# Statistical Modelling of Music

## Christophe Rhodes

Goldsmiths, University of London

Tuesday 3rd April

Music: a set of complicated interactions between

- **composer**
- arranger
- producer
- performer
- listener
- years of enculturation

Also: an enjoyable activity!

# What is music?

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- arranger
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Also: an enjoyable activity!

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Two reasons:

- to build tools to achieve specific tasks;
- to increase our understanding of musical processes.

Don't (yet) model the entire world: work on smaller aspects.

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# Why model music?

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Modelling chords

The task: identifying chords and assigning labels in music

- currently to MIDI transcriptions of performances;
- could be applied to audio directly (given suitable processing).

Applications:

- generating fake books, guitar chords
- feeding into models of music cognition, melodic memory

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$$p_{\mathcal{D}}(\mathbf{x}|\alpha_c) = \frac{1}{B(\alpha)}\prod_i x_i^{\alpha_i-1} \qquad (\sum_i x_i = 1)$$

$$p(c|\mathbf{x}\Omega) = \frac{p(\mathbf{x}|c\Omega)p(c\Omega)}{\sum_c p(\mathbf{x}|c\Omega)p(c\Omega)}$$

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The chord model

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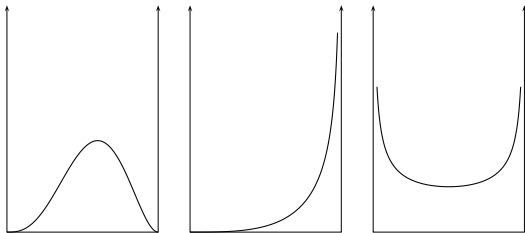
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# Dirichlet distributions

When does one chord end and another begin?
Assumptions:

- *bar* as fundamental unit;
- new chords only on beats.

Our MIDI transcriptions are clear enough

Models: all possible beatwise divisions of a bar. Choose using
Bayesian model selection.

$$p(\omega|\mathbf{x}\Omega') \propto \sum_c p(\mathbf{x}|c\omega\Omega')p(c\omega\Omega')$$

Current investigation: how much do experts' opinions on this
task differ?

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# Choosing a region

When does one chord end and another begin?
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Segmentation of musical audio. Applications:

- Chorus-finding: summary generation
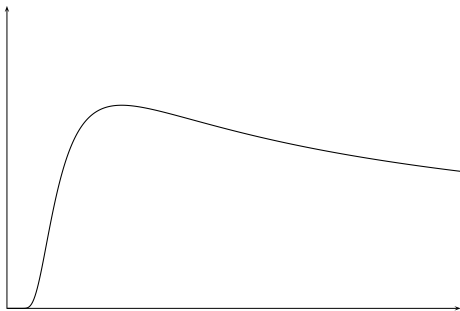- Structural annotation
- Query-by-content systems

Pop music: timbre / the way it sounds

Simple clustering leads to fragmentation:

- HMM states have exponential duration prior
- one-frame segments

# Choosing regions, continued

Segmentation of musical audio. Applications:

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# Segment durations

Introduce a duration prior.

$$\varepsilon_{\mathcal{H}}(x, \nu, \gamma) = \frac{1}{|\nu|} x^{-\nu} + (\gamma + 1) \log x.$$



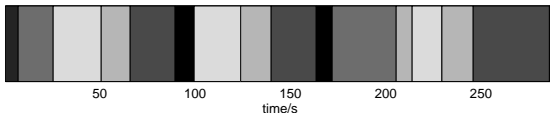Anneal over candidate segmentations, using modified Wolff algorithm.

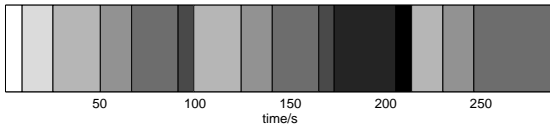Nirvana:Smells Like Teen Spirit, ms(200)/ms(400), 1/12–octave
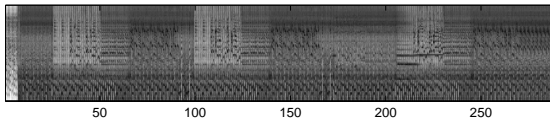
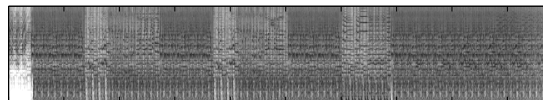histseg(wolff,genhyp) : regions(0.0603,0.0424,0.949)

segmentation

annotation

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Chumbawamba:Tubthumping, ms(200)/ms(400), 1/12−octave



histseg(wolff,genhyp) : regions(0.0903,0.403,0.753)



segmentation



time/s

annotation



time/s

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Investigating Culture

Musicologists make testable hypotheses, too!

- Tristan Chord (Ernst Knuth)
- Secret Chromatic Art (Edward E. Lowinsky)

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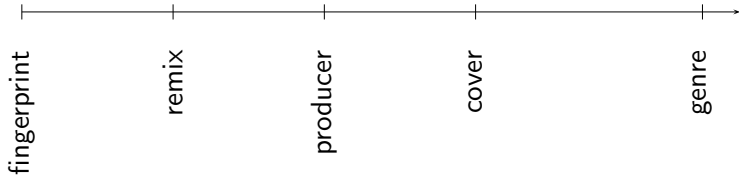
Summary

Music:

- complex activity;
- interactions between creators, performers, listeners, overall culture;
- people play multiple roles.

Statistical modelling:

- building intelligent tools;
- begin to understand the interactions involved