A STUDY ON THE PREFERRED LEVEL OF LATE REVERBERATION IN SPEECH AND MUSIC

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Background

- Known: Perception of reverberation depends from
  - Reverberation impulse response, and
  - Signal characteristics
- For example, reverberation is less audible with
  - Sustained sounds than with more changing ones (e.g., drums), and
  - Decreased pre-delay [Gardner & Griesinger 1994]
- Possible explanations include
  - Input signal masking the reverberation, and
  - Influence from learning

Study Motivation

- Scenario: Adding artificial reverberation to a dry signal
  - E.g., in automatic mixing
- Question: What is the subjectively preferred optimum level of reverberation?
  - Depending on the signal
  - Depending on the reverberation impulse response length
- Question: When deviating from the optimum level, which direction is less harmful?
- Tool: Subjective listening tests
  - Mixing ratio adjustment test
  - Preference rating tests

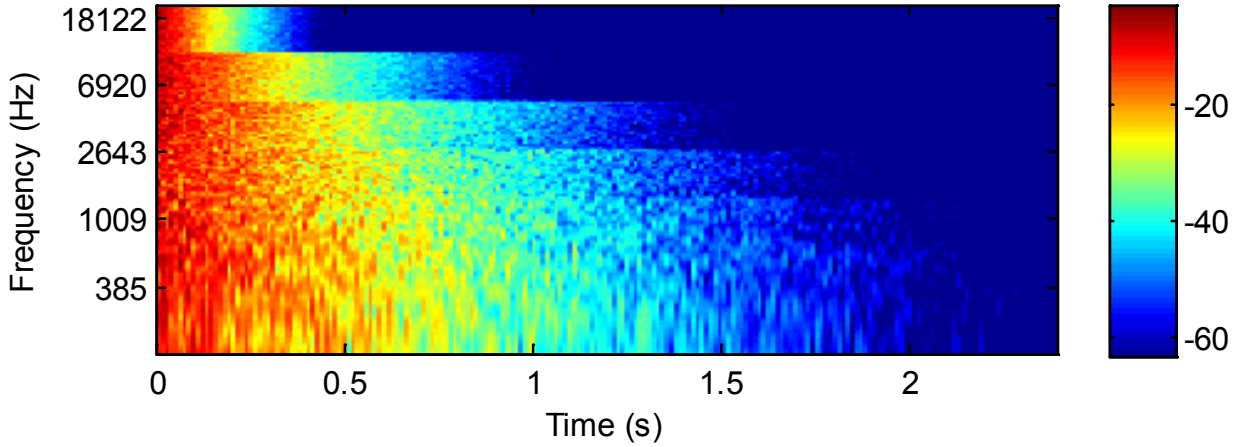
Test Stimulus - Items

- 8 excerpts of speech and music
- Obtained from
  - Anechoic recordings, and
  - Recordings deemed to contain very small amount of reverberation
- Length 10 - 20 s
  - Cut to enable creating a seamless loop

Item	Description
AC	Hard rock
Dr	Solo drums
Sp	Male speech
Gt	Solo acoustic guitar
Ba	Pop/rock
Op	Solo female opera singing
Tr	Solo trumpet
Or	Symphony orchestra

Test Stimulus - Reverberation

- Convolution reverberation using monophonic artificial impulse responses simulating late reverberation
- Nominal reverberation times (T60s): 1.0 s, 1.6 s, and 2.4 s
  - Corresponding T60 of the lowest octave band
- Reverberation signals normalized to equal loudness (ITU BS.1770)



Test Setup - Room

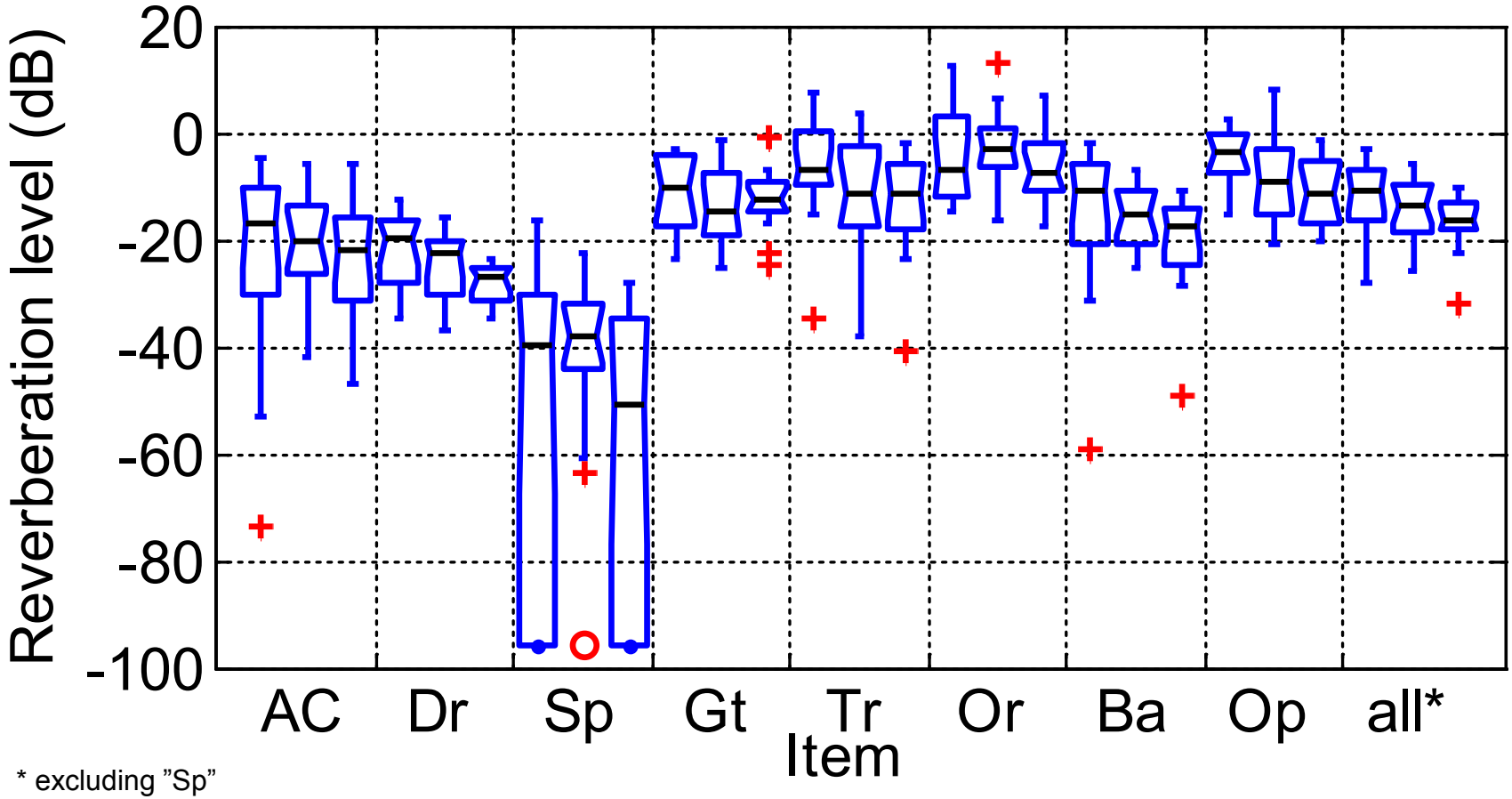
- Try to eliminate the influence of the room acoustics
- Acoustically isolated room
- Headphone reproduction
  - Stax SR Lambda Pro

Mixing Ratio Adjustment Test

- Listener task: Given a dry signal and a reverberation signal, adjust the mixing ratio for *maximal subjective preference*

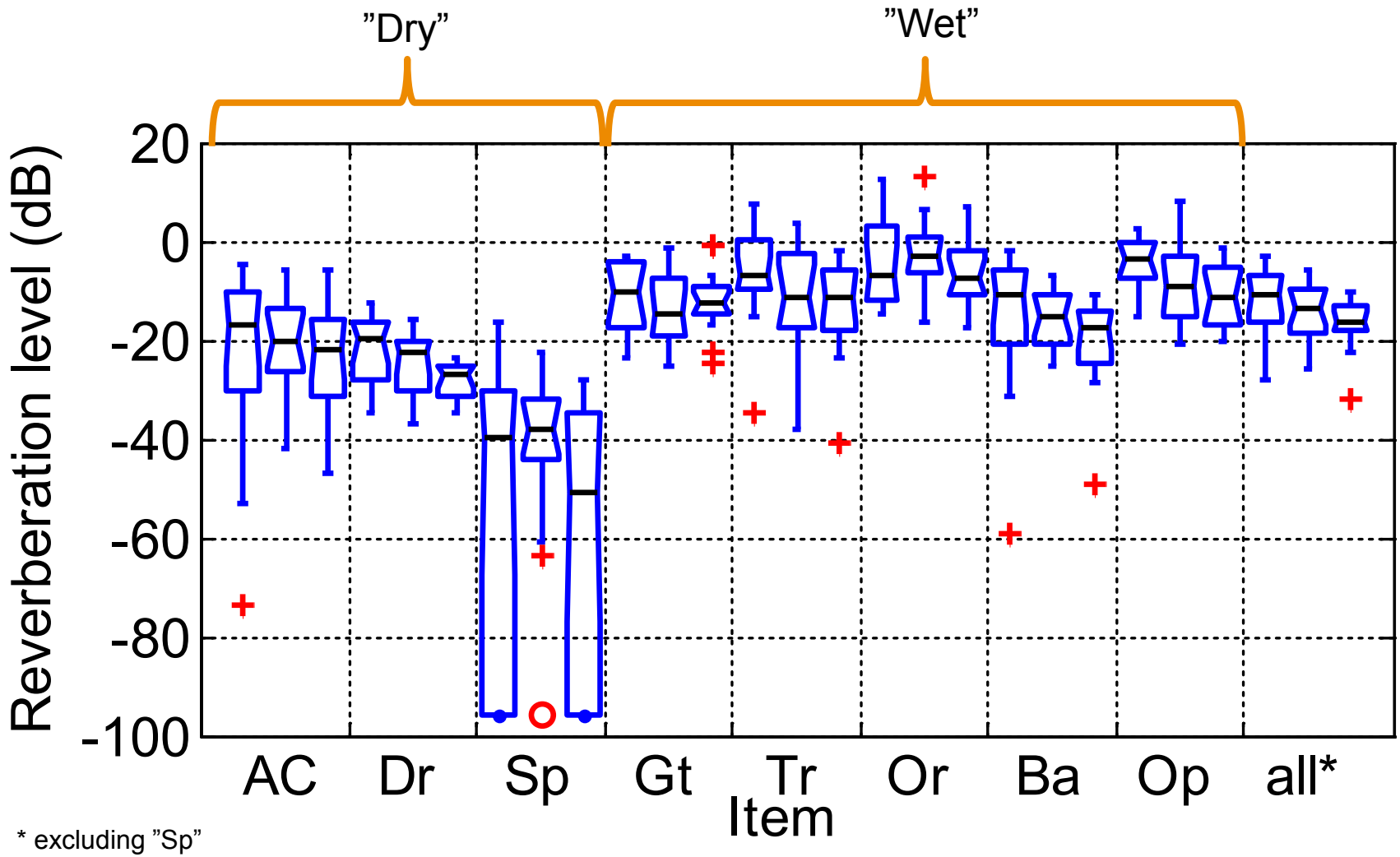
- Physical dial for the adjustment
- No visual feedback
- Nonlinear scale: -96 - +96 dB
- Mixed signal loudness-normalized
- 14 test participants

Mixing Ratio Adjustment Rest - Results



* excluding ”Sp”

Mixing Ratio Adjustment Test – Results & Conclusions



* excluding ”Sp”

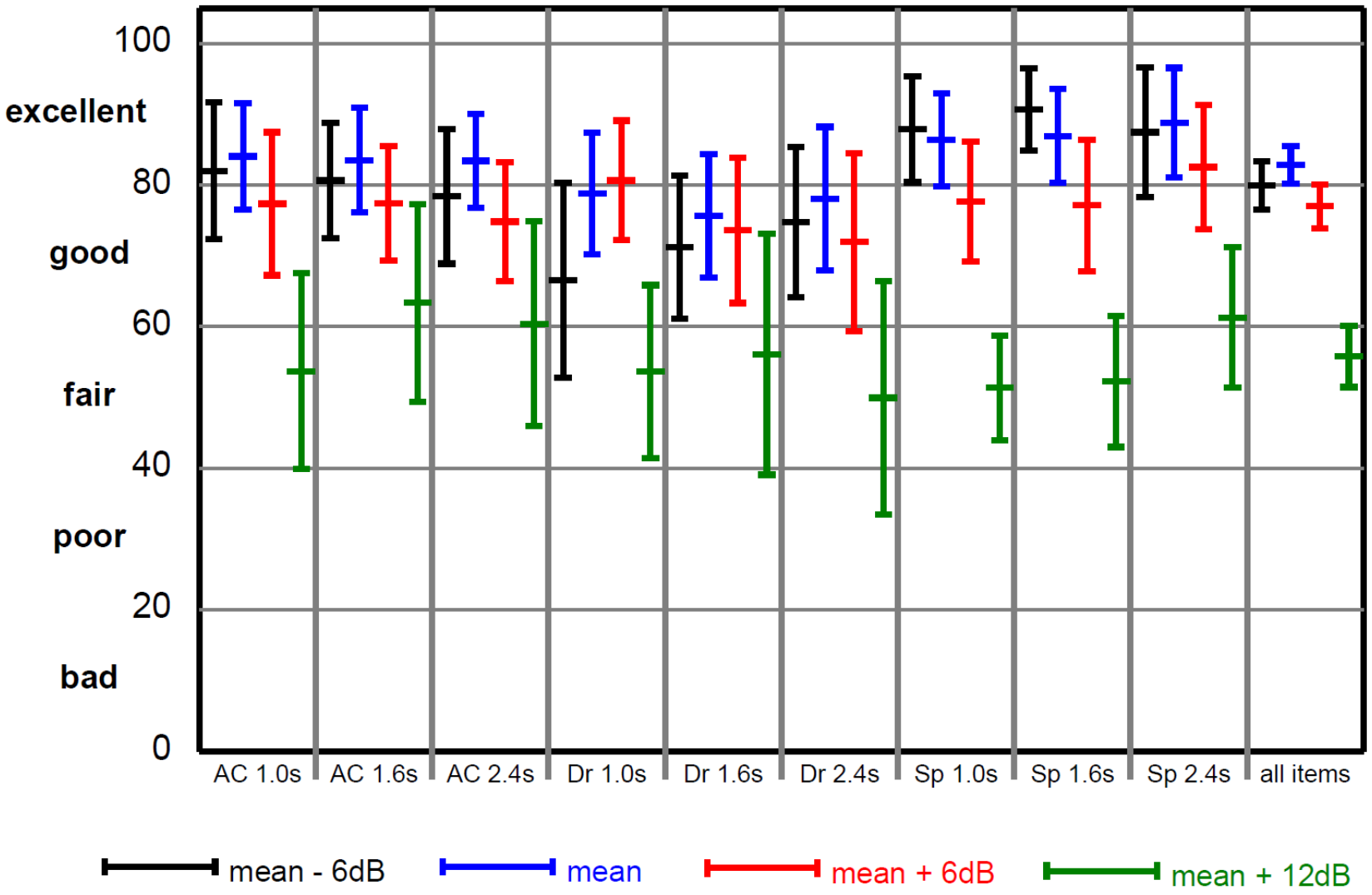
Reverberation Rating Tests

- Two tests studying subjective ratings when the reverberation level deviates from the optimal one
  - ”Optimal” defined for each item & reverberation time
- Multi-stimulus test
  - Listener rating personal opinion of the amount of reverberation
  - Quality range scale 0-100
  - Scale divided into 5 ranges with labels:
    - bad, poor, fair, good, excellent

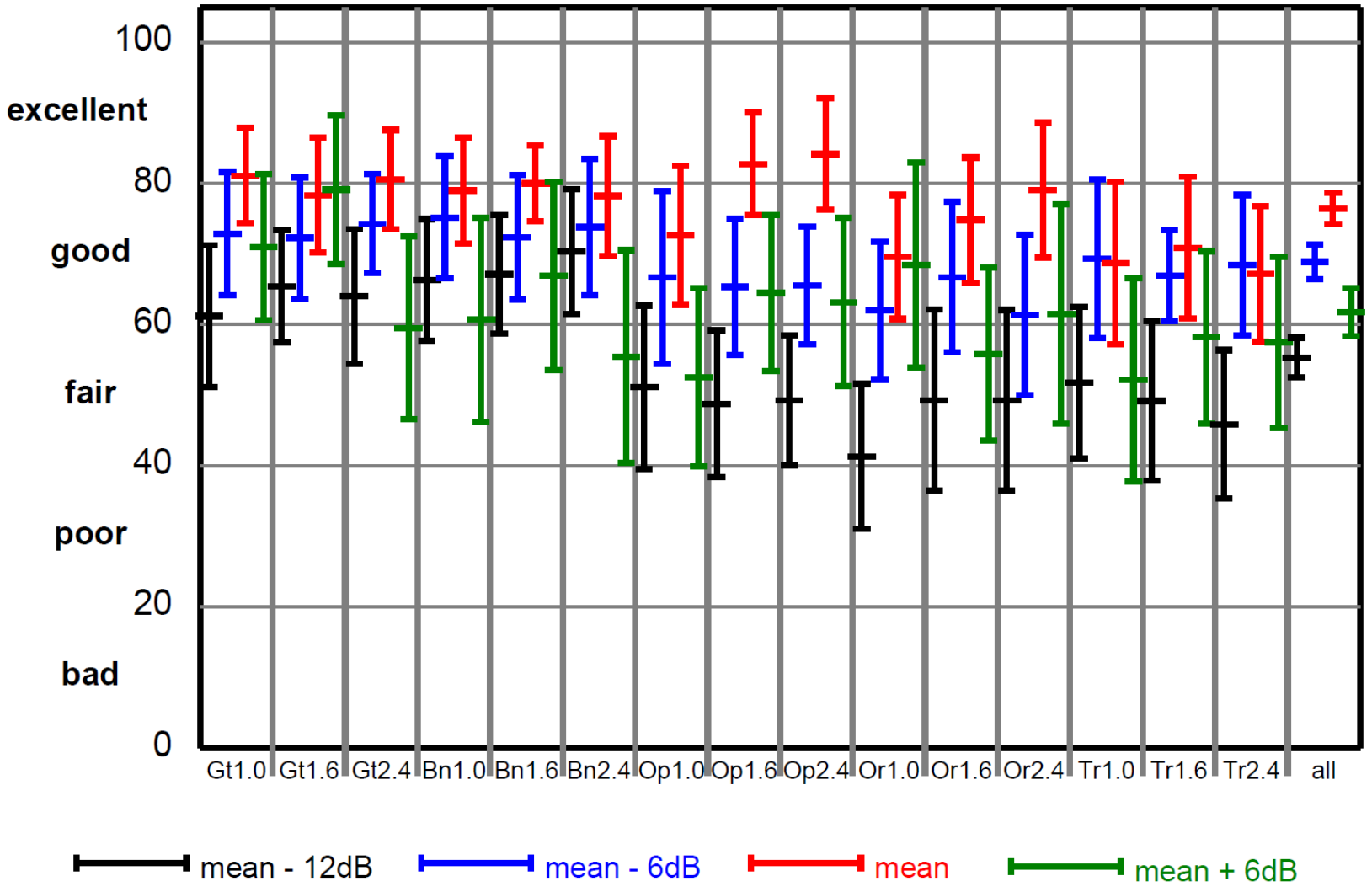
Rating Test 1 – Effect Of Items

- Using all test items and reverberation lengths
- Level of reverberation relative to the optimum level are
  - -12 dB, -6 dB, 0 dB, +6 dB ("wet" items), and
  - -6 dB, 0 dB, +6 dB, +12 dB ("dry" items)
- JND for dry-to-reverberation ratio is 5 - 6 dB [Zahorik 2002]
- Even number of conditions was selected to avoid implicitly indicating one condition being the "middle one”
- 17 test participants

Rating Test – ”Dry” Items Results



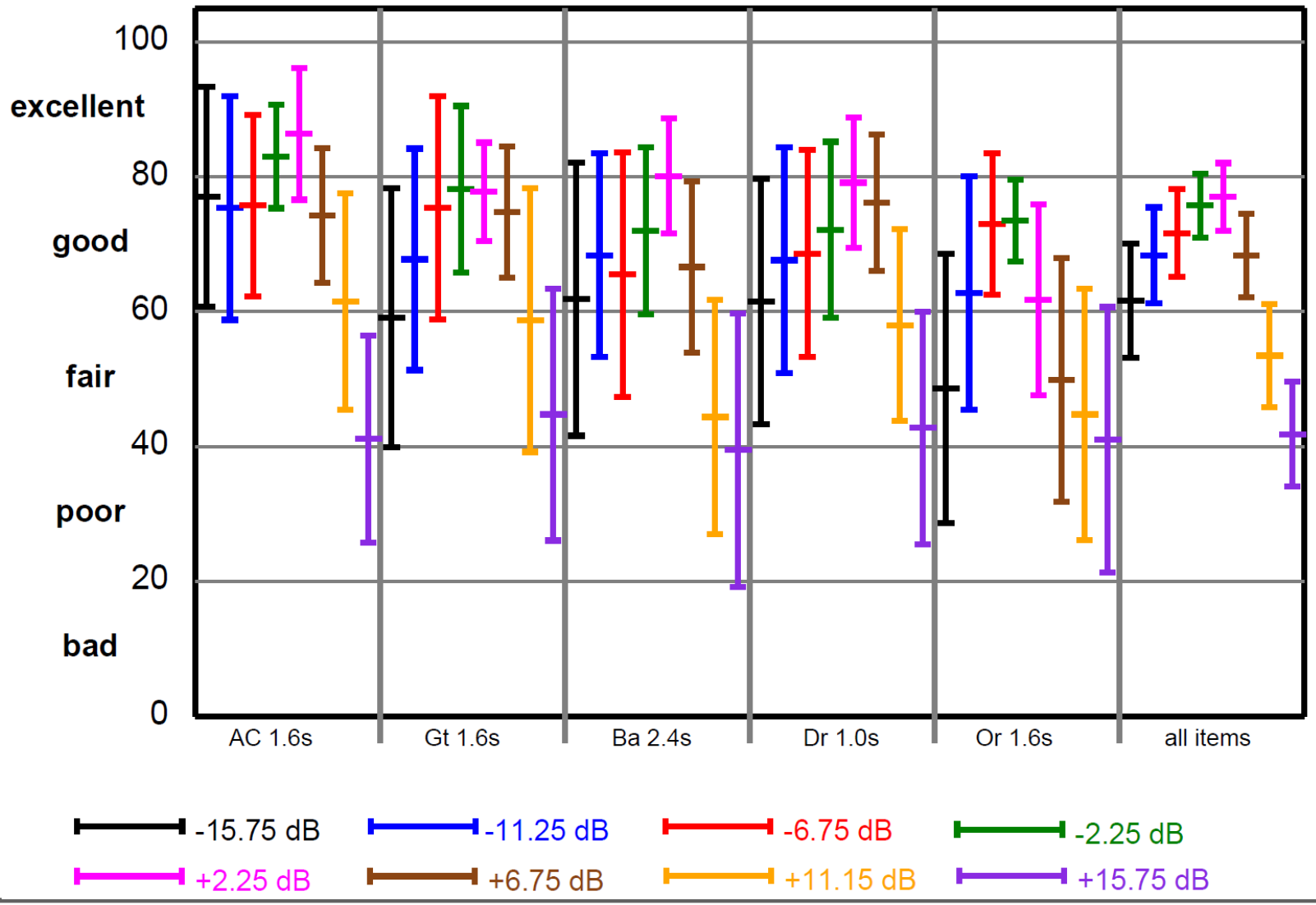
Rating Test – ”Wet” Items Results



Rating Test 2 – Non-optimal Reverberation Level

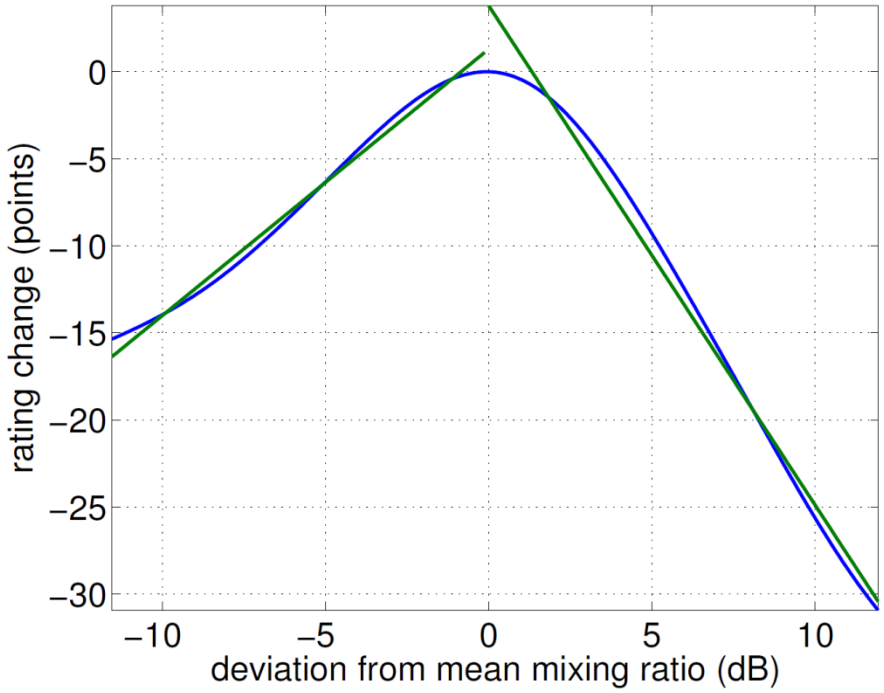
- Study the shape of the rating curve more closely
- Select a subset of items and conditions
  - AC@1.6 s, Gt@1.6 s, Ba@2.4 s, Dr@1.0 s, Or@1.6 s
- Sample the mixing ratio around the optimal level with
  - Higher resolution (4.5 dB step size), and
  - Broader range (from -15.75 dB to +15.75 dB)
    - -15.75, -11.25, -6.75, -2.25, +2.25, +6.75, +11.25, +15.75dB
- 8 listeners

Non-optimal Reverberation Level - Results



Change In Rating vs. Deviation From Optimum

- Too low level of reverberation: -1.5 points / dB
- Too high level of reverberation: -2.9 points / dB



Conclusions

- Mixing ratio adjustment test shows that
  - Test participants tend to agree on the mixing level
    - Signal-dependent, but -5 dB to -20 dB range is preferred
  - Lower mixing level are preferred for longer reverberation times
    - Even when the reverberation signals are normalized to equal loudness
- Quality rating tests show that the rating decreases almost twice as fast when too much reverberation is added compared to adding too little
- → When adding reverberation in automatic mixing, it is better to stay on the conservative side