Audio Quality Assessment

ECE 511 Guest Lecture

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Audio Quality Assessment

- Audio can have many difference ‘purposes’
- Audio is a signal which is a carrier of information
- We can measure how accurately the information is being carried. We can also measure how much we like or dislike the manner in which the information is being carried.
- OBJECTIVE Measures
- SUBJECTIVE Measures

Objective Audio Quality Assessment

- Measurement in relation to a known quantity
- Derived from measurable data
- The measurements are free from personal considerations, emotional predispositions, and personal perceptions
- Can be thought of as an inarguable fact; a direct representation of the signal information

Subjective Quality Assessment

- Measurement through someone's opinion
- Derived as a consequence of the perception of the information
- The measurements are unique to an individual and unique to a moment in time
- Subject measurement results are likely to change unless the biases that will greatly affect the measurement are attempted to be removed or at least controlled and accounted for in an experiment.

Objective Vs. Subjective

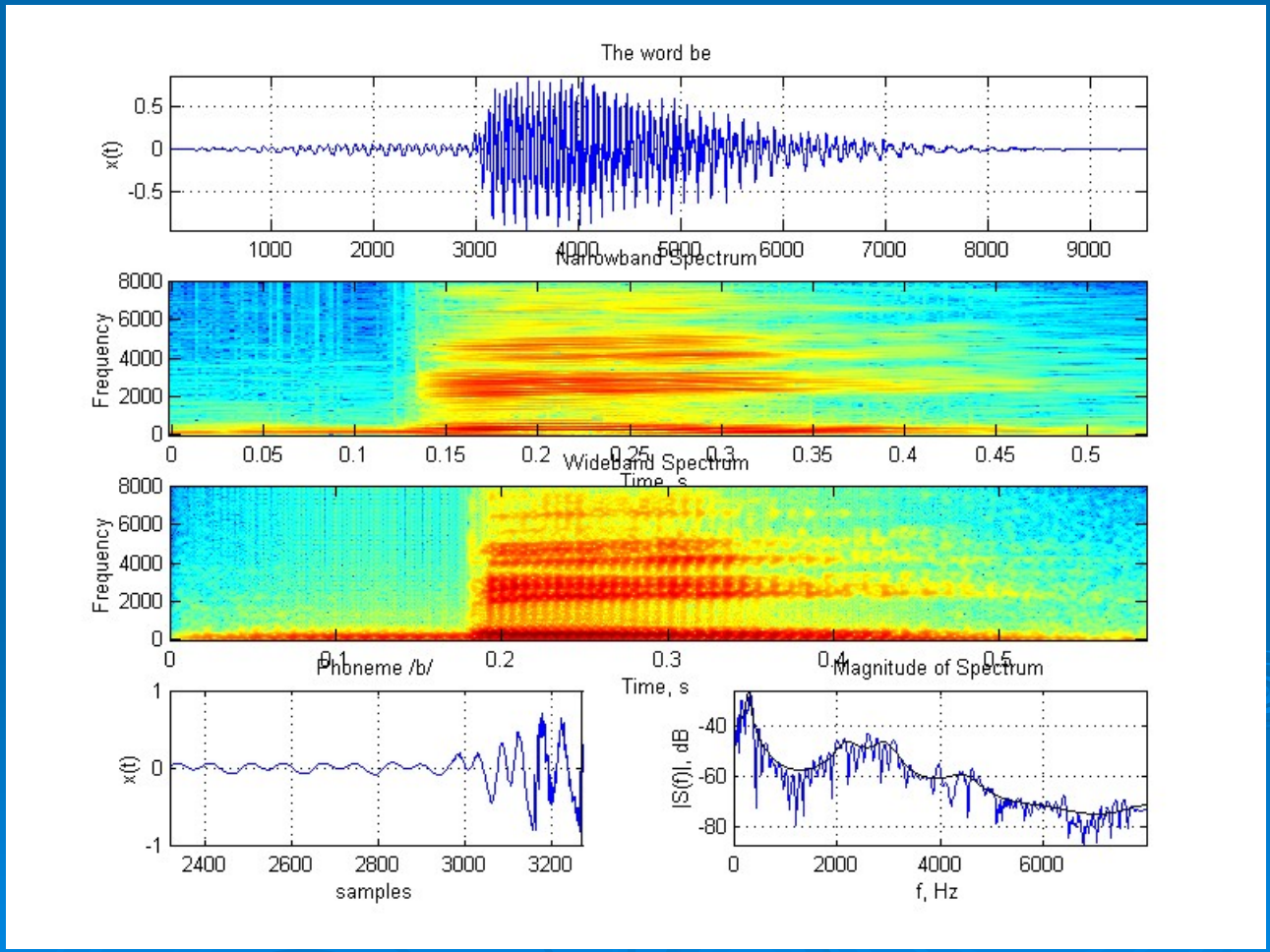
- General objective statement:
  - “I am six feet tall”
  - This can be accurately measured. It can be measured numerous times without deviation in the result
- General subjective statement:
  - “I am tall”
  - This is a personal opinion on my height. The idea of being ‘tall’ can only be compared to the height of people around me. I may be tall compared to a cat, but I am short compared to a giraffe. The context of the measurement is important.

Objective vs. Subjective

- Example of objective audio quality assessment:
  - Measuring a signal and determining a roll-off of high frequencies at a rate of -6dB/octave
- Example of subjective audio quality assessment:
  - Listening to the same audio signal and deciding that the passage sounds ‘muddy’
- Not everyone may agree that the passage sounds ‘muddy,’ but no one can argue the –6dB/octave measurement

Examples of Objective Audio Measures

- Amplitude
- Frequency
- Phase
- Harmonic content
- Envelope
- SNR



Subjective Correlations

- Amplitude → Loudness (without psychoacoustic considerations)
- Frequency → Pitch
- Phase → In general, we can not detect phase unless it results in signal change through additive iterations of the signal
- Harmonic content → Pitch, timbre
- Envelope → Timbre, duration

Audio Quality Measurement

- When measuring audio quality, you are measuring the difference between an original signal or a reference, and an affected output signal
- The effect of the system on the signal is what is being measured

Objective Measurement

- Oscilloscopes
- Spectrum Analyzers
- DAW (digital audio workstations)
- SPL meters (Sound Pressure Level)
- Can you think of others?

Importance of Subjective Audio Quality Measurement

- If we can objectively measure audio, why do we care about subjective measurement?
- Since we have the sense of hearing, we use this sense as a perception, or a representation, or the world around us. We use audio as a means of communicating. The quality of the exchange matters.
- Some subjective measures, such as the effects of reverberation, are difficult to measure objectively on uncontrolled signals

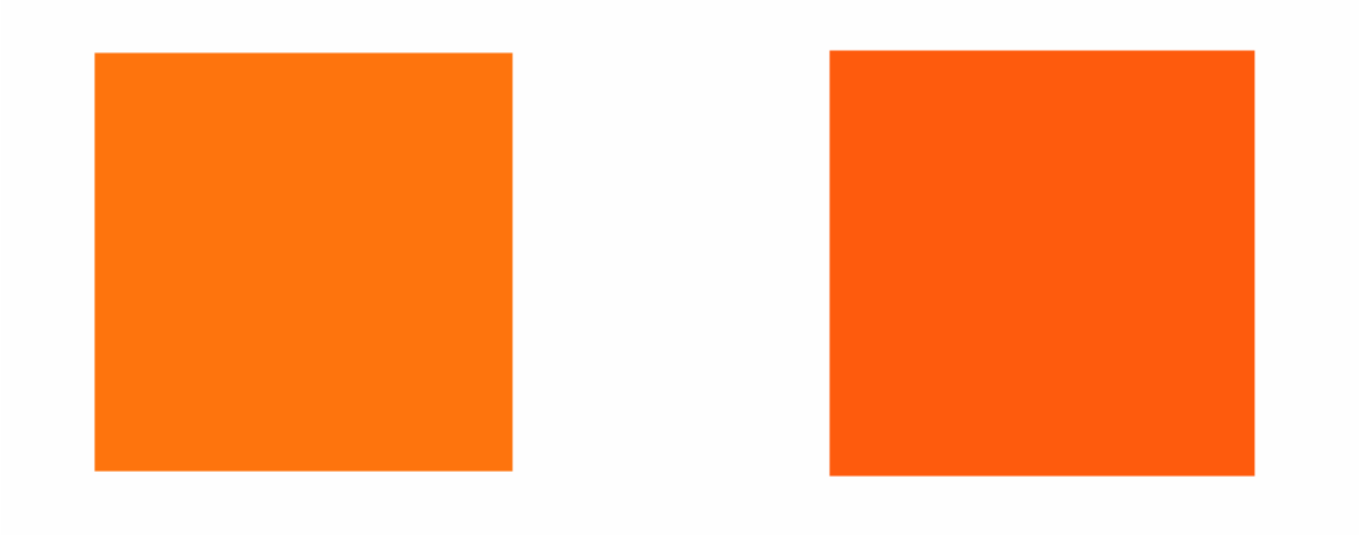
Subjective Measurement

- Objective measurements are sometimes irrelevant when it comes to subjective measurement. In the end, subjective measurement is all that really matters.
- Other times subjective measurements quantify the importance of objective measurements.
  - How much SNR is necessary for a task?
- Turn subjective measurement into pseudo-objective measurements by assigning numeric ratings to phenomenon. Provide the subject with a means to benchmark their opinion.
- The more objective you can make subjective assessment, the more useful the results are.

Subjective Testing

- Subjective opinions should be backed up by rigorous tests intended to remove or control all possible bias from human subjective judgments and opinions.
- Exercise variable control
- Match testing environment to real environment. Due not interpret results out of context.

Testing Environment Example



Testing Environment Example

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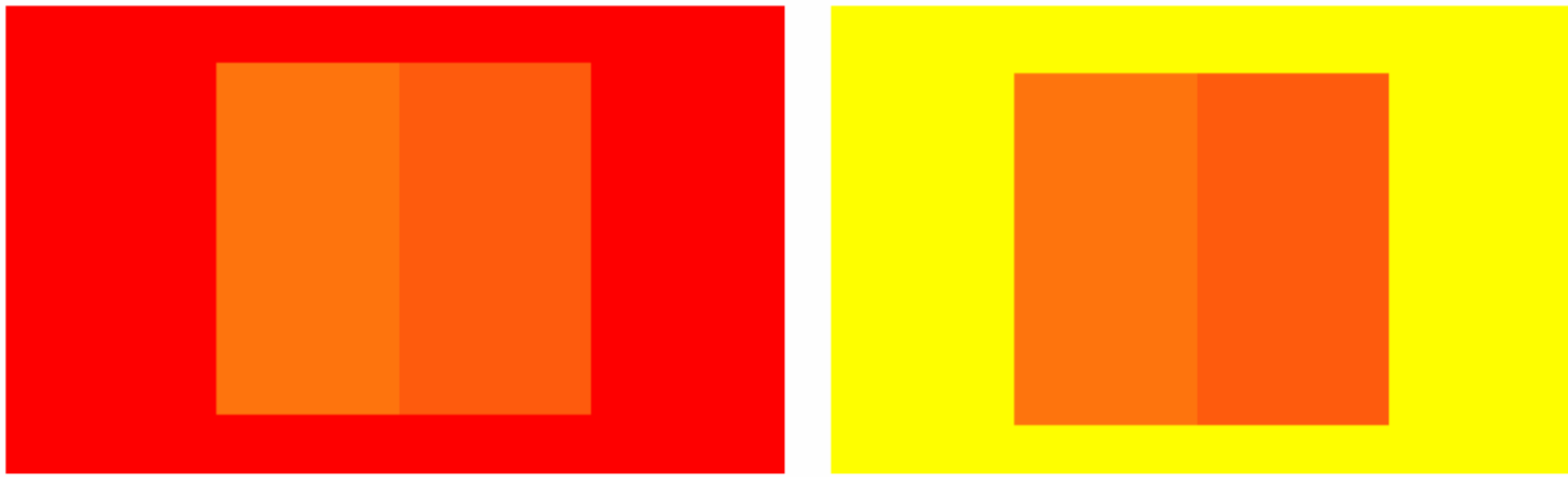

Psychoacoustics

- The information that your brain can interpret is dependent on other factors in the signal and environment
- Frequency Masking
  - Tones Masking Tones
  - Noise Masking Tones
  - Tones Masking Noise
  - Noise Masking Noise
- What are tones? How are they correlated to the information present in the signal?
- What is noise?

Psychoacoustics

- Temporal Masking
- Other Neurological Effects
  - Back to timbre
    - How do we differentiate between two sound sources?
  - Noise vs. Tones vs. Signal vs. Information
- Binaural Effects
  - Its effects on signal segregation through directionality

Subjective Opinions

- How do we represent opinions as objectively as possible?
- Example:
  - Excellent — Imperceptible
  - Good — Perceptible, but not annoying
  - Fair — Slightly Annoying
  - Poor — Annoying
  - Bad — Very Annoying
- What do these really mean?
- They are context sensitive. The grading process doesn't inherently answer why.

Example ITU Recommendations

- BS.1284-1 General methods for subjective assessment of audio quality
  - Experimental Design
  - Selection of Listeners
  - Test Method
    - Grading Scales (Comparison Tests)
    - Auditory Memory
  - Clearly Defined Attributes (type of audio setup)
  - Program Material (Stochastic nature of general audio)
  - Reproductive Devices
  - Listening Conditions
  - Analysis of Data
  - Descriptive Terms for Audio Quality Assement

Example ITU Recommendations

- BS.1116 – Methods for subjective assessment of small impairments in audio systems
- ABC Tests
- Testing for Transparency

Example ITU Recommendations

- BS.1534 – Method for the subjective assessment of intermediate audio quality level of coding systems
- MUSHRA – Multiple Stimulus Hidden Reference and Anchor
- Tests for quality comparison

Example ITU Recommendations

- BS.1387 – Method for objective measurements of perceived audio quality
- PEAQ – Perceptual Evaluation of Audio Quality
- Uses the researched correlation between objective measurements and subjective measurements to obtain a single objective rating

Objective and Subjective Measurements

- SNR
- THD (Total Harmonic Distortion)
- DIX (Disturbance Index)
- NMR (Noise to Mask Ratio)
- POM (Perceptual Objective Measure)
- JND (Just Noticeable Difference)
- OASE (Objective Audio Signal Evaluation)
- Many Others

Conclusion

- There is not a concise way to measure audio quality.
- Much thought needs to be put in to devise a proper experiment protocol.
- It is much more difficult to isolate variables when testing audio quality than many other experiments.
- It is important to include all of the variables that can potentially affect audio quality perception in the experimental design. The analysis must be designed to try to substantiate the effect of each variable in a single experiment.

Questions?