Ontology based Music Theory - Comparative Cadence Analysis in Classical and Popular Music

Knowledge Engineering Project & Project Work

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Abstract

This paper compares cadential patterns between Franz Schubert's Winterreise and The Beatles' songs from the Isophonics dataset, using a custom ontology for musical cadences. The study highlights distinct cadential usage across the two genres: Schubert's work shows a preference for Half and Avoided Cadences in minor keys, reflecting the emotional tension typical of Romantic music, while The Beatles' songs favor Perfect and Plagal Cadences in major keys, aligning with the harmonic clarity of popular music. The results demonstrate how cadence types vary by genre, with classical music emphasizing tension and complexity, and popular music focusing on resolution and structure.

1 Introduction

This project aims to extend the development of a musical cadence ontology, building on previous work that formalized cadence structures and relationships in classical music compositions. The core focus of this study is to apply the same ontology framework to analyze and compare cadential patterns across two distinct musical genres: classical art song (Lieder) and popular music (rock/pop).

The ontology has been designed to represent various types of cadences, such as Perfect, Imperfect, Deceptive, Plagal, Half, and Avoided cadences. By formalizing these concepts in a machine-readable format, the ontology enables a structured analysis of harmonic progressions, specifically in how cadences function within different tonal and formal contexts.

For this study, two distinct datasets are used:

- Franz Schubert's Winterreise song cycle, a key example of Romantic art song from the classical genre.
- The Beatles' compositions, representing the popular music genre, which relies on different harmonic conventions and formal structures compared to classical music.

The ontology was once again visualized using Graffoo in draw.io, and the analysis was performed using a custom Python notebook. Through this approach, we extract data on cadential structures, chord progressions, and key changes from both datasets, allowing for a systematic comparison of how cadences are employed across these two genres.

2 Background

In music theory, a cadence is a sequence of chords that brings a musical phrase to a conclusion, providing a moment of resolution, rest, or continuation. Cadences play a crucial role in shaping the structure and flow of a piece by signaling the end of phrases, sections, or the entire composition. To identify a cadence, one typically examines the last two chords of a phrase and analyzes their harmonic relationship in the context of the key.

The identification of a cadence is closely tied to the scale degree of the chords in relation to the key of the piece. Scale degrees are represented using Roman numerals, with I (the tonic) being the first degree and V (the dominant) being the fifth degree. For example, in the key of C major, the tonic chord (I) is C (C-E-G), and the dominant chord (V) is G (G-B-D).

Types of Cadences Several types of cadences can be identified based on the progression between the final two chords. The most common types include:

- Perfect Authentic Cadence (PAC): A dominant (V) to tonic (I) resolution, both in root position, providing a strong sense of closure.
- Imperfect Authentic Cadence (IAC): A weaker version of PAC, where one or both chords are inverted, or the tonic is not in the highest voice.

- Deceptive Cadence (DC): The dominant (V) resolves unexpectedly to a chord other than the tonic, often the submediant (vi), creating surprise.
- Plagal Cadence (PC): Known as the "Amen cadence," it moves from the subdominant (IV) to the tonic (I) and provides a softer resolution.
- Half Cadence (HC): Ends on the dominant (V), leaving the phrase unresolved and creating tension.
- Avoided Cadence (AC): A resolution is deliberately interrupted, avoiding the expected resolution to the tonic, often leading to an unexpected progression.

Cadences Across Different Musical Genres The use and prominence of cadences can vary significantly between different musical genres, as reflected in the classical art song of Schubert's Winterreise and the rock/pop music of The Beatles. Each genre has distinct stylistic conventions that influence the types of cadences commonly used.

- **Classical Art Song**: In Schubert's Winterreise, a Romantic-era song cycle, the emotional depth and harmonic complexity are often reflected in the varied use of cadences. Perfect Cadences are used to create strong resolutions at key moments in the narrative, while Half Cadences and Deceptive Cadences are frequently employed to maintain tension and express unresolved emotions. Schubert's intricate harmonic language, including modulations and chromaticism, allows for a wide range of cadential patterns, with Avoided Cadences being particularly useful for expressing the protagonist's psychological turmoil and longing.
- **Popular Music (Rock/Pop)**: The Beatles' songs, with their more predictable verse-chorus structure, tend to favor Perfect Cadences for conclusive endings at the end of choruses or verses. Plagal Cadences (IV to I) are also common in rock and pop music, often providing a softer, more reflective resolution. While Half Cadences may be used at the end of a verse or bridge to create momentum, Deceptive Cadences are less frequent in this genre. The harmonic structure in pop and rock tends to be simpler, focusing on clear, repetitive chord progressions that support melody and lyrical content rather than the more complex harmonic narratives found in classical music.

3 System description

The system was developed by first creating an ontology in RDF/XML format to represent musical cadences and their relationships within a composition. The ontology was then visualized using the Graffoo library (available at Graffoo), which was integrated with the draw.io tool to create a clear graphical representation of the ontology's structure.

Following the creation and visualization of the ontology, a Python notebook was developed to analyze the musical data. This notebook allowed for querying the ontology and extracting insights related to cadential patterns and harmonic progressions, particularly from the Schubert Winterreise files within the CHOCO dataset. The Python environment facilitated the automation and detailed analysis of the data, utilizing SPARQL queries to explore the relationships between cadences, keys, and chords in the compositions.

4 Data

The data for this project consists of musical compositions from two distinct sources: Franz Schubert's Winterreise and The Beatles' songs, both obtained from the CHOCO dataset. Despite the differences in genre and style, the datasets share a similar structure, as they both provide detailed musical annotations in the JAMS (JSON Annotated Music Specification) format. This format captures a variety of musical features essential for analyzing cadential patterns, such as chord progressions, key changes, and section segmentation.

Each JAMS file within the dataset represents an individual piece providing annotations on:

- Chords: Captures harmonic progression with chord names, durations, and additional confidence scores. For instance, it identifies chords like "C:min," "F:min7," and "G:7."
- Keys: Key annotations, such as "C:min" or "D#:maj," capture the overall harmonic environment of the piece and any modulations.
- Sections: Structural divisions like "A," "B," "C," and their respective time durations allow

the analysis of how harmonic and cadential features relate to different musical sections.

Through the integration of these JAMS files with the ontology, it becomes possible to systematically analyze the cadential patterns across different sections of the compositions.

5 Comparison of Cadences by Section

The comparison of cadences between Schubert's Winterreise and The Beatles' compositions from the Isophonics dataset reveals distinct patterns in how cadences are employed across the different sections of each musical work, reflecting the contrasting compositional approaches and genre-specific characteristics.

Schubert's Winterreise In Schubert's Winterreise (Figure 1), cadences are distributed unevenly across the sections, with some sections like section_A and section_I containing a high number of cadences, particularly Cadence and Half Cadence types. For instance, section_A shows a high number of Half Cadences (16) and Avoided Cadences (34), reflecting a tendency toward harmonic tension and resolution avoidance, which aligns with the emotional intensity and unresolved narrative themes of the song cycle.

Sections such as section_B and section_C show a more balanced use of Perfect Cadences (6 in section_A) and Half Cadences (14 in section_B2), indicating moments of harmonic resolution that may align with thematic or structural closures in the music. The presence of Imperfect Cadences and Deceptive Cadences is relatively low, suggesting that Schubert primarily uses Perfect and Half Cadences for key structural moments, while Avoided Cadences serve to prolong tension and drive the narrative forward.

Isophonics (The Beatles' Songs) In contrast, the analysis of The Beatles' songs from the Isophonics dataset (Figure 2) shows a different distribution of cadences across sections, with a more regular and predictable use of cadences. The most prominent cadence types in this dataset are Cadence and Half Cadence, with Perfect Cadences being significantly more common than in Winterreise. For example, section_A shows a large number of Cadences (42), indicating a more straightforward harmonic resolution often found in popular music, where clear and strong cadences mark the ends of verses or choruses.

Additionally, Plagal Cadences (a signature cadence type in rock and pop music) are more common in this dataset, reflecting the stylistic tendency in popular music to use softer harmonic resolutions, particularly at the end of phrases or sections. Avoided Cadences, which are more frequent in Schubert's work, are comparatively less common, aligning with the pop genre's preference for more conclusive harmonic statements rather than prolonged tension.

Overall, the cadence distribution in Winterreise shows a more complex and varied use of cadences, with a preference for Half and Avoided Cadences, reflecting the dramatic and unresolved emotional narrative of the piece. In contrast, The Beatles' songs exhibit a more consistent and predictable use of Perfect and Plagal Cadences, reinforcing the genre's emphasis on clear harmonic closure and structural simplicity. This comparison highlights the contrasting approaches to harmonic resolution between classical Romantic music and 20th-century rock/pop music.

6 Cadence Analysis by Tonality

The comparison of cadential patterns across different keys between Schubert's Winterreise and The Beatles' compositions (Isophonics dataset) reveals important differences in how each genre utilizes cadences in relation to tonality. Both datasets provide insight into the harmonic frameworks of classical and popular music, showing distinct tendencies in key usage and cadence types.

Schubert's Winterreise In Winterreise (Figure 3), cadences are distributed across a variety of keys, with a particularly high concentration in minor keys. This is evident in keys such as C minor, which features a significant number of Half Cadences (40) and Avoided Cadences (10). The dominance of Half and Avoided Cadences in minor keys aligns with the emotional tone of the piece, reflecting the unresolved tension and darker themes that are characteristic of Romantic music.

Keys such as G minor and D minor also exhibit high numbers of Perfect Cadences (18 in G minor) and Cadences (26 in D minor), indicating moments of harmonic resolution that may coincide with key structural points in the music. However, there is still a noticeable presence of Avoided and Half

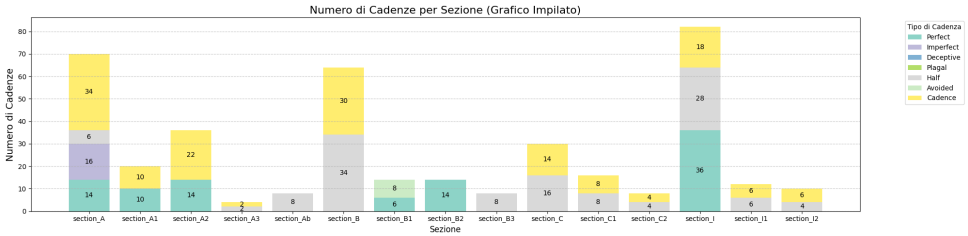

Figure 1: Cadence count per section - Schubert's Winterreise

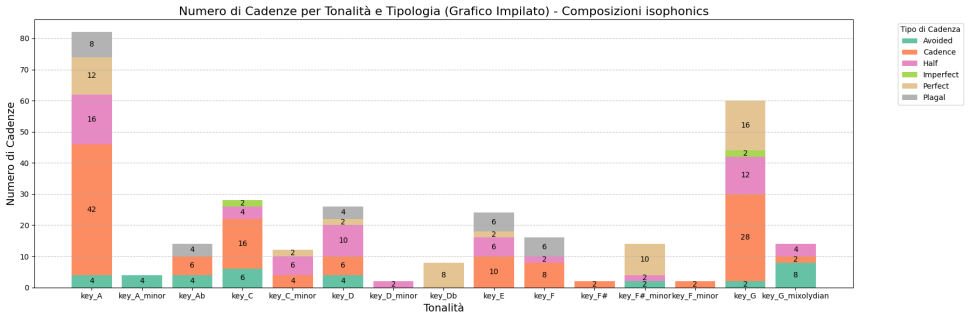

Figure 2: Cadence count per section - Isophonics

Cadences, suggesting that even when harmonic closure is achieved, Schubert often uses cadential ambiguity to maintain emotional complexity.

In contrast, major keys like C major and F major show fewer cadences overall, but the types of cadences are more varied. For instance, C major features a more balanced mix of Perfect, Half, and Imperfect Cadences, reflecting Schubert's ability to shift between resolution and tension even in brighter tonal contexts.

The Beatles' Songs (Isophonics Dataset) The Beatles' compositions, as seen in the second graph (Figure 4), display a very different tonal and cadential landscape. There is a clear preference for major keys, particularly A major, which shows a strong presence of Cadence (42) and Half Cadence (16) types, as well as notable use of Perfect Cadences (12). This reliance on major keys and the prevalence of Cadence and Perfect Cadence types reflect the structural clarity and harmonic resolution typical of popular music. Plagal Cadences (8 in A major), often associated with rock and pop, also make an appearance in this dataset, further emphasizing the genre's preference for softer, conclusive cadential patterns.

Minor keys, such as C minor and G minor, exhibit far fewer cadences compared to their major counterparts. However, Half Cadences and Avoided Cadences do appear, showing moments of harmonic tension, albeit less frequently than in Winterreise. Keys such as D minor also contain Perfect and Cadence types, aligning with popular music's tendency toward more straightforward harmonic resolution even in minor keys.

Interestingly, the Beatles' compositions show a greater variety of Plagal Cadences, especially in keys like D minor and A major, which are less frequent in Schubert's work. This cadence type, common in rock and pop, offers a distinctive stylistic marker of The Beatles' harmonic approach, providing softer resolutions that complement their song structures.

7 Conclusion

The comparative analysis of cadential patterns between Schubert's Winterreise and The Beatles' songs from the Isophonics dataset reveals clear distinctions in how cadences are employed across different sections and tonalities, closely reflecting the stylistic and structural conventions of each genre.

In classical Romantic music, as seen in Winterreise, cadences are used with great variety and complexity. Schubert frequently employs Half and Avoided Cadences, especially in minor keys, to sustain harmonic tension and emotional depth, aligning with the unresolved and introspective themes of the song cycle. The preference for minor keys and more ambiguous cadential types highlights how classical compositions often prioritize emotional expression over harmonic closure.

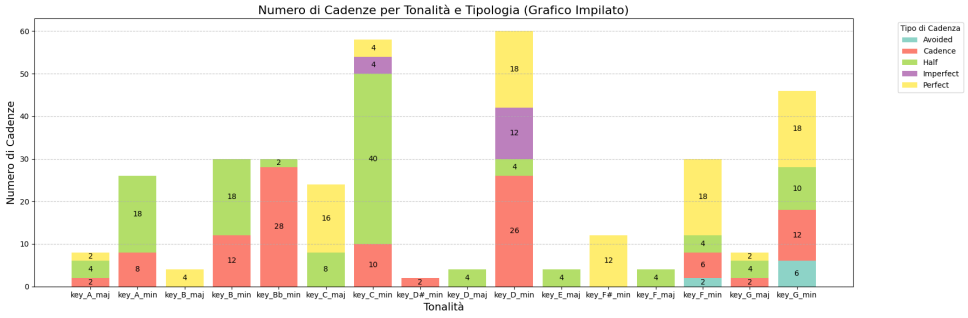

Figure 3: Cadence count per key - Schubert's Winterreise

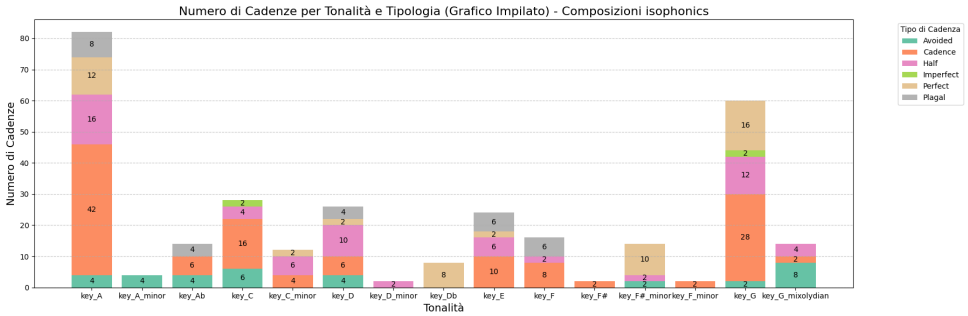

Figure 4: Cadence count per key - Isophonics

In contrast, popular music, as demonstrated by The Beatles' compositions, favors Perfect and Cadence types, particularly in major keys, reflecting the genre's emphasis on harmonic clarity and structural resolution. The use of Plagal Cadences, a hallmark of rock and pop, further emphasizes the genre's tendency toward softer, yet conclusive, resolutions. This focus on major keys and predictable cadential patterns underscores the goal of creating clear, memorable song forms that appeal to a broad audience.

Overall, the comparison confirms that cadence usage shifts significantly depending on the musical genre. Classical music, particularly from the Romantic era, uses cadences to maintain tension and support the emotional narrative, while popular music tends to employ cadences to provide harmonic closure and reinforce song structure. This genre-based difference in cadential use illustrates how harmonic conventions are shaped by the compositional goals and aesthetic priorities of each style, with Schubert's work leaning toward complexity and unresolved tension, and The Beatles' music emphasizing accessibility and harmonic finality.

8 Links to external resources

Link to the GitHub repository: ke_projects.git