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The semantics of Timbre:

perceptual measurement and control of timbre in location recordings

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Overview

- Timbre… what's that then?
- How can we measure it?
- An example
- Now you try
- Questions?

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Timbre… what's that then?

- There are three perceptual characteristics of sound:

  Loudness
  Pitch
  Timbre

Timbre |'tambər; 'tä n brə| (noun)

the character or quality of a musical sound or voice as distinct from its pitch and intensity ("trumpet mutes with different timbres", "a voice high in pitch but rich in timbre")

- New Oxford Dictionary

Timbre… what's that then?

- If these characteristics can be measured, they can be modeled and/or controlled.
- Measurement is usually either acoustic, perceptual (listening tests), or a combination

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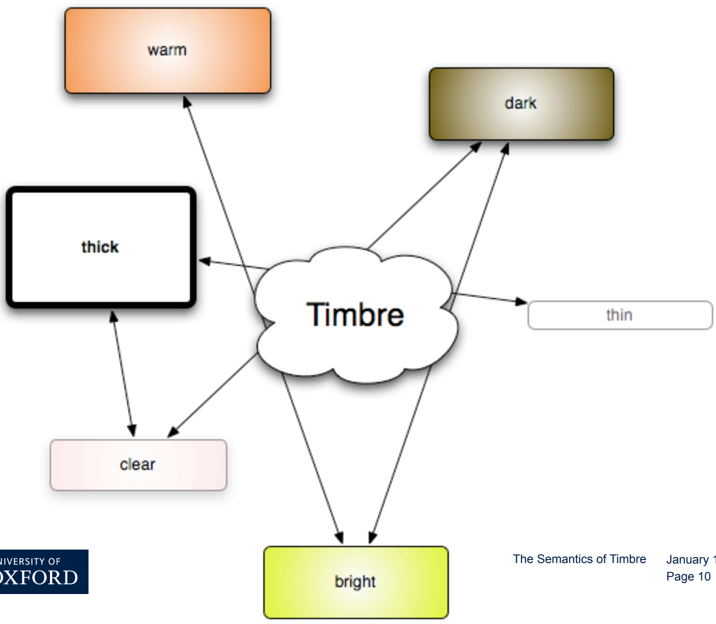
Timbre… what's that then?

- There might be many elements of a sounds timbre - 'timbral attributes'
- Some are directly correlated to acoustic properties
- Some overlap in their acoustic correlation with other attributes
- Some are familiar, universally understood terms
- Once acoustic correlation has been determined, methods for manipulating the intended timbral attribute can be devised

Timbre… what's that then?



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How can we measure it?

- Possibly by acoustic analysis
- Once acoustic correlation has been determined for a particular attribute, methods for manipulating it can be devised
- Usually we ask listeners to describe, then quantify differences in a stimulus set
- If the stimulus set has limited acoustic variation, we can correlate this variation with the described/quantified listener responses to create *timbral metrics*

How can we measure it?

- Timbral metrics already exist for some attributes, for example:

Timbral attribute	Unit	Determined Correlation	Researcher/s
Sharpness	Acum	Relative strength of spectral energy across critical bands	Zwicker, Fastl, Gabrielsson..
Brightness	N/a	Relative strength of frequency / overall strength in all frequencies	Von Bismarck, Wessel, Gordon etc..
Roughness	Asper	Proximity of harmonics to / within overlapping critical bands	Aures, Terhardt, Backus…
Pleasantness	N/a	Combination of tonal / noise content, roughness, sharpness etc	Zwicker, Fastl, Mantle..

How can we measure it?

$$S = 0.11 \frac{\int_0^{24Bark} N^1 g(z) z dz}{\int_0^{24Bark} N^1 dz} \; acum$$

$$SC = \frac{\sum_{i=1}^{N} m_i f_i}{\sum_{i=1}^{N} m_i}$$

$$R \sim f_{\mathrm{mod}} \int_0^{24Bark} \Delta L_E(z) dz$$

$$\frac{P}{P_0} = e^{-(0.0023 \frac{N}{N_0})^2} e^{-1.005 \frac{S}{S_0}} e^{-0.7 \frac{R}{R_0}} (1.24 - e^{-2.43 \frac{T}{T_0}})$$

How can we measure it?

Equation showing Spectral Centroid (SC), an acoustic correlate found to correlate with *brightness*

where N = number of partials, m_i = magnitude of partial i and f_i = frequency of partial i

$$SC = \frac{\sum_{i=1}^{N} m_i f_i}{\sum_{i=1}^{N} m_i}$$

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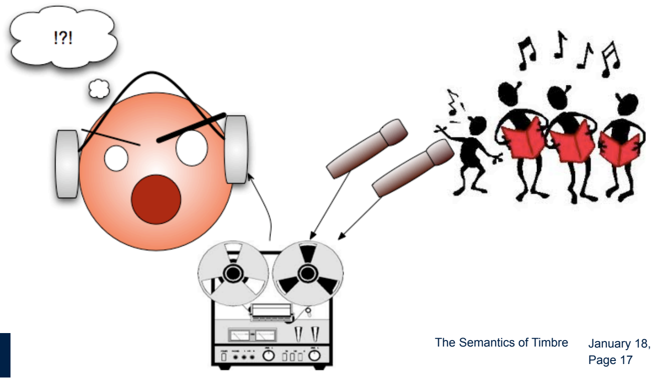
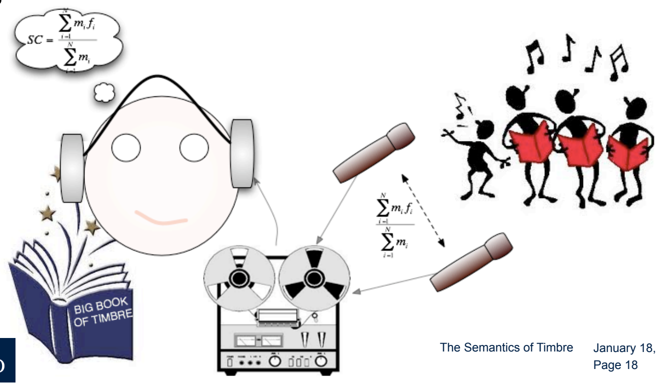
An example

- **Problem**: Live recordings usually sound subjectively “worse” than studio recordings, because recording on location is difficult. Recording studio engineers have it comparatively easy - they have time to experiment, and space to set up adequate monitoring.



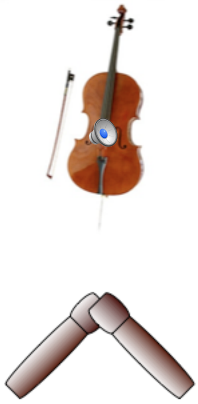
An example

- **Solution**: devise a hands-on guide for location recording engineers seeking to improve or selectively manipulate the timbral fidelity of their recordings
- ***How***? Two-stage experiment evaluate recordings made on location using (1) perceptual listening test/s and (2) acoustic analysis



An example

- Stimuli: Pilot study evaluated solo Cello recordings made using four simultaneous stereo microphone techniques



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An example

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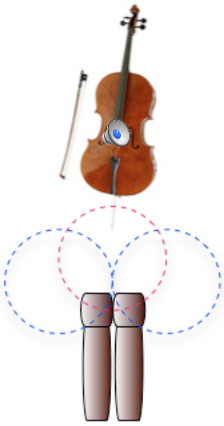

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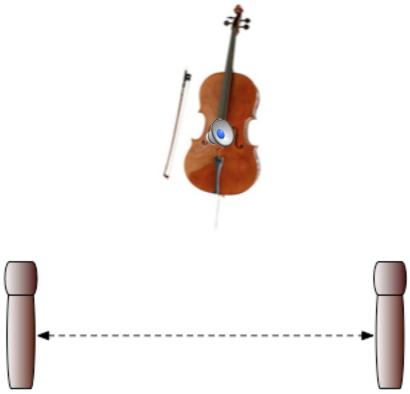

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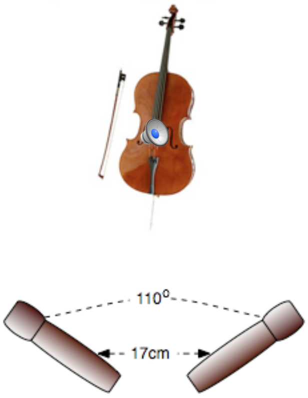
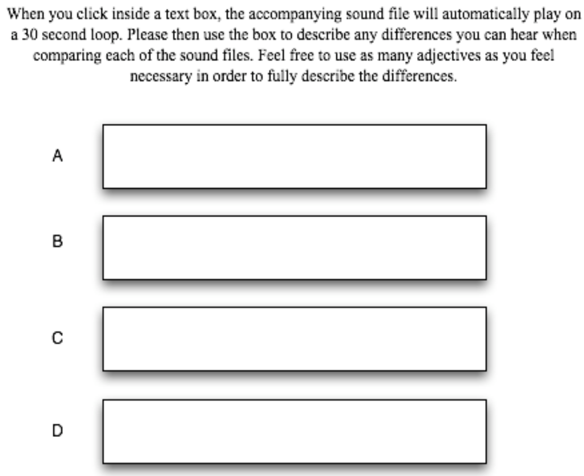


An example

- Experiment 1: Verbal elicitation


When you click inside a text box, the accompanying sound file will automatically play on a 30 second loop. Please then use the box to describe any differences you can hear when comparing each of the sound files. Feel free to use as many adjectives as you feel necessary in order to fully describe the differences.

A

B

C

D

An example

- … and the results?

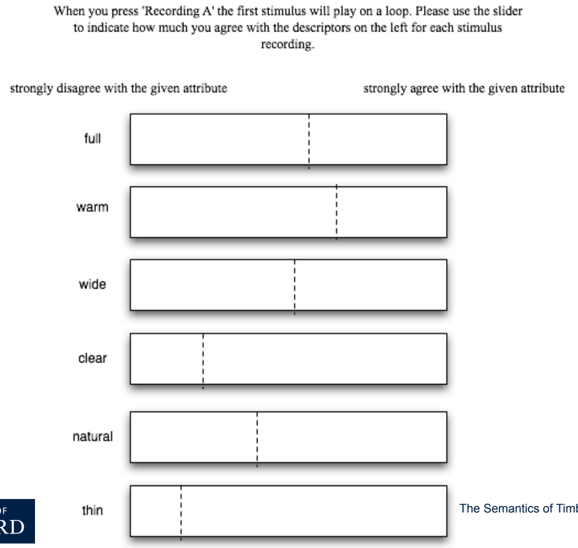
- Responses grouped by an independent researcher. Number of instances in each group summed, and divided by total number of responses to establish a “perceptual prominence” fpr each descriptor.

- Six terms with a prominence of >0.1 were found: *full, warm, wide, clear/bright, natural, thin*

- Discarded responses included *airy*, *sharp*, *scratchy*, *bowed*, *scraping*...

An example

- Experiment 2: Pairwise scaling



An example

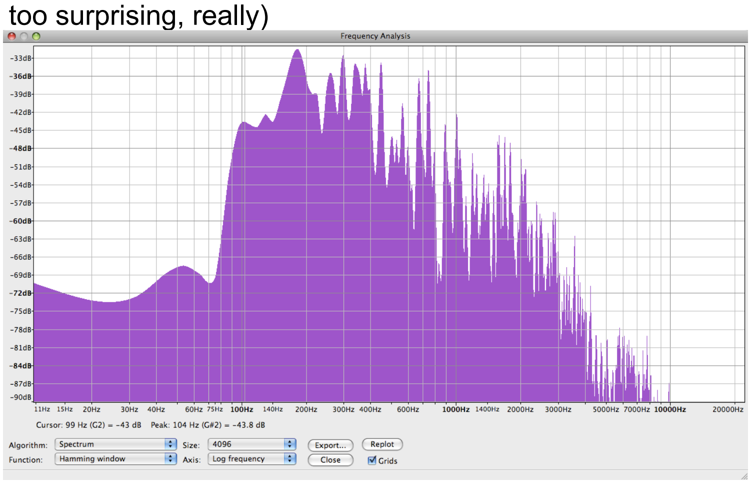
- … and the results?
- Statistical analysis in SPSS determined standard deviation and mean for listener responses
- Low standard deviation indicated good agreement amongst listeners (in most attributes – **not** *full* or *natural*, though!)
- Comparison of mean values combined with low standard deviation indicated variation in three attributes across the four stimulus recordings: *width*, *clear/bright*, and *thin*

An example

- Two example acoustic analyses (though many more are possible!)
- … Examining phase, amplitude, and frequency / time

An example

- Spaced pair has a comparatively wide reading on a goniometer and an increase in HF – correlated with *width* and *clarity* (not too surprising, really)



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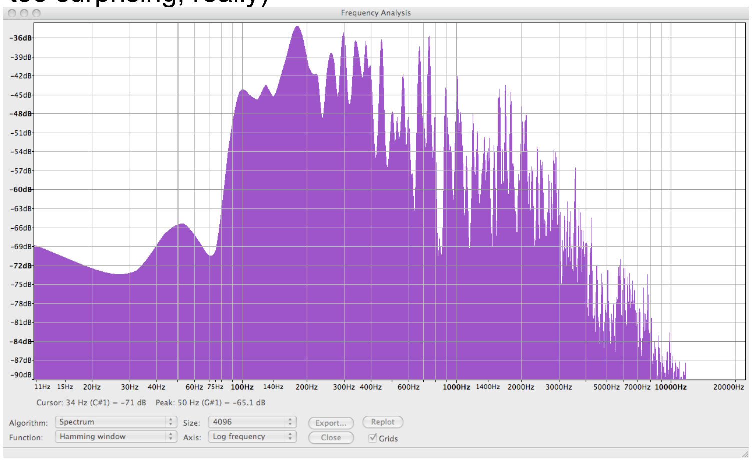

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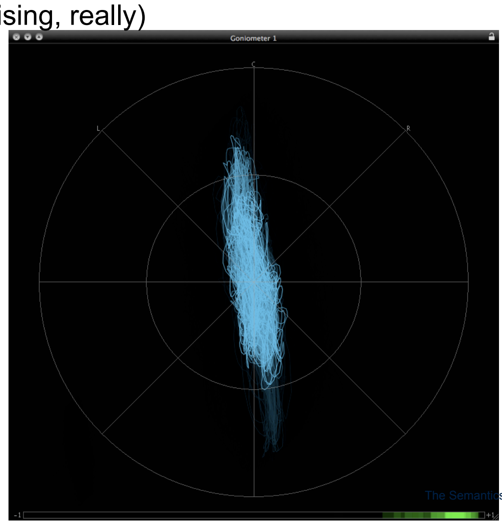

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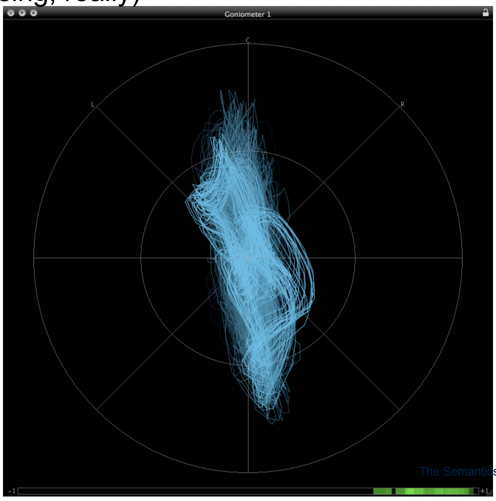
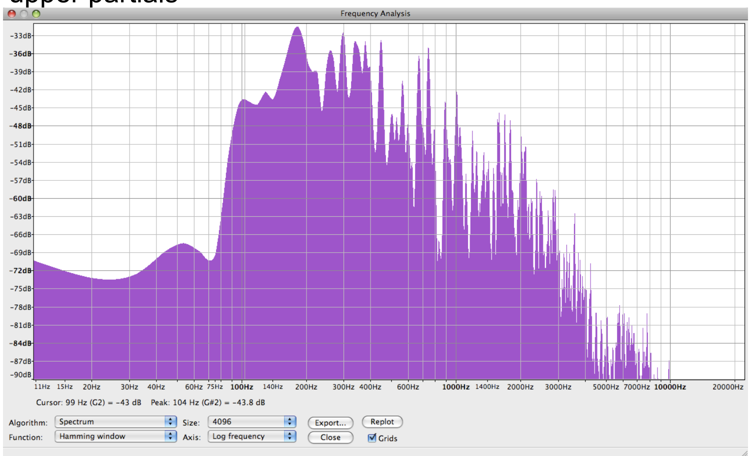


An example

- M/S also exhibits a wide goniometer reading, with less amplitude in LF than spaced pair and an increase in energy in upper partials



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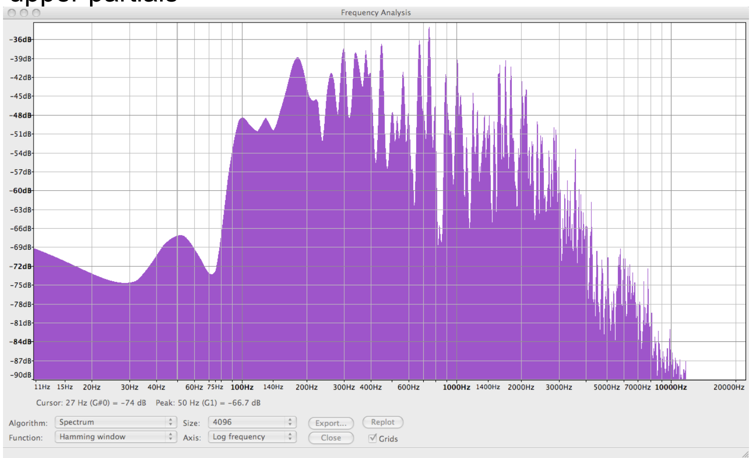

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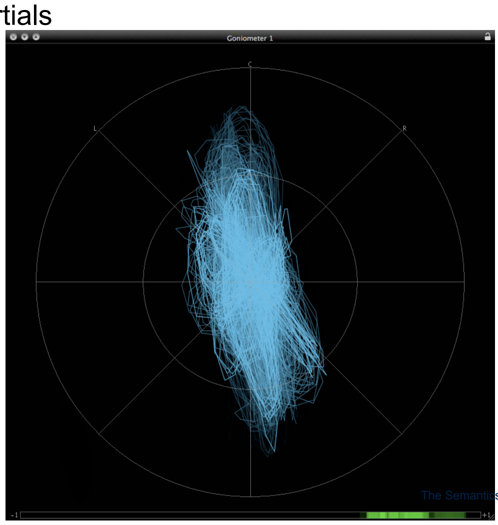

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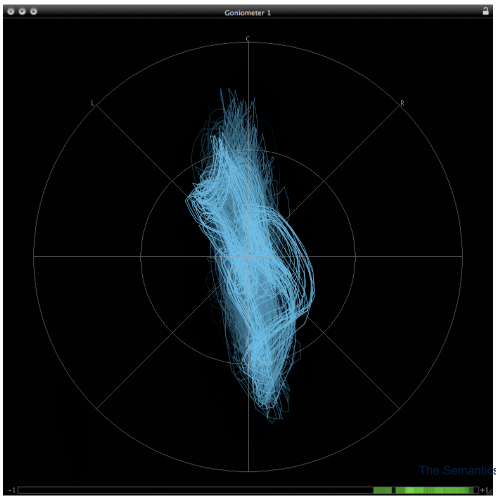

An example

- Conclusions; statistical evidence and acoustic analysis indicated that width, clarity, and thin/thickness can be adjusted by means of basic microphone technique (within the boundaries of the stimulus source and location used)

- Further work, identifying specific metrics of these and additional attributes, with a broader spectrum of stimulus signal types, can be considered.

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Now you try

- Part 1: A fifteen second segment recorded with technique A will be played, before the same segment, recorded with technique B, is played
- Write adjective/s describing the sound of clip A
- Write adjective/s describing the sound of clip B

(N.B. ordinarily, you would hear several repeats!)

Now you try

- Part 2: Please swap your notes with your neighbours. The same stimuli will now be played (A, B, A, B).

- Rate the difference in each adjective by using the blank "sliders" to mark whether you agree or disagree with the descriptors your neighbour has used.

Now you try

- How did you do?
- Was 'A' warmer, thicker, fuller, fatter, wider?
- Was 'B' thinner, clearer, crisper, sharper, shriller?
- Which did you *prefer*?
- ('A' was made using M/S - 'B' was made using an X/Y pair)

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The End…

- … Thank you for listening!
- Questions are welcome

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