Pattern usage in monophonic Jazz solos

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jazzomat

DFG
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How do they improvise?

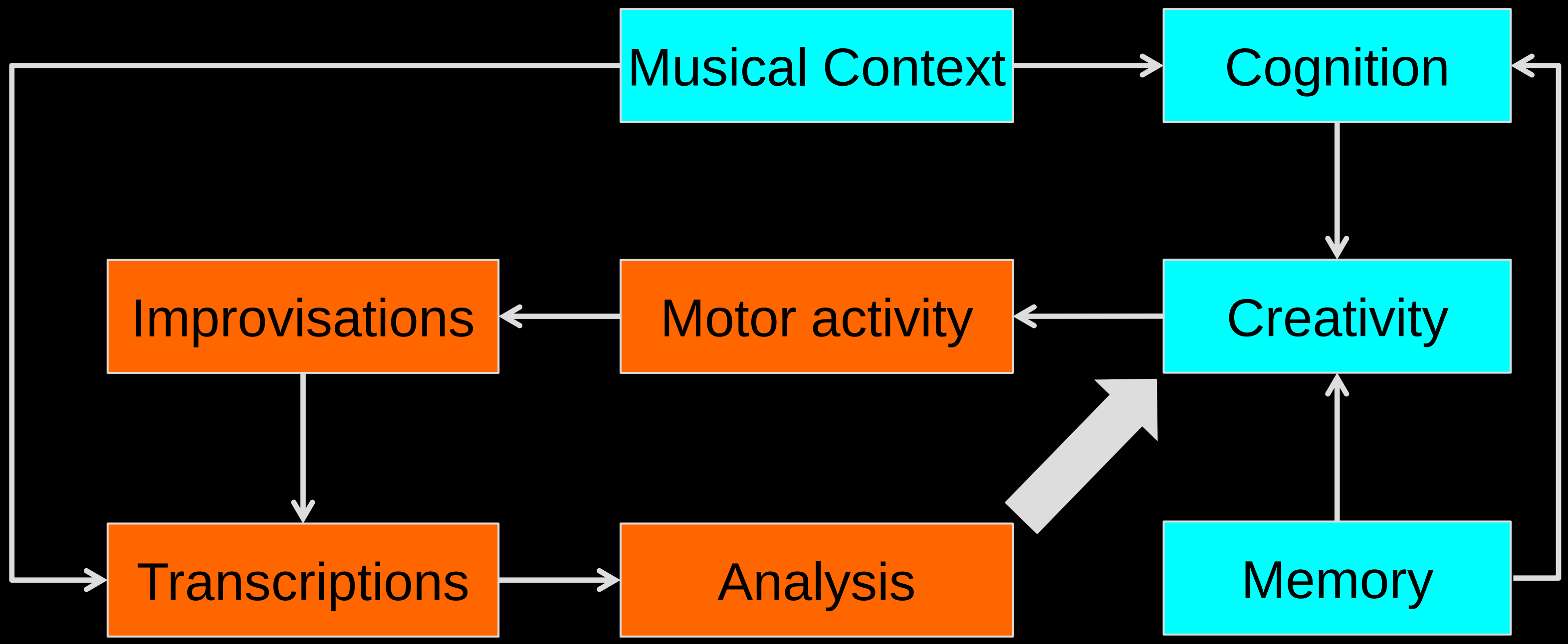
The Big picture

- Why does an improviser play exactly this note and not another one?
- Why do they play a note at this time point and not at another time point?
- Little is known about the “true” low-level neural mechanism that make action decisions and control actual motor behavior.
- Likewise about underlying psychological mechanism.
- However, some basic facts & constraints are known.

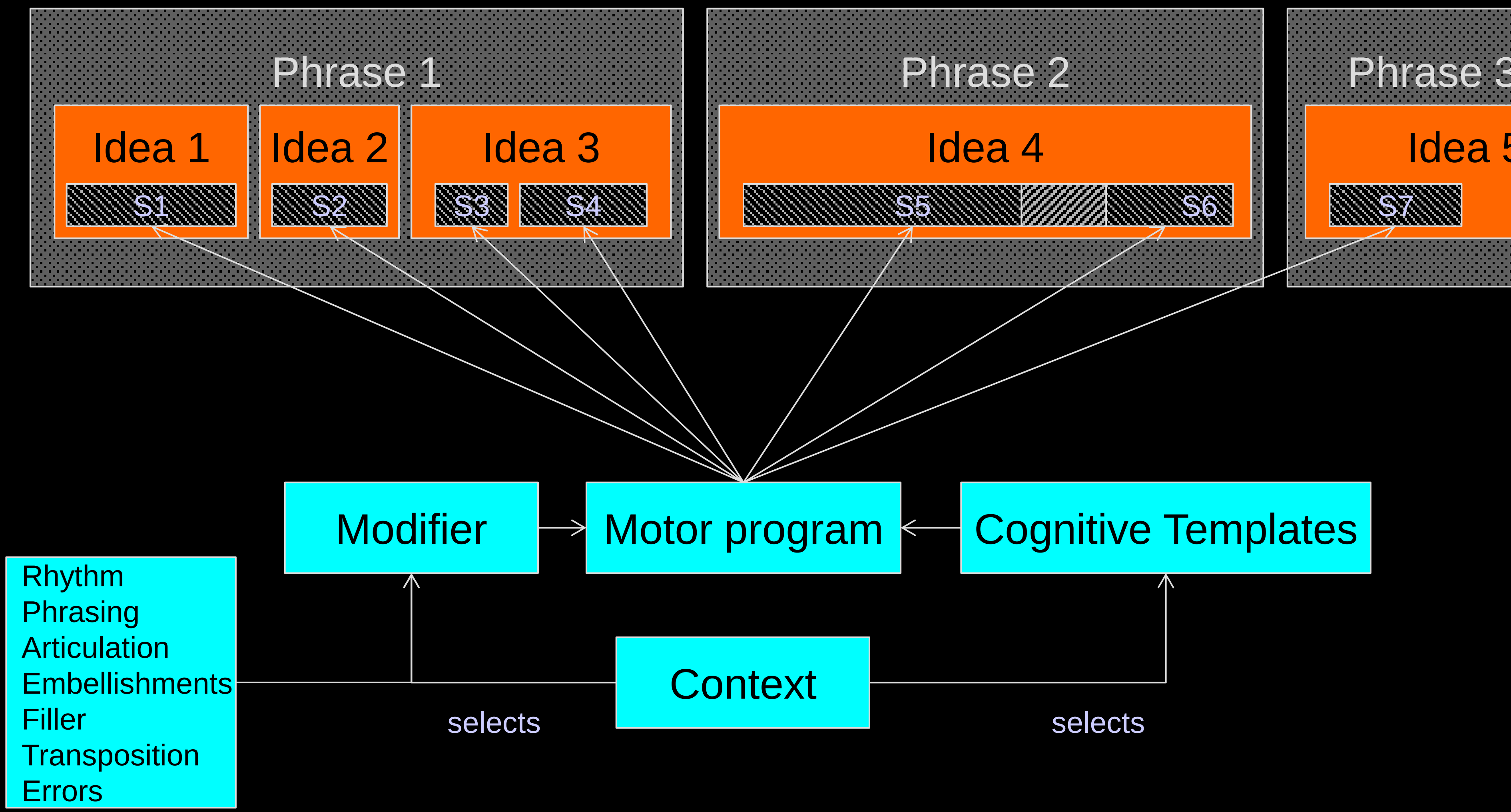
Issues

- Are the psychological processes the same in absolute beginners and in professionals?
- Are the psychological processes the same among professionals, styles, genres, tempo etc.?
- How is consciousness is involved?
- (BTW: What is consciousness?)
- How much is essential randomness involved?
  - Epistemological sidestep: As long as the underlying (causal) mechanisms are not fully known, improvisation must be considered a random process.
  - Note: Random process does NOT mean erratic or without structure or intention.

Jazzomat Flow Chart
Reverse engineering Approach



Ideational Flow Model



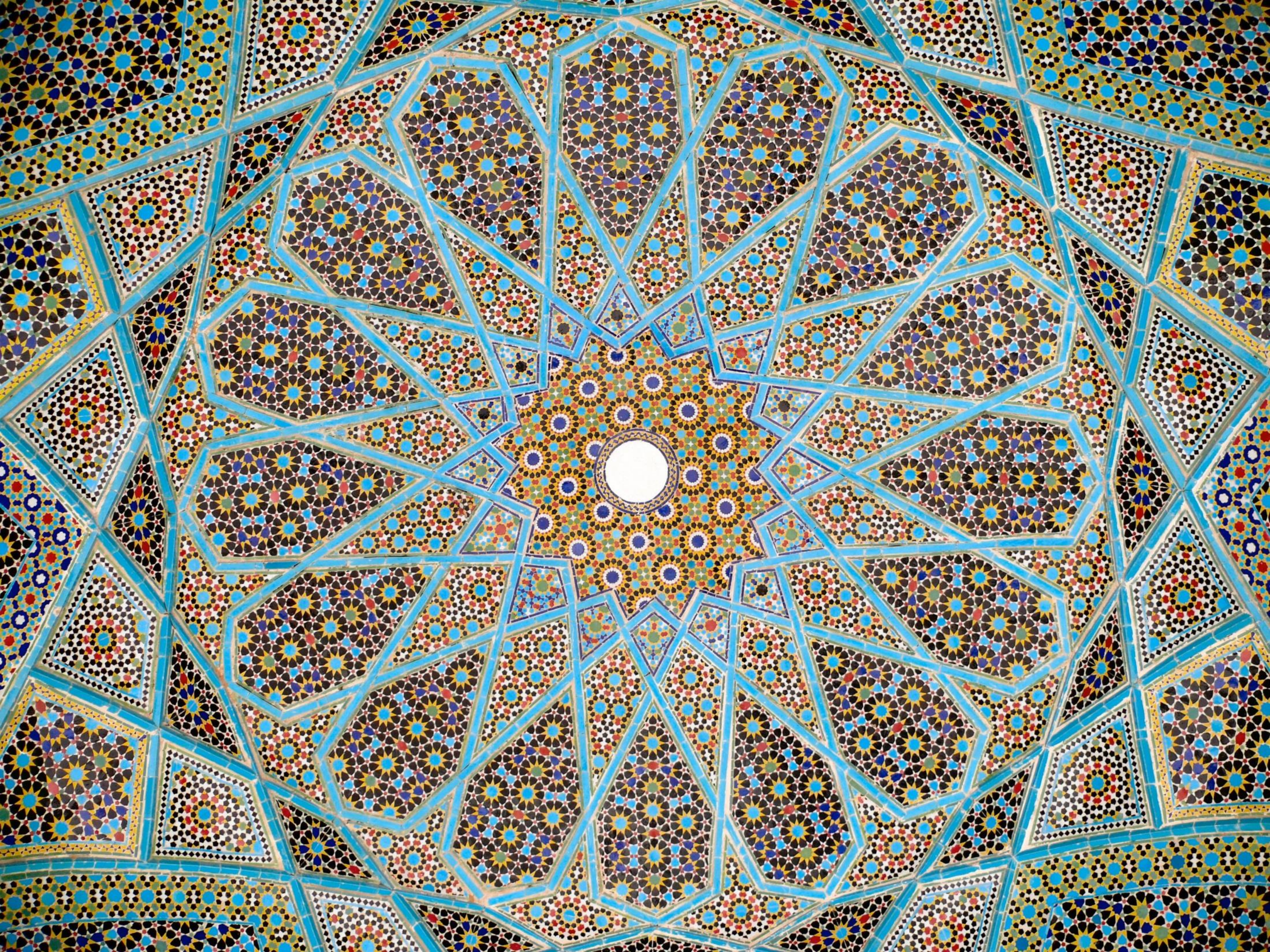
Context

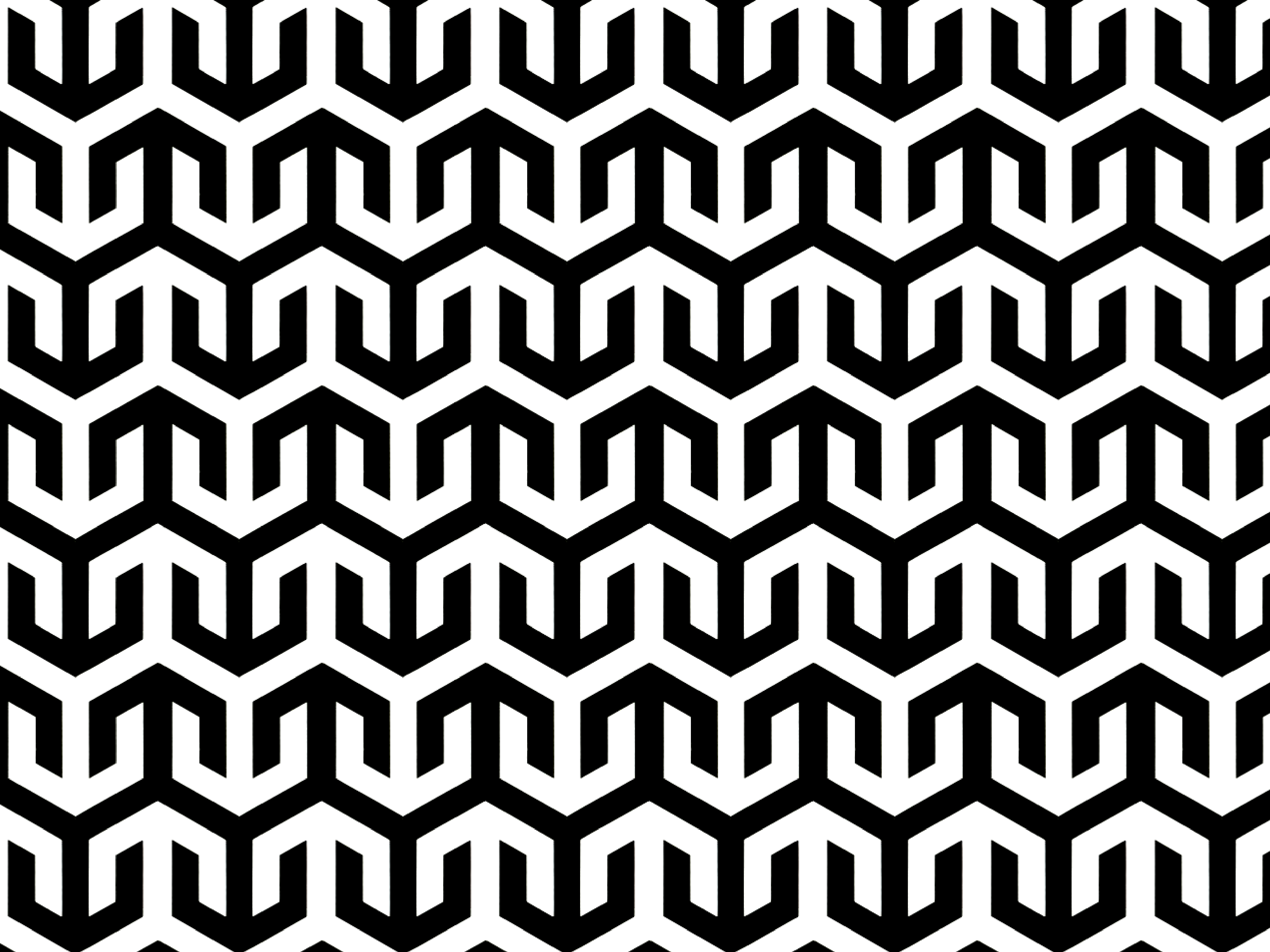
	Internal	External
Short-term	– IMP (immediate musical past) – Last Ideas – Mood – Flow	– Fellow Musicians – Audience
Long-term	– Musical Training – Music Theory – Musical Preferences – Personality – Persona	

Improvisational Process

- Conscious or semi-conscious planning of mid-level ideas.
- Semi- or unconscious selection of patterns from memory fitting the idea and the current musical context.
- Shaping and modification of raw patterns according to idea, context and intended expression.
- Recent own ideas and fellow musicians are main inspiration: ontinuation, contrast, expression, “energy”, external input (reactive).
- Higher order patterns of ideas and ideational flows.

So, What are Patterns?





Terminology

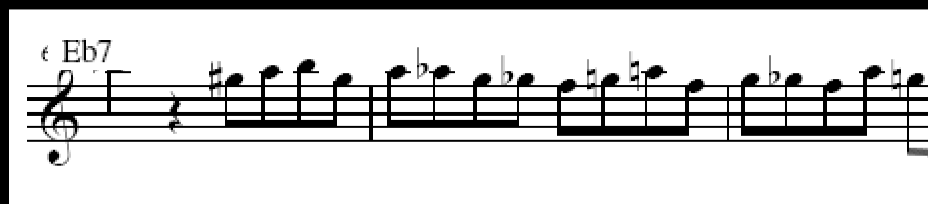
- No clear definition of “pattern”, “formula”, “lick”, “riff”, or “dittey”.
- “Pattern”, “formula” more often used in scientific contexts.
- “Lick”, “riff” more common in jazz musician lingo.

Terminology

- Patterns are statistically recurring building blocks.
- Patterns can be occur on different hierarchical levels (tone event level, abstraction level, idea level).
- (Proposal: Introduce term “trope” for general patterns and reserve “pattern” for patterns on event level. Connotation to narratological concepts)
- Licks are (short) sequences with certain musical properties.
- Licks are not necessarily a subset of patterns.
- Tentatively: Formula are abstract patterns that can be used to construct patterns (e.g. digitals).

Example: Licks

- 18-note lick by Bob Berg on „Angles“.
  [-2, 1, 1, -2, 1, -1, -1, -1, -1, 2, 2, -4, 2, -1, -1, 4, -2]



- 17-note Charlie Parker-Lick: „Scrapple from the Apple“ & „Billies Bounce“.
  [-1, -2, -2, -2, -1, -2, -2, -1, 3, 3, 3, 2, -3, -2, 2, -3]
- A (Bebop) lick typically contains a mixture of scale-parts and arpeggios, often with turns, a few unusual intervals and chromatic approaches. (Blues licks? Latin licks?)

Abstractions

- What is the “real” event space for tone events?
- Even a faithful description (onset, pitch, duration etc.) is only a rough proxy for the neuronal patterns.
- Much too complex to model thoroughly (time continuous, high-dimensional).
- Approach: Use derived, simple representations (abstractions, transformation view-points).
- First approximation: Discard rhythm, only pitch sequences.
- Derived abstractions: Pitch, pitch class, interval (class), tonal (diatonic) pitch class, chordal (diatonic pitch class).

Abstractions

- Assumptions:
  - Pitch patterns and rhythmic patterns are approx. independent.
  - Pitch patterns are partly transposition-invariant.
  - Hence, interval patterns are meaningful.
- Issues:
  - Complex interaction between different pitch based representations (only partly equivalent).
  - Instrument dependencies (e.g., transposition on guitar much easier than on wind instruments, ease of realization).
  - Chords and keys are not uniformly distributed.

Experiment

- In any discrete random process, patterns will occur.
- Question: How to discern “real” patterns from chance patterns?
- Approach: Compare real patterns structure with pattern structure from simulated solos using unigram distributions (Markov process 0^{th} order.)
- For now: Only interval representation.
- Minimal working definition: Patterns are N-Grams occurring at least twice.
- Sampling problem

Data

- 204 monophonic solos by 60 improvisers taken from the Weimar Jazz Database.
- Note counts: 72-4955, Median: 352.5, Total: 90401.
- Mostly wind instrument, some guitars.

Art Pepper	4	David Murray	4	John Abercrombie	1	Pat Martino	1
Ben Webster	4	Dexter Gordon	4	John Coltrane	12	Paul Desmond	7
Benny Carter	2	Dickie Wells	2	Johnny Dodds	1	Rex Stewart	1
Benny Goodman	6	Dizzy Gillespie	4	Joshua Redman	5	Roy Eldridge	6
Bix Beiderbecke	2	Don Byas	5	Kenny Dorham	4	Sonny Rollins	8
Bob Berg	5	Don Ellis	2	Kenny Garrett	2	Sonny Stitt	2
Buck Clayton	3	Eric Dolphy	1	Lee Konitz	3	Stan Getz	4
Cannonball Adderley	5	Fats Navarro	2	Lee Morgan	1	Steve Coleman	2
Charlie Parker	4	Freddie Hubbard	5	Lester Young	4	Steve Lacy	4
Chet Baker	6	Gerry Mulligan	1	Lionel Hampton	1	Steve Turre	3
Chu Berry	1	Hank Mobley	2	Michael Brecker	2	Warne Marsh	2
Clifford Brown	4	Harry Edison	1	Miles Davis	7	Wayne Shorter	7
Coleman Hawkins	5	J.J. Johnson	2	Milt Jackson	1	Woody Shaw	4
Curtis Fuller	2	Joe Henderson	6	Nat Adderley	1	Wynton Marsalis	2
David Liebman	4	Joe Lovano	2	Ornette Coleman	4	Zoot Sims	2

Method: N-Grams

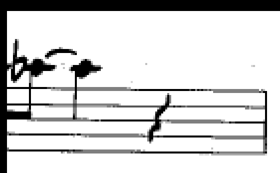
- Calculate maximal N-gram partitions for interval-sequences for a range of N's (using `melpat`).
- Maximal N-gram length: 30.
- Minimal N-gram lengths: 3, 5, 7, 9,11.
- Keep N-Grams that occur at least twice.
- Discard proper sub-patterns.
- Filter trills.
- Simulation of 204 solos (matching lengths) based on interval distribution.
- Same procedure for simulated sequences.
- Approx. 10h computing time

Example: Pattern Partition
(Trane: Giant Steps, Pitch Pattern)

Result: Example

- John Coltrane „Giant Steps“.
- 20-tone pattern.

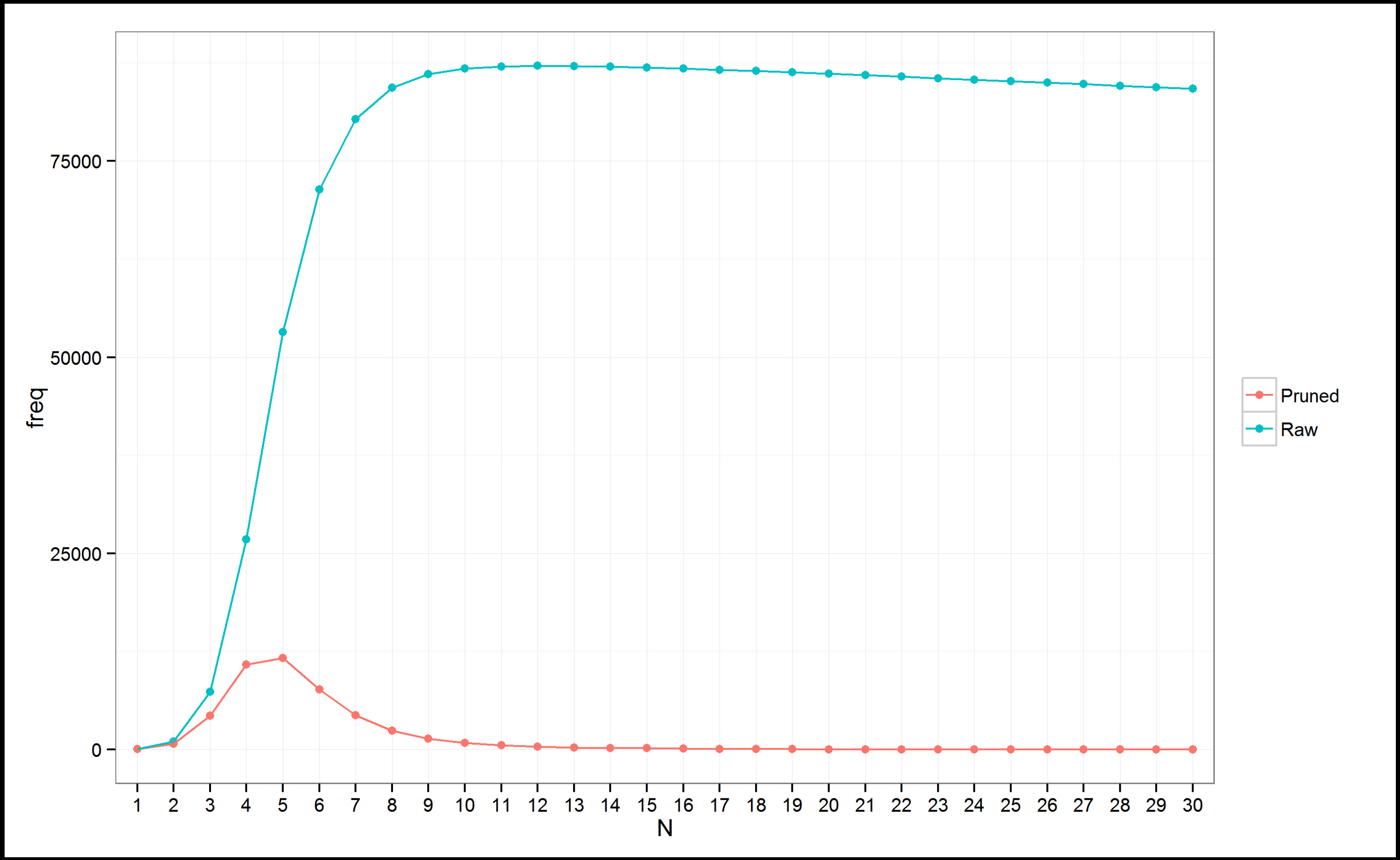
  [4, -1, -1, -1, -2, -2, -1, -2, -2, 10, -1, -5, 3, -2, -1, 3, -1, -4]
- Based on C-Bebop-scale.



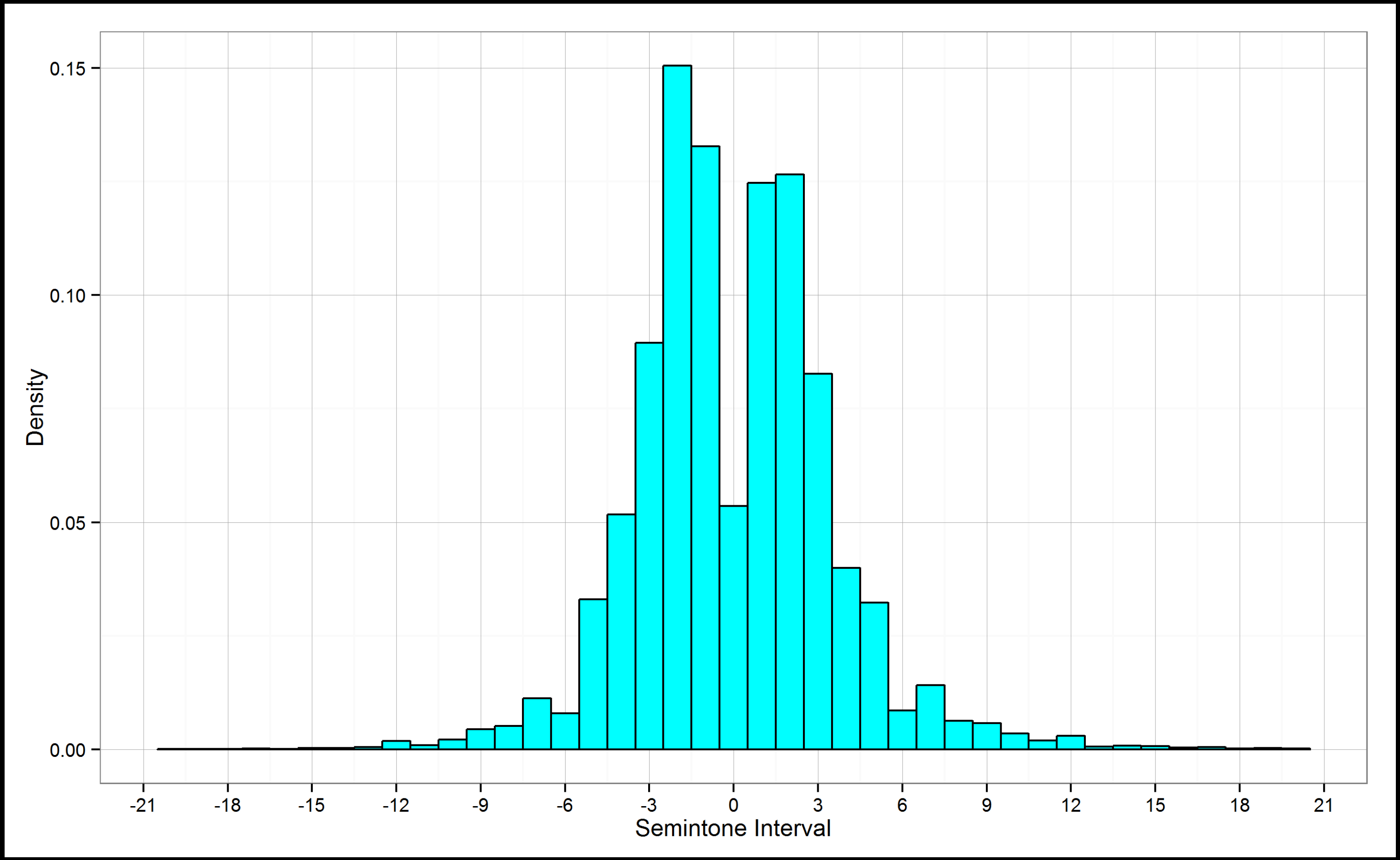
Method: Pattern Features

- Calculate features for N-Gram-Partitions:
  - Average pattern length,
  - coverage (percentage of elements contained in at least one pattern),
  - logarithm of excess probability log (p_{exp}/p_0),
  - average overlap between patterns,
  - number of patterns.
- Additional metadata from the database:
  - Performer,
  - style, red. style (traditional/modern),
  - tempo class, red. tempo class (slow, medium, up).

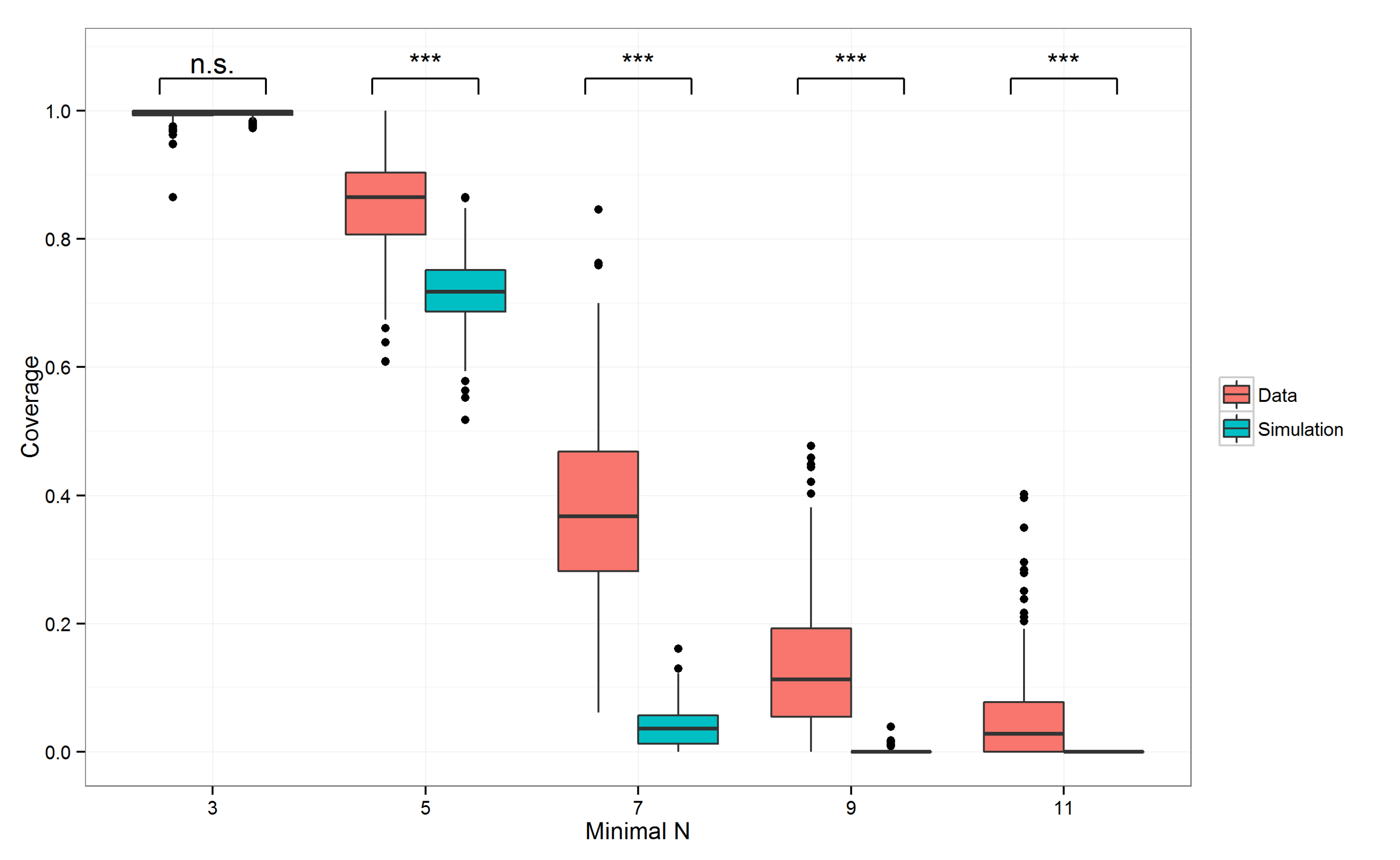
Results: NGram Stats



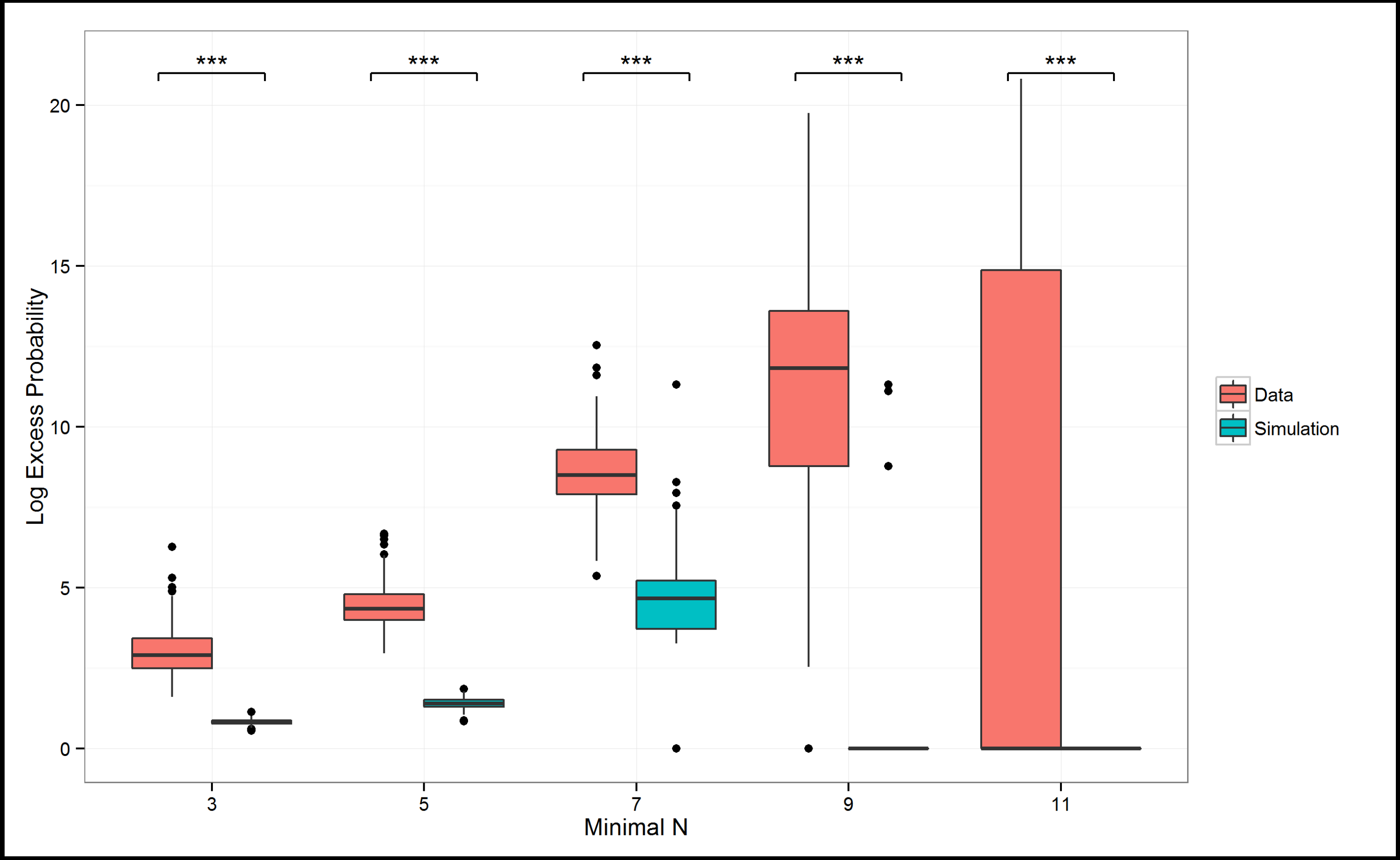
Results: Interval Distribution



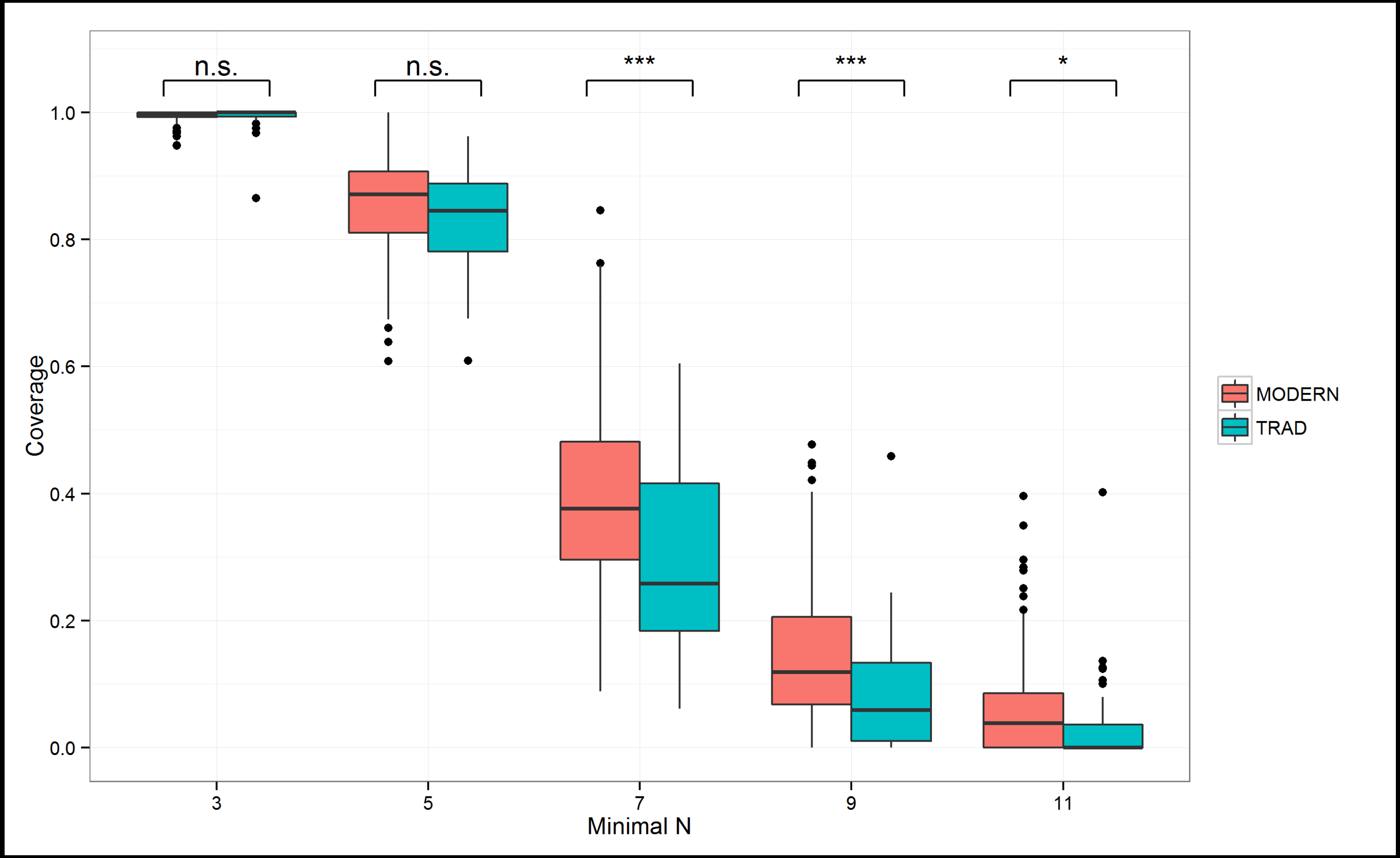
Results: Pattern Coverage



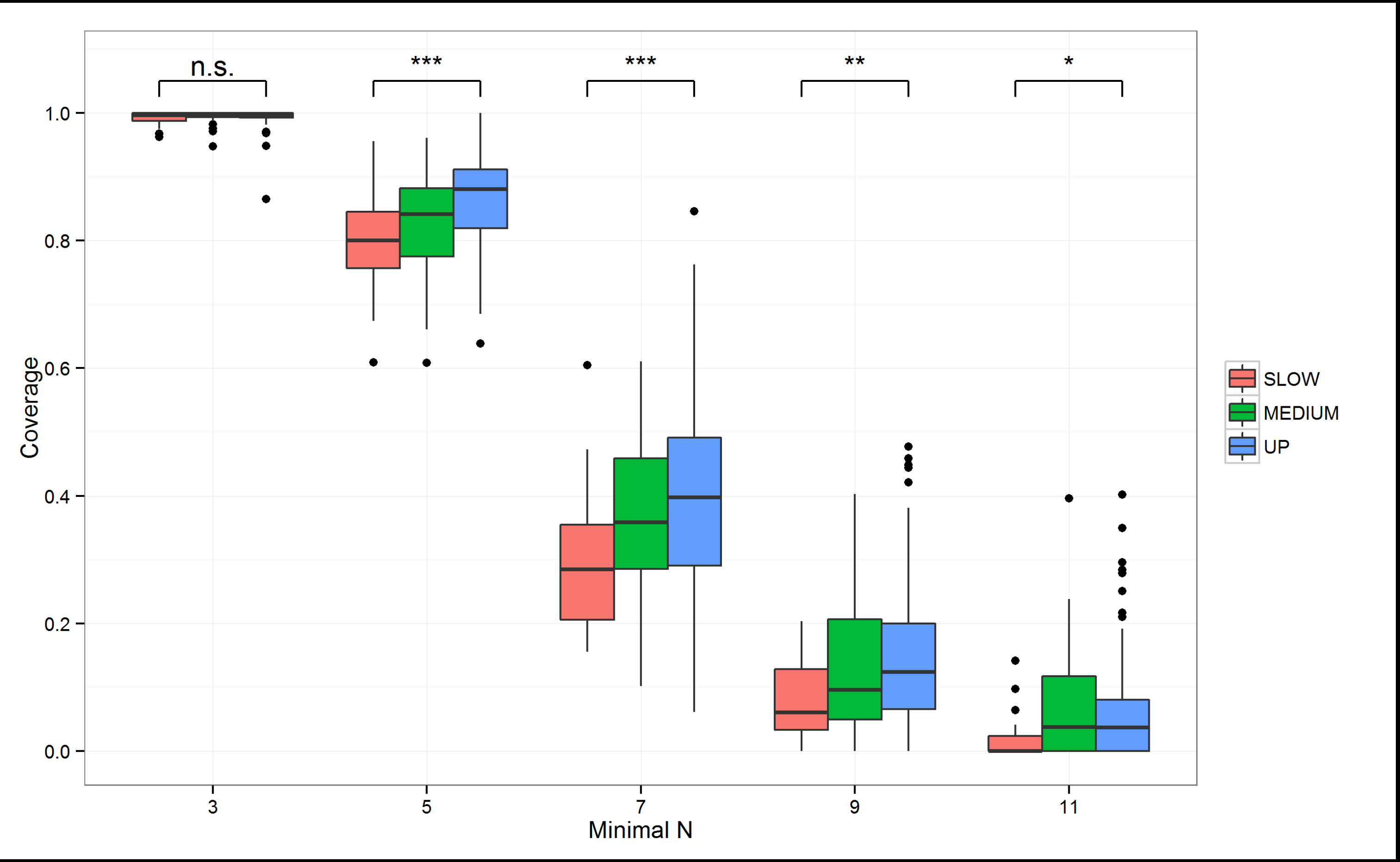
Results: Log Excess Probability



Results: Pattern Coverage by Style



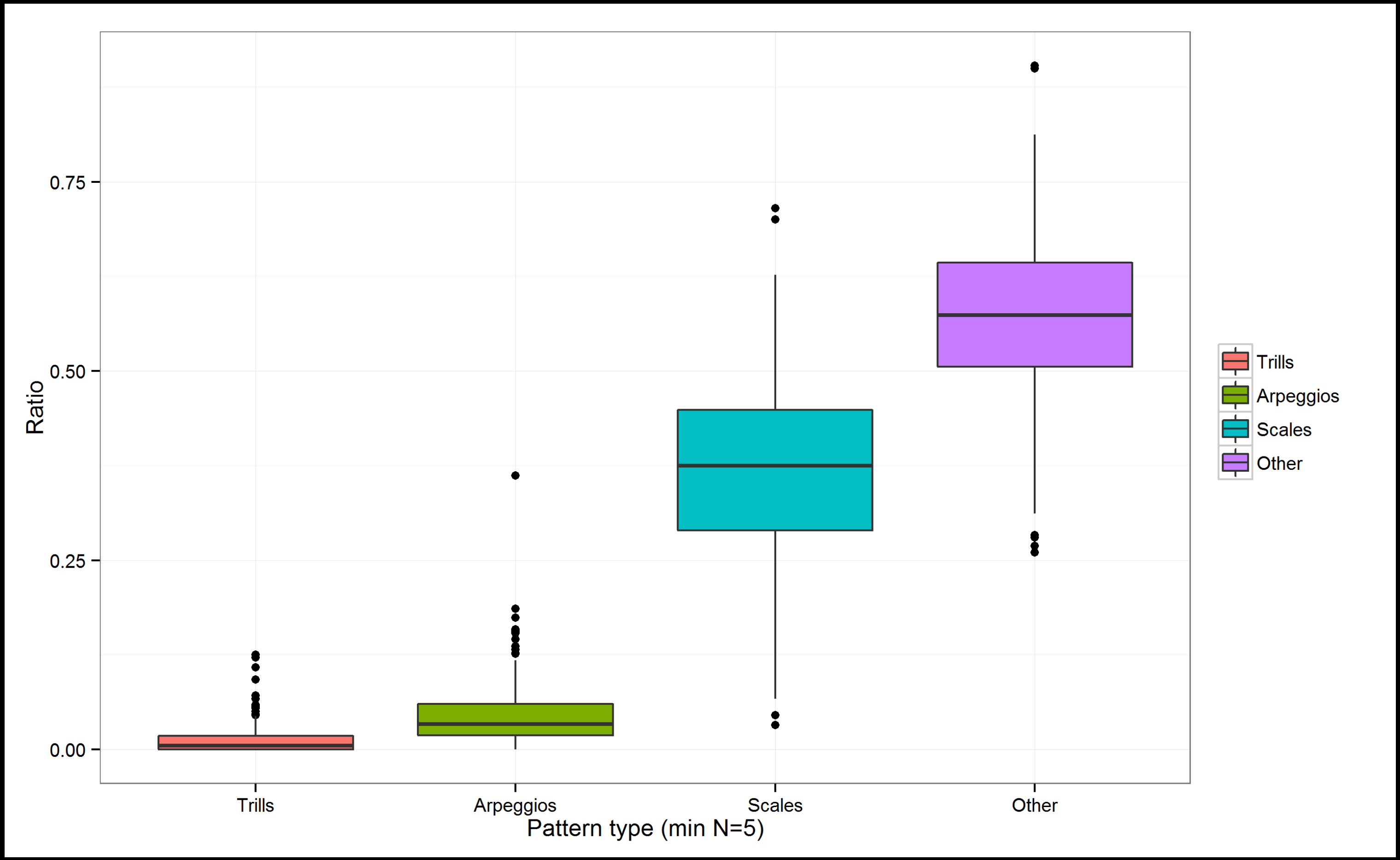
Results: Pattern Coverage by Tempo



Pattern Types

- Rough classification of patterns into four classes:
  - Trill: Repetitions of P notes (P=2-7)
  - Arpeggios: Directed sequences of min./maj. thirds.
  - Scale-like: Directed sequences of min./maj. seconds.
  - Other (Licks): Everything else.

Pattern Types (min N=5)



Summary

- Patterns are ubiquitous.
- Pattern length of 5 intervals (6 tones) most significant, 40% coverage.
- Short patterns (N=3) seem to be random, but log excess probability proves otherwise.
- From bebop onwards increased pattern usage (but not much).
- More patterns in higher tempo (reducing cognitive load).
- Other (licks) and scale-like patterns are the most common (very rough classification).

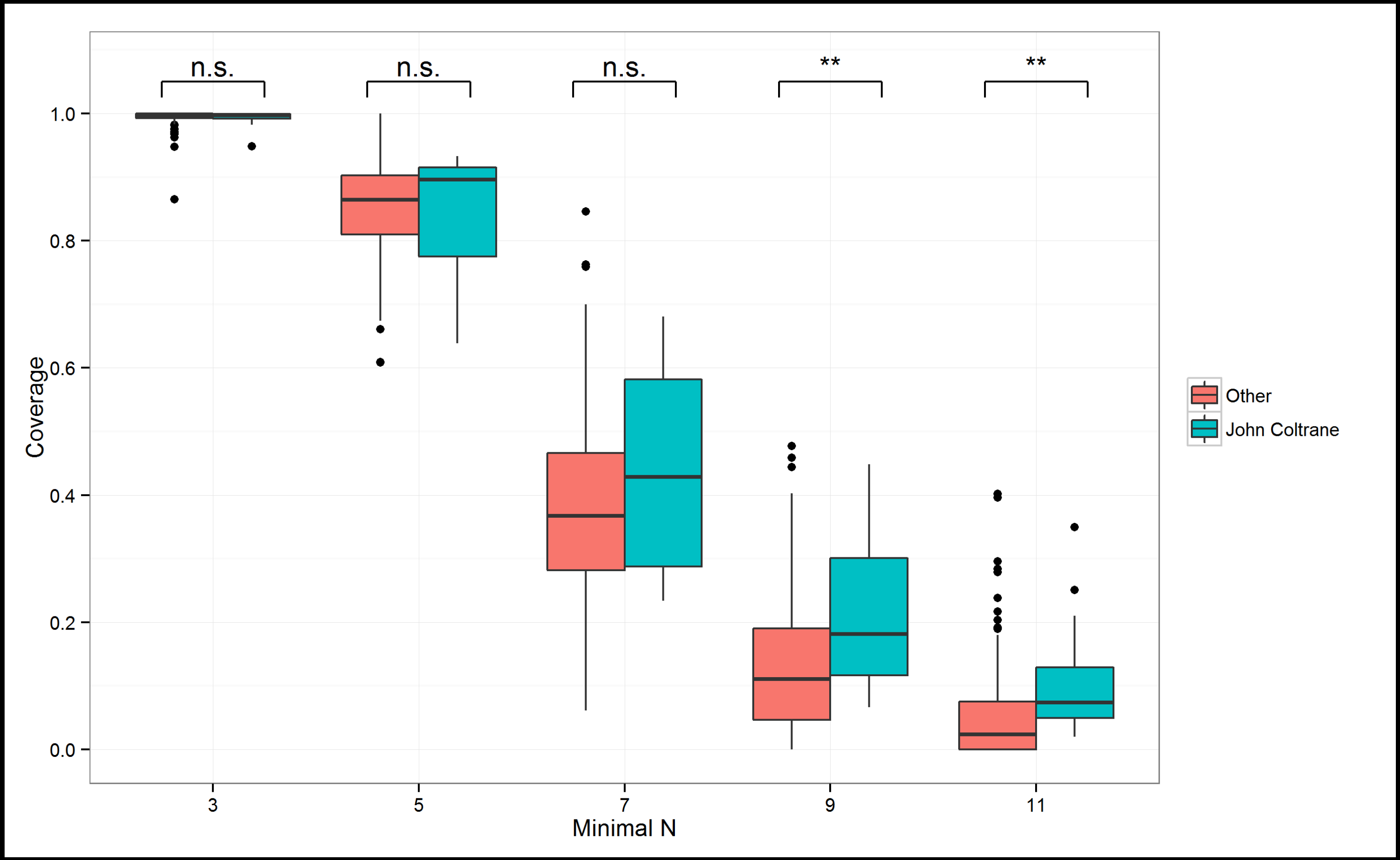
Some more observations

- Patterns strongly tend to occur in the same solo, not across solos.
- Pattern tend to occur in similar musical contexts and with similar musical shape (rhythm, chord, meter).
- Rather few systematic differences between performers.

Some more observations

- Scale-like patterns are more often used in modern than in traditional style (#scale-like patterns / notes, $p<0.0062$**, $d=.46$)
- Scale-like patterns are more often used in higher tempo (#scale like patterns / notes, $p<0.0162$*, $\eta^2=.0446$)
- John Coltrane is an exceptional case in excessive pattern usage (modal & motivic improvisations).

Results: Coverage Coltrane vs. others

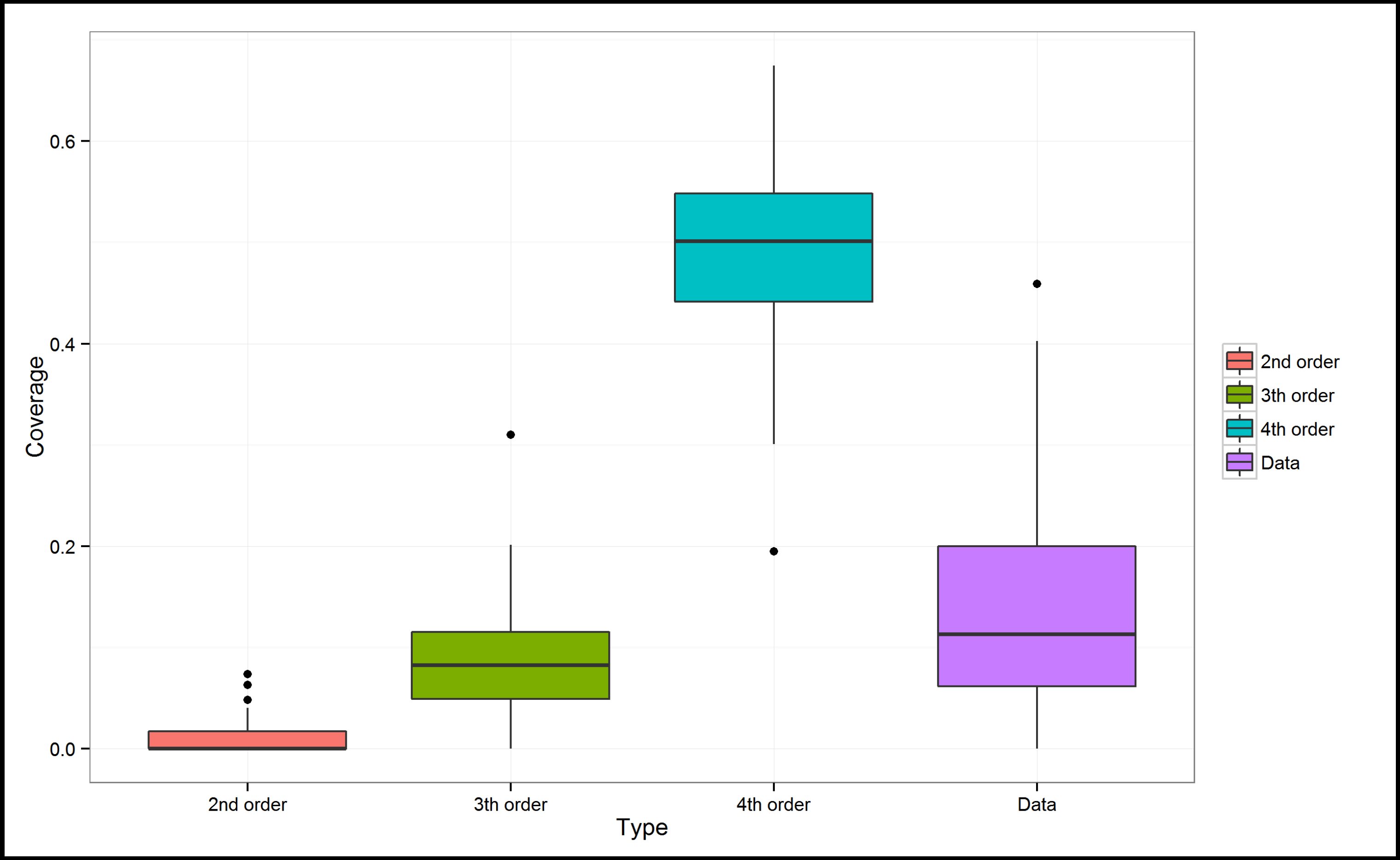


Outlook

- Simulation with unigram model might be too simple, →using higher order models (computing intensive).
- More elaborate pattern classification.
- Using and comparing different representations.
- Differentiating sequences and motivic improvisation from stock patterns..
- Fuzzy pattern matching.

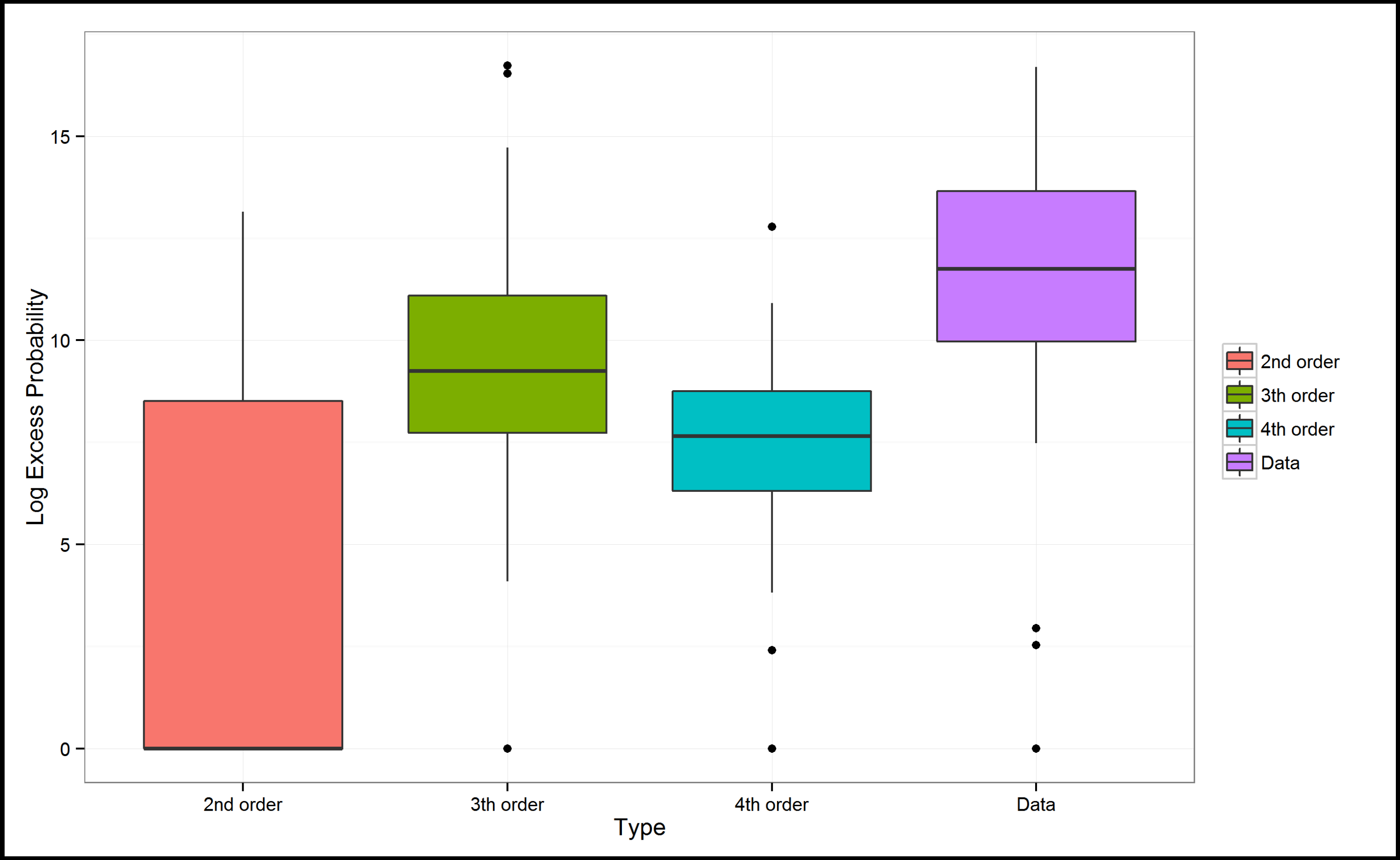
Coverage by Markov order

min N = 9, Data = 55



Log Excess Prob BY Markov order

min N = 9, Data = 55



Thanks!

All 31 1235 patterns in Coltrane’s solo on „Giant Steps“