Evaluating Rule- and Exemplar-Based Computational Approaches for Modelling Harmonic Function in Music Theory Pedagogy

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Introduction 1
Motivations.

Phrase model 2
Hierarchical analysis.

Rule- and Exemplar-based models 3
Formalizing the text and modeling the musical examples.

Evaluation 4
Testing the models on the Laitz textbook and workbook.

Conclusions 5
Pedagogical implications and future directions.

Introduction

Empirical consideration of music theory pedagogy

- **Music theory texts provide prose and annotated example scores in order to explain analytical concepts**
- **These two pedagogical methods can be empirically compared by implementing**
  - a rule-based computational model derived from the written text
  - an exemplar-based computational model derived from the musical examples
- **This project uses the phrase model described in Steve Laitz's *The Complete Musician* for testing**

Previous Work

Computational analysis of symbolic music

- **Computation harmonic analysis of dates back to Winograd's work in the 1960s**
- **Recently work has included hierarchical models, including phrase-level function (Rohrmeier, Granroth-Wilding, and de Haas)**
- **Textbook corpora are particularly useful for computational modelling because they provide expert annotations (Temperley's use of Kostka and Payne, Schmuckler's use of Piston)**

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Phrase Model

General Overview

- **Phrases are complete musical statements**
  - Typically contain a tonic, pre-dominant, and dominant function
- **General idea of functional harmony dates back to Rameau and was explored extensively by Riemann**

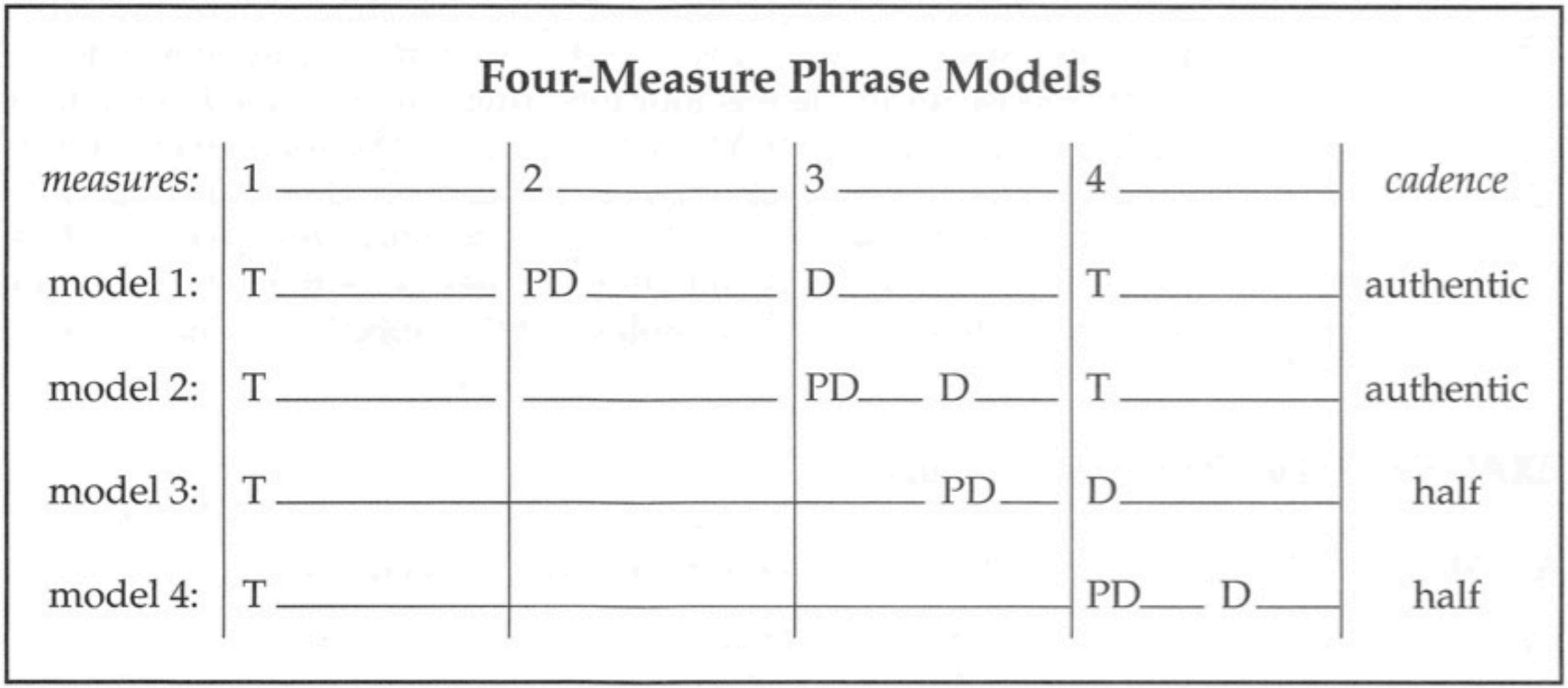
Phrase Model

Functions

- **Tonic function (T)**
  - at the beginning of a phrase it serves to establish the tonal center
  - at the end of a phrase it provides closure
- **Pre-dominant function (PD)**
  - prepares for the arrival of the dominant function
  - may not be present in short phrases
- **Dominant function (D)**
  - creates a sense of tension that is resolved by the return of the tonic function

Phrase Model

Laitz's Schematic



Four-Measure Phrase Models

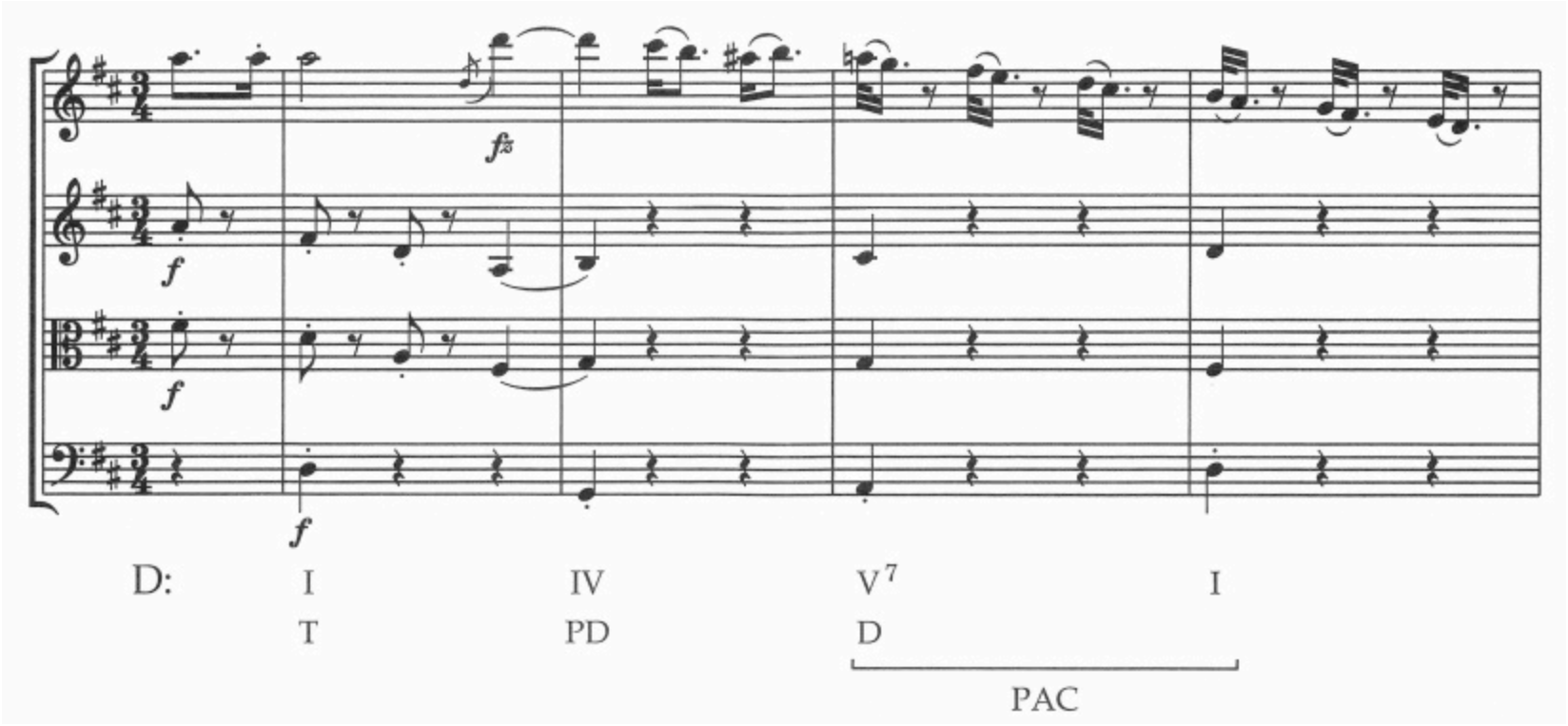
measures:	1	2	3	4	*cadence*
model 1:	T	PD	D	T	authentic
model 2:	T		PD D	T	authentic
model 3:	T			PD D	half
model 4:	T			PD D	half

Laitz, p 201

Phrase model

Simple example

Haydn, String Quartet in D major, "The Frog," op. 50, no. 6, Hob 111.49, Menuetto

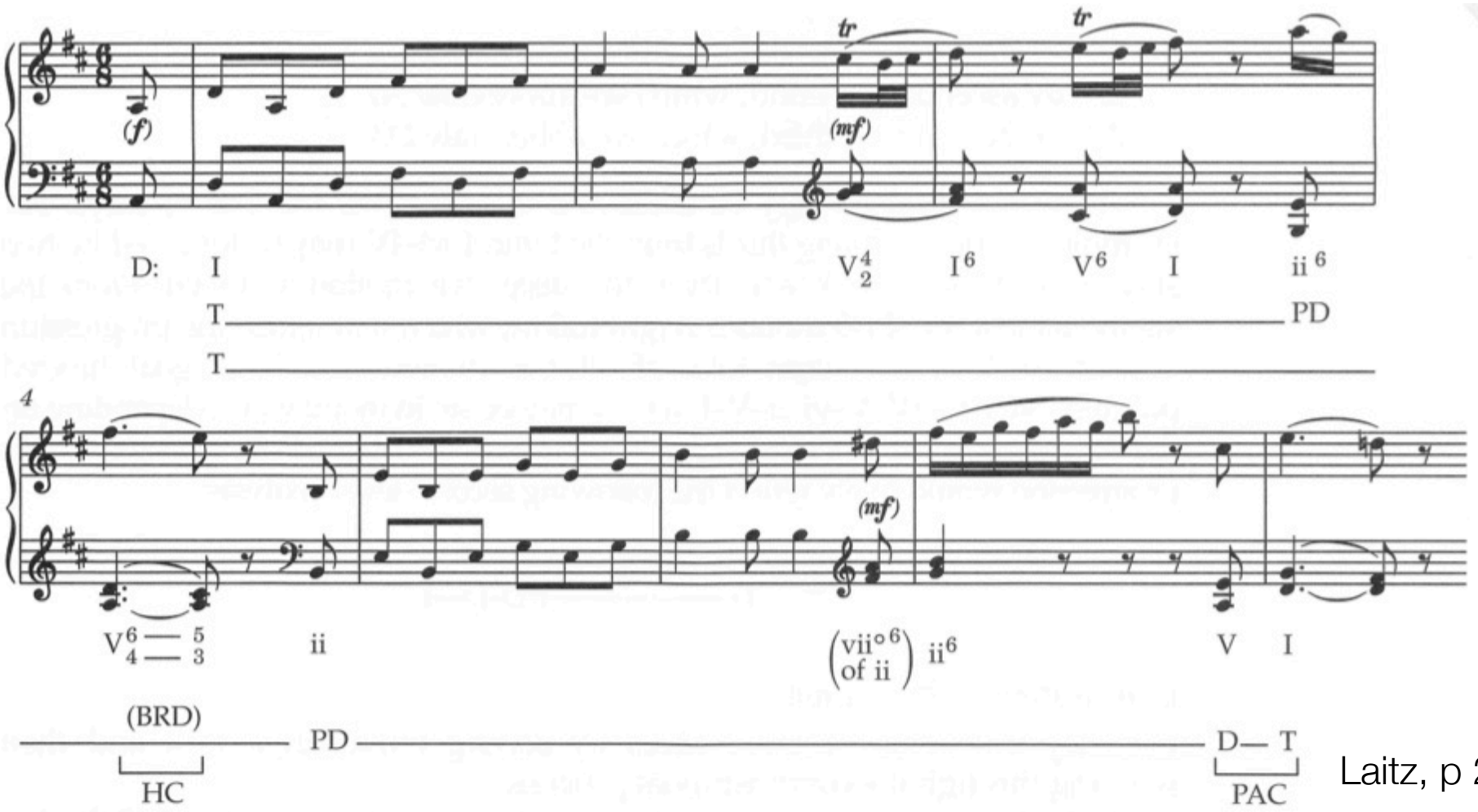


Laitz, p 201

Phrase model

Complex example

Mozart, Piano Sonata in D major, K. 576, Allegro



Laitz, p 293

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Formalizing the rules

Roman Numeral- and Phrase-level Rules

- **18 Roman numeral-level rules were derived from the Laitz chapters on diatonic harmony (Ch. 7–14)**
  - Example
    - "I6 is an ideal choice for a passing chord between ii and ii6. The I6 chord is subordinate to the prevailing pre-dominant"
    - IF currentChord == I6 AND previousChord == ii AND nextChord == ii6
      THEN currentFunction = predominant
- **3 phrase-level rules to ensure that the phrase model was adhered to**

Formalizing the rules

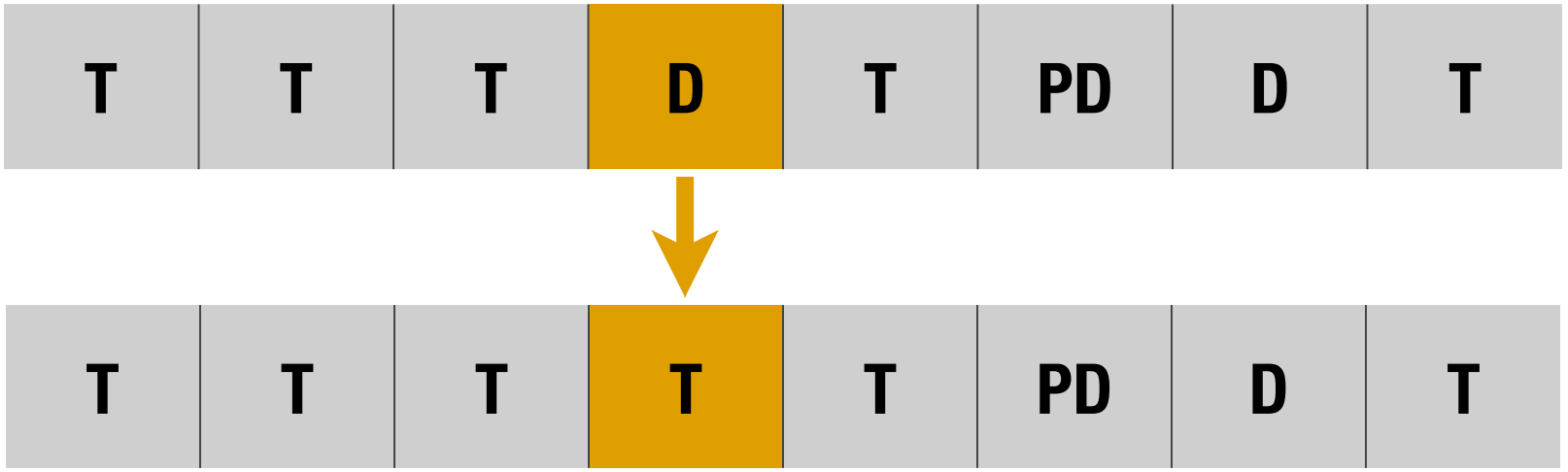
Direct Labels

I Chords		
1	Opening and closing I chords	T
2	I^{64} followed by a V chord	D
3	I^{6} chords between a ii and a ii^{6}	PD
4	I^{64} chords between a IV and a IV^{6}	PD
ii Chords		
5	ii chords	PD
6	ii^{65} chords before or after a I chord	T
iii Chords		
7	iii chords	T
IV Chords		
8	IV chords	PD
9	IV chords before or after a I chord	T
10	IV^{6} chords between I and I^{6} chords	T
11	IV^{6} chords between V and V^{6} chords	D
V Chords		
12	V and V^{7} chords	D
13	V^{6} between two I chords	T
vi chords		
14	vi chords	T
15	vi chords between two V chords	D
vii° Chords		
16	vii° chords	D
17	vii° ^{6} between two I chords	T
Second Inversion Chords		
18	Any remaining second inversion chords are assigned the function of the previous sonority	

Multiple-progressions

Formalizing the rules

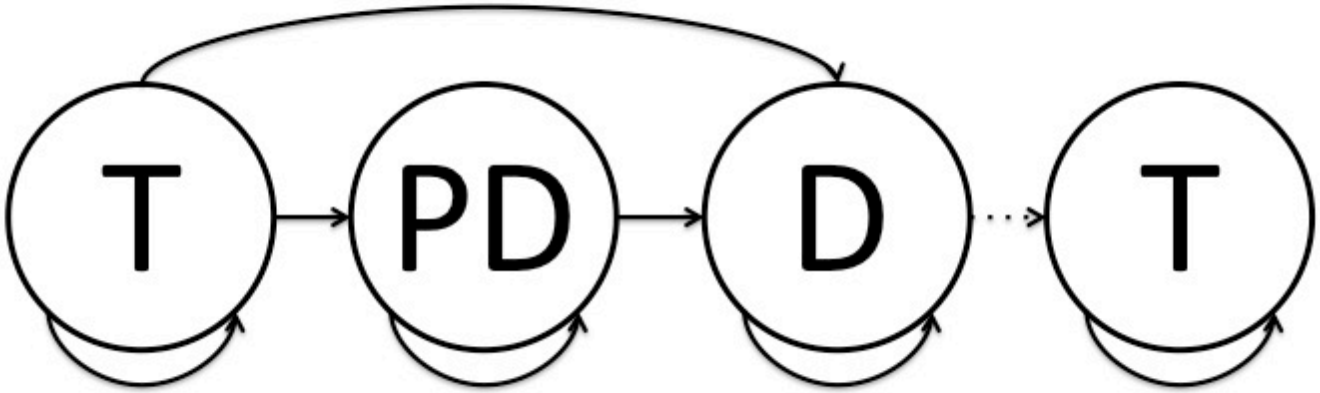
Phrase-level Rules	
1	P or D between two Ts
2	T or D between two PDs
3	T or P between two Ds



Exemplar Model

Hidden-Markov model

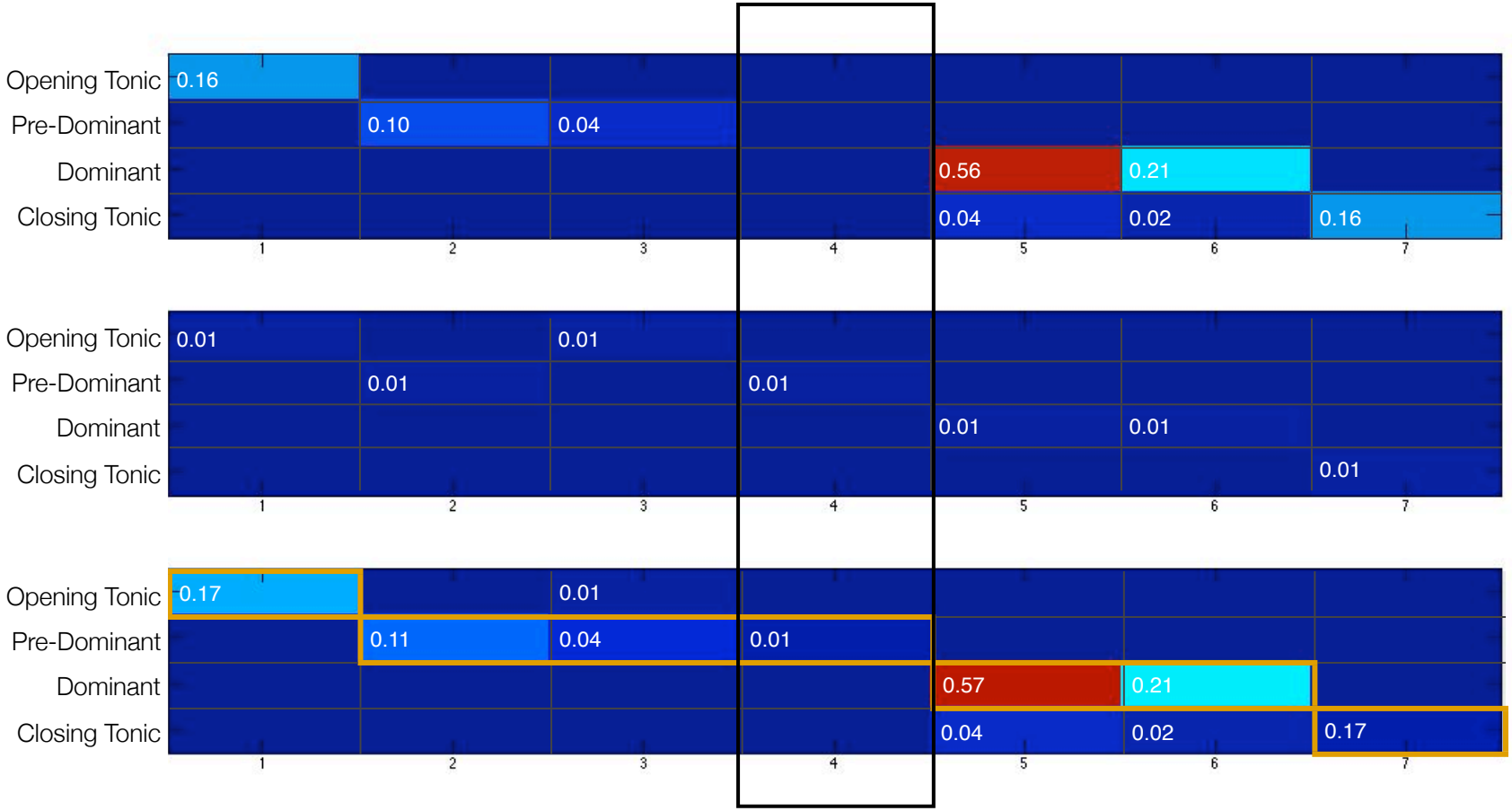
- **Observations:** chord labels
  - With and without duration information
- **Predictions:** function labels
- **State space:**



Combined Model

Rule-based + Exemplar-based

- **Output of rules-based model used as prior the exemplar-based model's HMM**



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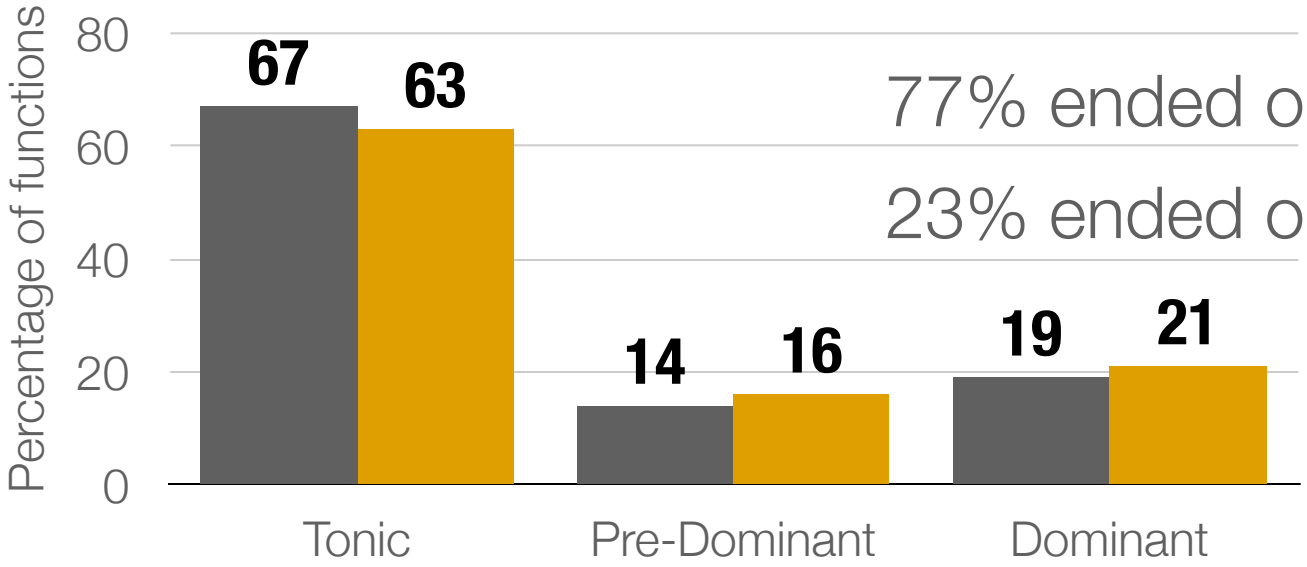
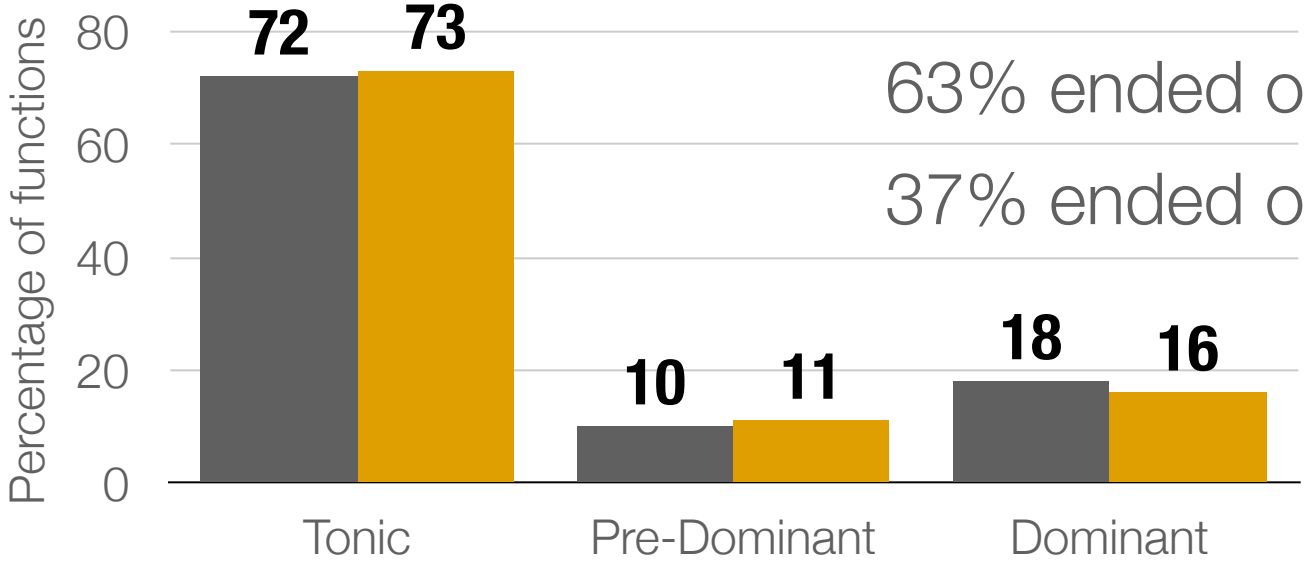
Textbook (85 phrases)



77% ended on a tonic function

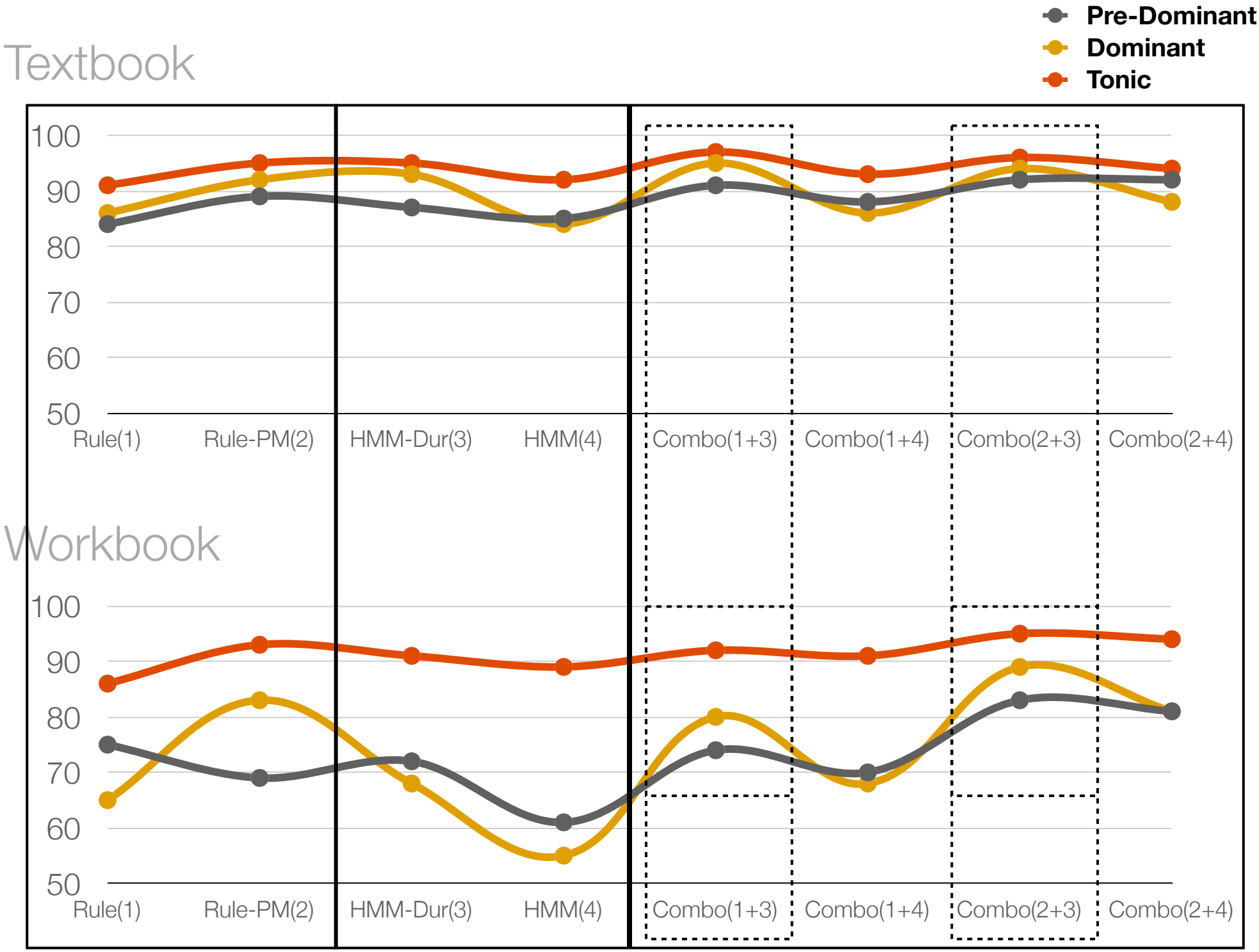
23% ended on a dominant function

Workbook (51 phrases)

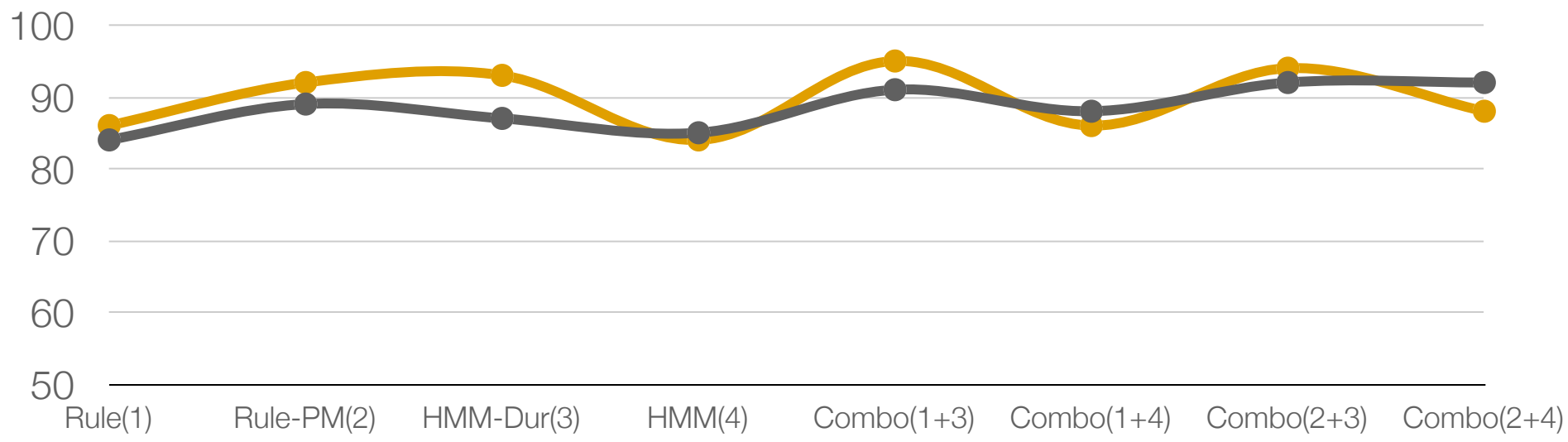


63% ended on a tonic function

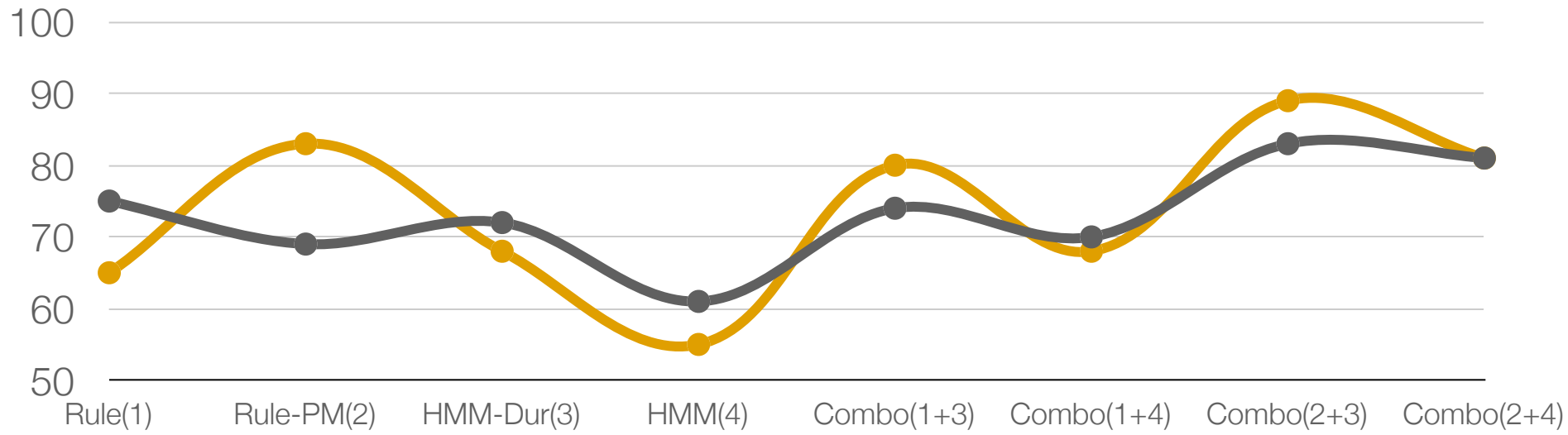
37% ended on a dominant function


Pre-Dominant
Dominant
Tonic
Textbook
100
90
80
70
60
50
Rule(1)
Rule-PM(2)
HMM-Dur(3)
HMM(4)
Combo(1+3)
Combo(1+4)
Combo(2+3)
Combo(2+4)
Workbook
100
90
80
70
60
50
Rule(1)
Rule-PM(2)
HMM-Dur(3)
HMM(4)
Combo(1+3)
Combo(1+4)
Combo(2+3)
Combo(2+4)

Textbook



Workbook



Summary

Rules versus exemplar-based systems

- **There is unique information captured by both the Rule- and Exemplar-based models**
  - phrase-level rules may be overzealous in re-assigning pre-dominant function labels
  - duration modeling is useful for the exemplar-based model
- **There may be different phrase-level characteristics between the textbook and the workbook**

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Pedagogical Implications

What these results suggest for music theory pedagogy

- **The higher accuracy of the Combination models demonstrates that both the text-based rules and musical examples contain important information**
- **Difference in accuracy for different functions suggests that**
  - a rule-based approach conveys important information for differentiating between tonic functions and pre-dominant and dominant functions
  - a repertoire-based approach is needed to differentiate between pre-dominant and dominant functions

Future Work

Improving/expanding

- **Incorporate metrical information**
- **Expand to include modulation, chromatic harmonies, and irregular phrases**
- **Run similar experiments with the Clendinning and Marvin textbook, *The Musician's Guide to Theory and Analysis***

Thank you!