Segmentation and grouping structures in jazz chord sequences: An information-theoretic approach

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Segmentation and Grouping Structures in Jazz Chord Sequences: An Information-theoretic Approach.

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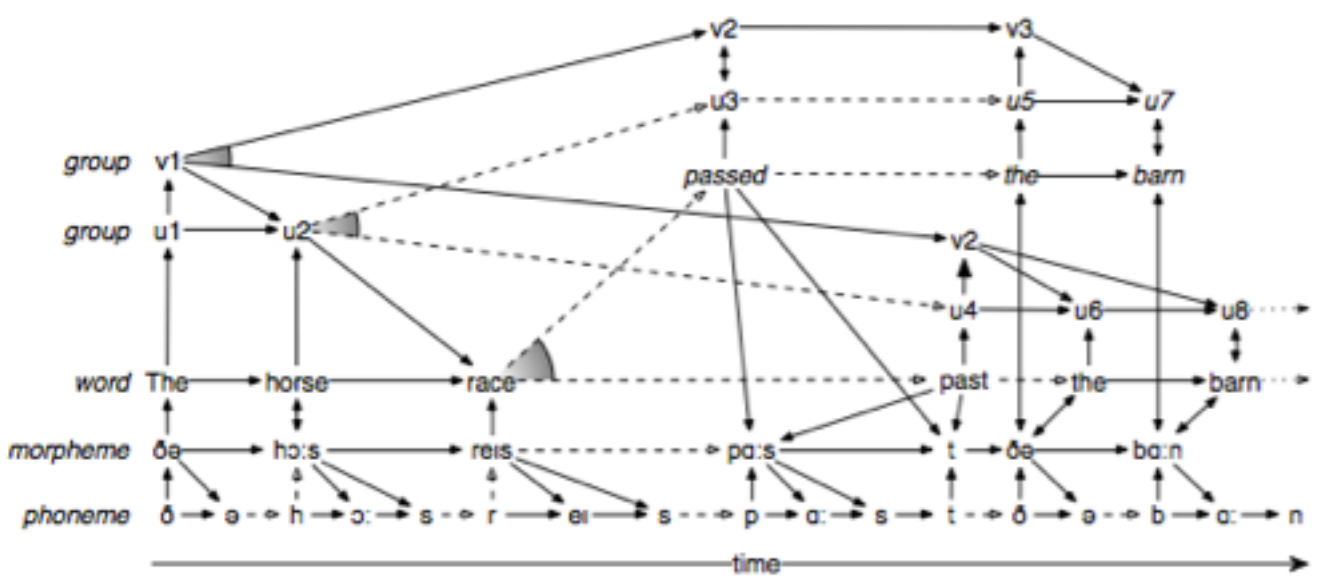
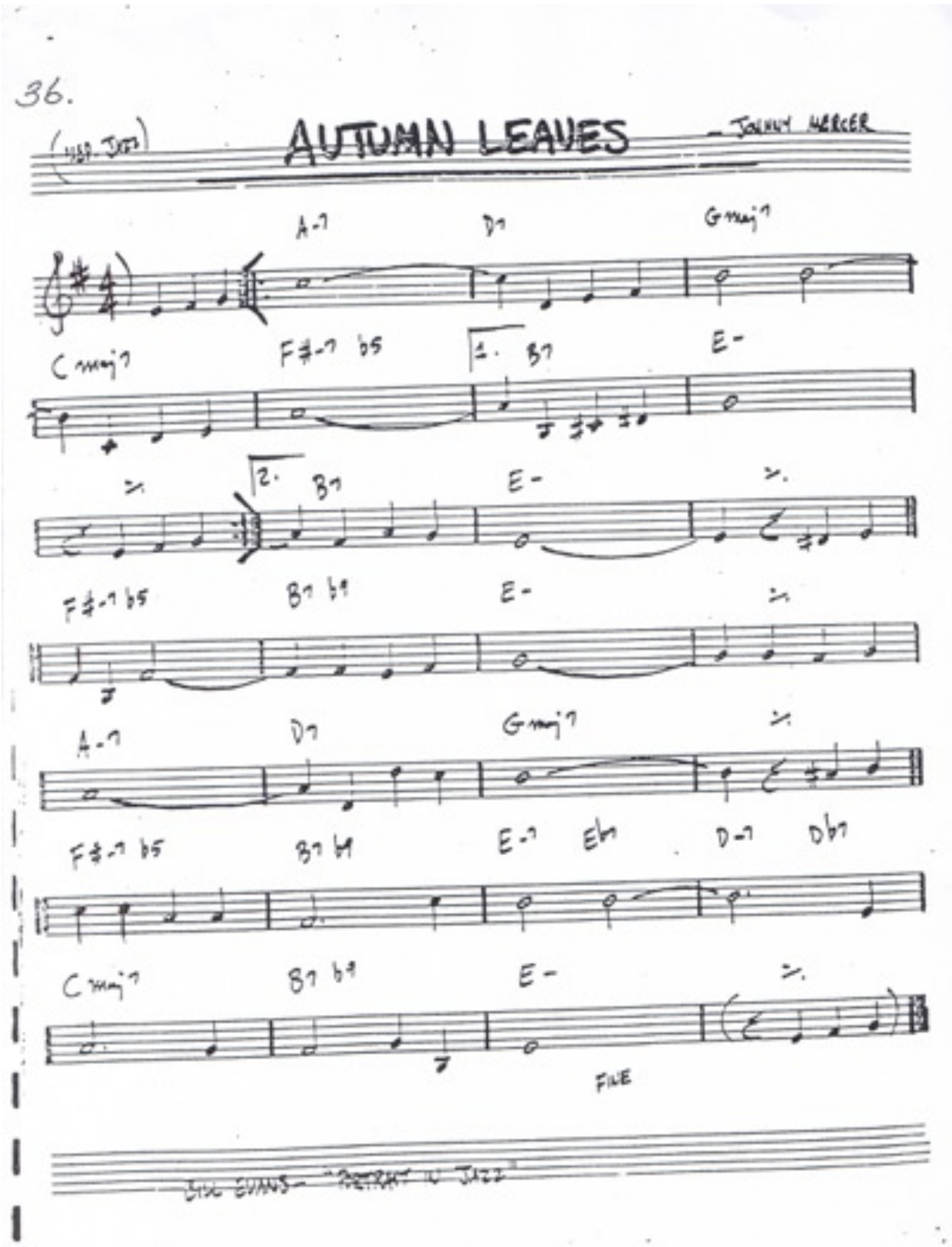
Introduction

- How to model higher order / hierarchical structure with bottom-up, statistically driven models?
- Forth & Wiggins (2015) present IDyOT (Information Dynamics of Thinking), a cognitive architecture which expatiates IDyOM (Pearce 2005) to account for many aspects of human behaviour across multiple domains (language and music).
- The current research focusses on tonal harmony, in particular jazz.
- Segmentation is the first stage in these bottom-up models.



Jazz Leadsheets



- The entry point of the model is at the chord symbol level.
- 348 leadsheets (15,197 events) compiled by Pachet et al. (2013), taken from the Real Book vol. 1.
- Typical sequence learnt:

  Am7, D7, DM, CM, F#halfdim7, B7, Em

IDyOM: Statistical learning and modelling of the musical surface

- Information Dynamics Of Music (Pearce 2005)
- An unsupervised probabilistic model using variable order Markov models (PPM* - Cleary & Teahan 1997), interpolated smoothing (Cleary & Witten 1984, Moffat 1990) and multiple viewpoints weighted by entropy (Conklin & Witten 1995) to model expectation.

	BM^7	D^7	GM^7	$B\flat^7$	$E\flat M^7$
Root	11	2	7	10	3
ChordType	M	7	M	7	M
PosInBar	0	2	0	2	0
RootInt	$\perp$	3	5	3	5
ici	$\perp$	2	2	2	2
RootIntFiP	0	3	8	11	4
RootInt⊖FiB	$\perp$	$\perp$	8	$\perp$	8

Information theoretic segmentation

- Perceived segment boundaries before difficult to predict events (Pearce et al. 2010, Wiggins 2012, Griffiths et al. submitted).
- Difficulty to predict modelled by unexpectedness, defined by information content:

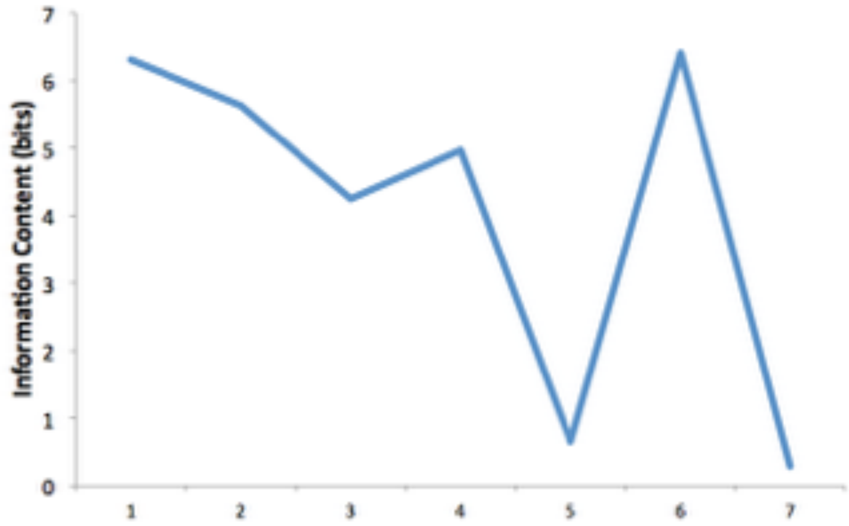
$$h\left(e_i|e_1^{i-1}\right) = -\log_2\ p\left(e_i|e_1^{i-1}\right)$$

- Place segment when before large rise in information content, when ratio between *h* of two adjacent events exceeds a threshold, *d*.

$$\frac{h\left(e_i|e_1^{i-1}\right)}{h\left(e_{i-1}|e_1^{i-2}\right)} > d$$

Information theoretic segmentation

- Information content profiles calculated with 10-fold cross validation.
- Viewpoint selected with forward stepwise selection algorithm.
- Viewpoints: ROOTINT⊗ICI, CHORDTYPE⊗ROOTINTTHRBAR, CHORDTYPE⊗ROOTINTFIP, POSINBAR⊗ROOTINTFIP, CHORDTYPE⊗POSINBAR, CHORDTYPE⊗ROOTINT, ROOT⊗CHORDTYPE



Information theoretic segmentation

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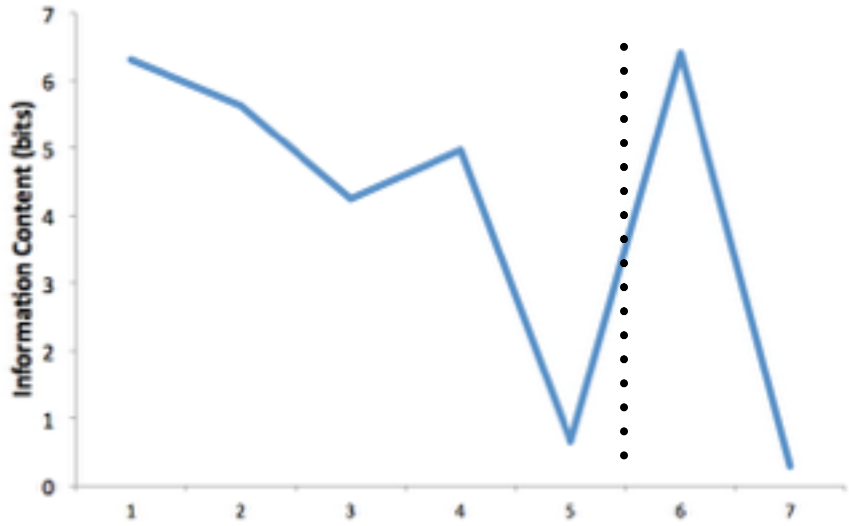
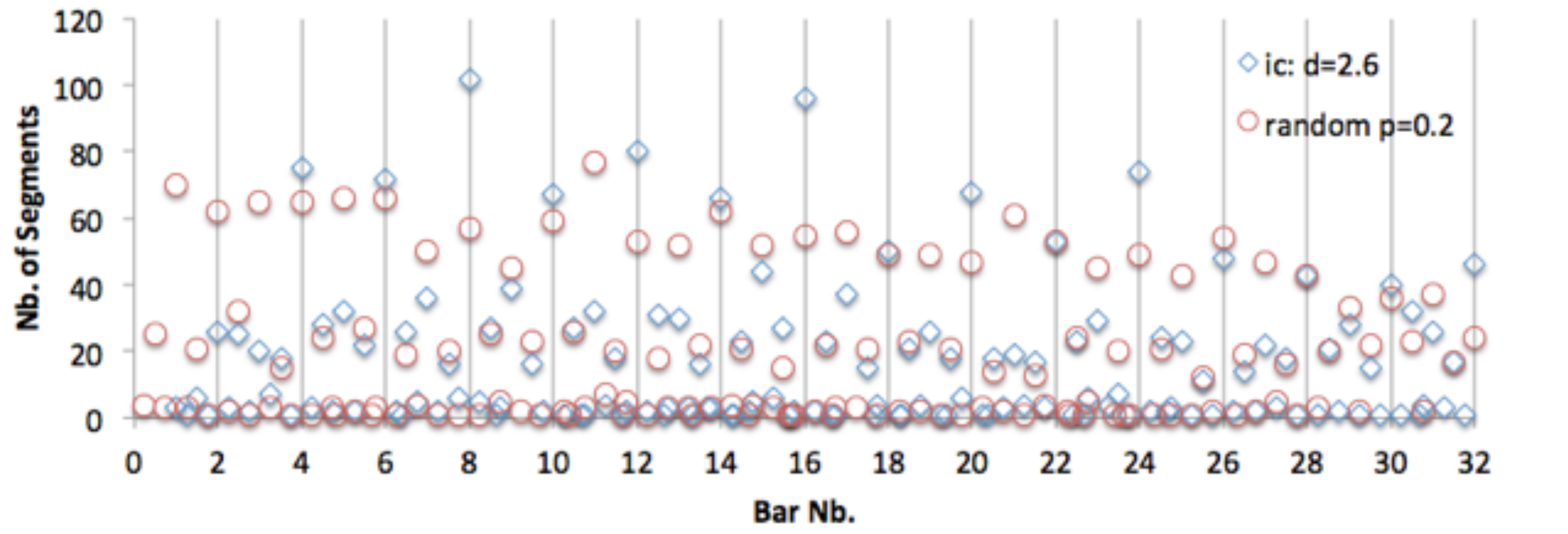
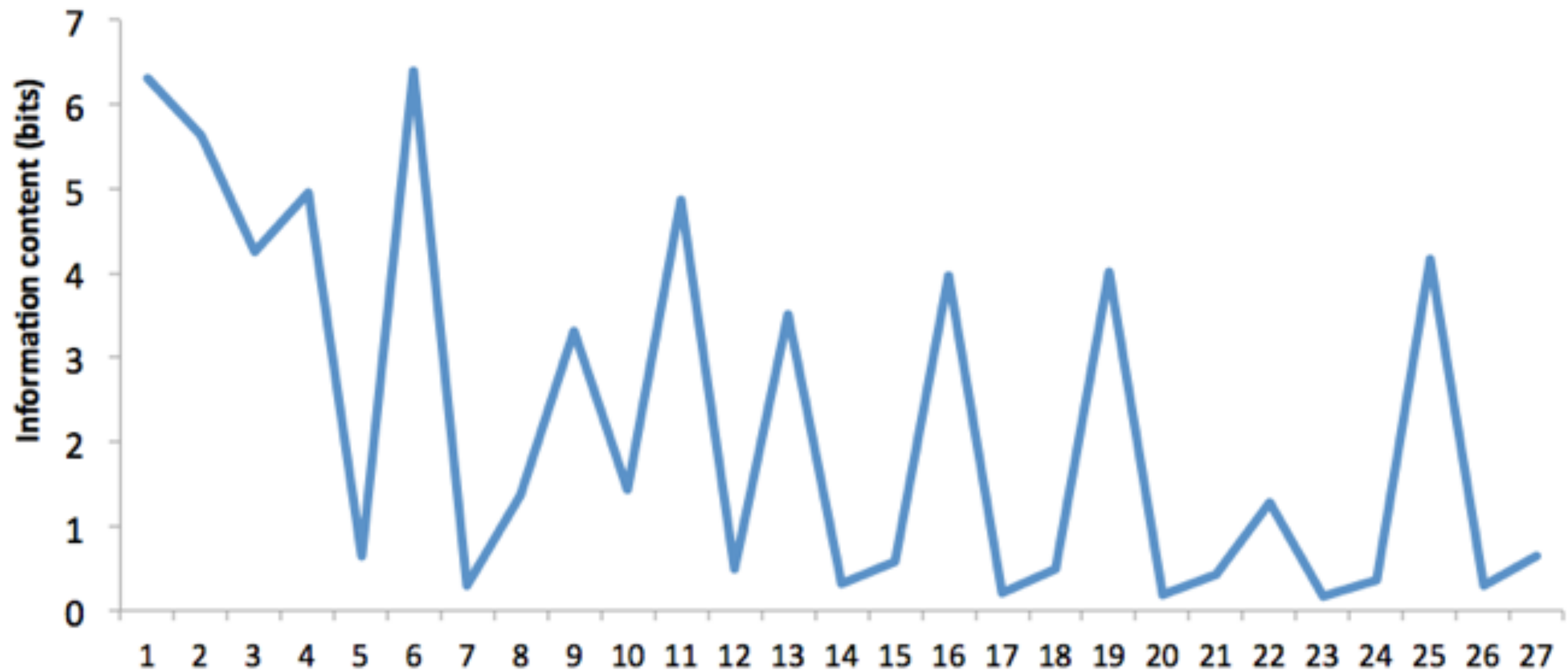


Phrase Structure

- No ground truth.
- Harmonic segmentation approximately reflect phrase structure.
- 4-bar phrases can be found segmenting with *d* = 2.6
    - κ: .24, accuracy: .76
- Random segmenter segments with *p* = .2
    - κ: .09, accuracy: .70



Giant Steps - John Coltrane



Threshold
$d = 2.6$

B	D7	G	Bb7	Eb		Am7	D7
G	Bb7	Eb	F#7	B		Fm7	Bb7
Eb		Am7	D7	G		C#m7	F#7
B		Fm7	Bb7	Eb		C#m7	F#7
B							

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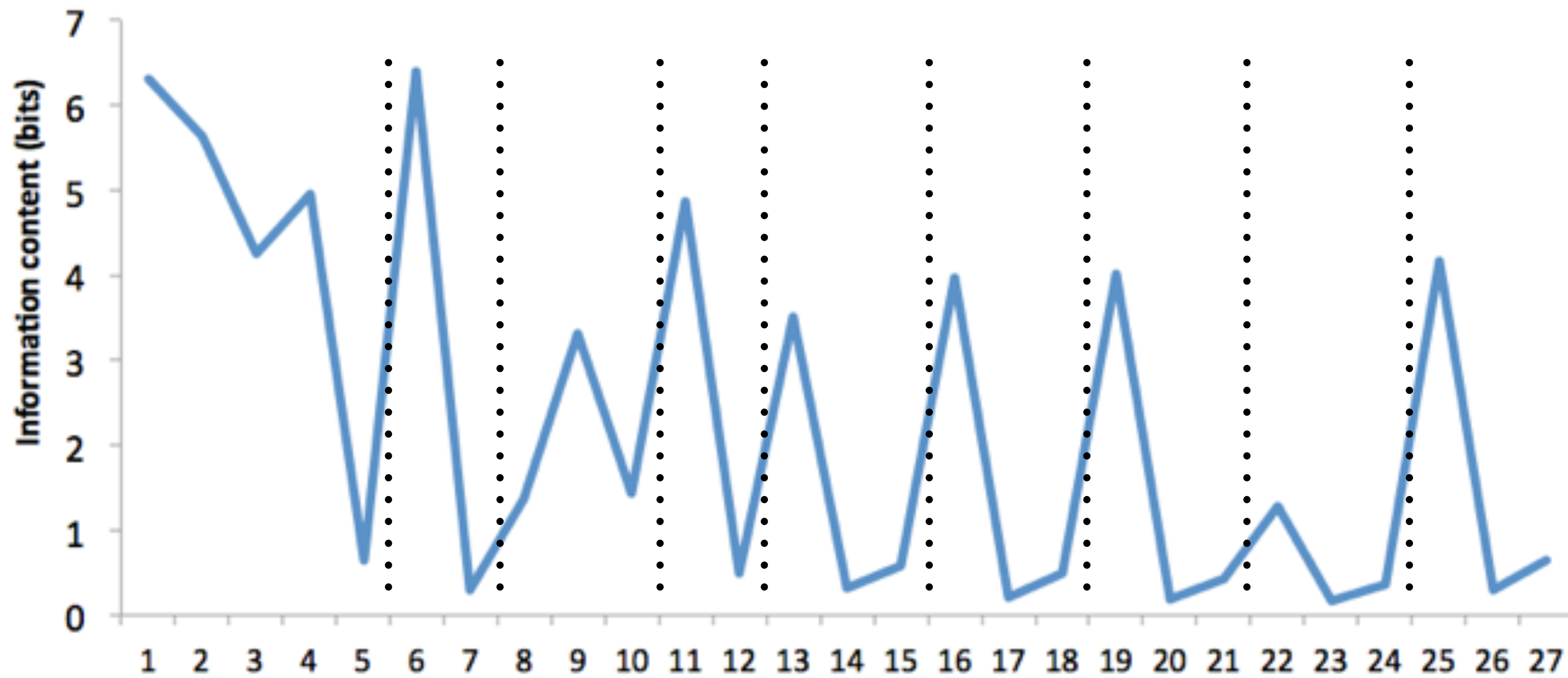

Threshold
$d = 2.6$

B D7	G Bb7	Eb	Am7 D7
G Bb7	Eb F#7	B	Fm7 Bb7
Eb	Am7 D7	G	C#m7 F#7
B	Fm7 Bb7	Eb	C#m7 F#7
B			

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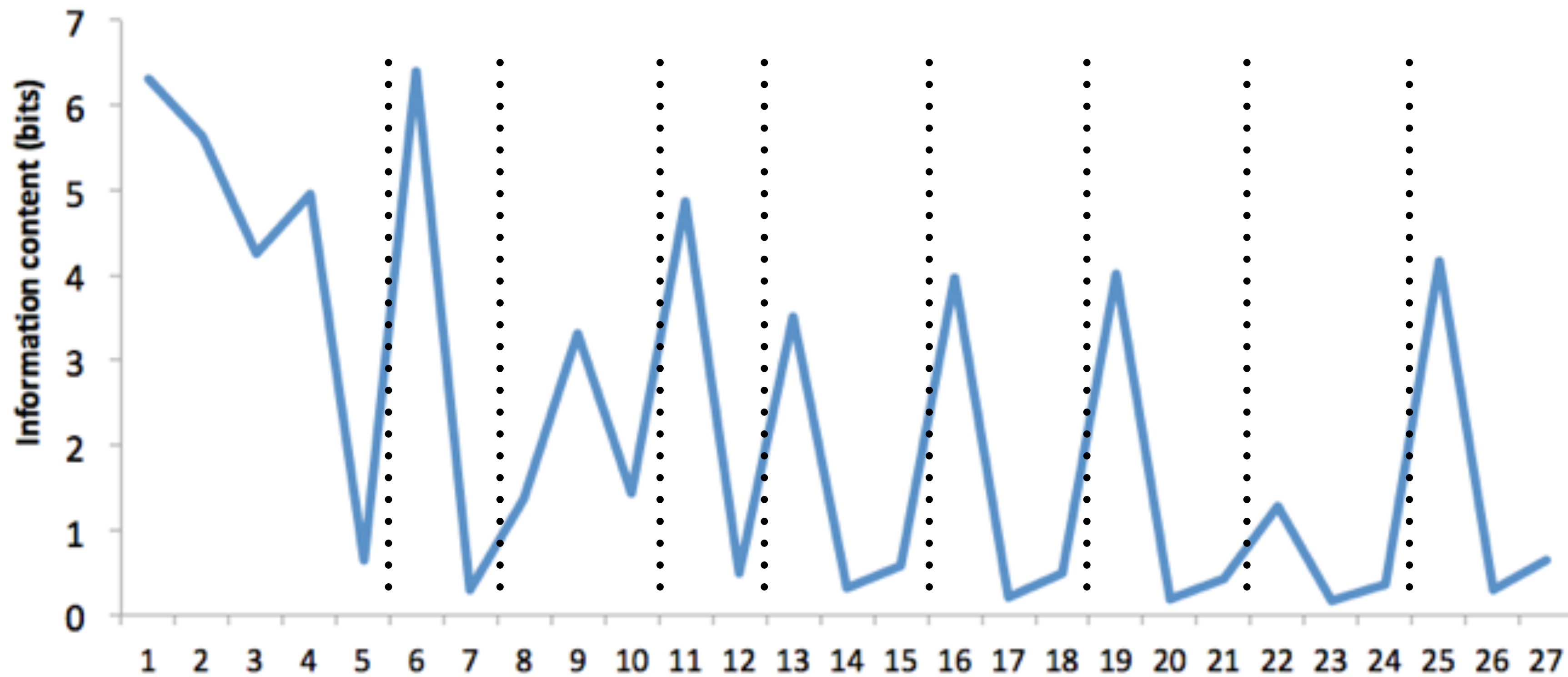

Threshold
d = 2.6

B D7	G Bb7	Eb	Am7 D7
G Bb7	Eb F#7	B	Fm7 Bb7
Eb	Am7 D7	G	C#m7 F#7
B	Fm7 Bb7	Eb	C#m7 F#7
B			

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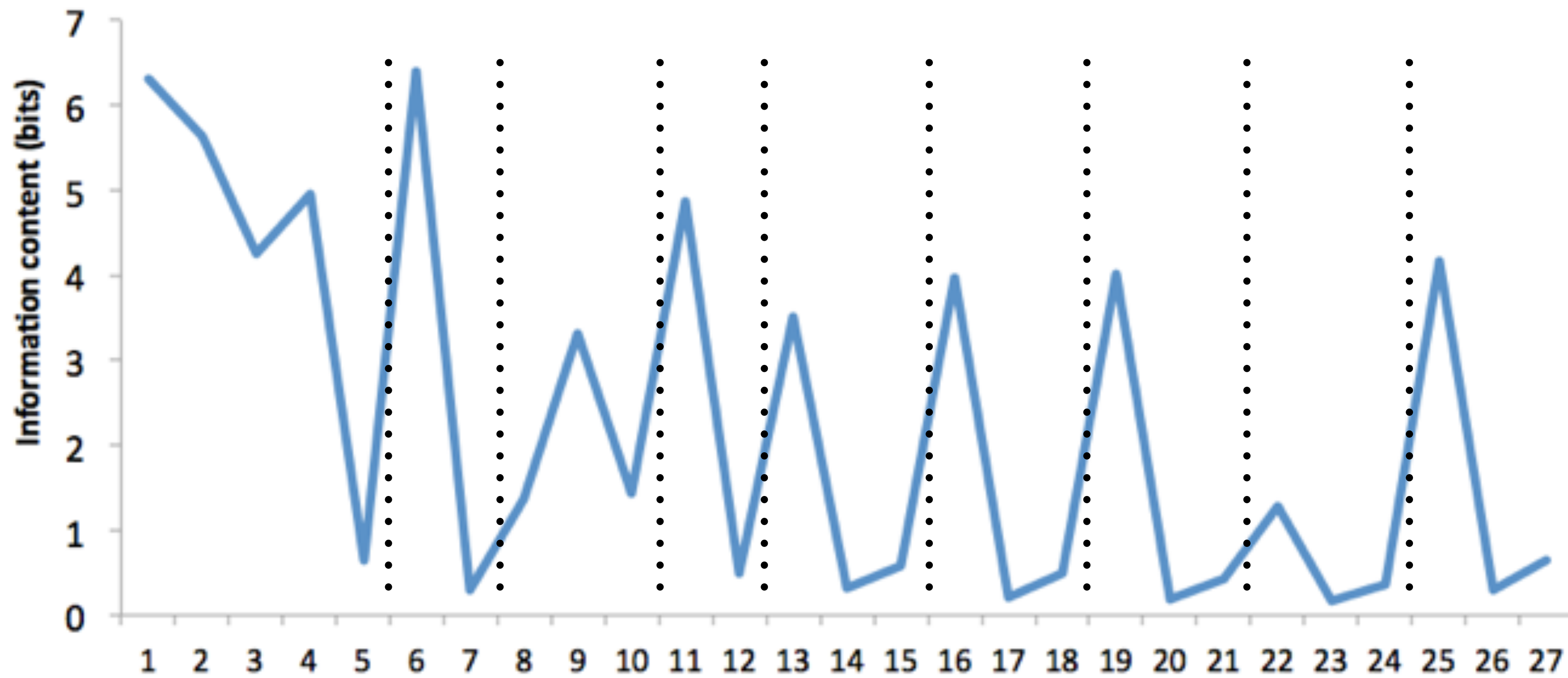

Threshold
$d = 2.6$

B D7	G Bb7	Eb	Am7 D7
G Bb7	Eb F#7	B	Fm7 Bb7
Eb	Am7 D7	G	C#m7 F#7
B	Fm7 Bb7	Eb	C#m7 F#7
B			

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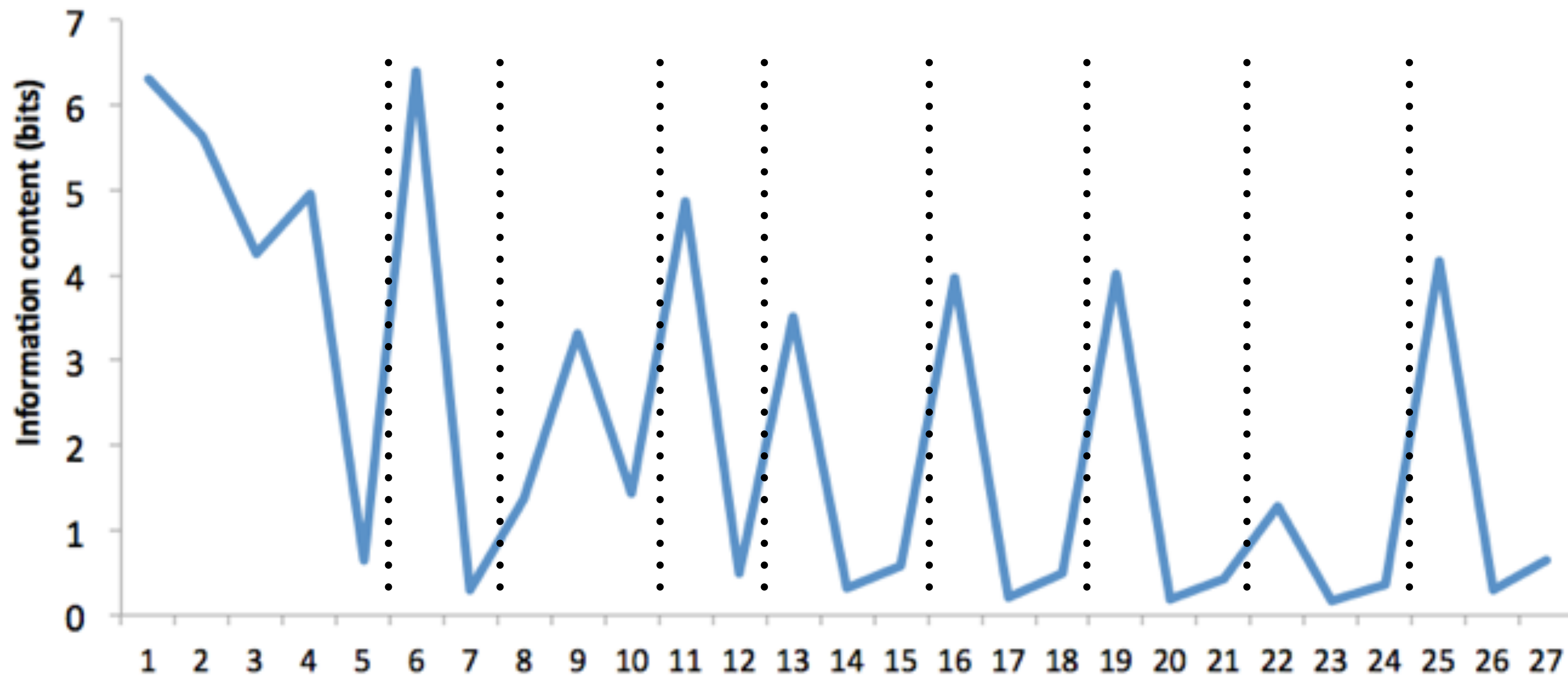

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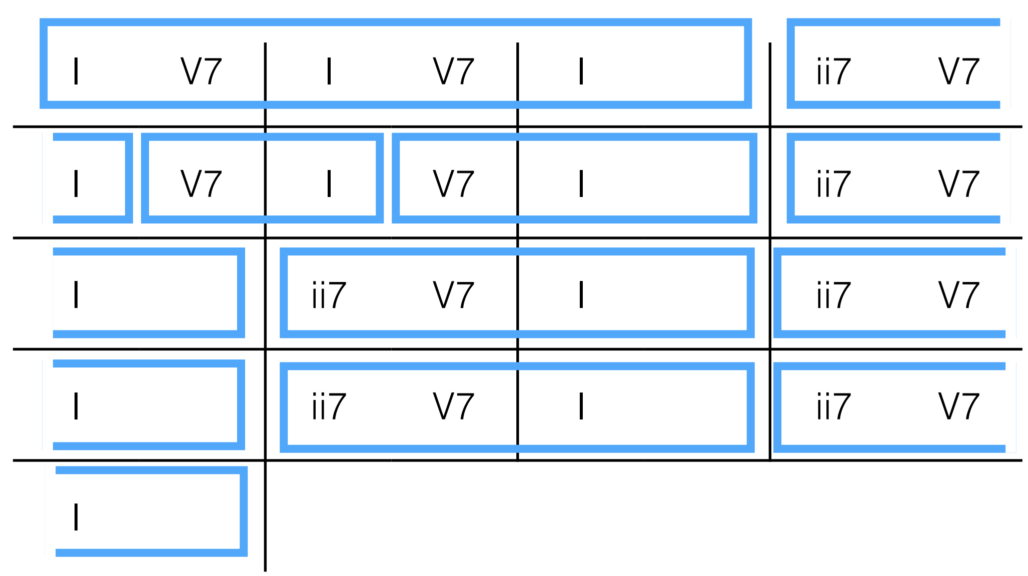
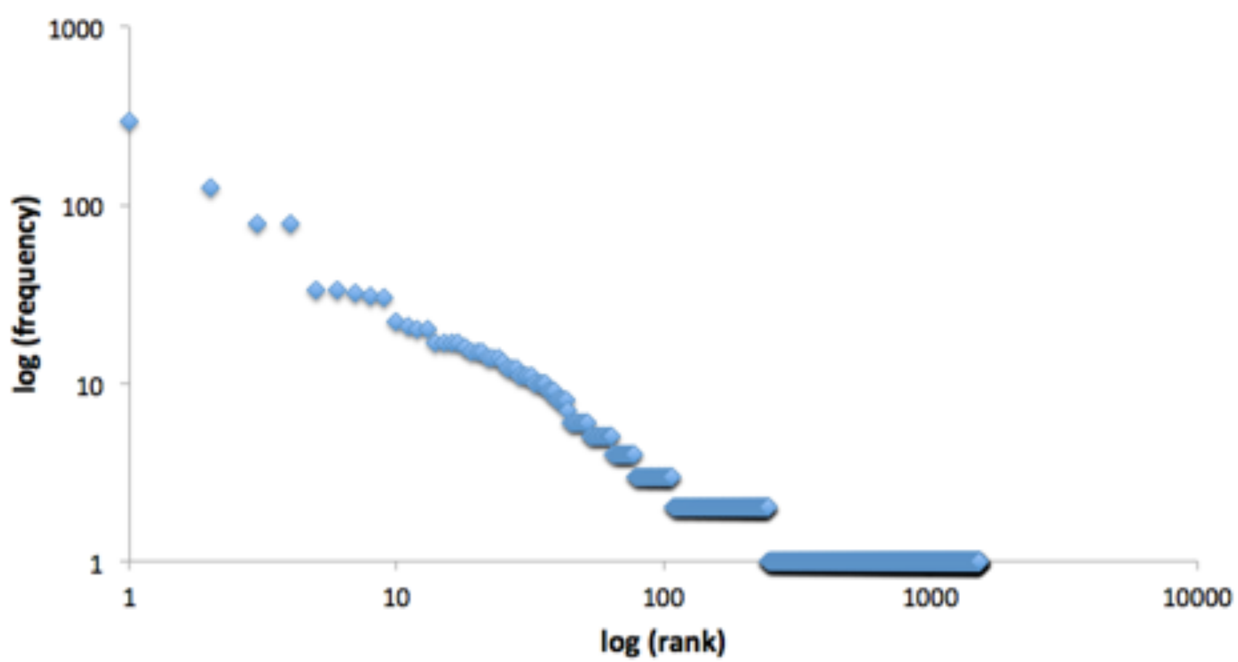


Segment Types

- Segmenting the whole corpus (15,197 chords) at $d = 2.6$
- 3,007 segment tokens
- 1,531 segment types (unique)



Rank	Frequency
1	297
2	125
3	79
4	78
5	33
6	33
7	32
8	31
9	30
10	22

Conclusion and Future Work

- Difficult to evaluate without a ground truth.
- Useful segmentations of jazz chord sequences.
- Rough phrase structure found.
- Key tonal-harmonic units identified (e.g. ii^7-V^7-I).
- No in-built knowledge of music theory or tonal harmony.
- Future work will compare with human segmentations of harmony.

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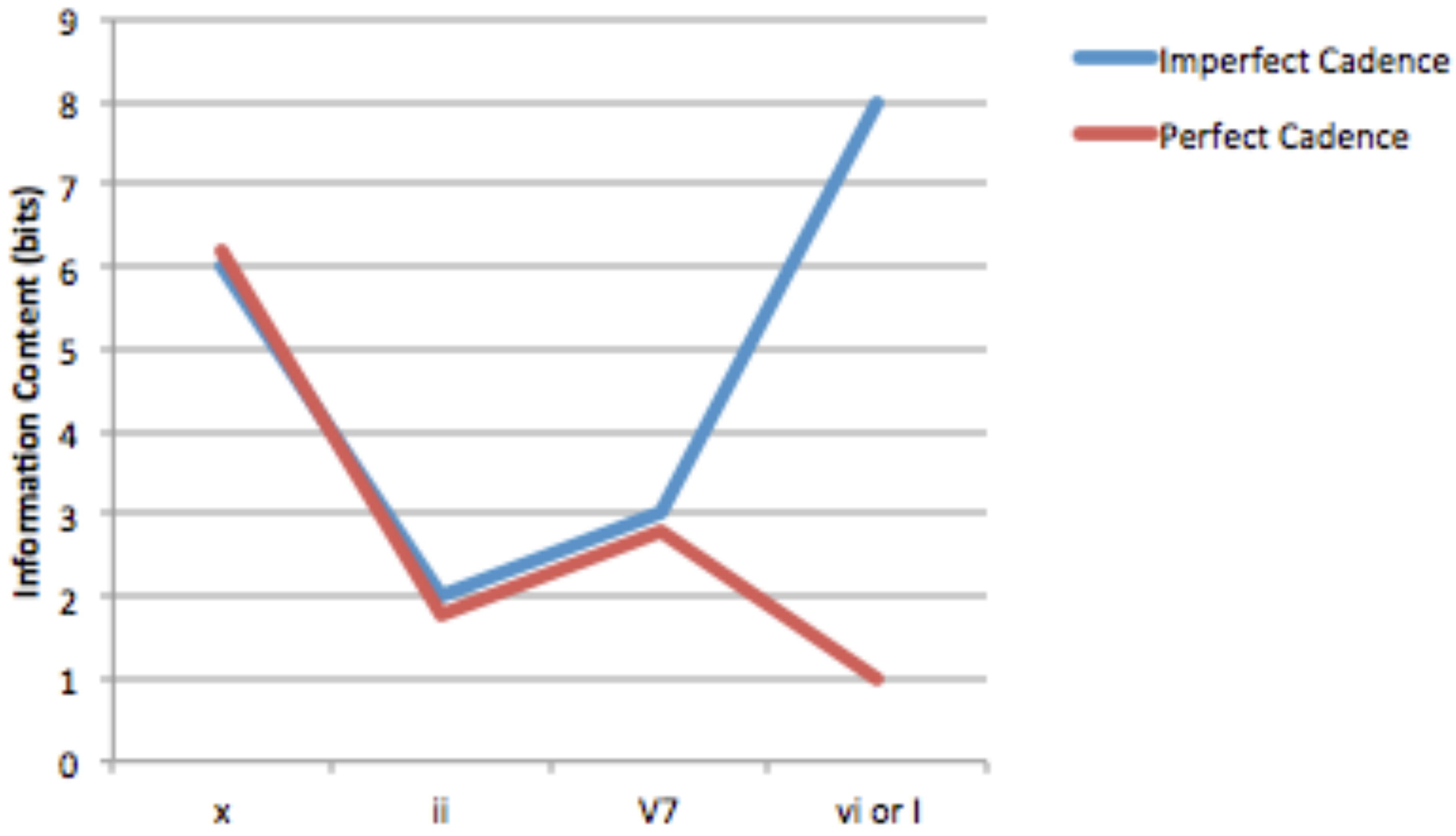
cclab bonus: Imperfect Cadence Problem



cclab bonus: ’Round Midnight