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

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.
The Relationship between Perception and Measurement of Headphone Sound Quality

Sean E. Olive¹ and Todd Welti²

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.
# Headphones Tested

<table>
<thead>
<tr>
<th>Brand / Model</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>AKG K701</td>
<td>$278</td>
</tr>
<tr>
<td>AKG K550</td>
<td>$245</td>
</tr>
<tr>
<td>Audeze LCD2 (rev 2)</td>
<td>$995</td>
</tr>
<tr>
<td>Beats by Dre Studio Limited Edition</td>
<td>$270</td>
</tr>
<tr>
<td>Bose Quiet Comfort 15</td>
<td>$299</td>
</tr>
<tr>
<td>V-Moda Crossfade LP</td>
<td>$115</td>
</tr>
</tbody>
</table>
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.
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
Is there a better sounding headphone target response curve than the current recommended standards?

Listener Preference For Different Headphone Target Response Curves

Sean E. Olive\textsuperscript{1}, Todd Welti\textsuperscript{2}, and Elisabeth McMullin\textsuperscript{3}

Harman International, Northridge, CA, 91329, USA

\textsuperscript{1} sean.olive@harman.com
\textsuperscript{2} todd.welti@harman.com
\textsuperscript{3} elisabeth.mcnullin@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 11992-2, 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.
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
Before Target Curve EQ Are Applied
# Headphone Target Curves Tested

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

Sennheiser HD 518 ($120)

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

Audeze LCD2 ($995)

The test was repeated using two different headphones equalized to the different target responses.
Results
Preferred Headphone Target Response

- JBL Target 1: 5.85
- DF_M: 3.77
- DF_MH: 3.35
- DF_L: 3.28
- No EQ: 2.88
- FF: 1.32
Preferred Headphone Target Response

- JBL Target 2: 7.03
- JBL Target 1: 4.83
- DF_M: 4.75
- No EQ: 4.08
- DF_MH: 2.27
- FF: 1.39
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.
Do listeners agree on the preferred in-room loudspeaker and headphone target responses?

Are they the same?

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.
Methodology

Preferred In-Room Loudspeaker Target Response

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

Left Channel
Right Channel

Flat In-Room Loudspeaker Target Curve

Target Response
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 Powermats 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

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

Each subject completed 27 trials for each task.

3 programs × 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

Loudspeaker & Headphones Data Combined

-6.8
-4.5
-2.3
0.0
2.3
4.5
6.8
8.3
10.0
-6.8
-4.5
-2.3
0.0
2.3
4.5
6.8
8.3
10.0

Trained
Untrained

Bass
Treble
Effect of Listener Experience

-6.0  -3.0  0.0  3.0  6.0  9.0  12.0

Trained  Untrained

1.8  1.8  1.8  1.8

-4.8  -4.0

Headphones  Loudspeaker

Bass  Treble

4.6  5.4  4.9  11.2

Relative Level (dB)

Trained  Untrained

4.6  5.4  4.9

Bass

1.8  1.8  11.2  1.8

Treble

-4.8  -4.0
Loudspeaker Vs Headphone

Bass (Loudspeaker)  Treble (Loudspeaker)

Bass (Headphone)  Treble (Headphone)

Listener ID
1 4 53 58 345 346 357 359 400 401 402

Relative Level (dB)
Preferred Delta Level (ie Bass - Treble Level)

![Graph showing Preferred Delta Level with Listener IDs and Loudspeaker vs Headphones]

- Bass/Treble Level Delta (dB)
  - 0.0
  - 4.5
  - 9.0
  - 13.5
  - 18.0

- Listener ID:
  - 1
  - 4
  - 53
  - 58
  - 345
  - 346
  - 357
  - 359
  - 400
  - 401
  - 402

- Loudspeaker
- Headphones
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

Preferred In-Room Target from [6]

Revel F208 Equalized to New Preferred In-Room Target

Predicted In-Room Response
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.
Different models of headphones (targets) are simulated and compared through a single headphone (replicator) that is equalized to produce 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

1. Measure at DRP
2. Design Virtual HP Filter (IIR)
3. Apply Virtual HP Filter to Simulator Phone

Simulator Headphone

Measure at DRP

Flatten EQ

Target Headphone
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

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

Real

Virtualized

HP1

HP2

HP3

HP4

HP5

HP6
Effect of Method

- **Preference Rating**
  - 0.0
  - 1.2
  - 2.5
  - 3.7
  - 4.9

- **Method**
  - Standard Method
  - Virtual Method

- **Preference Rating**
  - 4.9 (Standard Method)
  - 4.0 (Virtual Method)
Test Method vs Headphone Interaction

Preference Rating

- Virtual Method
- Standard Method

Visual /Weight Biases

Bass Leakage Effects

Headphone
Individual Listener Preferences
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
Do college kids prefer the same headphone sound quality as trained Harman listeners?

Sean E. Olive
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.
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 kbps) 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.
“..In mobile age sound quality steps backwards...”

.. 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.

“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

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

<table>
<thead>
<tr>
<th>Sample Size</th>
<th>Ages</th>
<th>Gender Male/Female</th>
<th>Experience/Expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>18 High School</td>
<td>18 High School</td>
<td>71% male</td>
</tr>
</tbody>
</table>
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

Percentage of Trials CD Preferred

<table>
<thead>
<tr>
<th>Listening Group</th>
<th>Cal Arts</th>
<th>High School</th>
<th>LMU</th>
<th>ICU</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>63</td>
<td>67</td>
<td>72</td>
<td>86</td>
</tr>
</tbody>
</table>

More Trained
Individual Listener Preference Choices For CD

- Significant preference for CD: $p \leq 0.05$
- Significant preference for MP3: $p \leq 0.05$
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

- Infinity Primus 362: $500
- Polk Rti 10: $800
- Klipsch RF35: $600
- Martin Logan Vista: $3,800
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

- High School Students (n = 18)
- Japanese College Students (n= 59)
- LMU College Students (n = 20)
- Harman Trained Listeners (n = 12)
- Japanese College Students Nov. 2011 (n= 90)
- Cal Arts (n=14)
- UC Irvine (n=6)

Preference Rating

Loudspeaker

A  B  C  D

Untrained

Trained
Correlation between Preferred Sound Quality and Measurements

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

<table>
<thead>
<tr>
<th>Preference Rating</th>
<th>Loudspeaker</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.36</td>
<td>A</td>
</tr>
<tr>
<td>6.19</td>
<td>B</td>
</tr>
<tr>
<td>5.46</td>
<td>C</td>
</tr>
<tr>
<td>4.96</td>
<td>D</td>
</tr>
</tbody>
</table>

Graph showing the correlation between preferred sound quality and measurements.
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

1. **Target Headphone**
2. **Measure at DRP**
3. **Design Virtual HP Filter (IIR)**
4. **Apply Virtual HP Filter to Simulator Phone**

5. **Simulator Headphone**
6. **Measure at DRP**
7. **Flatten EQ**
8. **Result**
## Headphones Tested

<table>
<thead>
<tr>
<th>Brand / Model</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harman Target Curve</td>
<td>Based on latest AES paper October 2013</td>
</tr>
<tr>
<td>Sennheiser HD800</td>
<td>$1500</td>
</tr>
<tr>
<td>Audeze LCD2 (rev 2)</td>
<td>$995</td>
</tr>
<tr>
<td>Beats by Dre Studio Limited Edition</td>
<td>$270</td>
</tr>
</tbody>
</table>
## Listeners

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

Preference Rating

None: 5.02
A Little: 4.86
A Medium Amount: 4.74
A Lot: 4.79
Listening Experience * Headphone Preference Rating

Listening Experience:
- None
- A Little
- Medium Amount
- A Lot

Headphone:
- HP1
- HP2
- HP3
- HP4

Preference Rating
- 1.0
- 3.0
- 5.0
- 7.0
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

Currently Virtualizing: AKG K701

Select a Song:
- Jennifer Warnes - Bird on a Wire
- Kanye West/Estelle - American Boy

Blind Comparison Mode: Off

Select a Headphone:
- AKG K550
- AKG K701
- Audio-Technica ATH-M50
- Beats Studio
- Bowers & Wilkins P3
- Fender Sonic 200

Pause Playback
Volume: