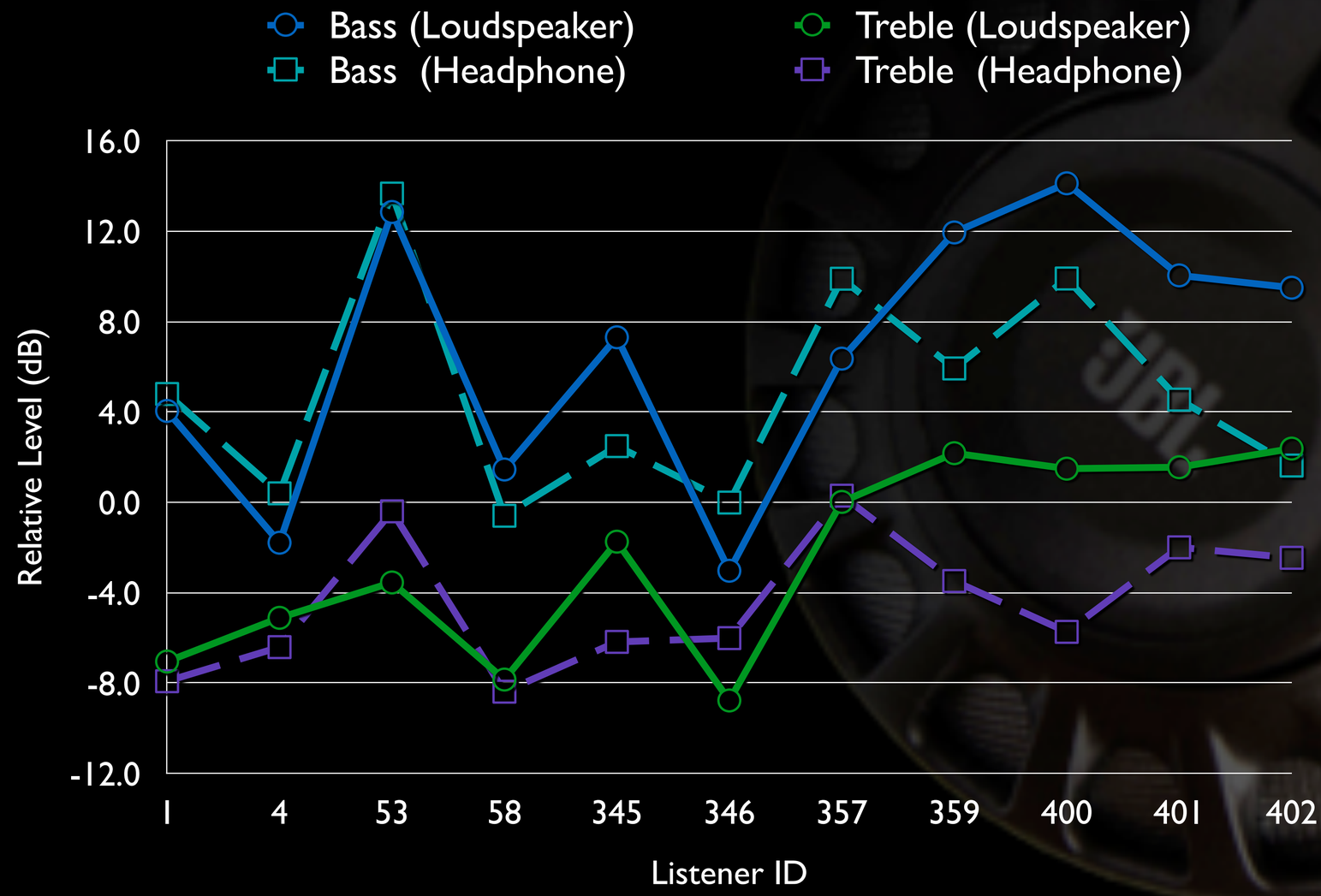
Effect of Listener Experience



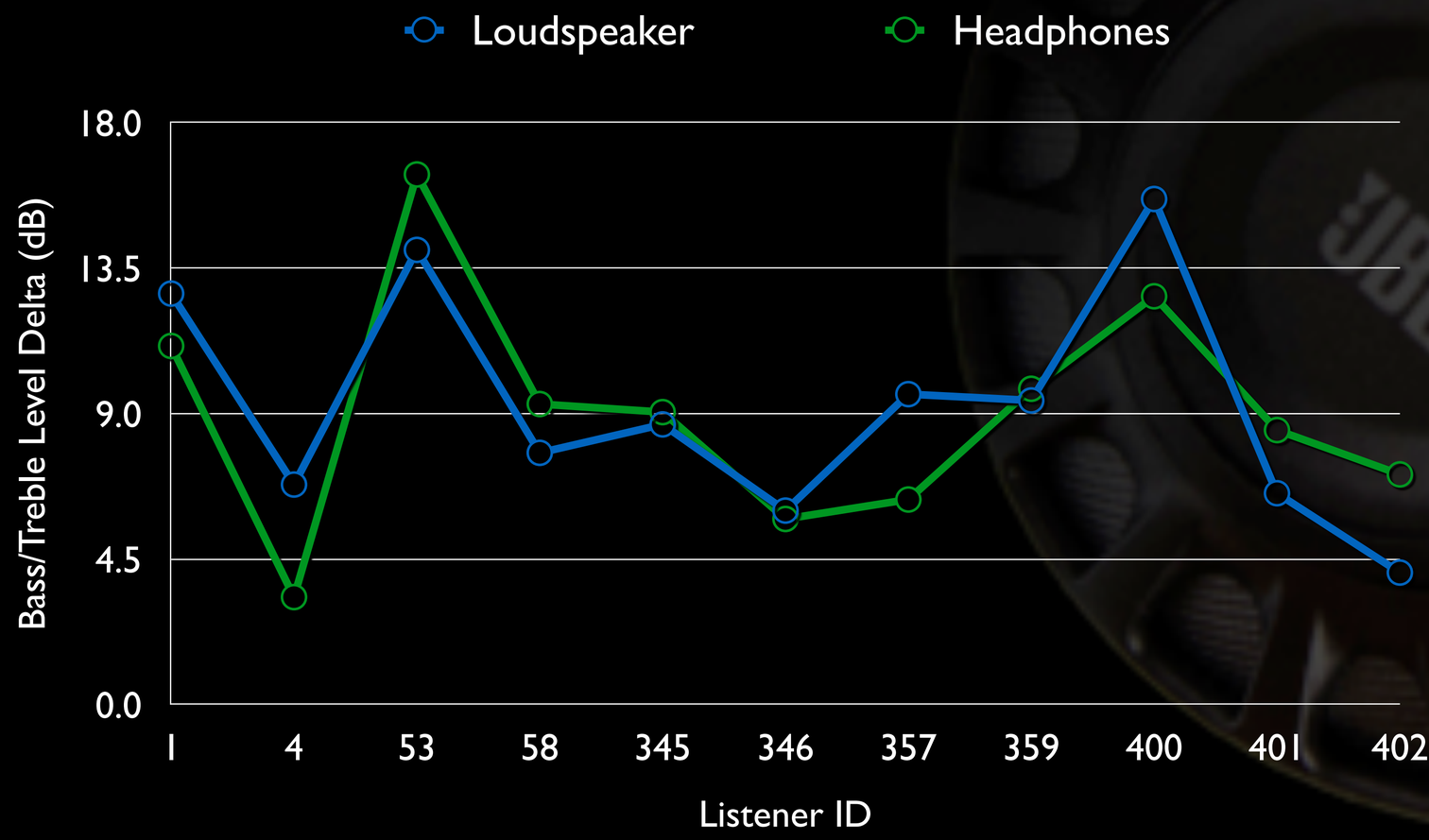
Effect of Listener Experience



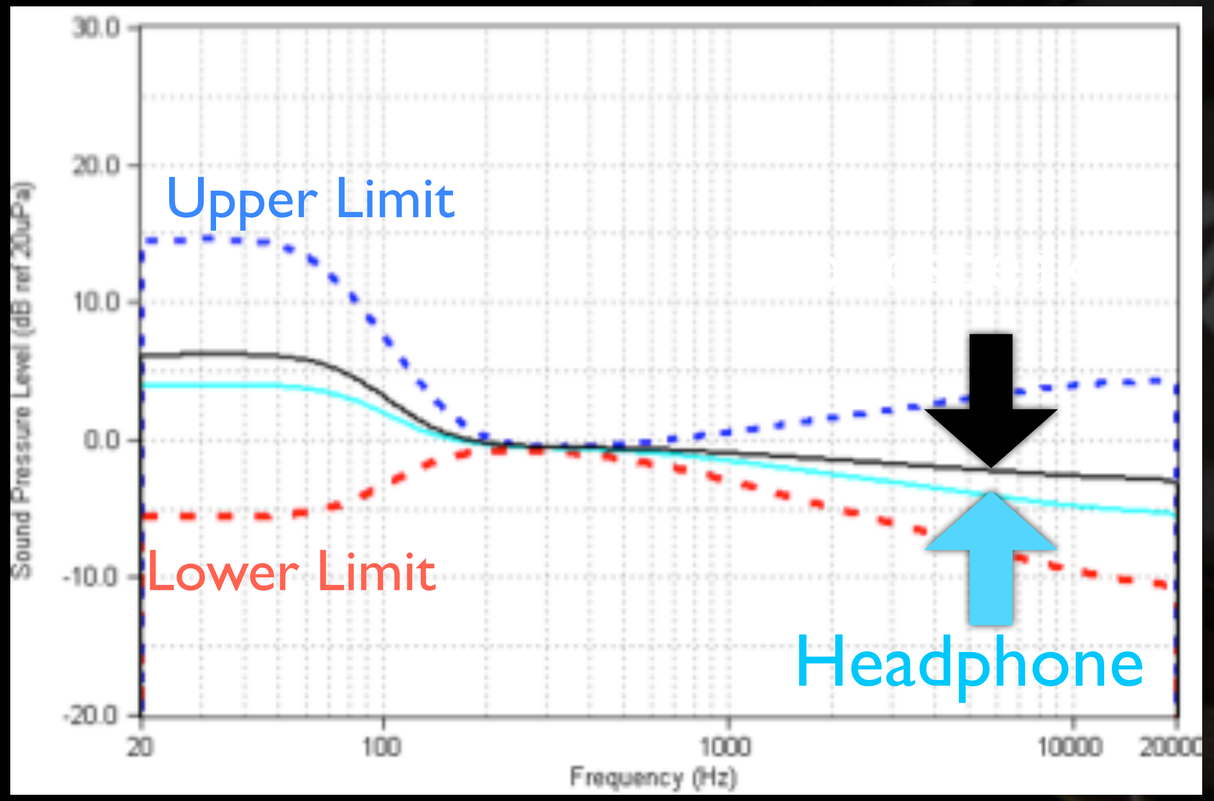
Loudspeaker Vs Headphone



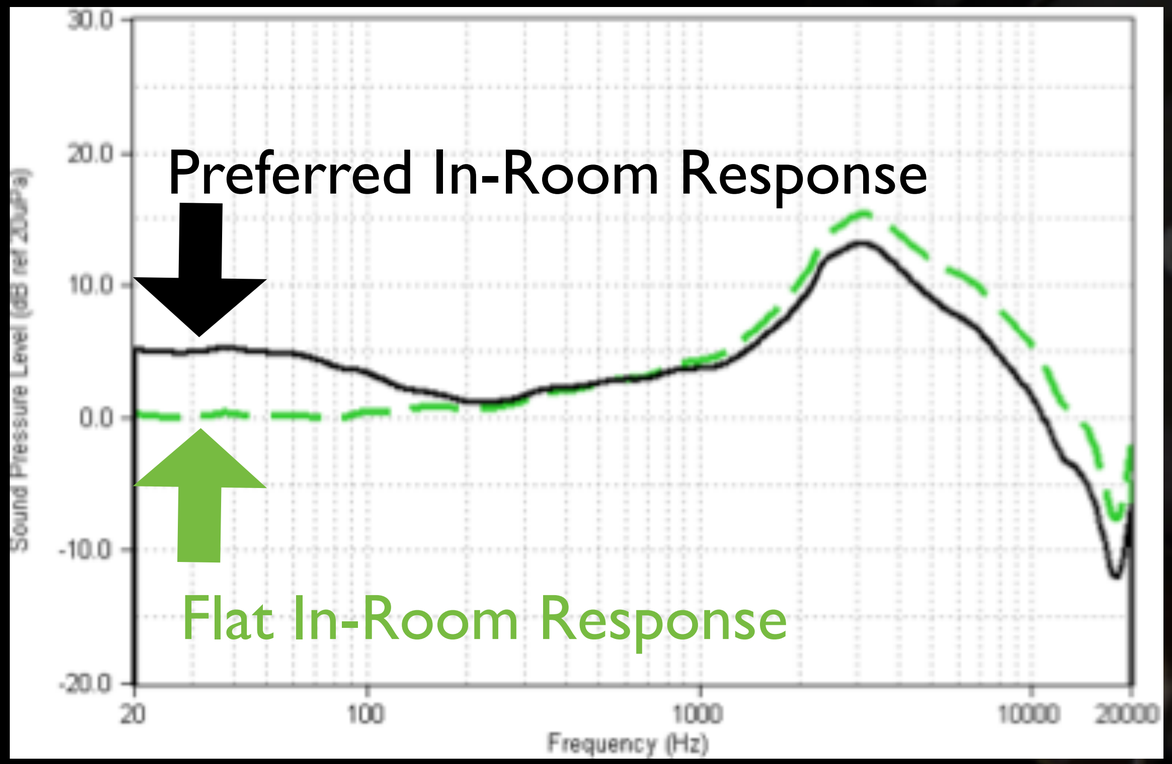
Preferred Delta Level (ie Bass - Treble Level)



Preferred In-Room Loudspeaker and Headphone Response

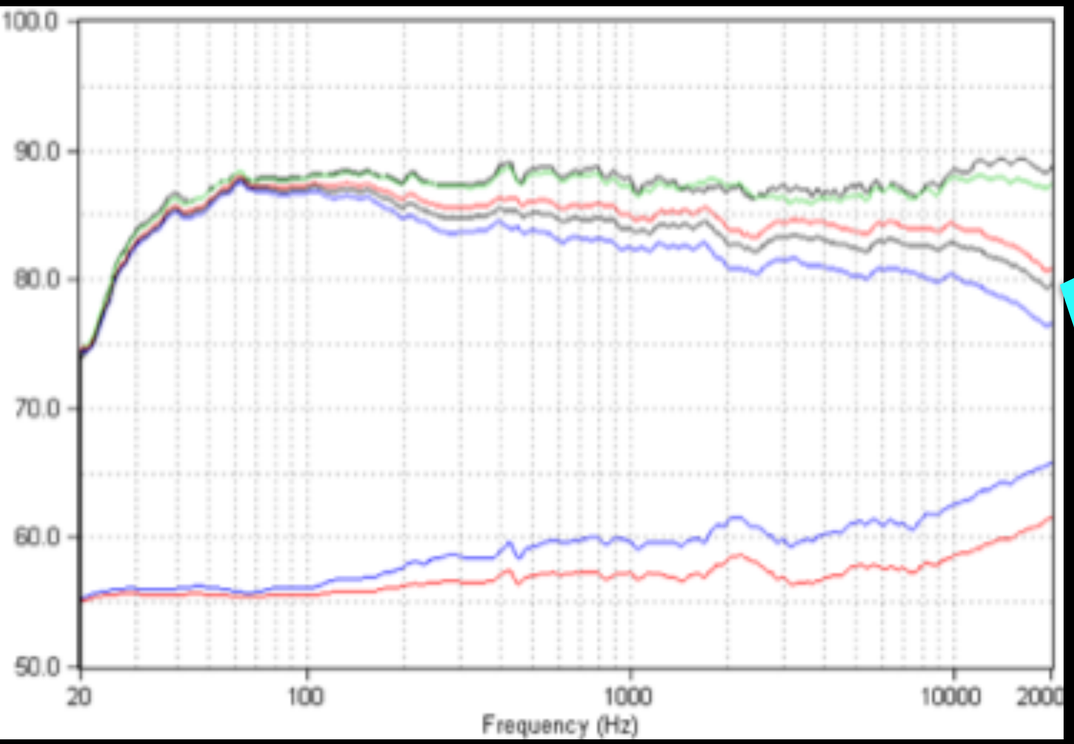


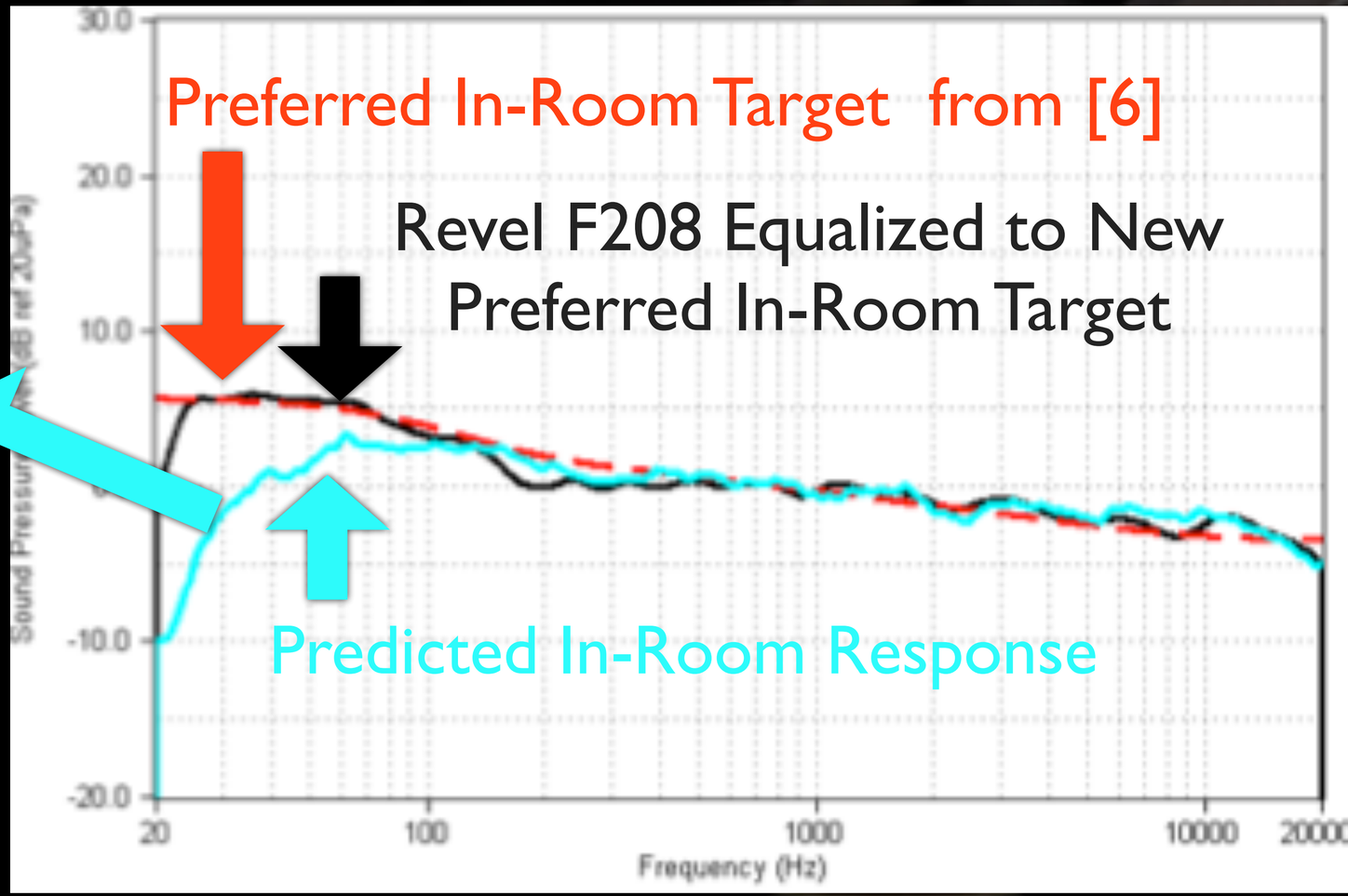
In-Room Response of Loudspeaker Set to Preferred Target Response



Preferred In-room Loudspeaker Response

Anechoic Measurements
of Revel F208





Conclusions

Preferred in-room loudspeaker response is not flat but has a bass boost about 6.6 dB @ 105 Hz and treble cut of -2.4 dB above 2.5 kHz

The general shape of the in-room target response approximates the sound power or predicted in-room response of a well-designed loudspeaker above 200 Hz

Below 200 Hz listeners prefer to hear some “room gain” probably because it was accounted for in the mixing/mastering of the recording

Conclusions

The preferred headphone target response closely approximates the preferred in-room loudspeaker response with about 2 dB less bass and treble.

The preferred bass and treble levels of the target function for loudspeakers and headphones varied among individual listeners (see Fig 14). For loudspeaker playback, the range of preferred bass and treble levels was 17 dB and 11 dB, respectively. For headphones the preferred bass and treble levels varied from 14 dB and 9 dB respectively.

Conclusions

Listeners tended to adjust their preferred level of bass and treble up and down using the same distance or delta between the bass and treble levels.

Listening experience had an influence on the preferred bass and treble levels. The preferred bass and treble levels were higher for untrained listeners than the trained listeners for both headphone and loudspeaker target responses.

Audio Engineering Society

AES 51st International Conference, Helsinki, Finland, 2013 August 22–24

A VIRTUAL HEADPHONE LISTENING TEST METHODOLOGY

SEAN E. OLIVE[1], TODD WELTI[2], AND ELISABETH MCMULLIN[3]

Harman International, Northridge, CA, USA
sean.olive@harman.com
todd.welti@harman.com
elisabeth.mcmullin@harman.com

Comparative listening tests on multiple headphones are challenging to conduct in a controlled, double-blind manner. One solution is to present the listener virtualized versions of the headphones through a single reference headphone that is equalized to simulate the linear magnitude response of the different headphones under test. This paper describes a method for conducting virtual headphone listening tests and presents results of a validation experiment where listener sound quality ratings from standard and virtual headphone listening tests are compared. The listening test results show good correlation between the two methods in terms of perceived spectral balance and overall preference.

INTRODUCTION

Comparative listening tests on headphones are challenging to conduct in a controlled, double-blind fashion. With some effort, the sighted nuisance variables (e.g. headphone brand, price and industrial design) can be eliminated [1]. However, biases from cues related to headphone tactile/fit are virtually impossible to remove from the test. Moreover, blind comparative headphone listening tests require the test administrator to manually substitute the different headphones on the subject's head over several trials making it an extremely tedious, intrusive, and fatiguing exercise for both the listener and administrator.

Different models of headphones (targets) are simulated and compared through a single headphone (replicator) that is equalized to produce to the same measured frequency response as the targets

The listening test is truly blind with no influence of visual, tactile or psychological biases on the judgment of sound quality

Headphone Virtualization Method

Target Headphone

Measure at DRP

Design Virtual HP Filter (IIR)

Apply Virtual HP Filter to Simulator Phone

Simulator Headphone

Measure at DRP

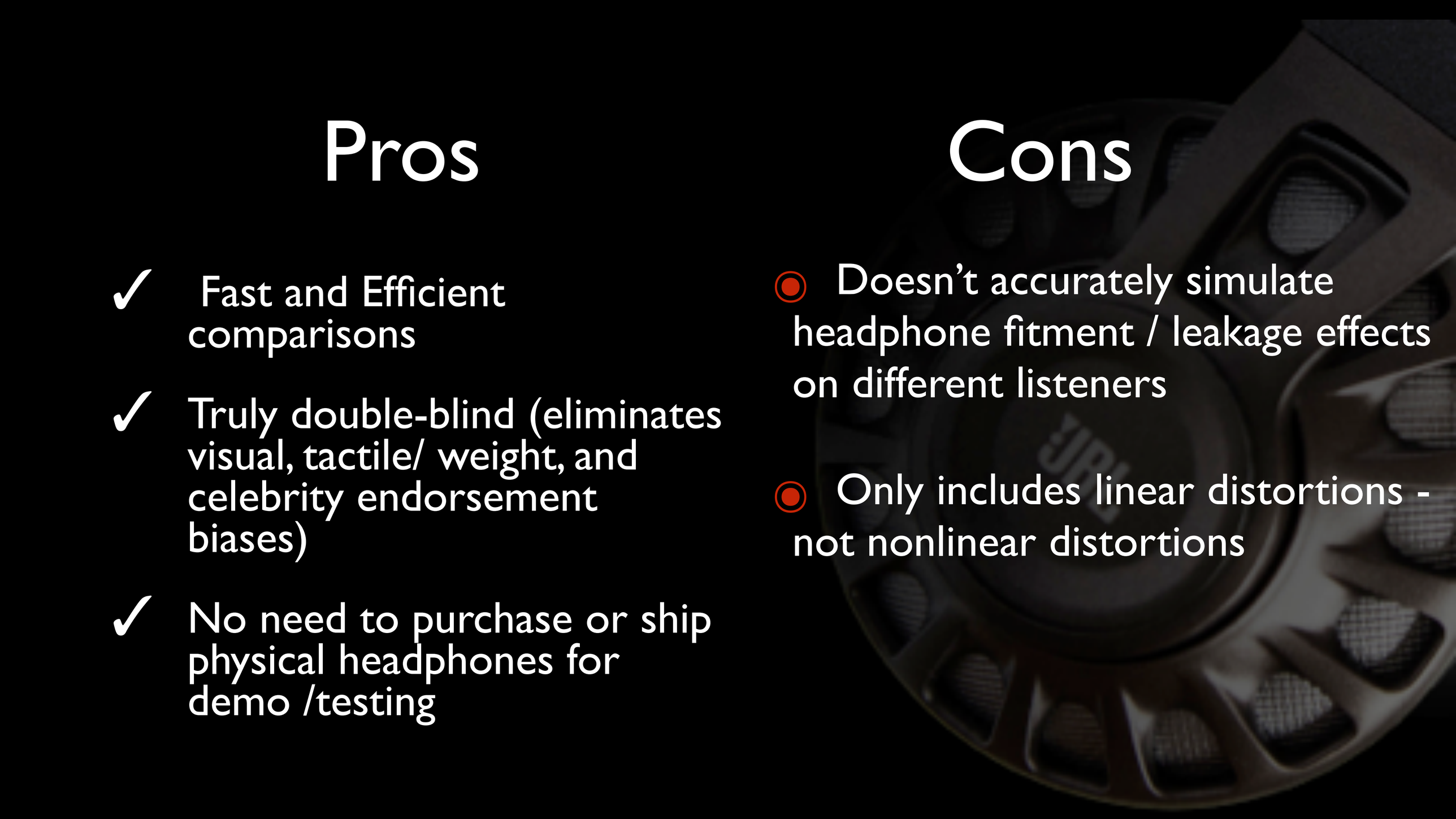
Flatten EQ

Pros

- ✓ Fast and Efficient comparisons
- ✓ Truly double-blind (eliminates visual, tactile/ weight, and celebrity endorsement biases)
- ✓ No need to purchase or ship physical headphones for demo /testing

Cons

- Doesn't accurately simulate headphone fitment / leakage effects on different listeners
- Only includes linear distortions - not nonlinear distortions



Headphones Tested

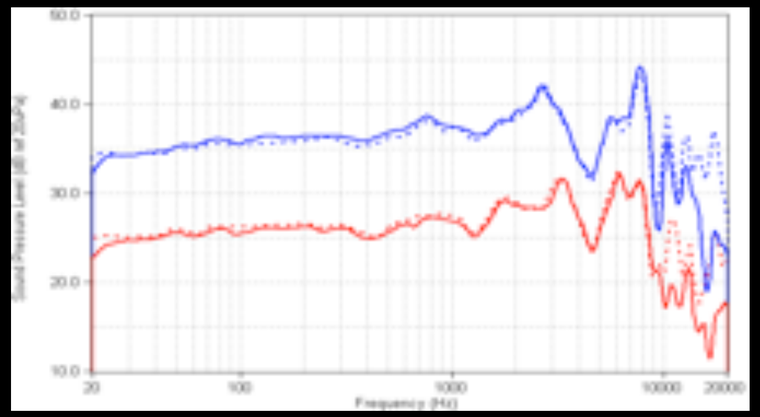
Brand / Model	Price	Description
AKG K701	$278	Dynamic / Open Back
AKG K550	$245	Dynamic / Closed Back
Audeze LCD2 (rev 2)	$995	Planar Magnetic / Open Back
Beats by Dre Studio Limited Edition	$270	Dynamic / Closed with ANC
Bose Quiet Comfort 15	$299	Dynamic / Closed with ANC
V-Moda Crossfade LP	$115	Dynamic / Closed

Measurements

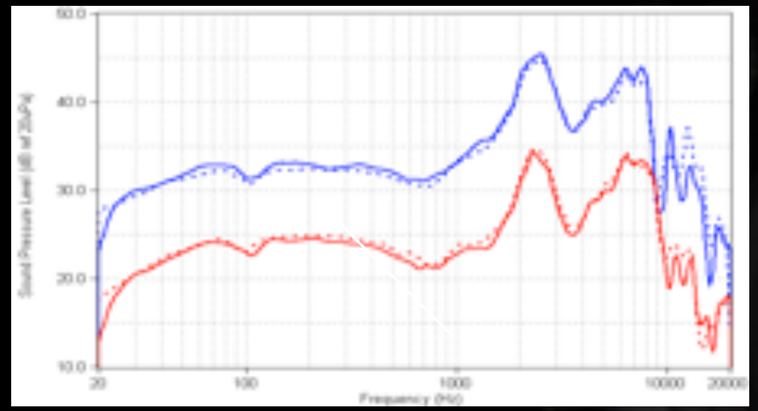
Real

Virtualized

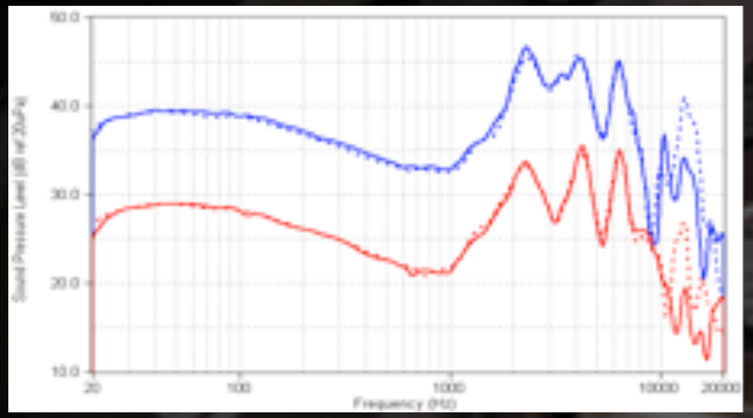
HP1



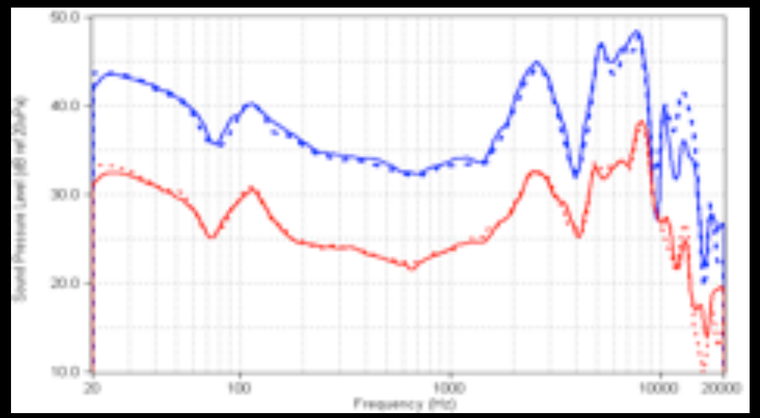
HP2



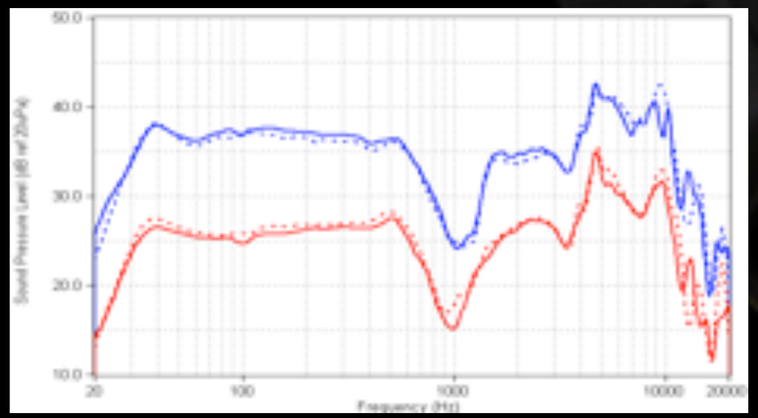
HP3



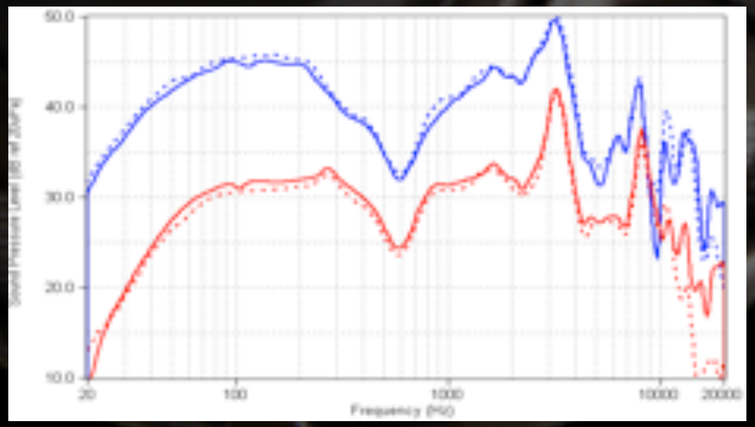
HP4



HP5

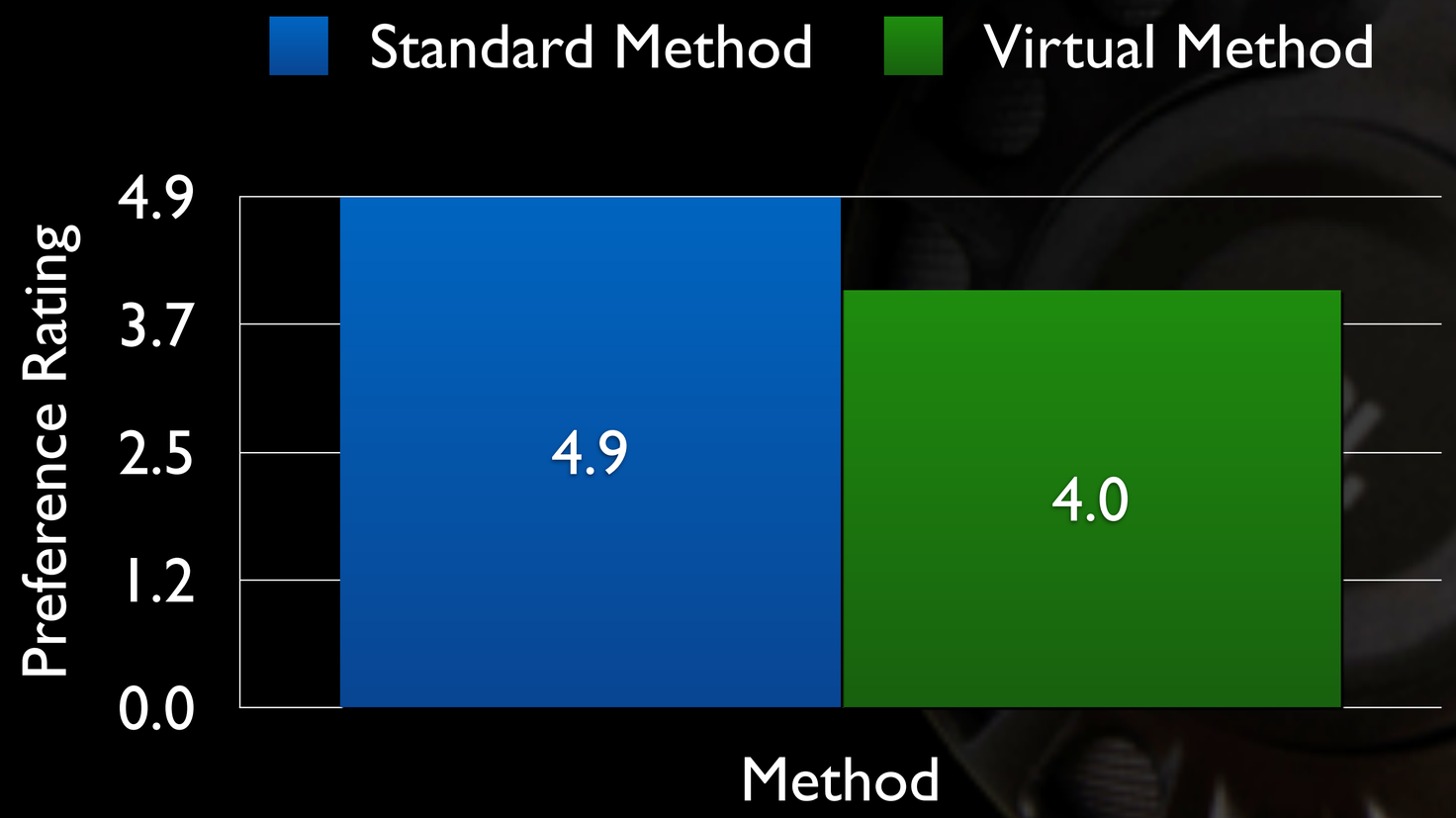


HP6

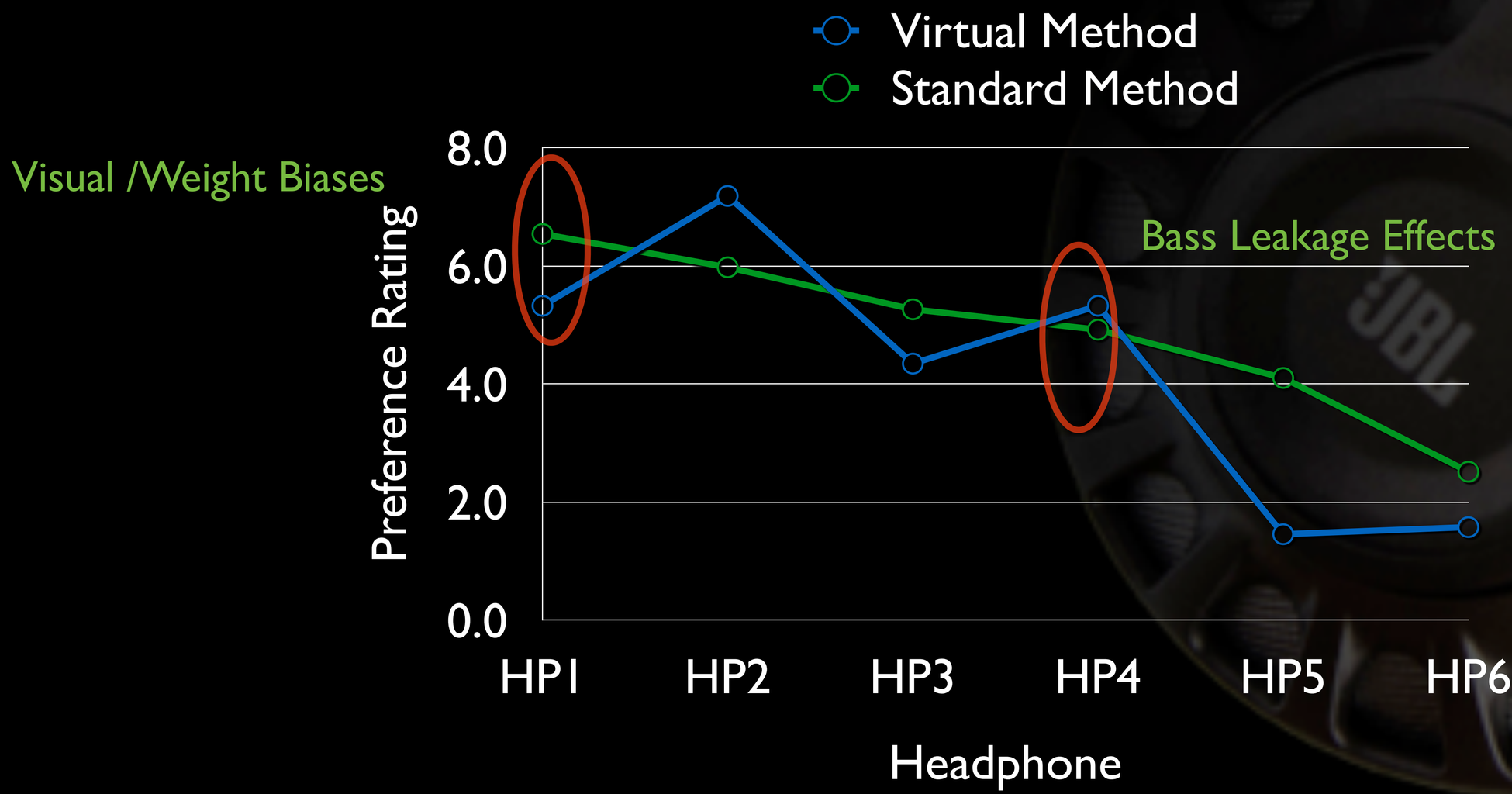


Results

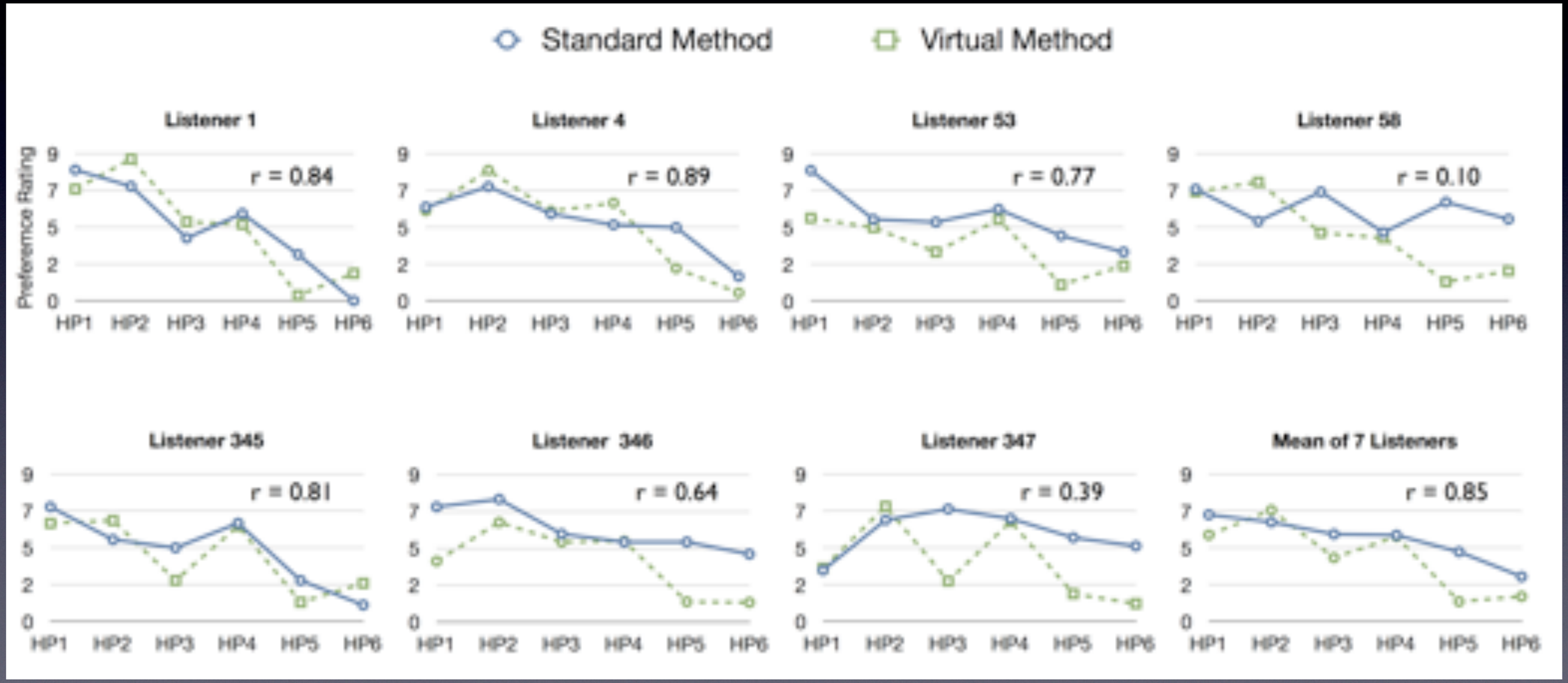
Effect of Method



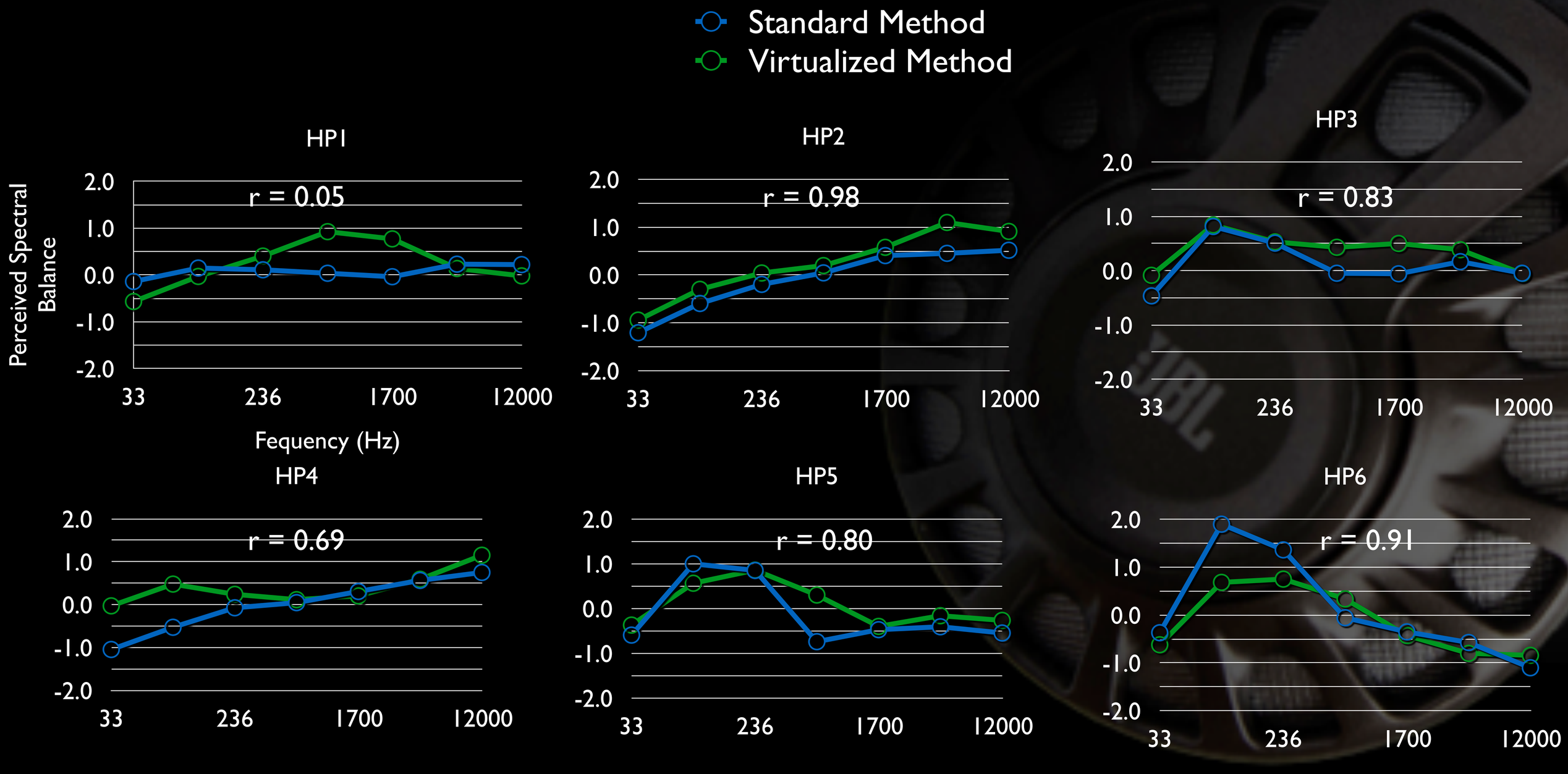
Test Method vs Headphone Interaction



Individual Listener Preferences



Perceived Spectral Balance



Conclusions

Overall lower average preference ratings (0.9 rating) in Virtual Tests

Larger headphone effect size in virtual tests due to wider distribution of ratings

Virtual Test faster and more efficient (3x times fewer trials required to test 6 headphones)

Good correlation between standard vs virtual methods in terms of headphone preference ratings ($r = 0.85$) and perceived spectral balance.

Errors likely related to fit / bass leakage and effects and visual/tactile biases in present in Standard Test but absent in Virtual Test

2013
ISEAT
International Symposium on ElectroAcoustic Technologies

do college students prefer the same headphone sound quality as trained listeners?

Sean E. Olive[1]
Harman International
8500 Balboa Blvd.
Northridge, CA, 91329
USA

ABSTRACT

There are no known published studies on the headphone sound quality preferences of college age students, even though they purchase a significant percentage of all headphones sold. To shed some light on this topic, a double blind listening test was conducted where 17 untrained college students gave preference ratings for four different around-ear (AE) and in-ear (IE) headphones using three stereo music programs. The same test was repeated with trained Harman listeners to determine the extent to which their headphone preferences are different from those of the college students. The results found good agreement in headphone preference between the two listening groups: the more neutral sounding headphones were preferred to the models that were bass heavy. Overall, the college students gave higher preference ratings than the Harman trained listeners, and were less able to discriminate among the different choices. This is consistent with previous studies that compared the loudspeaker preferences of trained versus untrained listeners.

Do college kids prefer the same headphone sound quality as trained Harman listeners?

Audio Engineering Society

Convention Paper

Presented at the 132nd Convention
2012 April 26–29 Budapest, Hungary

Some New Evidence That Teenagers and College Students May Prefer Accurate Sound Reproduction

Sean E. Olive, AES Fellow

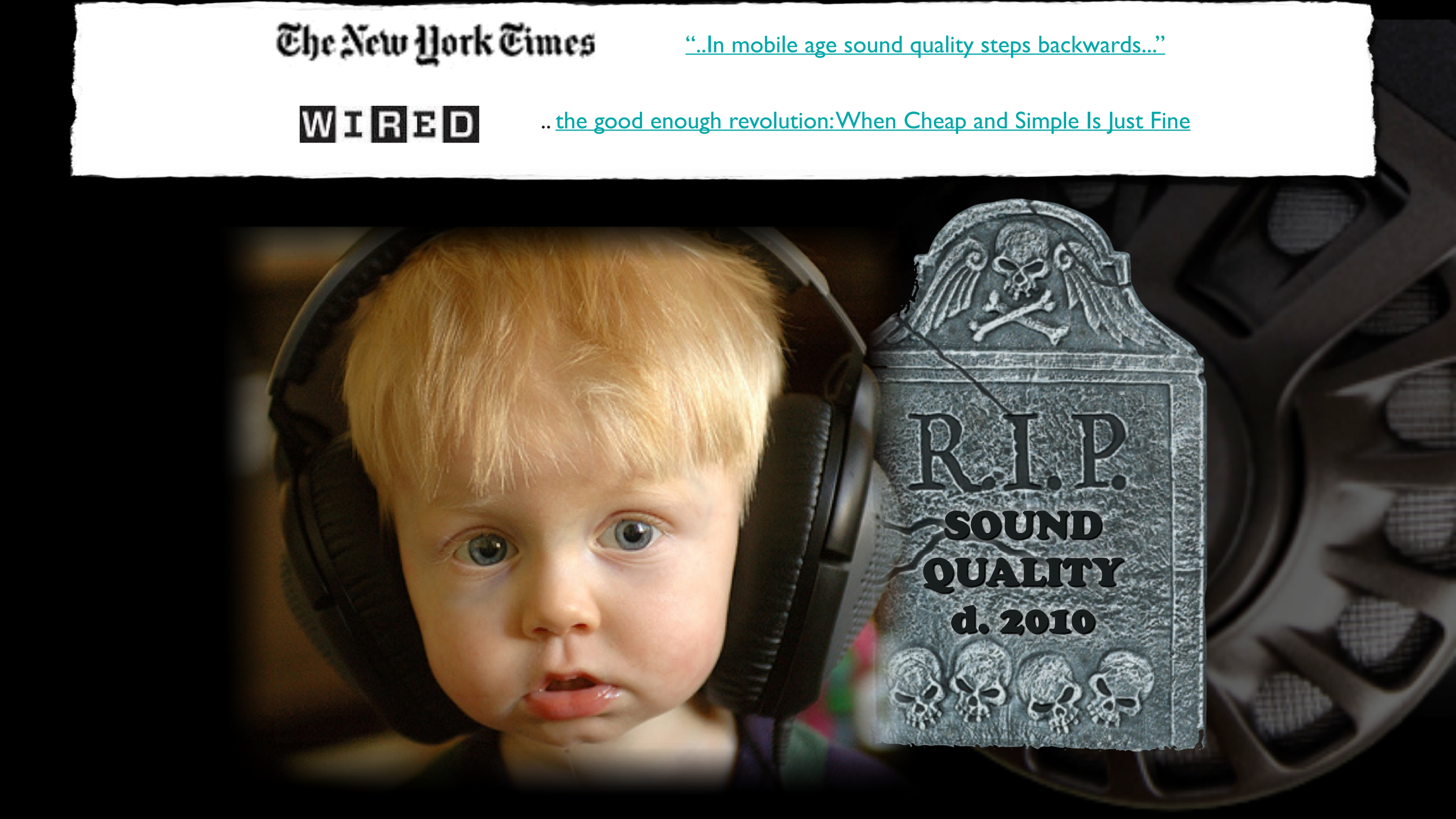
Harman International Industries Inc., Northridge, CA, 91329, USA
sean.olive@harman.com

ABSTRACT

A group of 18 high school and 40 college students with different expertise in sound evaluation participated in two separate controlled listening tests that measured their preference choices between music reproduced in 1) MP3 (128 kbp/s) and lossless CD-quality file formats, and 2) music reproduced through four different consumer loudspeakers. As a group, the students preferred the CD-quality reproduction in 70% of the trials, and preferred music reproduced through the most accurate, neutral loudspeaker. Critical listening experience was a significant factor in the listeners' performance and preferences. Together, these tests provide new evidence that both teenagers and college students can discern and appreciate a better quality of reproduced sound when given the opportunity to directly compare it to lower quality options.

The New York Times "..In mobile age sound quality steps backwards..."

WIRED .. the good enough revolution: When Cheap and Simple Is Just Fine



- A central piece of "evidence" used to support the acceptance and decline of sound quality is the "MP3 effect" observed in an informal study conducted by Jonathan Berger at Stanford University on music students

- This informal study has never been published so details about its methodology and results are not well known

The New York Times

..In fact, among younger listeners, the lower-quality sound might actually be preferred.
Jonathan Berger, a professor of music at Stanford, said he had conducted an informal study among his students and found that, over the roughly seven years of the study, an increasing number of them preferred the sound of files with less data over the high-fidelity recordings

"I think our human ears are fickle. What's considered good or bad sound changes over time," Mr. Berger said. "Abnormality can become a feature"

Listeners

- 18 high school students
- 40 college students from 3 colleges
- all attending school in Los Angeles area
- different levels of experience and expertise in critical evaluation of sound

Listeners

Listening Group	Sample Size	Ages	Gender Male/ Female	Experience/ Expertise
High School	n = 18	15 to 18 yrs	13/5	none
Loyola Marymount University (LMU)	n = 20	18 to 22 yrs	15/5	some
University of California Irvine (UCI)	n = 6	22 to 35 yrs	4/2	the most
Cal Arts	n = 14	19 to 36 yrs	9/5	none
Total	18 High School 40 College		71% male 29% female	

Method for Presenting Stimuli

Double-blind presentations

Paired (A/B) comparisons

12 trials (4 programs w. 3 observations)

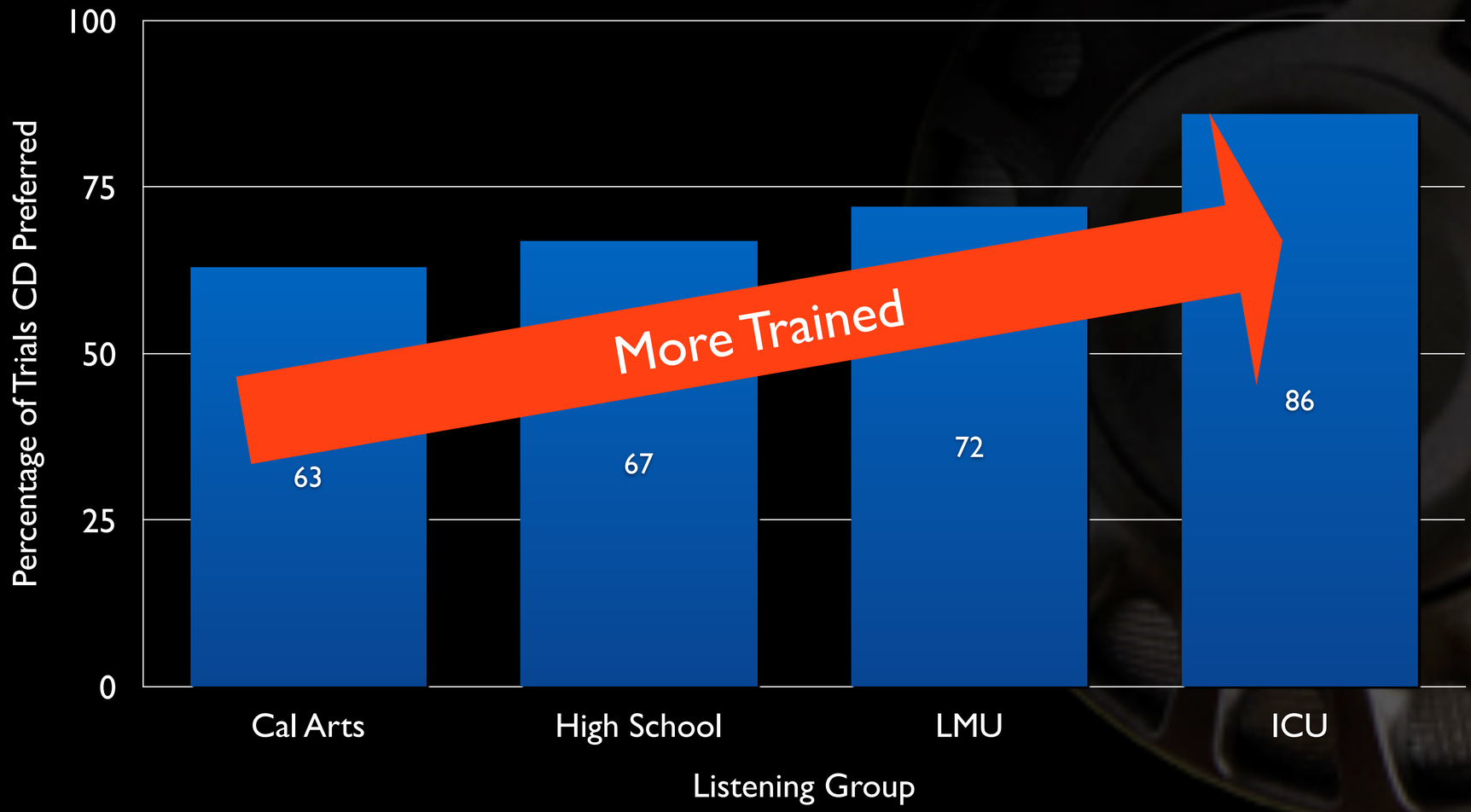
Order of programs and stimulus presentation randomized

9 listeners in two seating rows

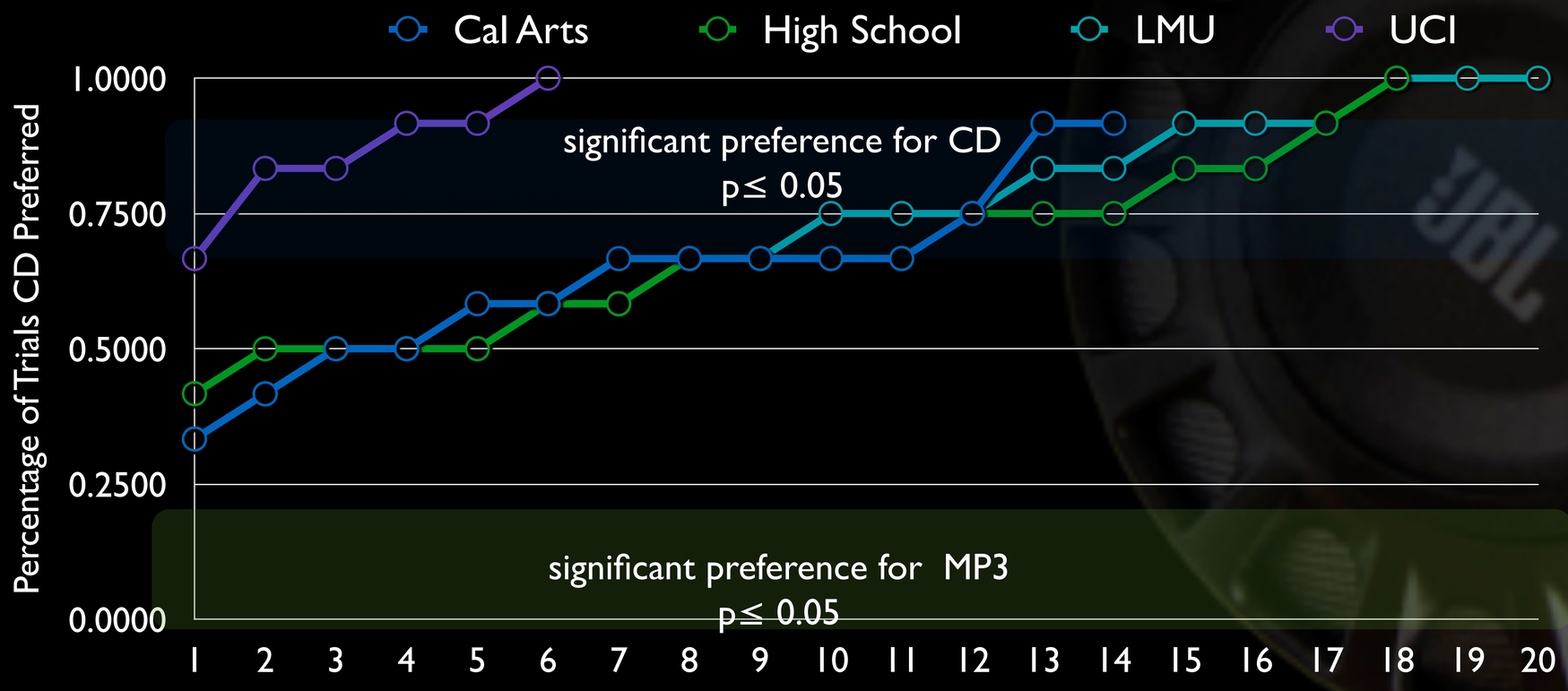
Average playback level @ 78 dB (B-weighted)

Test duration ~ 30 minutes

Preference Choices for CD



Individual Listener Preference Choices For CD



Listeners

High School Students (18)

American College Students (40) LMU, UC Irvine, Cal Arts

Japanese College Students (149) Kenshu College

Harman Trained Listeners (12)

Loudspeakers

$500.

Infinity
Primus 362

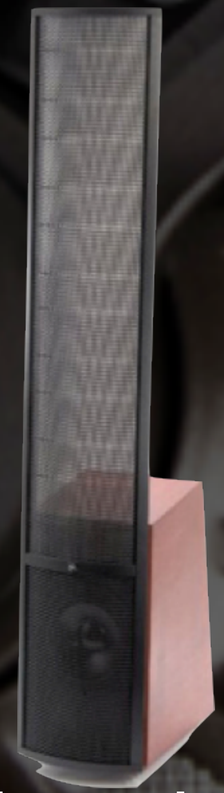
$800.

Polk Rti 10

$600.

Klipsch
RF35

$3,800.



Martin Logan
Vista

Test Method

Multiple (A/B/C/D) double-blind comparisons; loudspeakers level-matched

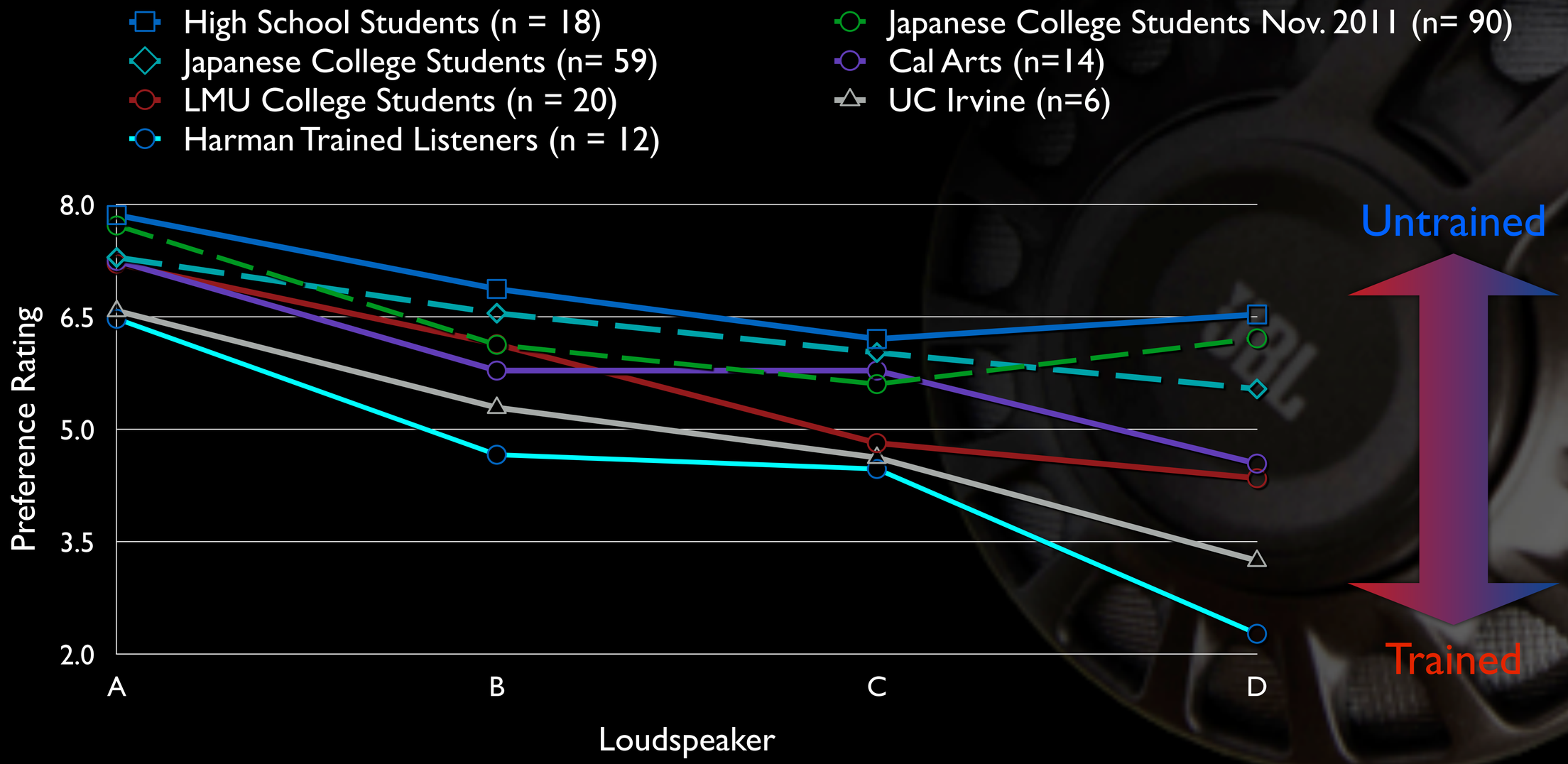
Speaker position held constant using automated speaker shuffler in MLL

4 trials (2 programs x 2 observations)

Program order and speaker presentations randomized

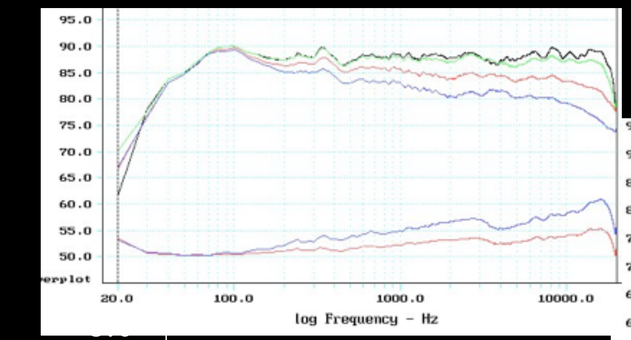
Average playback level @ 78 dB (B-weighted)

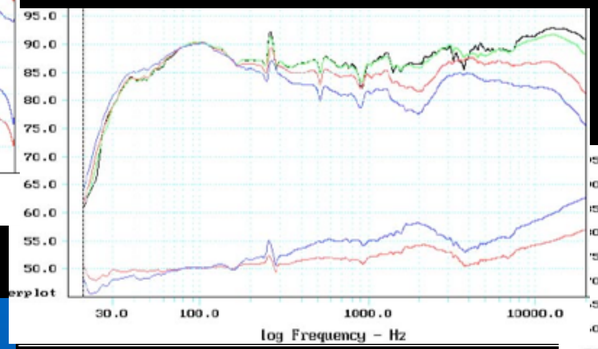
Trained Vs Untrained Listeners

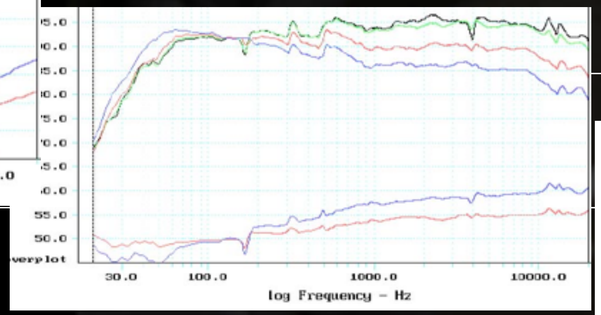


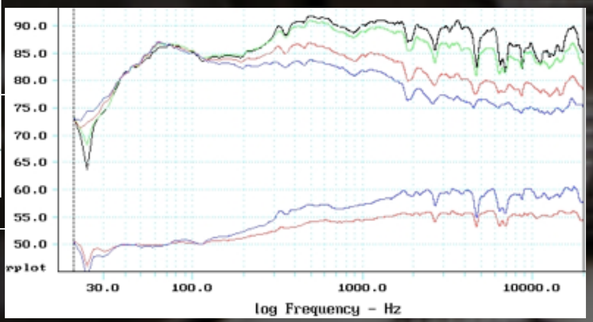
Correlation between Preferred Sound Quality and Measurements

- **Summary:** Listeners preferred the loudspeaker with the widest, flattest and smoothest frequency response curves anechoically measured









Audio Engineering Society

Convention Paper

Presented at the 137th Convention
2014 October 9–12 Los Angeles, USA

The Influence of Listeners' Experience, Age, and Culture on Headphone Sound Quality Preferences

Sean E. Olive[1], Todd Welti[2], and Elisabeth McMullin[3]

Harman International, Northridge, CA, 91329, USA

[1] Sean.Olive@harman.com

[2] Todd.Welti@harman.com

[3] Elisabeth.McMullin@harman.com

ABSTRACT

Double-blind headphone listening tests were conducted in four different countries (Canada, USA, China and Germany) involving 238 listeners of different ages, gender and listening experiences. Listeners gave comparative preference ratings for three popular headphones and a new reference headphone that were virtually presented through a common replicator headphone equalized to match their measured frequency responses. In this way, biases related to headphone brand, price, visual appearance and comfort were removed from listeners' judgment of sound quality. On average, listeners preferred the reference headphone that was based on the in-room frequency response of an accurate loudspeaker calibrated in a reference listening room. This was generally true regardless of the listener's experience, age, gender and culture. This new evidence suggests a headphone standard based on this new target response would satisfy the tastes of most listeners.

Does listener experience, age and culture influence headphone sound preference?

The Beats Factor

- **The Beats With a Billion Eyes**

He's conquered the headphones market, but Dr. Dre isn't selling great sound. He's not even selling celebrity. He's selling the concept of "bass."

Jesse Dorris. Slate Magazine Sept. 11 2013

Is their success more about the marketing than the sound (bass) ?

What about Cultural Differences in Taste in Headphone Sound Quality?

Canada
(untrained)

United States
(trained vs untrained)

China
(trained vs untrained)

Germany
(trained vs untrained)

Headphone Virtualization Method

Target Headphone

Measure at DRP

Design Virtual HP Filter (IIR)

Apply Virtual HP Filter to Simulator Phone

Simulator Headphone

Measure at DRP

Flatten EQ

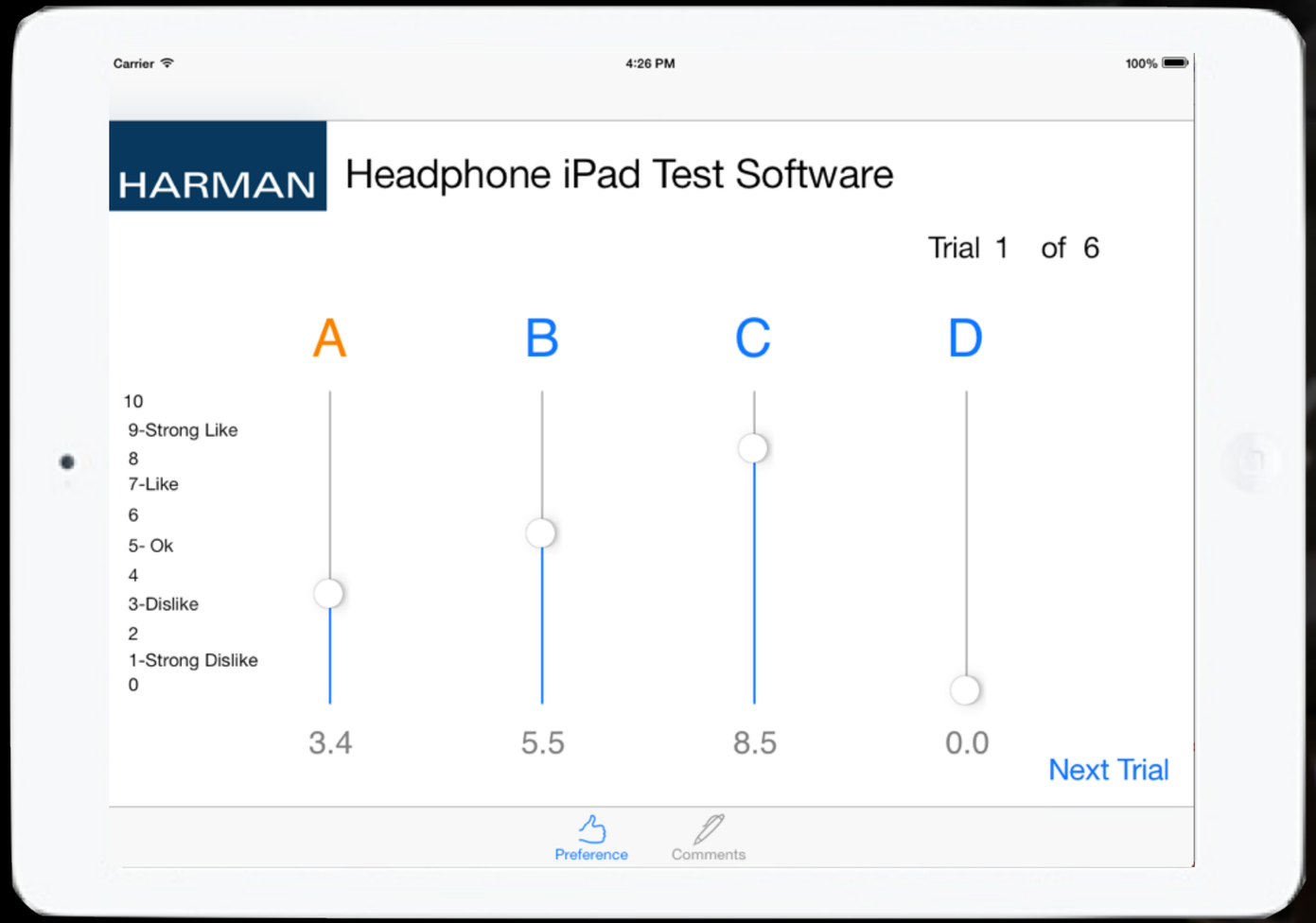
Headphones Tested

Brand / Model		Price
Harman Target Curve	Based on latest AES paper October 2013	----
Sennheiser HD800		$1500
Audeze LCD2 (rev 2)		$995
Beats by Dre Studio Limited Edition		$270

Listeners

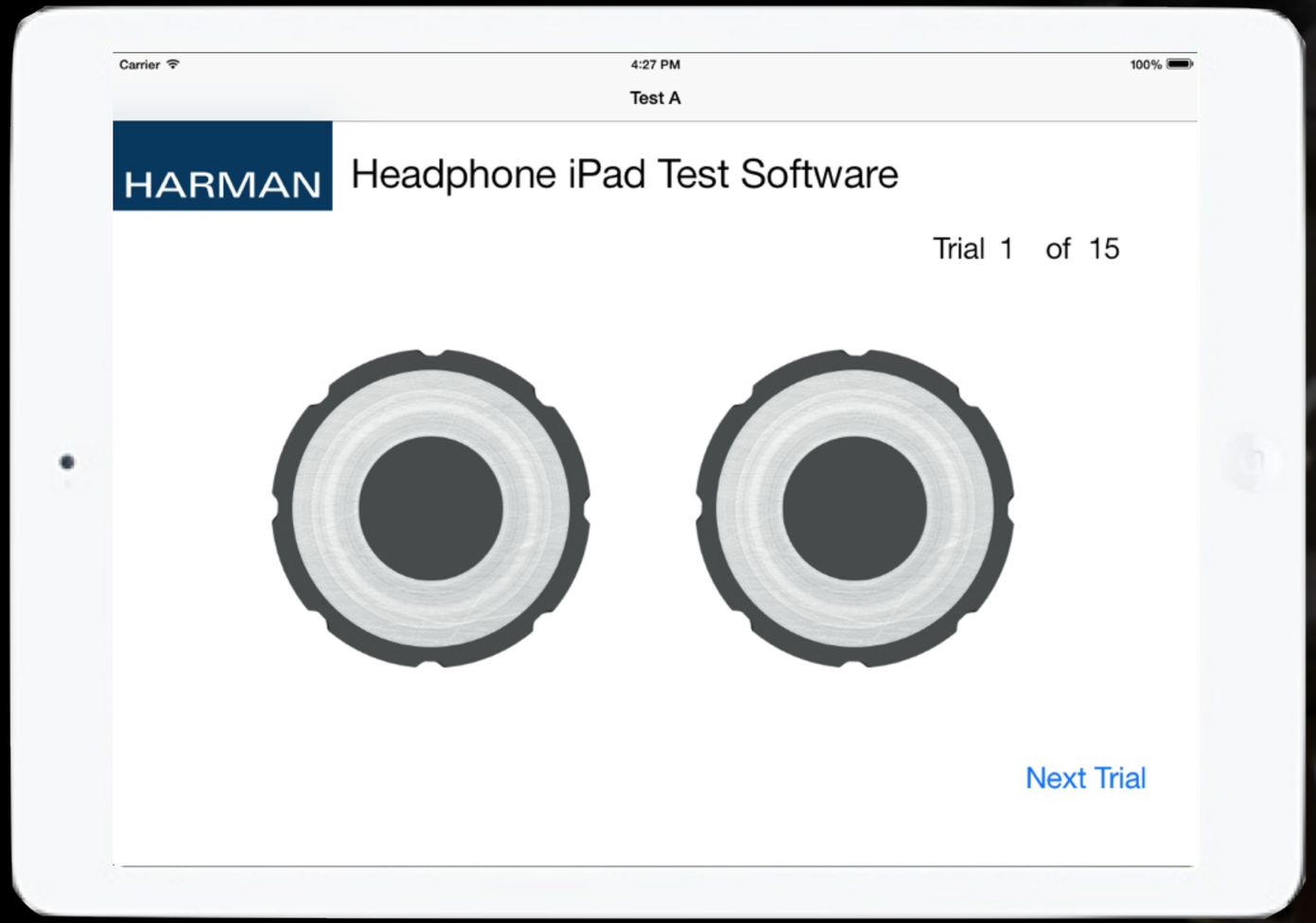
GROUP	Country	Count	Median Age (SD)	Gender
Harman NR	USA	9	39 (10.9)	7/ 2
Harman FH	USA	23	38 (13.4)	20 /3
Harman KB	Germany	72	38 (9.2)	67 /5
Harman SZ	China	26	31 (6.5)	19 /9
Citrus College	USA	24	23 (5.5)	18/ 6
LMU	USA	15	21 (1.2)	14/ 1
Harris Insitute	Canada	69	23 (8.9)	60/9
TOTAL		238		

Headphone Preference Test on Ipad



Listeners rate headphones A through D based on preference and give comments (optional)

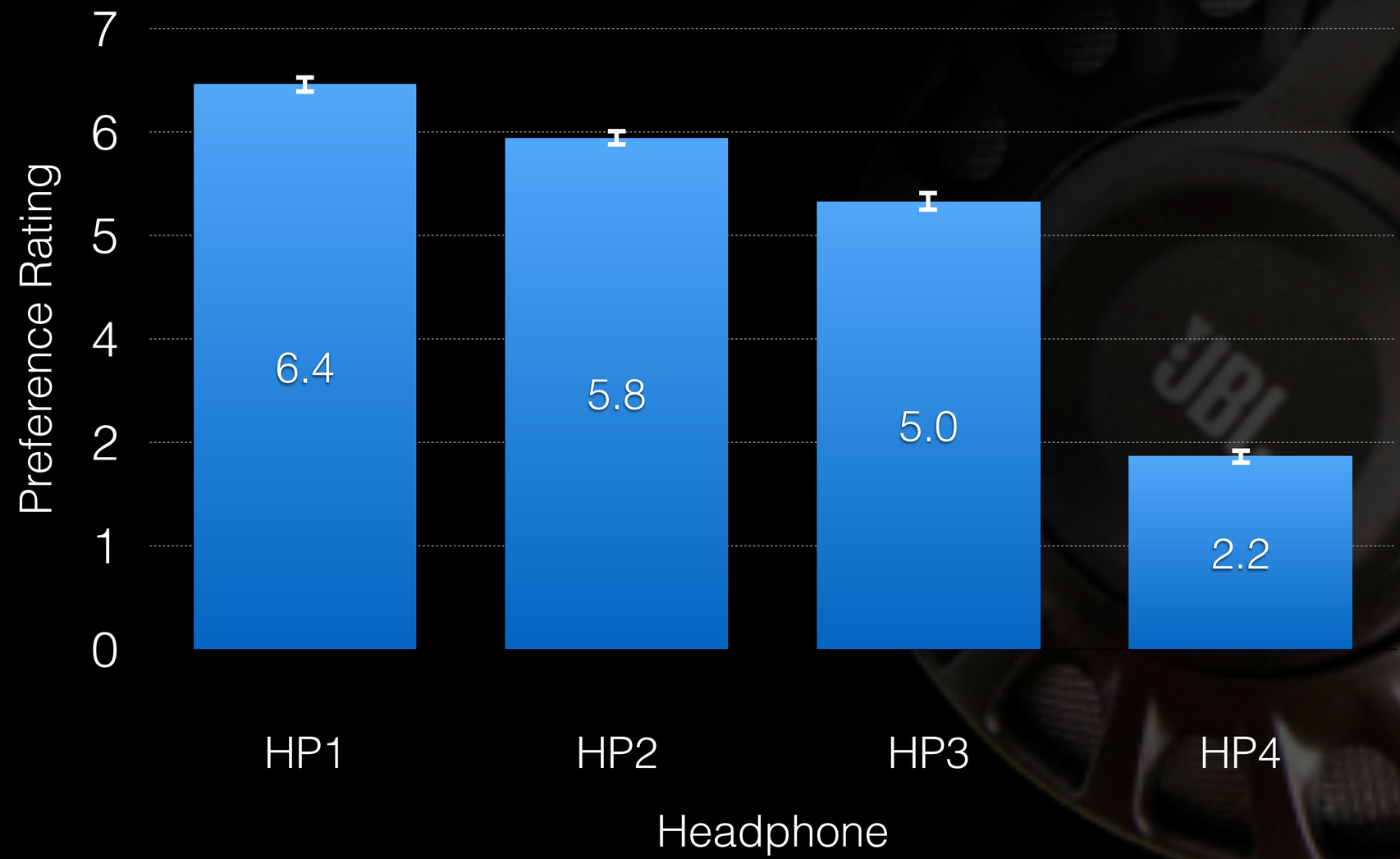
Preferred Bass and Treble Balance Test on Ipad



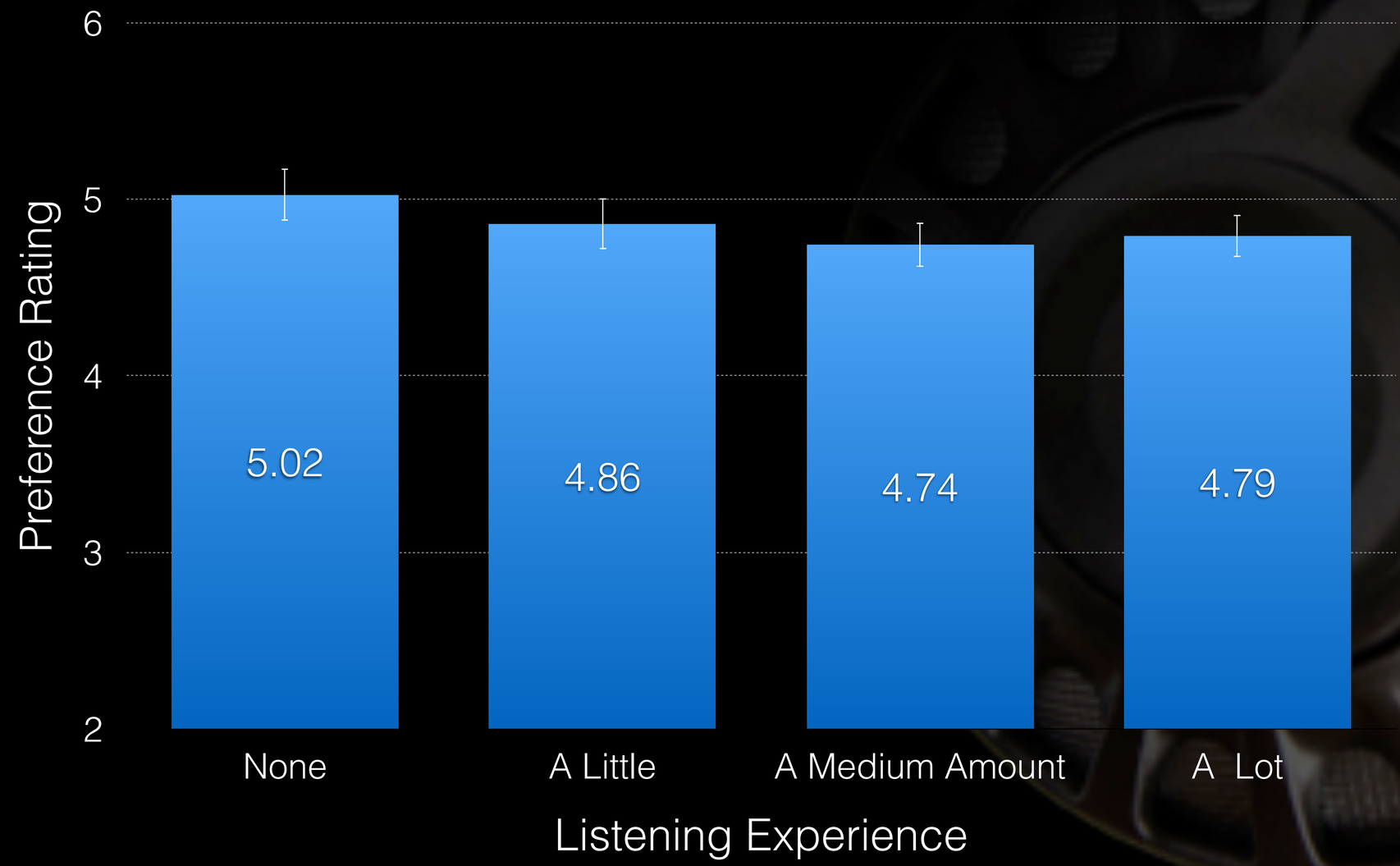
Listeners use the two knobs to adjust the bass and treble level to their preferred levels

Results

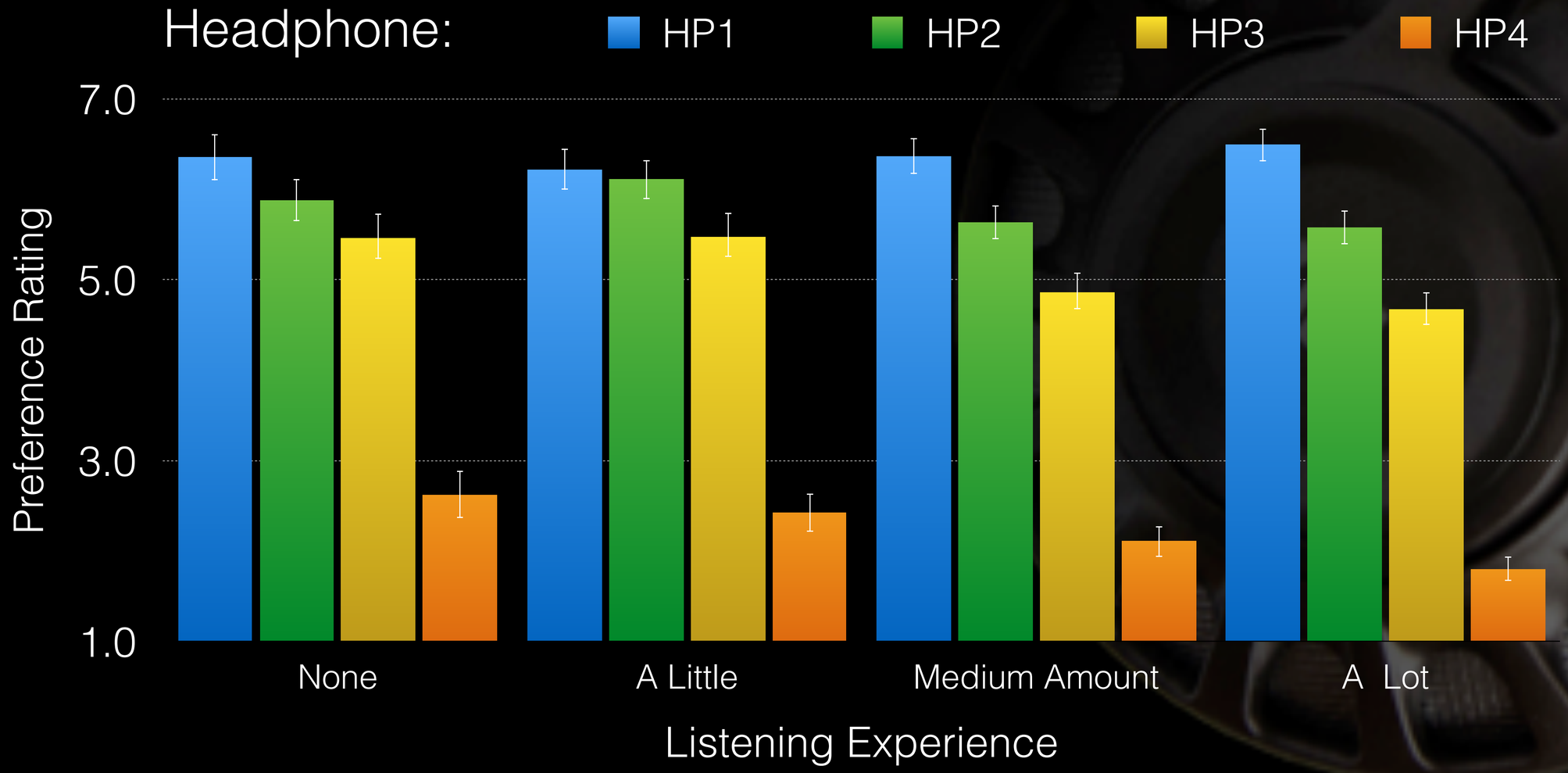
Headphone Preference



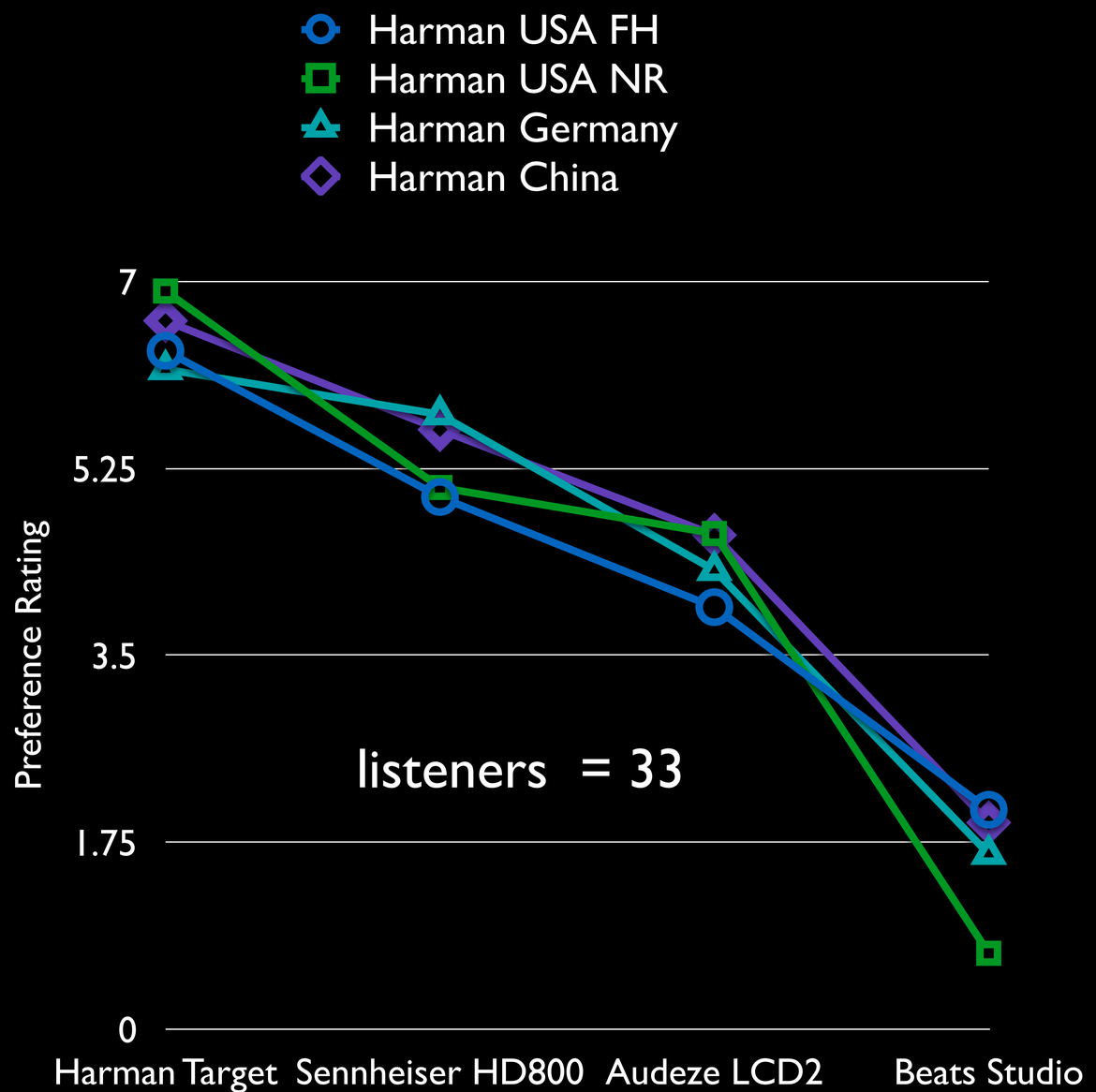
Listening Experience



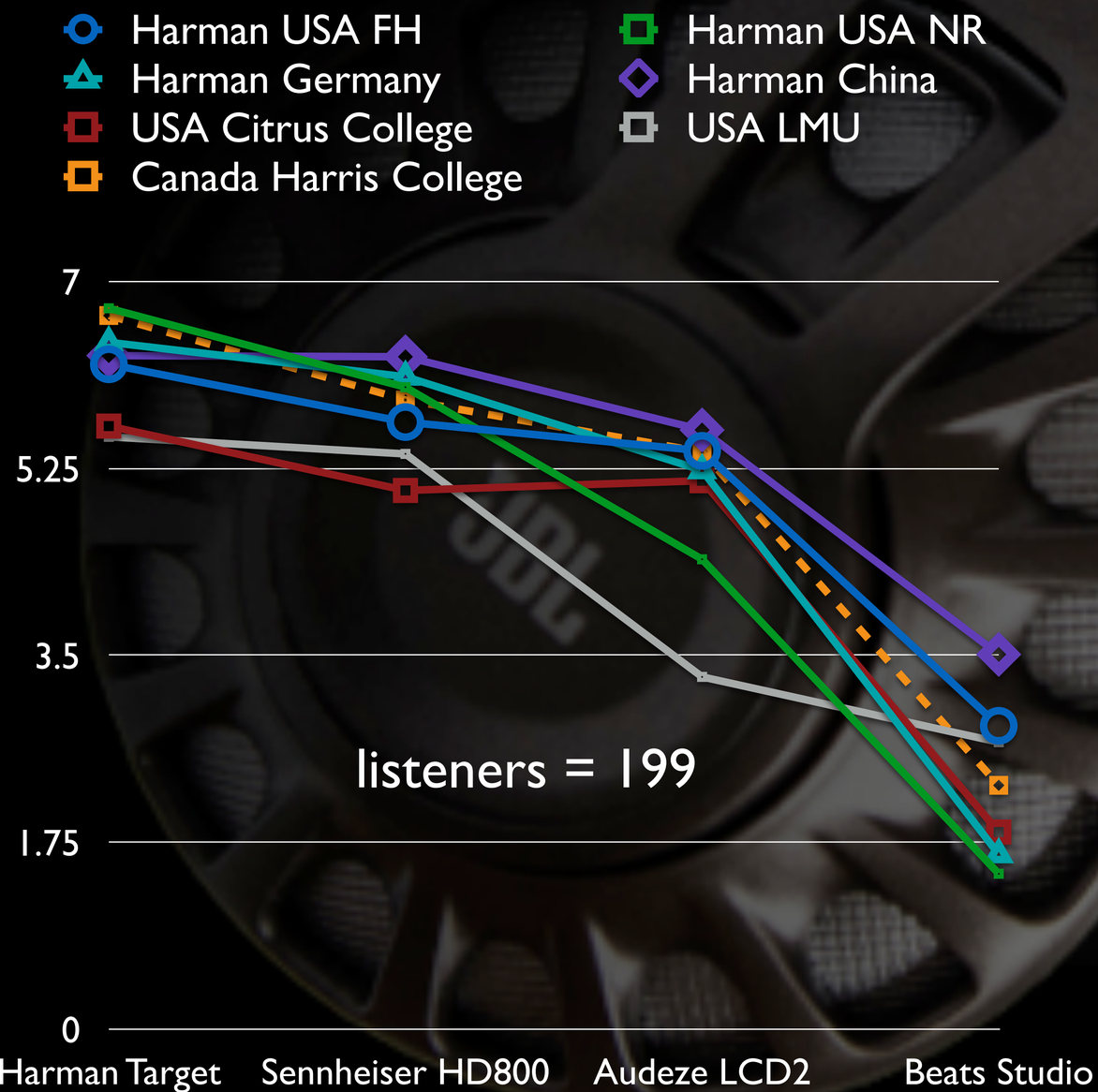
Listening Experience * Headphone



Trained Listeners



Untrained Listeners



Conclusions

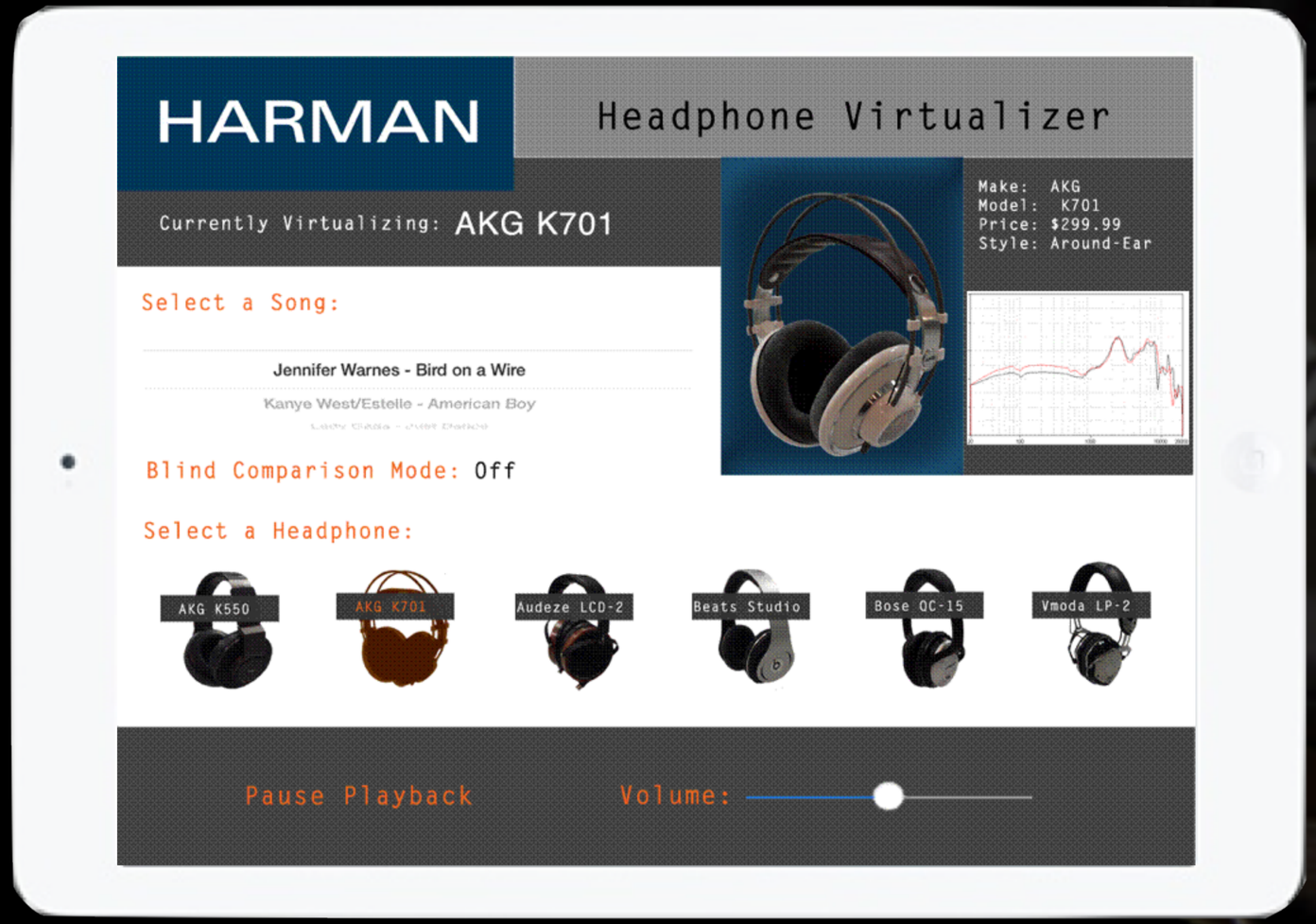
Untrained college students generally prefer the same headphone sound quality as Harman trained listeners

This is true regardless of culture (China, USA, Germany, Canada)

The more preferred headphones were perceived as more neutral and well-balanced across the audio spectrum (confirmed by the measurements)

There was no scientific evidence that these kids preferred headphones with boomy bass-heavy sound

Headphone Virtualizer App



WHERE SOUND MATTERS

AKG by HARMAN harman/kardon by HARMAN Infinity by HARMAN JBL by HARMAN Lexicon by HARMAN Mark Levinson by HARMAN