

Cadences

Some Goals

- Discuss how looking at cadences can help us with other questions, such as statistical learning, pattern detection, and the analysis of form.
- Discuss how we might define cadences, and how they represent varying degrees of perceived closure and tension.
- Discuss how cadences are historically, culturally, and stylistically situated.

What is a cadence?

- From the Latin *cadere*, meaning “to fall” (or *cadentia*, “a falling”).
- Cadences are more than simply a movement of one chord to another, which makes them a little tricky to find sometimes.
- So how might we define a musical cadence?

Cadence Fact #1

- A cadence generates expectations:
 - From Sears (2015):
 - “[...] a cadence, or more precisely, the progression preceding cadential arrival, elicits very definite expectations concerning the melodic scale-degree, the harmony, and the metric position of the goal event.” (p.254)
 - See also the collection this essay comes from (*What is a Cadence*, edited by Neuwirth and Bergé).

Cadence Fact #2

- A cadence is a confluence of many musical parameters, such as harmony, melody, rhythm, and meter:
 - From Hentschel, Neuwirth, and Rohrmeier (2021):
 - “Cadences are seen to emerge from coordinated activities of harmony, voice-leading, rhythm, and meter that are difficult to disentangle and have therefore been accounted for from a schema-theoretical perspective (e.g., Temperley, 2004; Gjerdingen, 2007).”

Cadence Fact #3

- Broadly defined, cadences are present in many types of music (if not all).
 - Jairazbhoy (1971) writes that, in North Indian classical music, phrases and sections often end with patterns that function in a cadential way.
 - Temperley (2011) points out that the V-I cadence is quite common as an end of sections in pieces in jazz standards.
 - Discusses the IV chord as a place of arrival, a cadential goal-point.

The Cadential IV in Rock (Temperley, 2011)

Slow and very free tempo

E: (I)

Way down in - side _____ Wo - man You _____ need it

IV

a tempo

I

Love _____

The image displays a musical score for the song "Whole Lotta Love" by Led Zeppelin. It is divided into two systems. The first system, marked "Slow and very free tempo", shows a vocal melody in E major (one sharp) with lyrics "Way down in - side _____ Wo - man You _____ need it". The melody is mostly on a half note, with some eighth notes. The second system, marked "a tempo", shows a guitar solo in E major. It begins with a half note on E4, followed by a series of eighth notes (F#4, G#4, A4, B4, C#5, D5, E5) marked with 'x's. The solo then moves to a lower register with eighth notes (D4, C#4, B3, A3, G#3, F#3, E3). The lyrics "Love _____" are written below the guitar line. Roman numerals I, IV, and I are placed above the first, fourth, and eighth measures of the second system, respectively.

Cadence Fact #4

- The cadences we will be talking about for the most part today are very stylistically, culturally, and historically situated:
 - Cadences in Western classical music function in a very specific way, and this is very different in jazz, pop, rock, or literally any other style that doesn't fit within this very specific geographic and historical context.

So...why, then?

- Although a very specific musical task, asking questions about classical cadences can allow us to better understand aspects of:
 - Pattern Recognition
 - Statistical Learning
 - Broader Musical Structures

So...why, then?

- Although a very specific musical task, asking questions about classical cadences can allow us to better understand aspects of:
 - Pattern Recognition
 - Statistical Learning
 - Broader Musical Structures

Pattern Discovery

- Cadences are about pattern discovery.
 - They are temporal patterns that functions as endings.
 - We have patterns that begin things, patterns that end things.
 - For example the Doo-Wop Cadence that Johanna Talked about:



The Doo Wop

C Am F G

C: I vi IV V

OR

C Am Dm G

ii substitutes for IV

C: I vi ii V

Pattern Discovery

- This cadence is part of a larger stylistic pattern that can be used for other research questions, such as genre classification.

So...why, then?

- Although a very specific musical task, asking questions about classical cadences can allow us to better understand aspects of:
 - Pattern Recognition
 - Statistical Learning
 - Broader Musical Structures

Pearce (2018)

- In C (bars 23–24), we see how the IDyOM model predicts a melodic cadence.
- By understanding when and how cadences occur, we can model long-term and short-term expectations, as well as more general aspects of statistical learning.

A (bars 1–2)



Pitch (Number)	Penultimate note		Final note	
	Probability	IC	Probability	IC
G ₄ (67)	0.015	6.02	0.289	1.79
A ₄ (69)	0.002	8.93	0.060	4.06
B ₄ (71)	0.003	8.58	0.059	4.08
C ₅ (72)	0.106	3.24	0.134	2.90
D ₅ (74)	0.344	1.54	0.067	3.89
E ₅ (76)	0.189	2.40	0.285	1.81
F ₅ (77)	0.128	2.96	0.028	5.15
G ₅ (79)	0.186	2.43	0.016	5.97
A ₅ (81)	0.013	6.29	0.000	13.81
Entropy	2.49		2.81	

B (bars 21–22)



Penultimate note		Final note	
Probability	IC	Probability	IC
0.015	6.02	0.001	10.24
0.002	8.93	0.000	11.41
0.003	8.58	0.003	8.24
0.106	3.24	0.003	8.18
0.344	1.54	0.028	5.16
0.189	2.40	0.034	4.86
0.128	2.96	0.048	4.38
0.186	2.43	0.535	0.90
0.013	6.29	0.170	2.56
2.49		2.15	

C (bars 23–24)

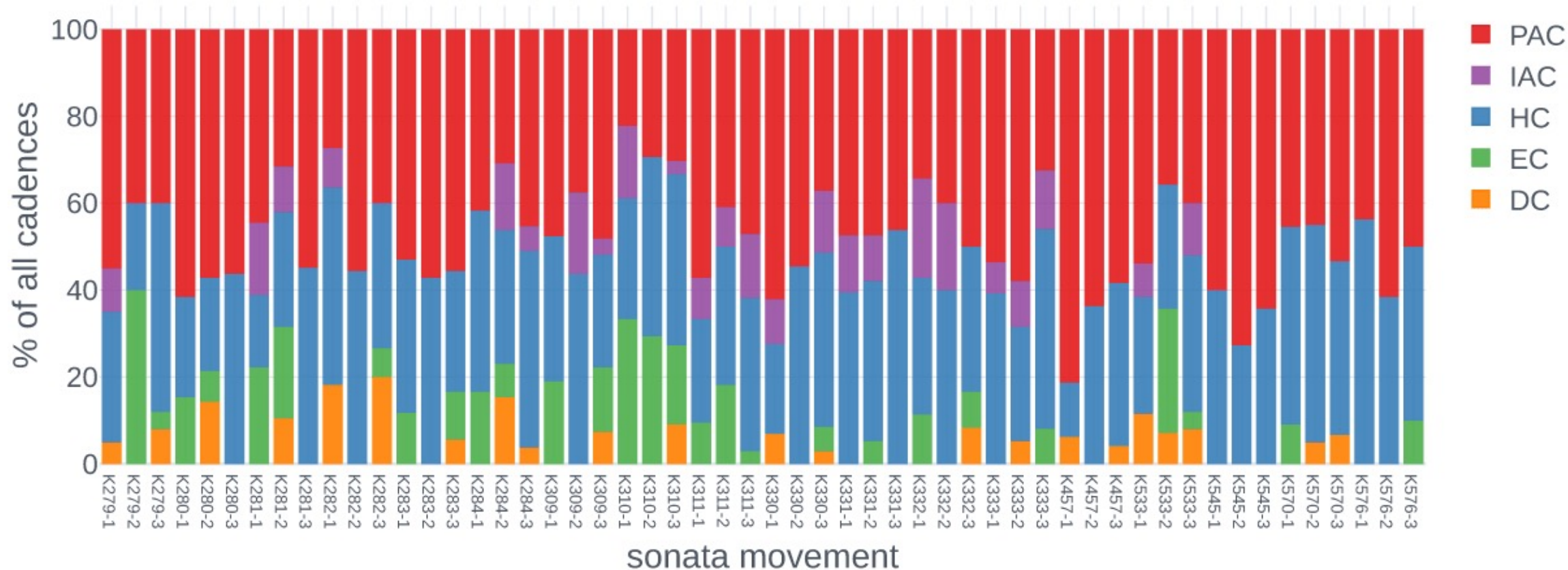


Position	1	2	3	4	5	6	7	8
Pitch	G ₅	F ₅	A ₄	B ₄	C ₅	E ₅	D ₅	C ₅
Probability	0.509	0.234	0.003	0.053	0.691	0.234	0.314	0.360
IC	0.98	2.10	8.34	4.25	0.53	2.09	1.67	1.47

So...why, then?

- Although a very specific musical task, asking questions about classical cadences can allow us to better understand aspects of:
 - Pattern Recognition
 - Statistical Learning
 - Broader Musical Structures

Distribution of Cadences by piece (from Hentschel, et al., 2021)



Distribution of Cadences (from Hentschel, et al., 2021)

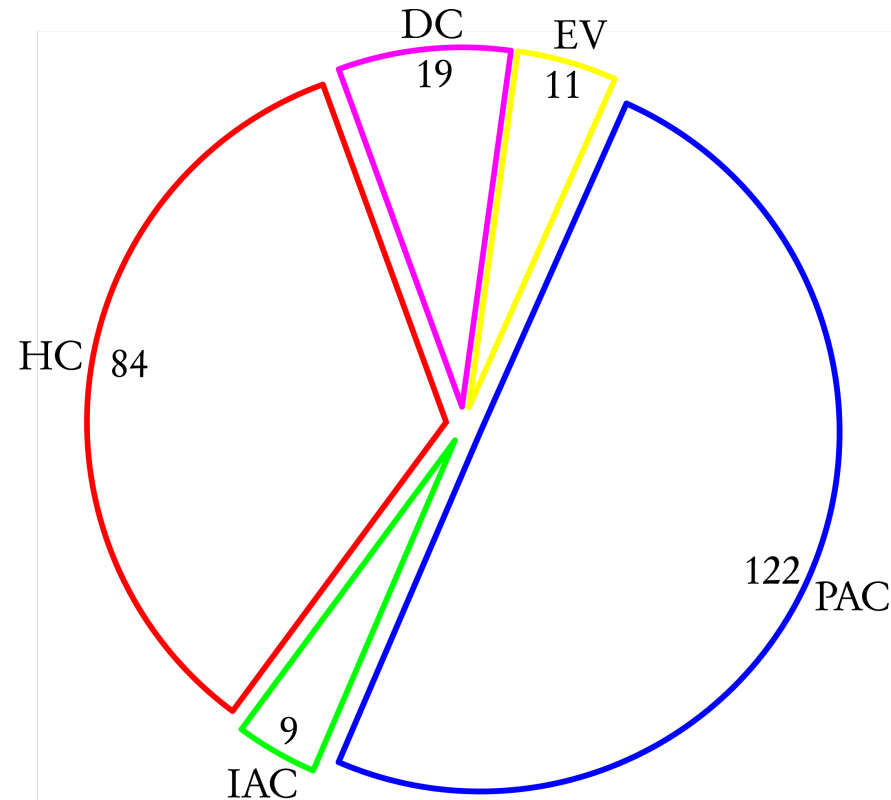
type	Mozart	%	Haydn	%
PAC	517 (528)	46.9	122	49.8
HC	398	36.1	84	34.3
EC	81	7.3	11	4.5
IAC	69	6.3	9	3.7
DC	38	3.4	19	7.8
sum	1103		245	

Details about the Haydn String Quartet Corpus. Here's a link to the data set:

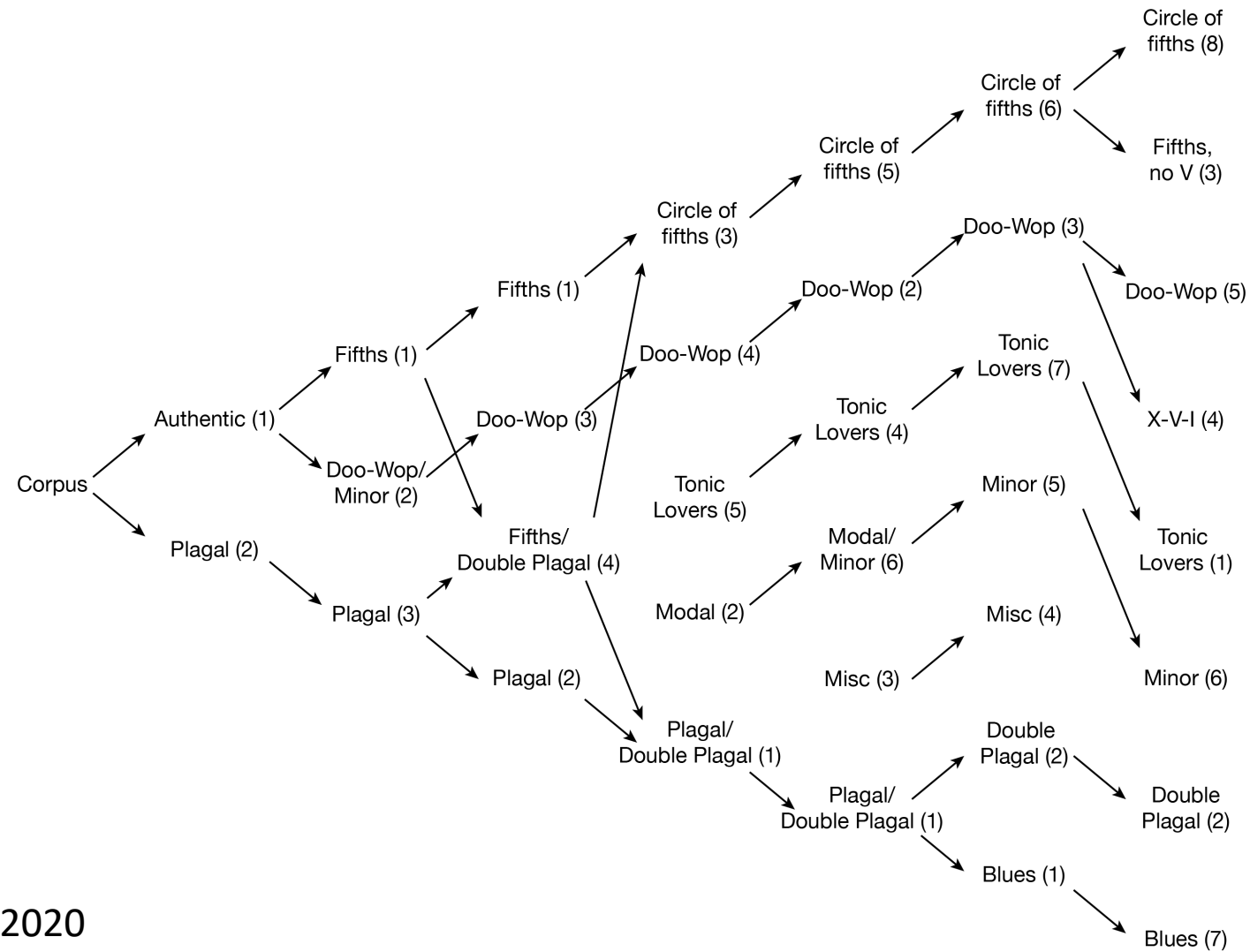
<https://www.tandfonline.com/doi/suppl/10.1080/09298215.2017.1367010?scroll=top>

Cadence Collection

- 50 exposition sections derived from sonata-form movements of Haydn's string quartets (1771-1803).
- Annotated the cadences whose cadential progression and cadential idea appear in the cello and first violin parts, respectively.



Clusters: 1 2 3 4 5 6 7 8



From Schaffer, et al. 2020

Defining a Cadence

- Some features we need to look for (in common practice Western Art Music):
 - Harmonic progressions ($V \rightarrow I$ for authentic cadences; $I \rightarrow V$ for half cadences)
 - Duration (a sense of finality)
 - Melody (movement to a specific scale degree)

Five types of cadences:

- Annotate five types of cadences:
 - Perfect Authentic
 - Imperfect Authentic
 - Half Cadence
 - Deceptive
 - Evaded

Cadence Types

- From Sears, 2015; p. 264


CADENCE CATEGORIES	CHARACTERISTICS	SUBTYPES
<i>Perfect</i>	- V and I in root position	Main Theme
<i>Authentic</i>	- Soprano $\hat{1}$	Subordinate Theme (ECP) ^a
<i>Imperfect</i>	- V and I in root position	Melodic Dissonance at CA ^b
<i>Authentic</i>	- Soprano $\hat{3}$	No Melodic Dissonance at CA
<i>Half</i>	- V in root position	Main Theme
	- No 7 th	Transition
<i>Deceptive</i>	- Ends grouping structure	Failed PAC at CA
	- Typically on vi	Failed IAC at CA
<i>Evaded</i>	- Melody leaps up	Tonic Harmony at CA
	- Provides no resolution	Non-Tonic Harmony at CA

Details for the five cadence types.

Cadences	Characteristics
Perfect Authentic (PAC)	1 V – I
Imperfect Authentic (IAC)	3 or 5 V – I
Half (HC)	5, 7, or 2 ? – V
Deceptive (DC)	Ends grouping structure V – ?, Typically on VI
Evaded (EV)	Melody leaps up, Typically to 5 V – ?

Five types of cadences:

- Annotate five types of cadences:
 - Perfect Authentic
 - Imperfect Authentic
 - Half Cadence
 - Deceptive
 - Evaded



Cadences	Essential Characteristics
Perfect Authentic (PAC)	1 V – I
Imperfect Authentic (IAC)	3 or 5 V – I
Half (HC)	5, 7, or 2 ? – V
Deceptive (DC)	Ends grouping structure V – ?, Typically on vi
Evaded (EV)	Melody leaps up, Typically to 5 V – ?

(Examples courtesy of David Sears)



Haydn, Op. 50/2, iv, mm. 48–50.

48



The musical score is written for four staves in 2/4 time. The first staff (treble clef) contains measures 48, 49, and 50. The second staff (treble clef) contains measures 48, 49, and 50. The third staff (bass clef) contains measures 48, 49, and 50. The fourth staff (bass clef) contains measures 48, 49, and 50. The score includes various musical notations such as notes, rests, and dynamic markings. A box labeled 'PAC' is located at the bottom right of the score.

I IV⁶ I⁶ IV V⁶₄ 7 I

mf


mf

PAC



Five types of cadences:

- Annotate five types of cadences:
 - Perfect Authentic
 - Imperfect Authentic
 - Half Cadence
 - Deceptive
 - Evaded



Cadences	Essential Characteristics
Perfect Authentic (PAC)	1 V – I
Imperfect Authentic (IAC)	3 or 5 V – I
Half (HC)	5, 7, or 2 ? – V
Deceptive (DC)	Ends grouping structure V – ?, Typically on vi
Evaded (EV)	Melody leaps up, Typically to 5 V – ?

(Examples courtesy of David Sears)




Mozart, K. 281, ii, mm. 4–8.

a)

The musical score is for a piano piece in 3/8 time, key of B-flat major. It consists of two staves. The first staff (treble clef) has a melodic line with a trill on the fifth measure. The second staff (bass clef) has a bass line. Dynamics include *f* (forte) at the beginning and *p* (piano) at the start of the fifth measure. Chord symbols are placed below the staff: *vi*, *IV*, *V*₄⁶, *7*, and *I*. Above the staff, figured bass notation is present: ⁶, ⁵, ⁴_{tr}, and ³. A bracket labeled *IAC* (Intervallic Analysis Chart) spans the last four measures. A speaker icon is located to the right of the score.

Five types of cadences:

- Annotate five types of cadences:
 - Perfect Authentic
 - Imperfect Authentic
 - Half Cadence
 - Deceptive
 - Evaded



Cadences	Essential Characteristics
Perfect Authentic (PAC)	1 V – I
Imperfect Authentic (IAC)	3 or 5 V – I
Half (HC)	5, 7, or 2 ? – V
Deceptive (DC)	Ends grouping structure V – ?, Typically on vi
Evaded (EV)	Melody leaps up, Typically to 5 V – ?

(Examples courtesy of David Sears)



Mozart, K. 332, i, mm. 31–37.




The image displays a musical score for measures 31 through 37 of the first movement of Mozart's Piano Sonata in G major, K. 332. The score is written for piano in 3/4 time, featuring a treble and bass staff. The key signature has one sharp (F#) and the time signature is 3/4. The notation includes various chords and melodic lines with slurs. Below the staff, harmonic analysis labels are provided for measures 31, 32, 33, and 34: i^6 ecp, bVI^6 , Ger^{+6} , and V HC. Above the staff, fingering and phrasing markings are present, including $\hat{1} \#4$ and $\hat{5}$ with a double bar line and arrows above them, and a $\hat{5}$ marking below the staff in measure 35.

Five types of cadences:

- Annotate five types of cadences:
 - Perfect Authentic
 - Imperfect Authentic
 - Half Cadence
 - Deceptive
 - Evaded

Examples



Cadences	Essential Characteristics
Perfect Authentic (PAC)	1 V – I
Imperfect Authentic (IAC)	3 or 5 V – I
Half (HC)	5, 7, or 2 ? – V
Deceptive (DC)	Ends grouping structure V – ?, Typically on vi
Evaded (EV)	Melody leaps up, Typically to 5 V – ?

(Examples courtesy of David Sears)



22



h)


DC

The Perceived Emotions of Harmonic Cadences (Smit, et al. 2020)

- The half cadence is more arousing than the authentic cadence (strong evidence)
- The deceptive cadence is more arousing than the authentic cadence (moderate evidence)
- Cadences in minor are less arousing than cadences in major (strong evidence).

Five types of cadences:

- Annotate five types of cadences:
 - Perfect Authentic
 - Imperfect Authentic
 - Half Cadence
 - Deceptive
 - Evaded



Cadences	Essential Characteristics
Perfect Authentic (PAC)	1 V – I
Imperfect Authentic (IAC)	3 or 5 V – I
Half (HC)	5, 7, or 2 ? – V
Deceptive (DC)	Ends grouping structure V – ?, Typically on vi
Evaded (EV)	Melody leaps up, Typically to 5 V – ?

(Examples courtesy of David Sears)



Haydn, Op. 20/4, i, mm. 22–24.

30



$V_5^6 \rightarrow V_5^6 \rightarrow V_5^6 I$ $\underline{ii^6 V_4^6 7}$ $\overset{fz}{I^6}$
EV

An example of the characteristics of a cadence

Haydn, Op. 76, No. 2, i, mm. 15–19

The image displays a musical score for Haydn's Op. 76, No. 2, i, measures 15–19. The score is written for Violin I, Violin II, Viola, and Violoncello. The key signature is one flat (B-flat) and the time signature is 4/4. The score includes various musical notations such as trills (tr), accents (acc), and dynamic markings (fz for fortissimo). A vertical dashed line at measure 18 marks the 'Cadential Arrival'. A bracket above measures 16 and 17 is labeled 'Cadential Idea'. A bracket below measures 16 and 17 is labeled 'Cadential Progression'. A box labeled 'HC' (Cadence Category) is positioned below the 'Cadential Progression' bracket. A speaker icon is located in the upper right corner.

Cadential Arrival

Cadential Idea

Violin I

Violin II

Viola

Violoncello

Cadential Progression

HC

Cadence Category

A Reprise

- These cadence labels help us to uncover the larger hierarchical structure of the music.
- Cadences act as signposts:
 - They can help to delineate sections, and different types of cadences serve different functions regarding the types of sections.
- Cadences serve as style markers:
 - Statistical learning questions.
 - Could inform genre classification.
- There are these categories, but they are not absolute.
 - There are likely incidents that won't get labeled by a human analyst.
 - False positives that the analyst will ignore.
 - We need to approach this in a holistic way.

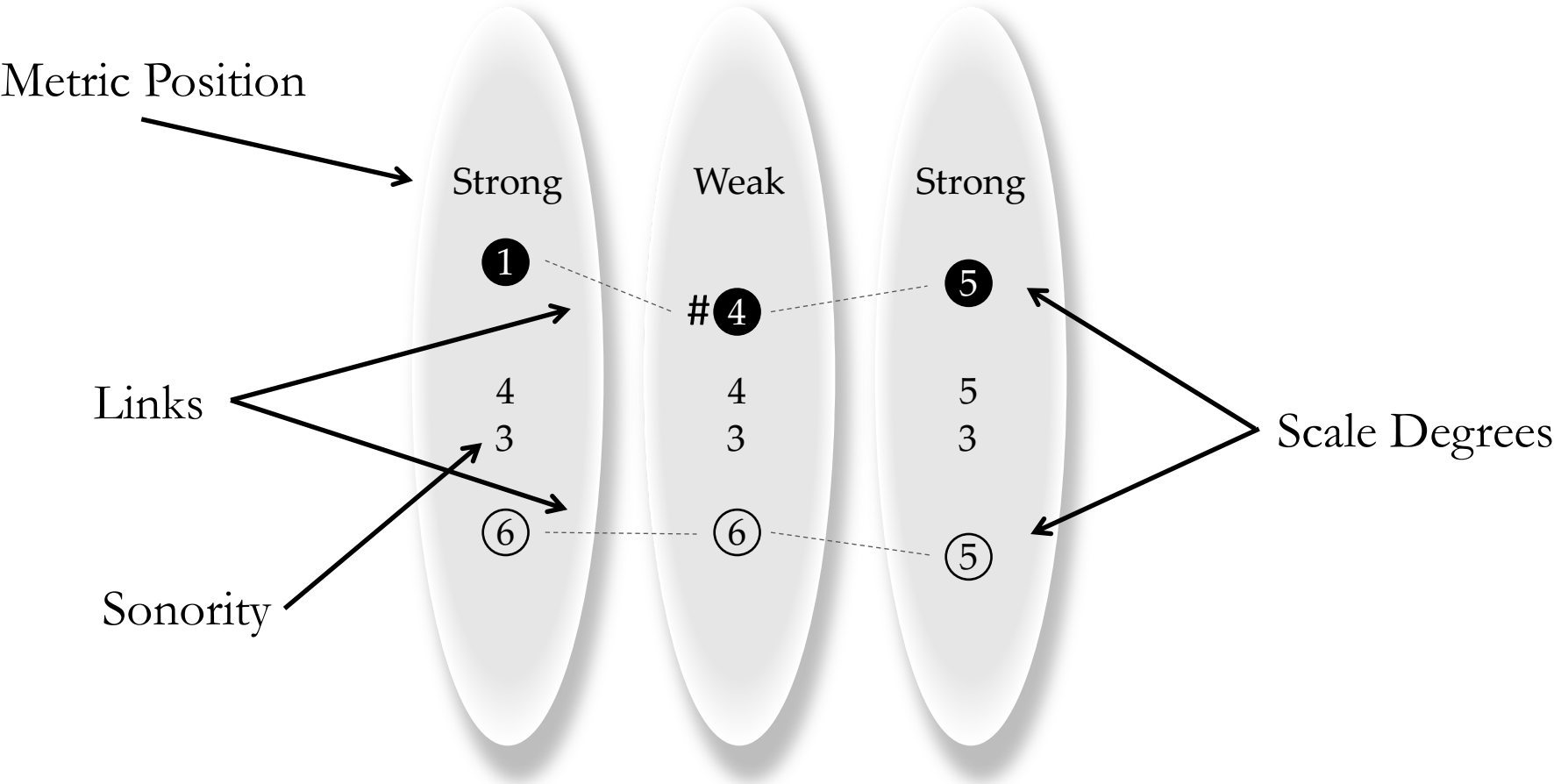
Recent Approaches to Cadence Finding

- Cadence or Not?
 - Duane (2019)
 - Uses n-gram models and HMMs to model the learning of cadences in Classical string quartets.
 - Supervised learning task was successful, but unsupervised was not.
 - Feisthauser, Bigo, and Giraud (2019)
 - Trained a model to find medial caesuras. Had decent success considering the many types of possible MCs, and the relatively small corpus
 - Bigo, Feisthauser, Giraud, Levé (2018)
 - Used 44 features to train an SVM classifier on two corpora from Bach and Haydn (162 PACs and 70 HCs)
 - HC or not; PAC or not.

Recent Approaches to Cadence Finding

- Distinguishing types of cadences
 - Finkensiep, Déguernel, Neuwirth, and Rohrmeier (2020):
 - Used skipgrams to identify schema candidates.

The cadence visualized as a closing schema using Gjerdingen's framework



Computational Approaches to Cadence Finding

- Expectation Based Models
 - Sears, Pearce, Caplin, McAdams (2018)
 - Used IDyOM; terminal events from cadences are more predictable than those from non-cadential contexts; typical theoretical models of cadential strength are related to schematic expectations.

Let's Take a Quiz!

- Example 1:
 - a) Perfect Authentic Cadence
 - b) Half Cadence
 - c) Deceptive Cadence
 - d) Evaded Cadence

Let's Take a Quiz!

- Example 2:
 - a) Perfect Authentic Cadence
 - b) Half Cadence
 - c) Deceptive Cadence
 - d) Evaded Cadence

Let's Take a Quiz!

- Example 3:
 - a) Perfect Authentic Cadence
 - b) Half Cadence
 - c) Deceptive Cadence
 - d) Evaded Cadence

Let's Take a Quiz!

- Example 4:
 - a) Perfect Authentic Cadence
 - b) Half Cadence
 - c) Deceptive Cadence
 - d) Evaded Cadence

Perceiving the Classical Cadence (Sears, Caplin, and McAdams, 2014)

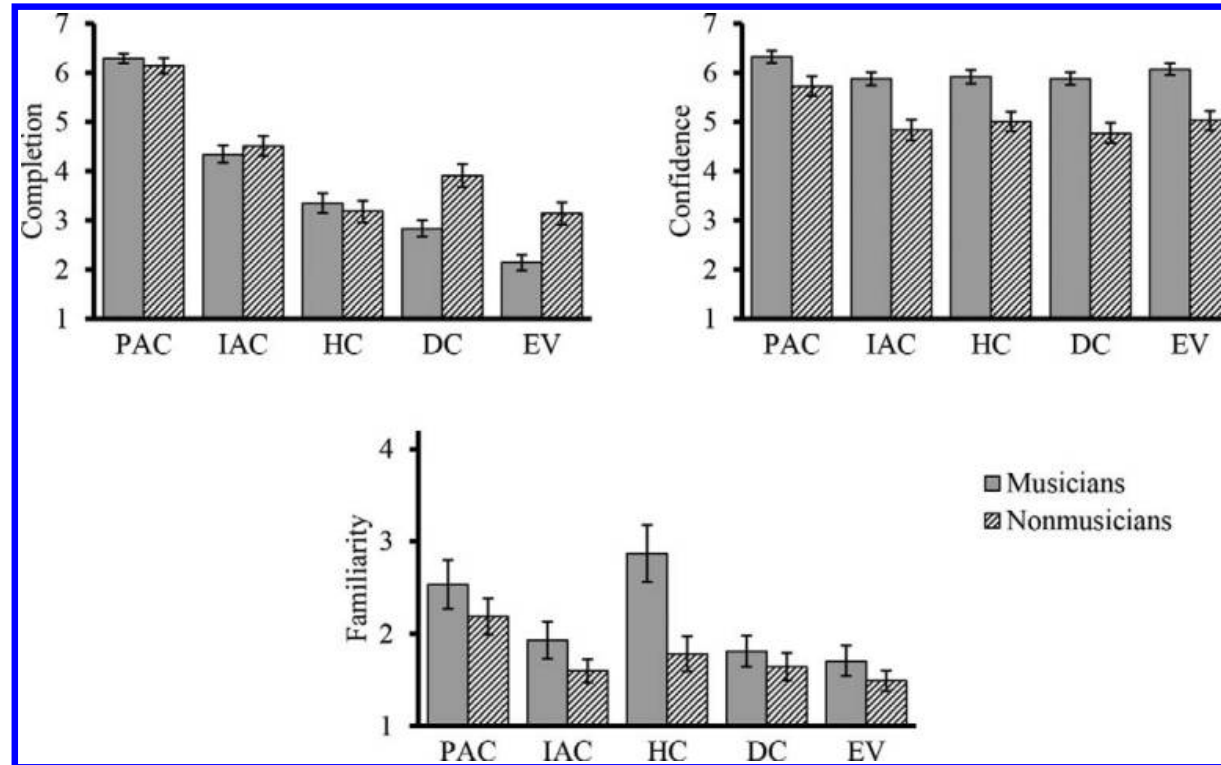


FIGURE 3. Bar plots of mean completion, confidence, and familiarity ratings of musicians and nonmusicians for each cadential category. Whiskers represent the 95% confidence interval. See text for the abbreviations of the cadence categories.

Main Takeaways

Cadences	Characteristics
Perfect Authentic (PAC)	1 V – I
Imperfect Authentic (IAC)	3 or 5 V – I
Half (HC)	5, 7, or 2 ? – V
Deceptive (DC)	Ends grouping structure V – ?, Typically on VI
Evaded (EV)	Melody leaps up, Typically to 5 V – ?

Main Takeaways

- Cadences are patterns that frequently occur within larger patterns (schemata)
- A cadence is comprised of a combination of melodic and harmonic features
- Patterns tend to be around 4-8 measures
- Analysts sometimes disagree on the type of cadence, or even whether something is a cadence
- Some focus on cadences in terms of their constituent features and others in terms of whether they evoke an expectation of an ending
- Even though there is disagreement, examining cadences computationally still allows us to better understand the broader questions of expectation, style, pattern recognition, and form