

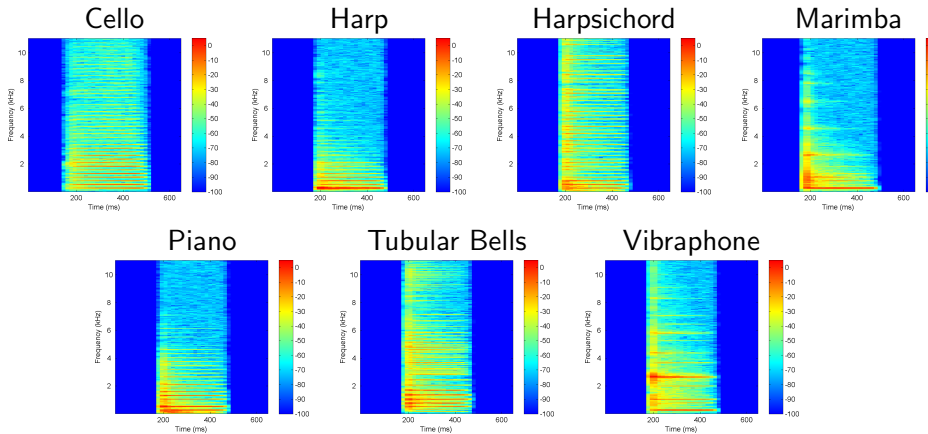
# Using auditory bubbles to determine spectro-temporal cues of timbre

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CogMIR  
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# Timbre differentiates instruments



# But what is timbre?

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<sup>1</sup> John M. Grey. Multidimensional perceptual scaling of musical timbres. *J. Acous. Soc. of America*, 61(5):1270, May 1977

<sup>2</sup> Anne Caclin, Stephen McAdams, Bennett K. Smith, and Suzanne Winsberg. Acoustic correlates of timbre space dimensions: A confirmatory study using synthetic tones. *J. Acous. Soc. of America*, 118(1):471, July 2005

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### Grey (1977)<sup>1</sup>

In discussing the attributes of complex tones, Licklider (1951) concludes that “Until careful scientific work has been done on the subject, it can hardly be possible to say more about timbre than that it is a ‘multidimensional’ dimension.”

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## Caclin et al. (2005)<sup>2</sup>

The holy grail of timbre studies has been to uncover the number and nature of these dimensions.

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# We propose a listening test that identifies distinctive time-frequency regions

- Mix the same sample with different noises, measure intelligibility
  - provides randomized glimpses of the target
- Use results to identify important time-frequency regions
  - where audibility is correlated with correct identification
- Identifies regions of spectrogram that are characteristic of each timbre

# This listening test shows great potential for timbre studies

- Preliminary results appear to agree with previous studies
- But provide much more specific identification of distinctive features
- This approach is useful for timbre, but also other classification tasks
  - in both music and speech perception

# Outline

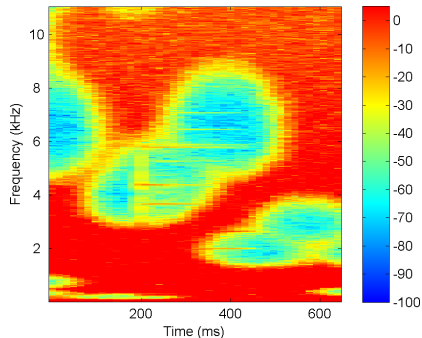
- 1 Example task
- 2 Listening test and analysis
- 3 Results for each instrument
- 4 Summary



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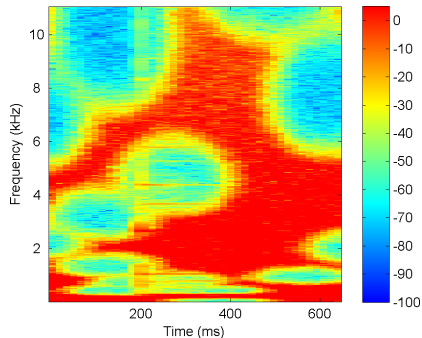
# Which instrument did you hear?



Which instrument did you hear?

Cello   Harp   Harpsichord   Marimba   Piano   Tubular Bells   Vibraphone

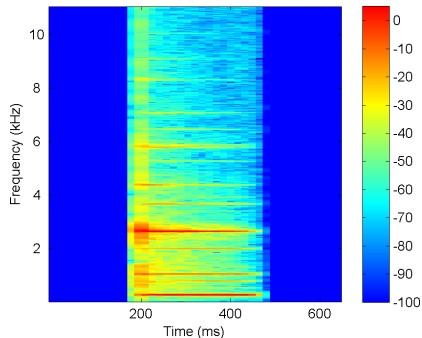
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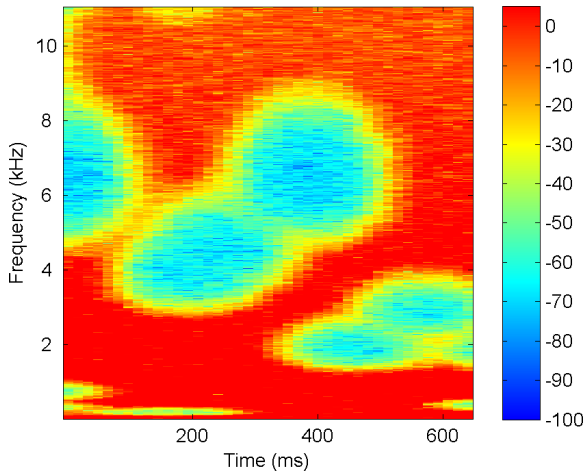
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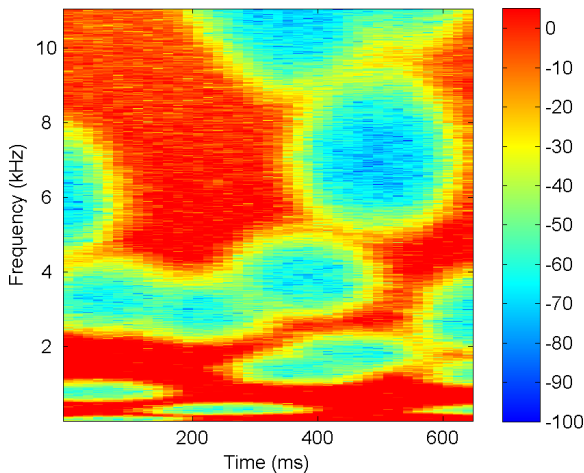
# Listening test specifics

- 7 instruments from Vienna Symphonic Library playing C4
  - normalized to same pitch, duration, loudness in pilot studies
- 200 mixtures of bubble noise with each instrument sample
- Two subjects (700 mixtures  $\approx$  45 minutes each)
- Bubbles-per-second adjusted to achieve  $\sim$ 50% correct identification

# Bubble noise provides randomized glimpses of sounds

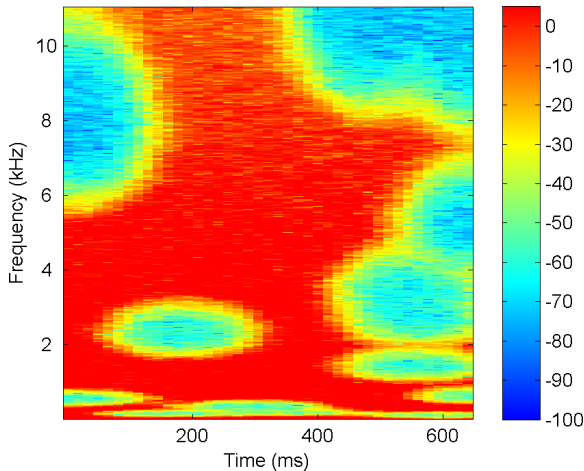


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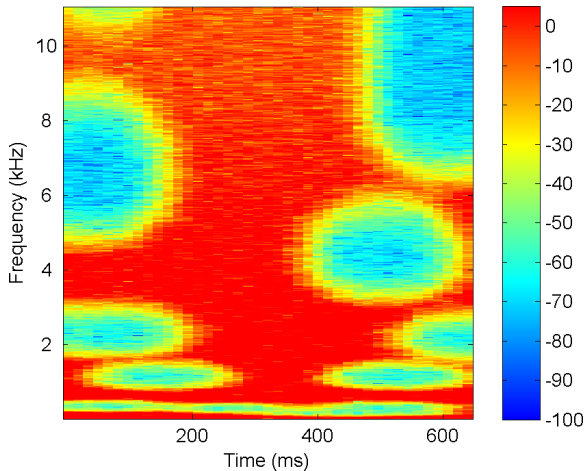




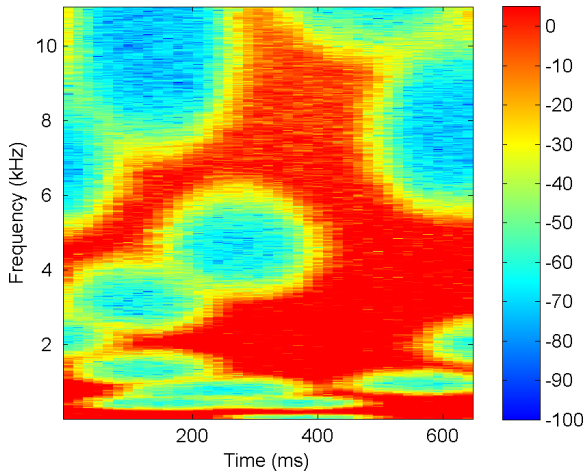
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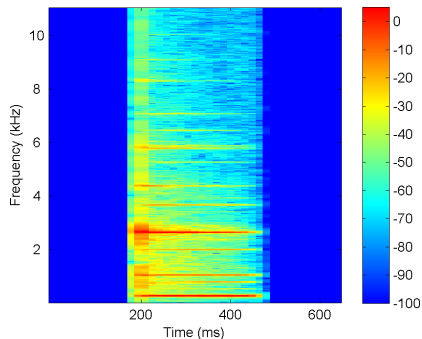
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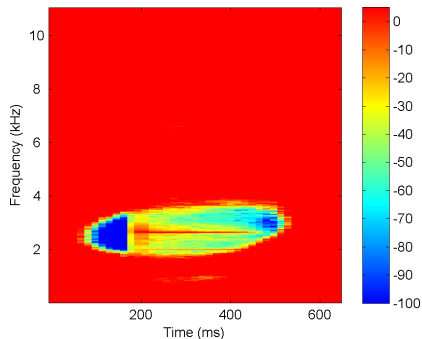


## Correlational analysis visualizes spectrogram points that are not independent of intelligibility



- Pearson's  $\chi$ -squared test of independence

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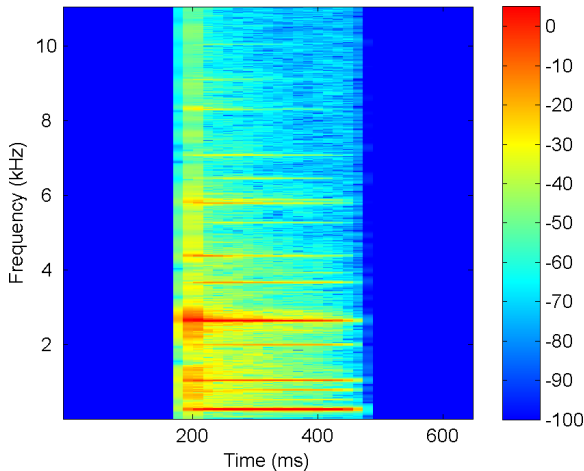


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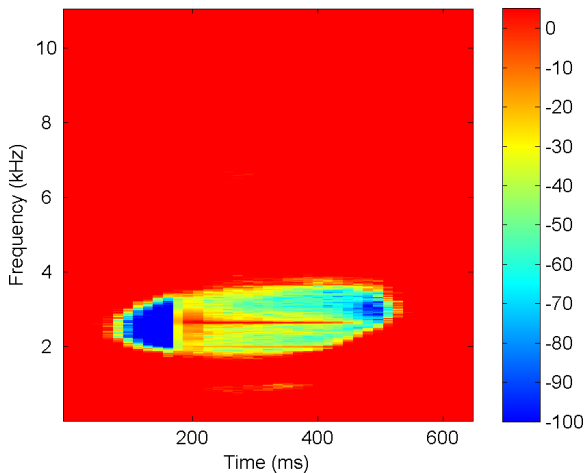
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## Correlational analysis results: Vibraphone

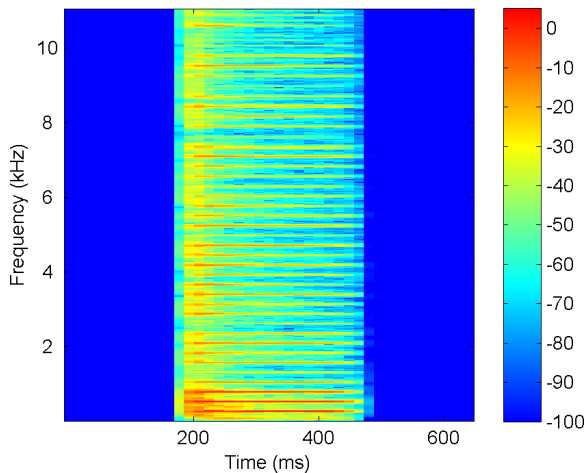


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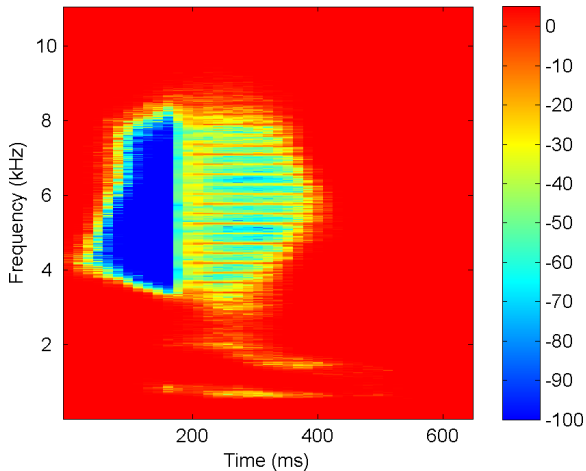




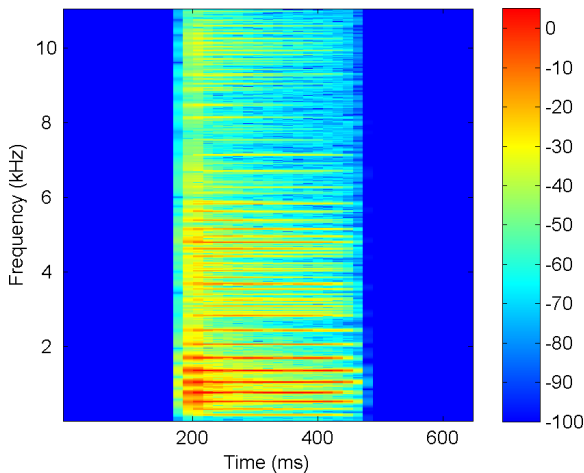
## Correlational analysis results: Harpsichord



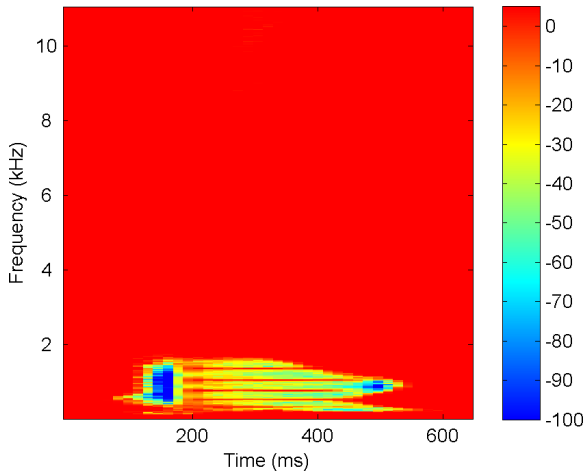
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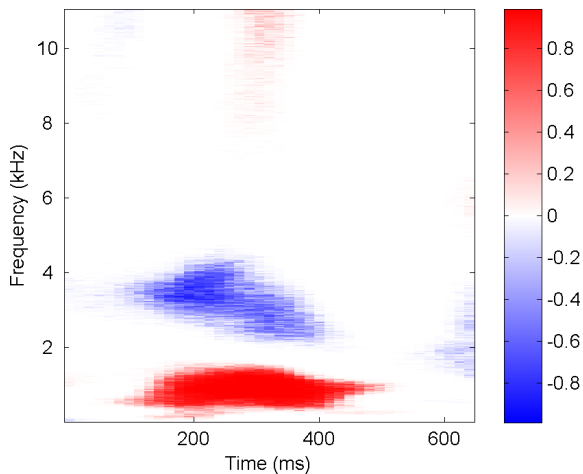
## Correlational analysis results: TubularBells



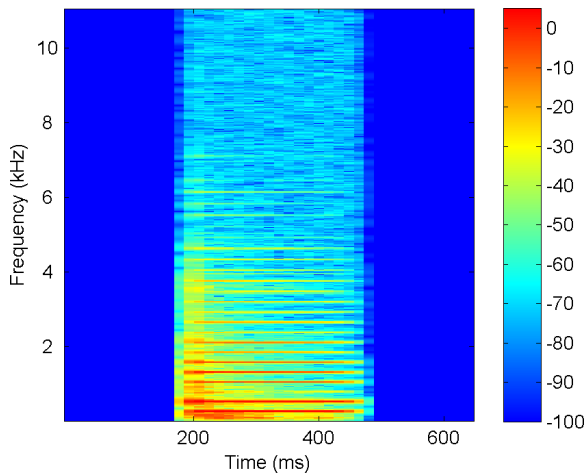
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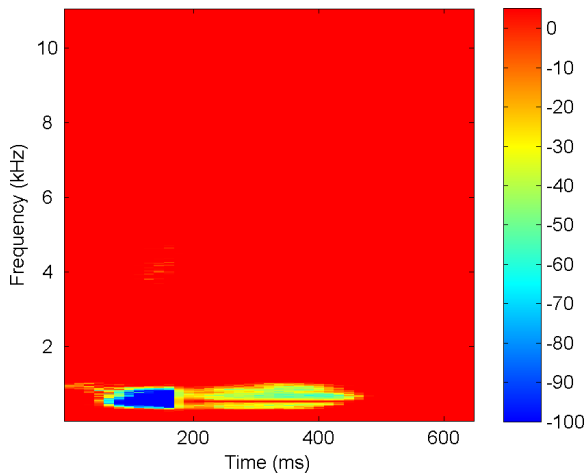
# Correlational analysis results: TubularBells (Subject 1)



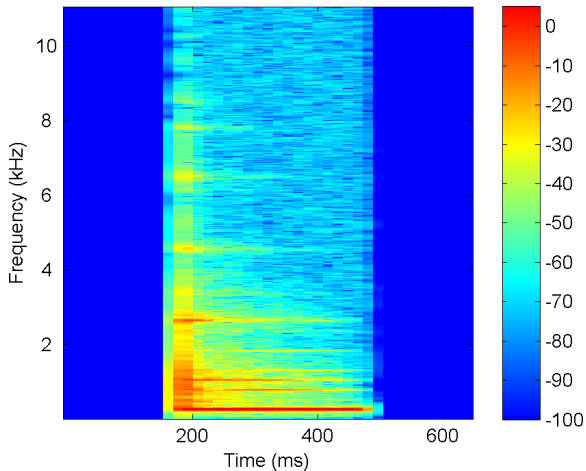
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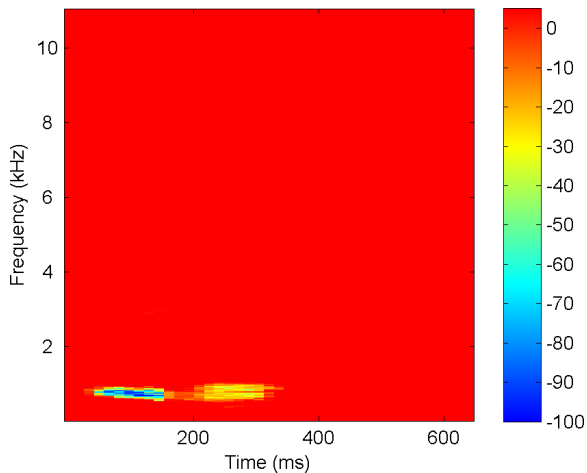


## Correlational analysis results: Marimba

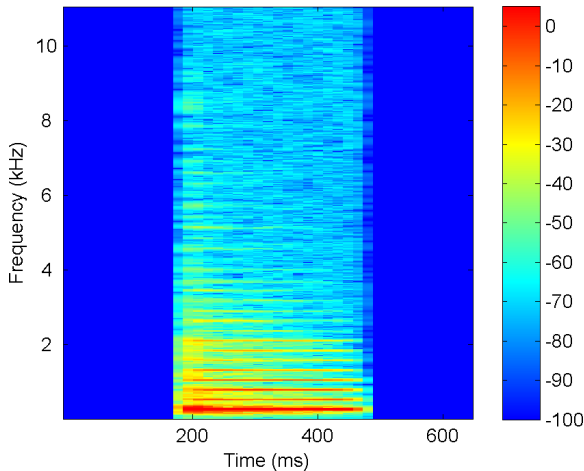




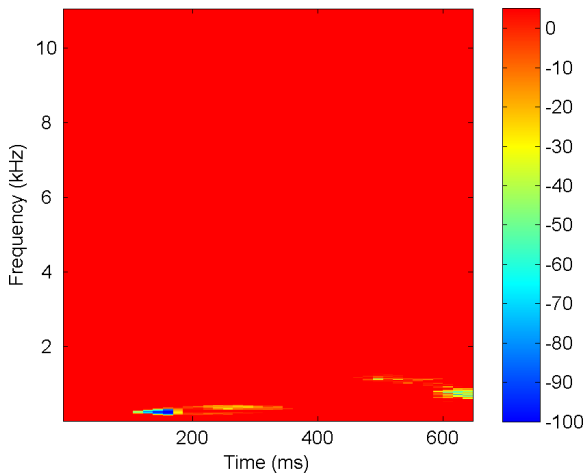
# Correlational analysis results: Marimba



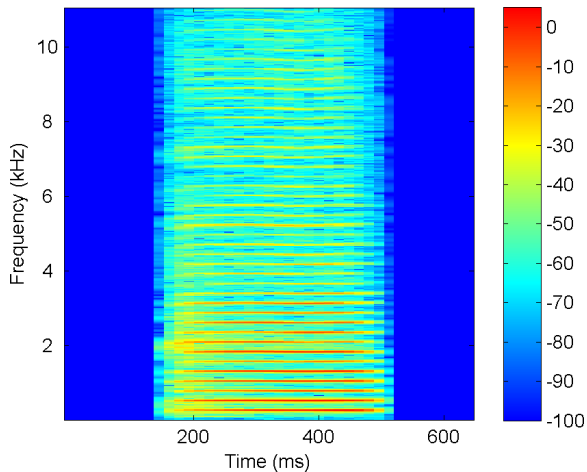
## Correlational analysis results: Harp



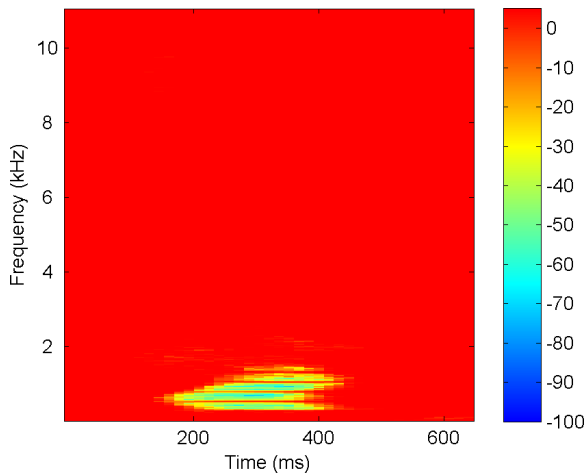
# Correlational analysis results: Harp



## Correlational analysis results: Cello



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# Auditory bubbles can capture time-frequency importance functions of musical timbre

- Listening test utilizing randomized glimpses finds informative regions
- Preliminary results appear to agree with previous studies
  - attack and spectral centroid are important
- But provide much more specific identification of distinctive features
  - around certain formants for each instrument

## Auditory bubbles could be useful for you

- Further timbre-related questions: dependence on pitch
- Other musical questions: identification and discrimination tasks
- Speech tasks: importance for different phonemes, talkers, listeners
- Code available on github<sup>3</sup> to generate, run, and analyze experiments

Thanks!

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Any questions?

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