Functioning of Directional Microphones and Digital Noise Reduction in Hearing Aids: Objective versus Subjective Measures

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Why do we care about the function of hearing aid features?

- To verify the function of HA features when they are initially sent from manufacturer to ensure optimal use by the client
- Important to make sure features are working to achieve optimal hearing aid fitting, to not only meet client's expectations, but they're also paying for these features, so they should work!
- Currently no guideline exists for determining feature function, so one has been generated at our clinic and is currently used at MSHC. This not only serves our clients well, but also serves as a teaching tool for students, as both objective and subjective may not always be available in a job setting.

Objectives

- Looking to assess the congruency of electroacoustic measures compared to subjective measurements of hearing aid features.

1. Do both measures give the same results?
2. Does a particular frequency range play a larger role when subjectively assessing directional microphone or DNR function?
3. Do these features work in the same way in the same model of hearing aid?
4. Do subjective measures vary among clinicians?

Research Design

- Blinded, randomized quasi experiment
  - Subjects and examiner were blinded
  - Hearing aids were presented to each subject according to previously determined randomization schedule (numbers out of a hat)

METHODS

Methods

- Seven pairs of BTE hearing aids, varying manufactures
- First programmed to 50 dB flat hearing loss, using each manufacturer's proprietary algorithm.
- Programming for features
  - First trial DM function programmed to maximal capabilities, all other features off
  - Second trial DNR function programmed to maximal capability, all other features off
  - In each trial one HA was randomly selected to have the feature under investigation deactivated, to serve as a catch trial
- Double blinding achieved by wrapping each hearing aid in bandage tape, assigning number.
- Hearing aids randomly selected, inserted battery, and tested.

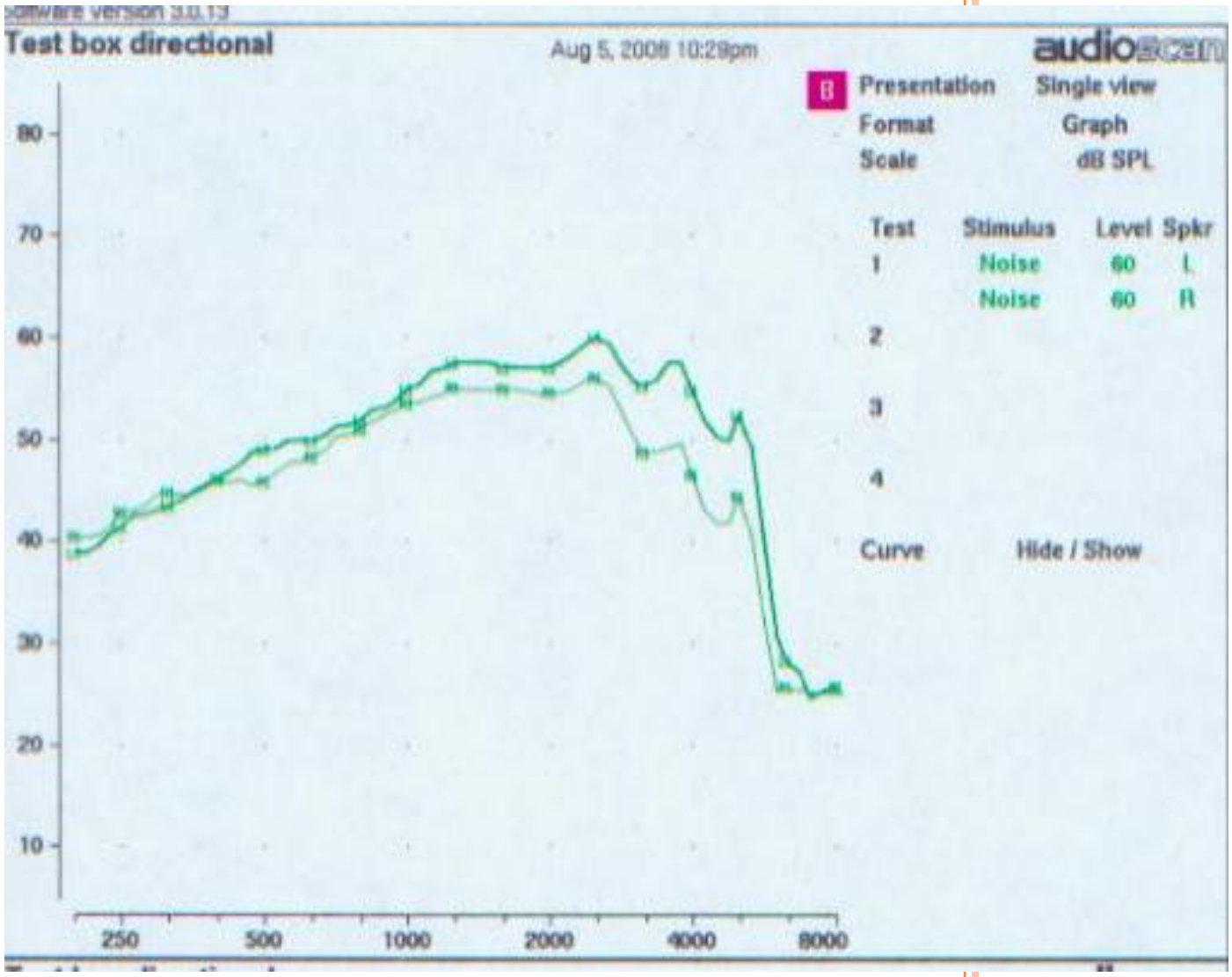
Subjective Measures

- 10 normal hearing subjects with audiology background and familiarity with hearing aid check-in protocol used at MSHC
- Presented 13 hearing aids (in random order) with same programming and blinding as performed in objective measures

Directional Microphone Methods

- Objectively measured in the test box

- Currently no guidelines exist for assessing HA feature function, so how do we know if these features really do work?



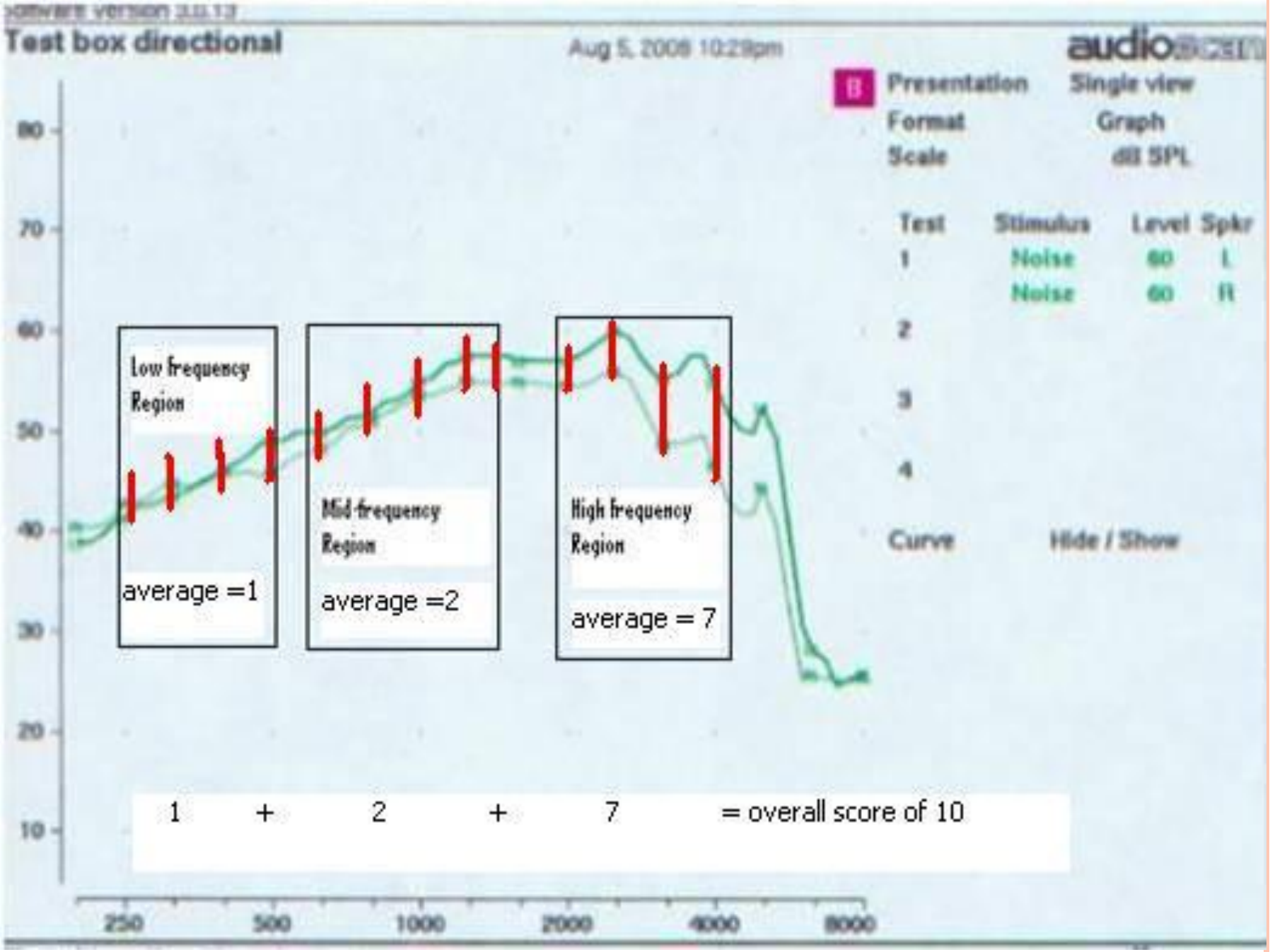
ELECTOACOUSTICAL ANALYSIS OF DIRECTIONAL MICROPHONE

Looking for at least (an arbitrary) 5 dB of separation across frequencies

Directional Microphone Methods

Objective Scoring

- HA programmed to directional mode
- HA placed in test box, lined microphone openings on horizontal line, directional test run with 60 dB input
- Divided output into 3 frequency ranges
  - 250-500Hz (low frequency region)
  - 630-1600 Hz (mid frequency region)
  - 2000-4000 Hz (high frequency region)
- Took the difference at each frequency, and took the mean of the 1/3 octave band frequency regions
- Added the 3 mean scores for an overall score


Test box directional
Aug 5, 2008 10:29pm
audiocon
Presentation
Single view
Format
Graph
Scale
dB SPL
Test
Stimulus
Level
Spkr
1
Noise
60
L
Noise
60
R
2
3
4
Curve
Hide / Show
80
70
60
50
40
30
20
10
Low frequency Region
average =1
Mid-frequency Region
average =2
High frequency Region
average = 7
1 + 2 + 7 = overall score of 10
250
500
1000
2000
4000
8000

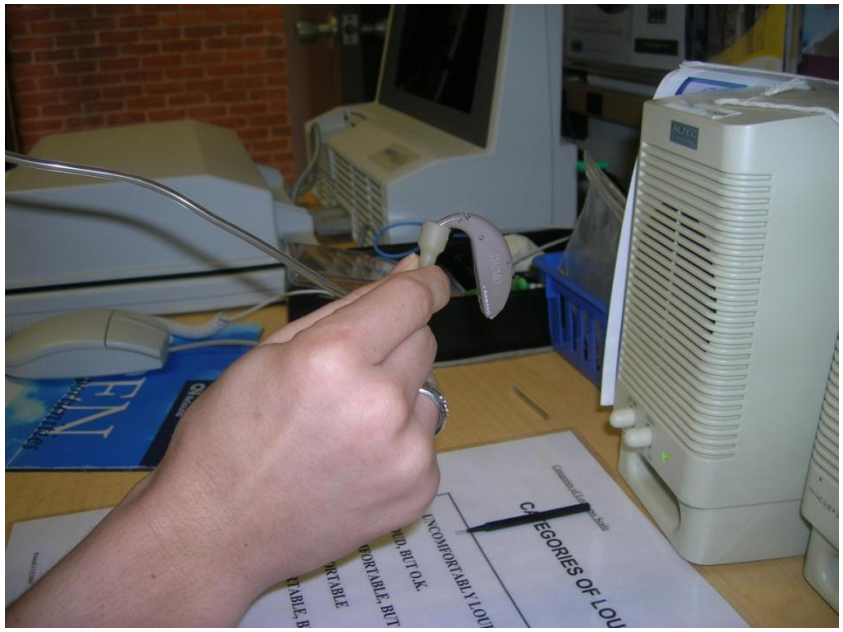
Directional Microphone Methods

Subjective Measurements

- HA's selected by investigator in order of a previously determined randomization schedule
- Stimulus consisted of calibration noise from the SIR test on the HARL Speech Intelligibility Tests CD
- Subject listens to HA through stethoset, adjusts the noise until it is 'loud and ok' with the front microphone facing the noise, then turn it around so the back microphone faces the noise
- Subjects asked to rate DM

Subjective Rating	Description	Score
Wired Backwards	Louder when back mic faced noise	-1
Not Noticeable	No difference, regardless of microphone position	0
Noticeable	Front mic louder than back mic	1
Very Noticeable	Front mic much louder than back mic	2


COCHLEAR IMPLANT
COCHLE
IMPLAN
EGORIES OF LOUDNESS



Subjective Scoring

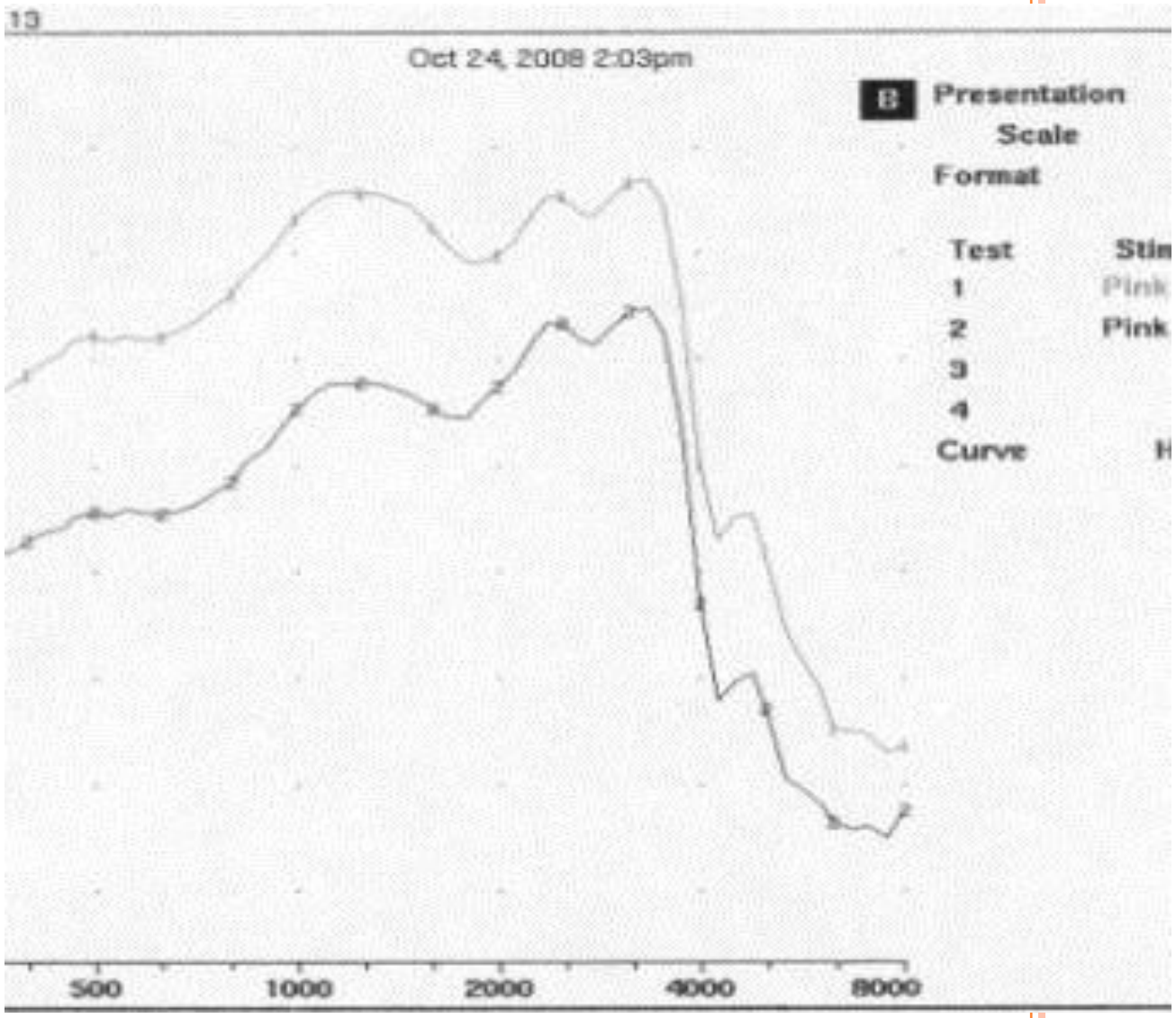
- Example:

Rating:	Wired Backwards	Not Noticeable	Noticeable	Very Noticeable
HA 1:		✓✓✓	✓✓✓✓✓	✓✓

Score: (x # responses)	-1	0 (x 3)	1 (x 5)	2 (x 2)	Total Score
HA 1:	0	0	5	10	15

- Example 2:

Rating:	Wired Backwards	Not Noticeable	Noticeable	Very Noticeable	Total Score
HA 2:			✓✓✓✓✓ ✓✓✓✓✓		10



Electroacoustic analysis of DNR

Digital Noise Reduction Methods

Objective Measurements

- HA programmed to maximal DNR capacity, all other features turned off.
- Objectively measured by placing in test box, "multicurves" test run twice with a 85 dB pink noise
  - First curve run for 2 seconds, before DNR feature reduced noise, served as reference
  - Second curve run for approximately 10 seconds, or until reduction and curve stabilized
- Divided output into 3 frequency ranges, as done in DM measure
  - 250-500Hz (low frequency region)
  - 630-1600 Hz (mid frequency region)
  - 2000-4000 Hz (high frequency region)
- Took the difference at each frequency, and took mean of the frequency regions
- Added the 3 mean scores for an overall score

Digital Noise Reduction Subjective Methods & Scoring

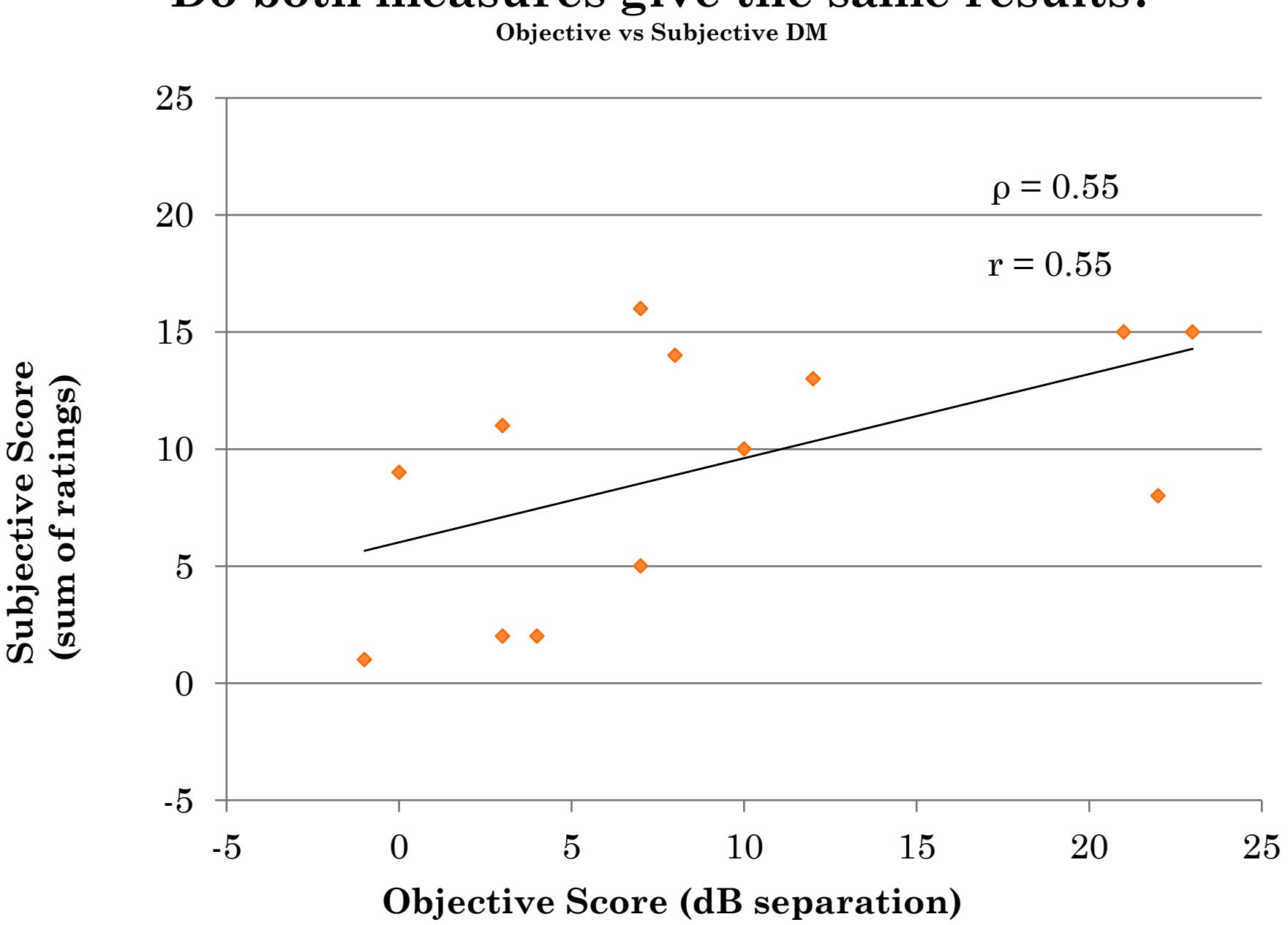
- Subjects presented 10 HAs in random order, all programmed to maximum DNR (same as in objective measures)
- Subjects listened through HA to track 2 (male speaker) on HARL Speech Intelligibility Tests CD, holding the front microphone of HA toward speaker. Volume on speaker adjusted by subject until "loud but comfortable." Subject continued listening while CD switched to calibration noise on CD
- Subjects asked rate DNR function

Rating	Description	Score
Not Noticeable	No reduction in volume noticed when switching to noise	0
Noticeable	Some reduction in volume noticed when noise introduced	1
Very Noticeable	Large amount of reduction in volume noticed when switching to noise	2

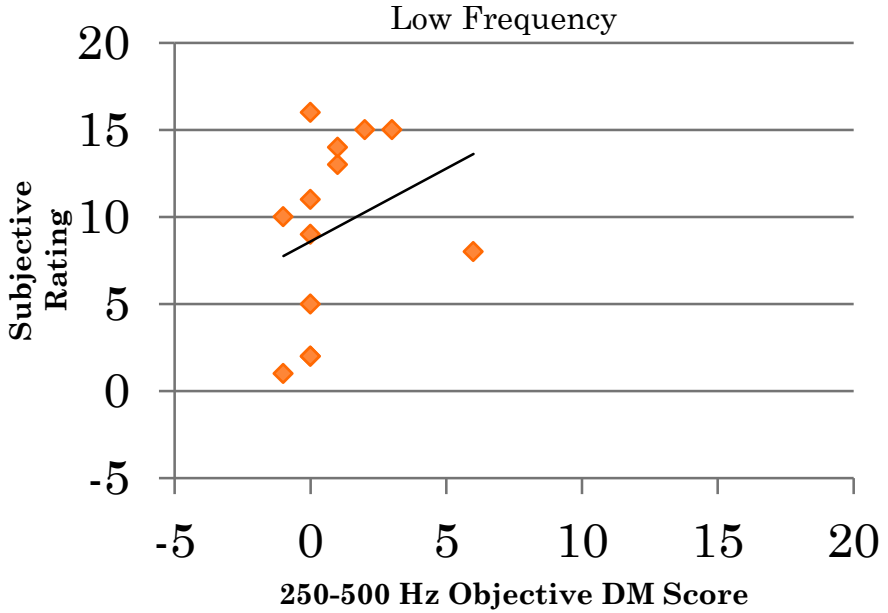
RESULTS

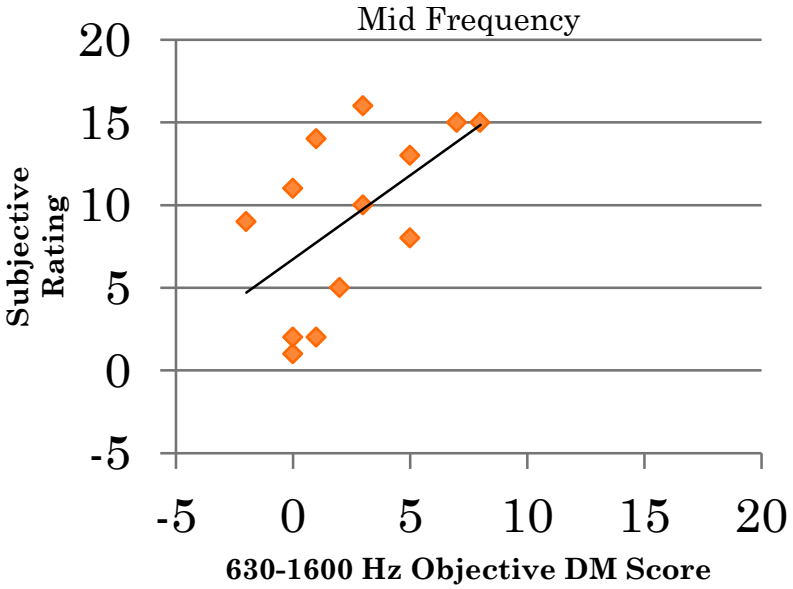
Directional Microphones

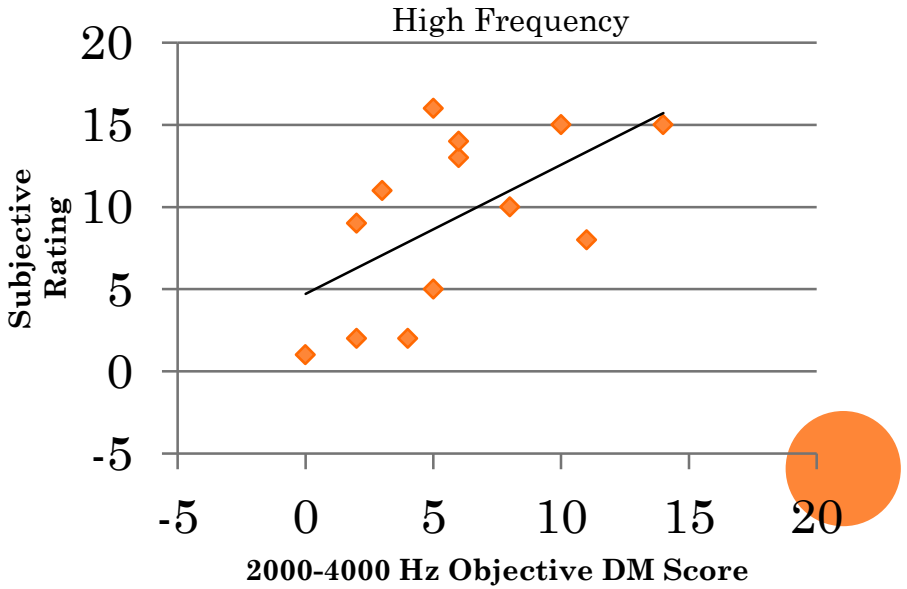
Do both measures give the same results?



Does a Particular Frequency Range Play a Larger Role When Subjectively assessing Directional Microphones?

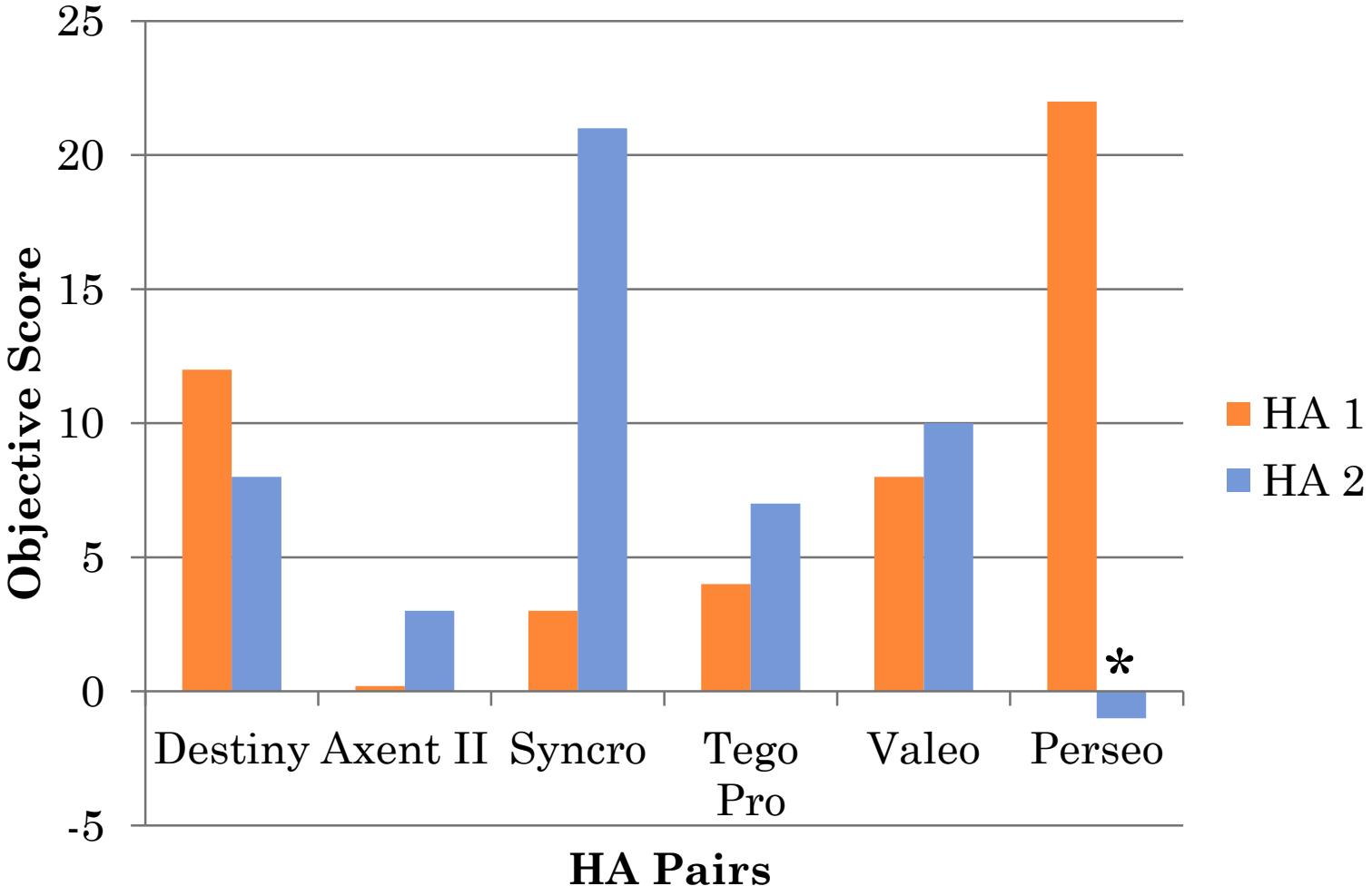






Do DMs work in the Same Way in the same model of HA?

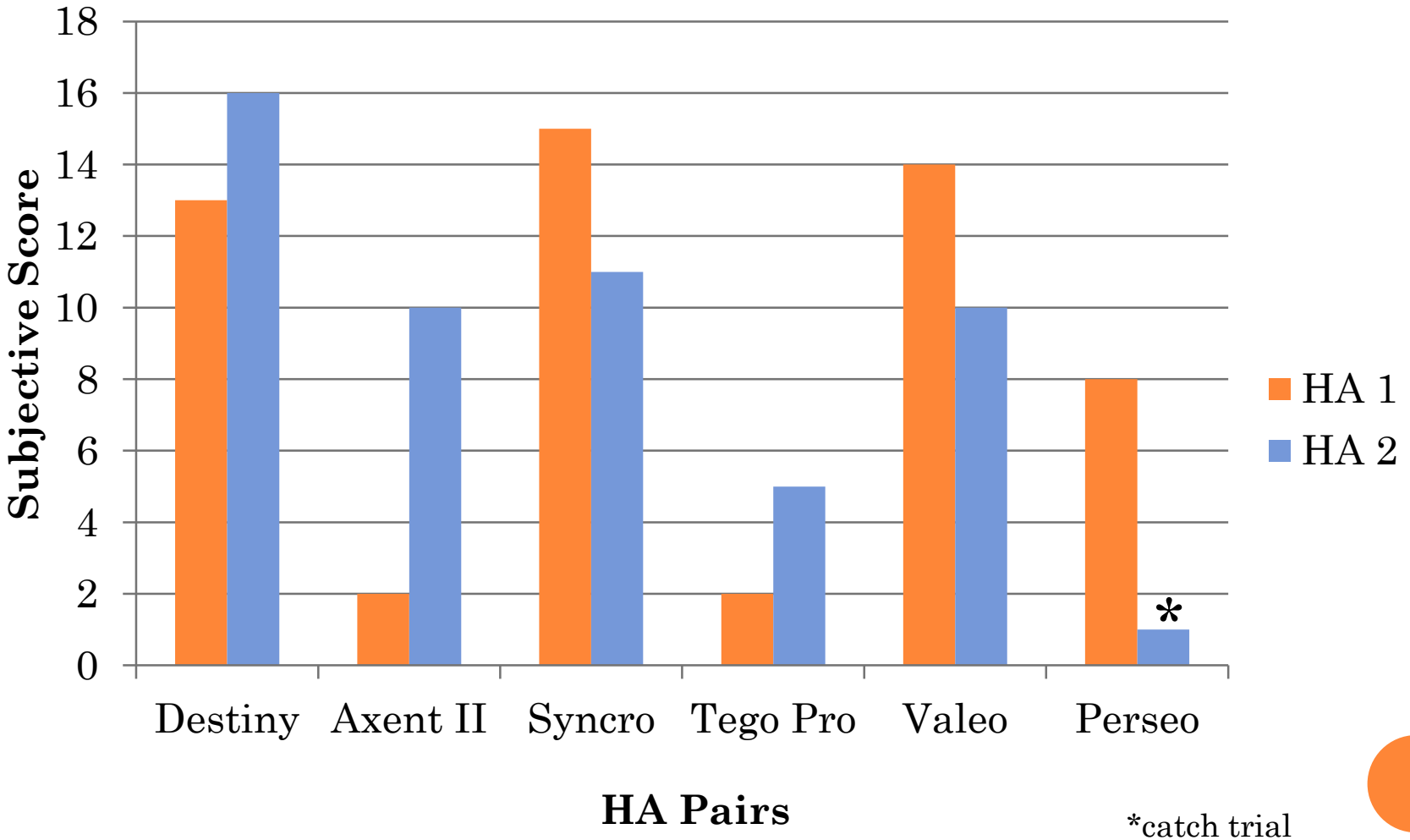
Objective Scores



*catch trial

Do DMs work in the Same Way in the same model of HA?

Subjective Ratings



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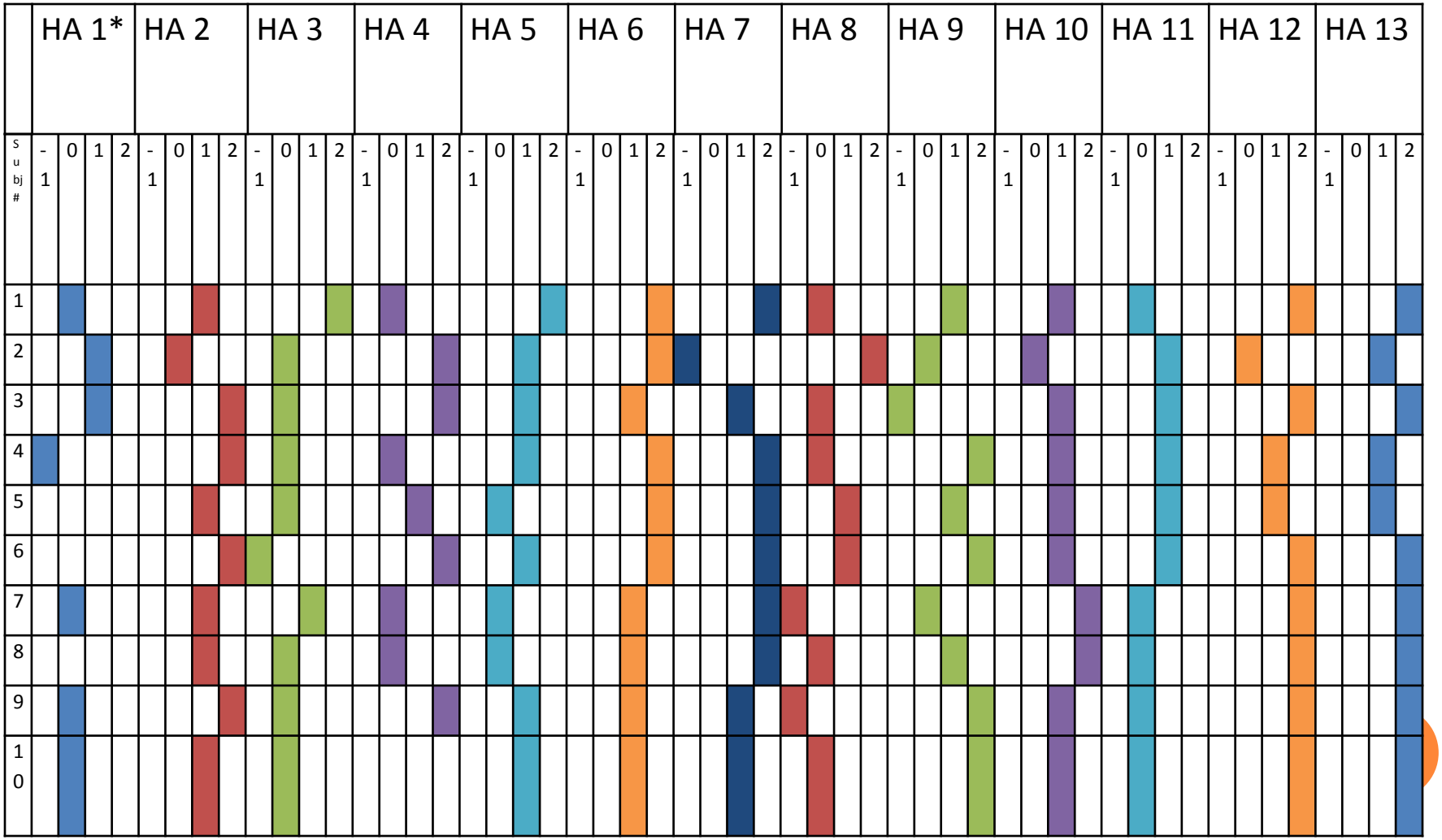
Do Subjective Measures Vary Among Clinicians?

Directional Microphones

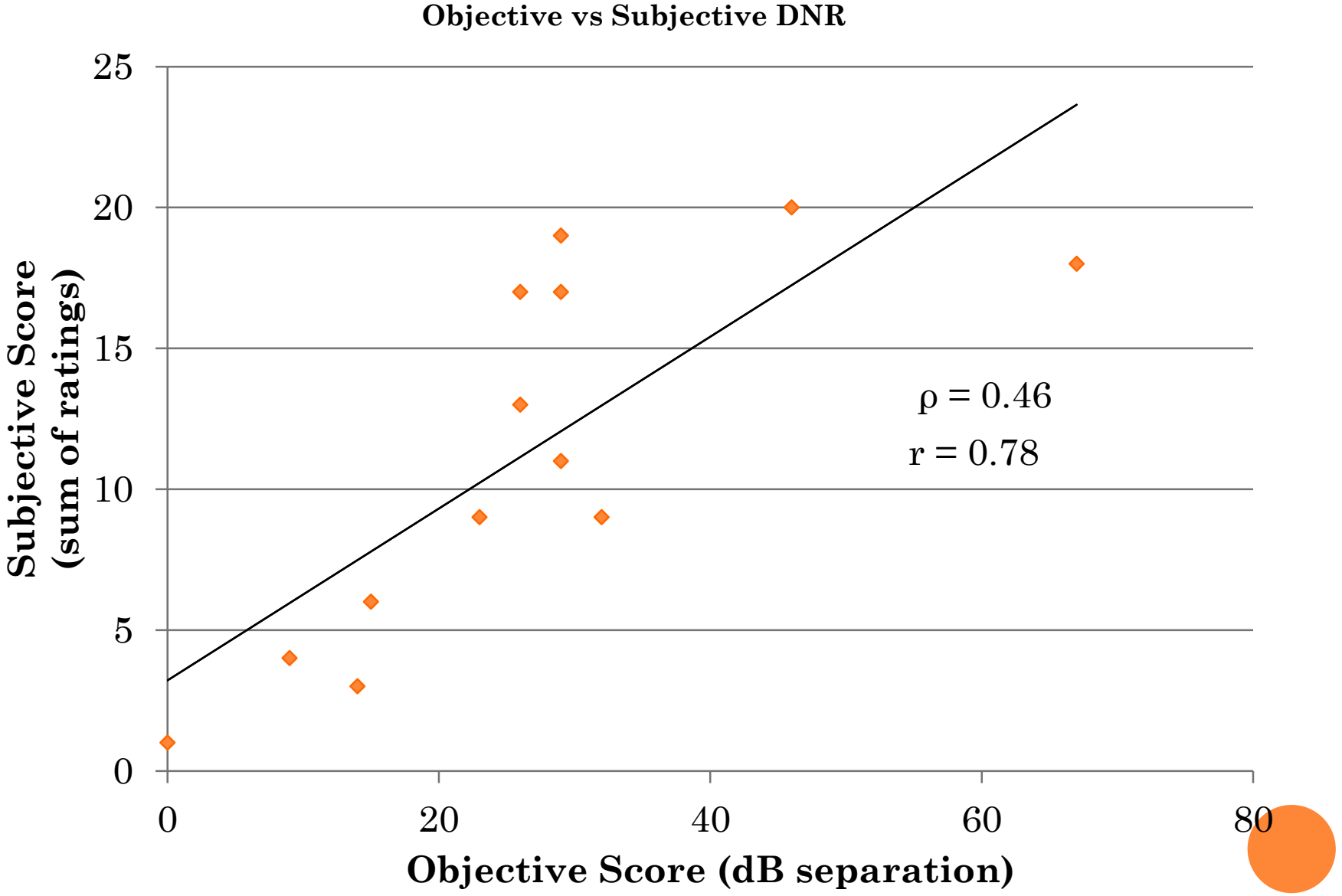


* Catch trial

RESULTS

Digital Noise Reduction

Do both measures give the same result?



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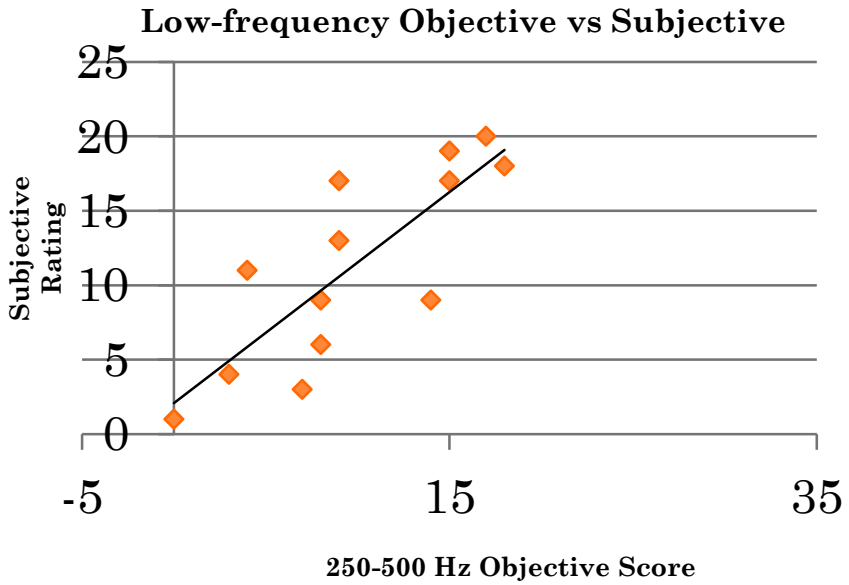
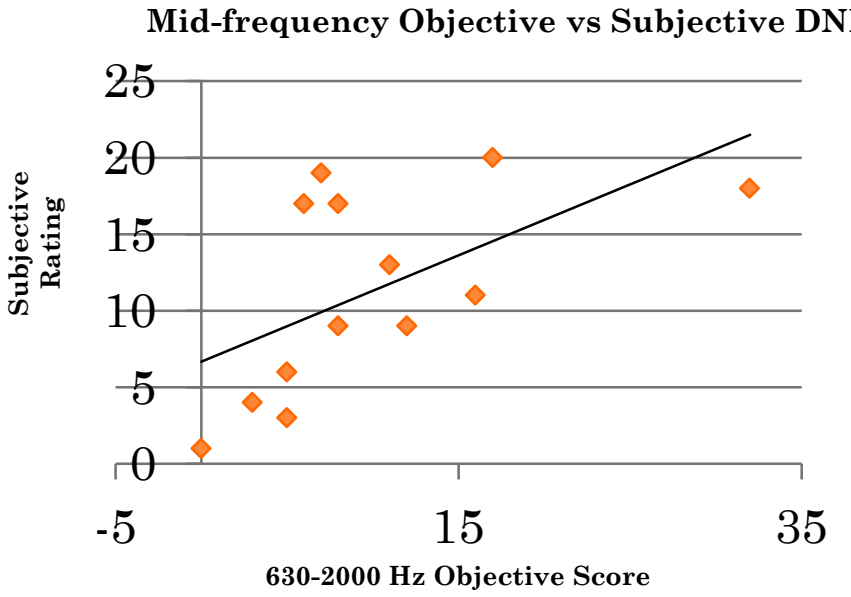
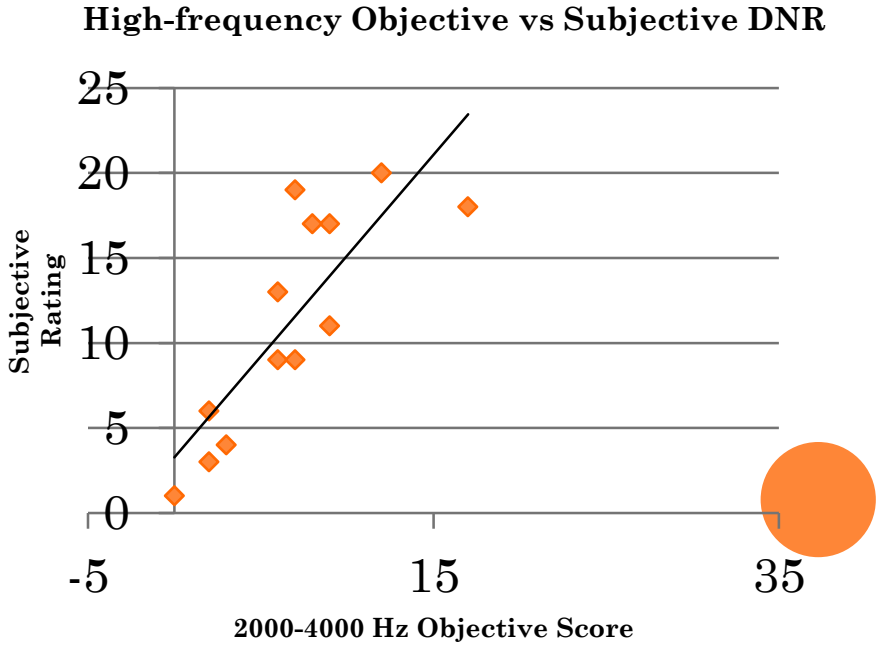
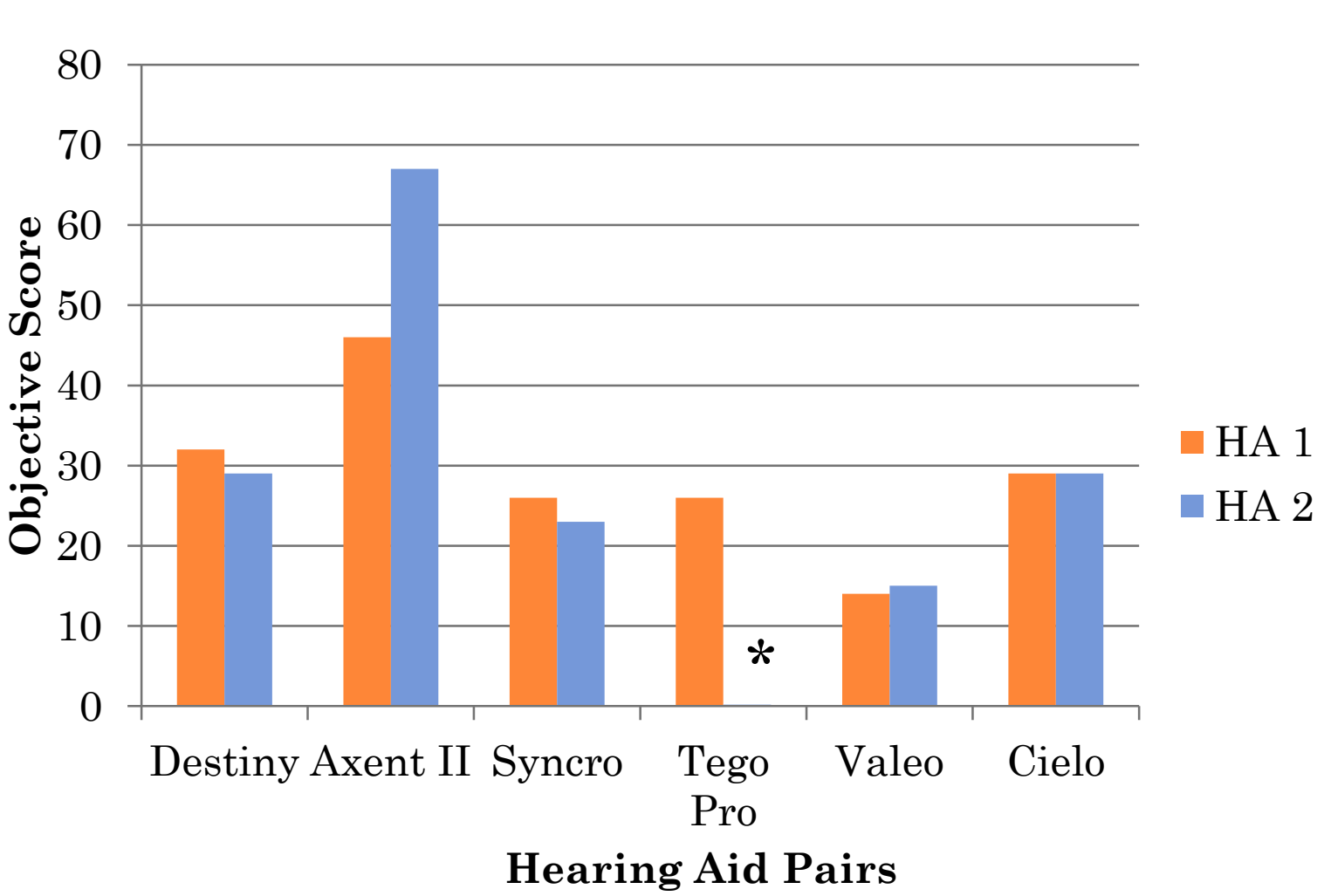






Do these Features Work in the Same Way in the Same Model of Hearing Aid?



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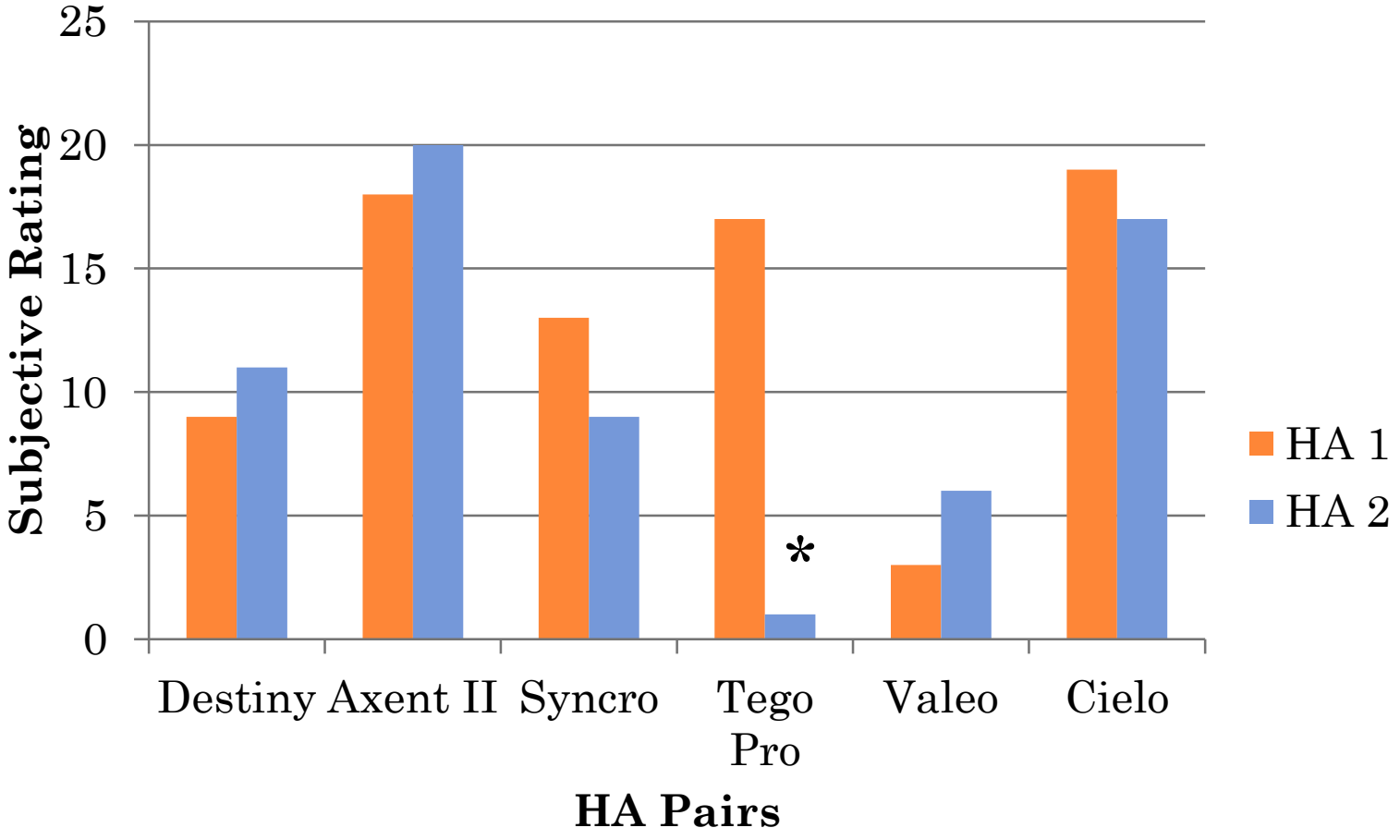
Do these Features Work in the Same Way in the Same Model of Hearing Aid?

Subjective Ratings



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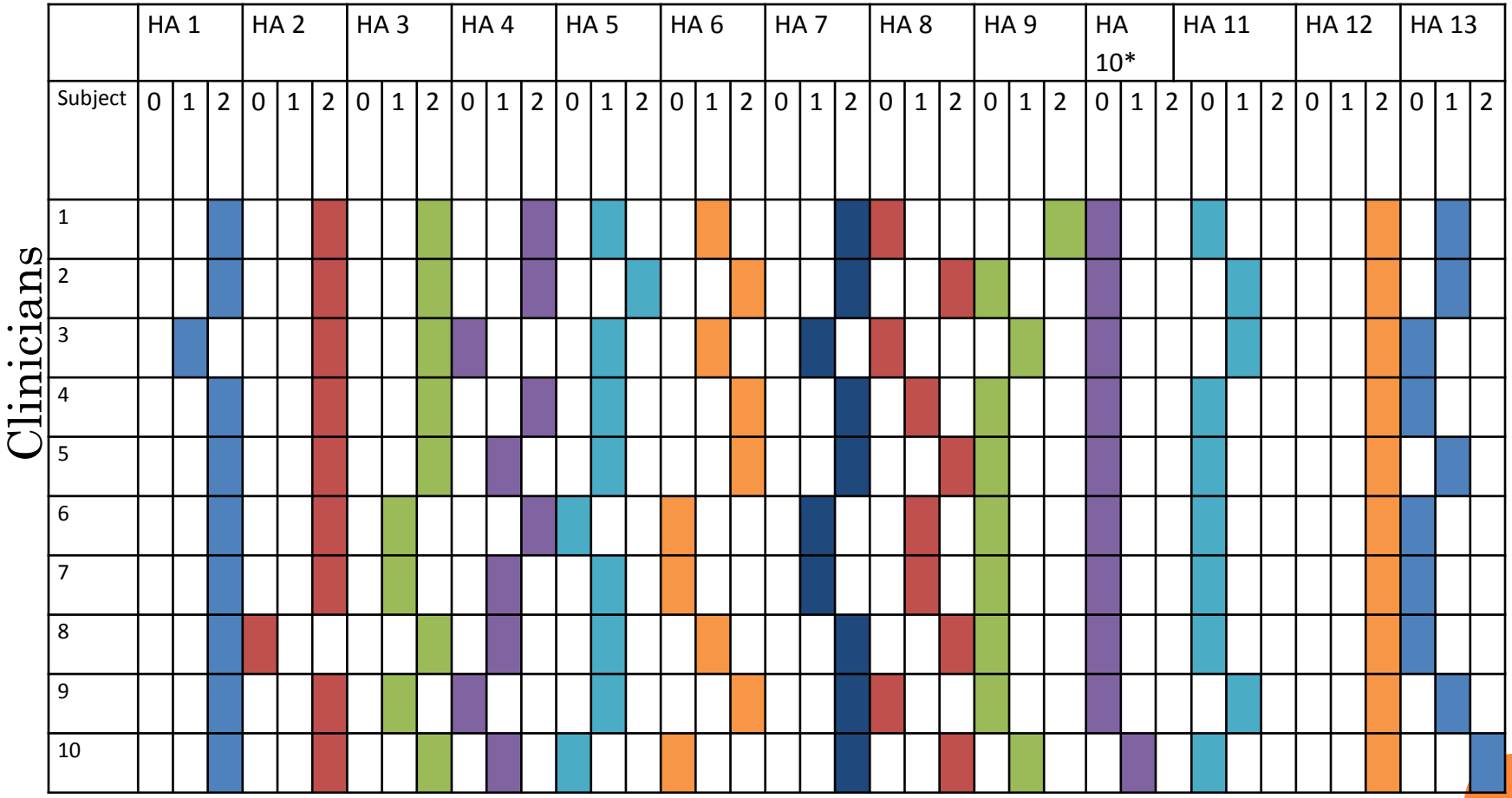
Do Subjective Measures Vary Among Clinicians?

DNR



*catch trial

Conclusions

What Does All This Mean?

- Subjective measurements were surprisingly accurate
- In DM, the low frequency region had little separation in this set of HAs, and did not play much of a role on subjective measures compared to mid and high frequency regions
- In this set of HAs, DNR operated across all frequency regions and played a role in subjective assessment in all regions
- Hearing aid performance was surprising variable within the same model of hearing aid and across manufacturers

Conclusions
Objective Measurements

- Directional Microphones
  - Recommend a ***summed*** difference of at least 10 dB across frequencies in objective measures, before it is judged "noticeable" by a trained clincian

- Digital Noise Reduction
  - Recommend a ***summed*** difference of at least 23 dB across frequencies in objective measures before it is judged "noticeable" by a trained clinician

Conclusions Subjective Measurements

- Subjective verification is important and valuable!
  - Produce results clearly in correlation with objective measures
  - Better than no verification
  - Easy to do
  - Does not require expensive equipment
  - HAs DO vary, so it is important to assess features such as DNR and DM
- Subjective verification will give useful and valid data of hearing aid features
- Subjective verification useful when clinician does not have access to test box