The Syntax of Music

Patel ch. 5.1-5.3

Introduction

- Syntax: "The principles governing the combination of discrete structural elements into sequences."
- The vast majority of the world's music is syntactic:
  - One can identify both perceptually discrete elements (tones with distinct pitches or drum beats with distinct timbres) and norms for the combination of these elements into sequences.
    - These norms are contravened by composers and performers for artistic purposes.
  - We'll be focusing on Western tonal music.

The structural richness of linguistic and musical syntax

- The simple fact that a non-linguistic system is syntactic does not guarantee an interesting comparison with syntax.
  - The song of a swamp sparrow are made up of a few notes combined together in a distinctive way in a geographic area ("dialect").
  - But human syntax is more complex:
    - Multilayered: morphology, recursive syntax.
    - Paired with combinatorial semantics.
    - Context sensitive interpretation of phrases.
      - Grammatical functions: subject, direct object, indirect object.
- However, musical structure has many of the key features that make linguistic syntax so rich.

Birdsong isn't as rich

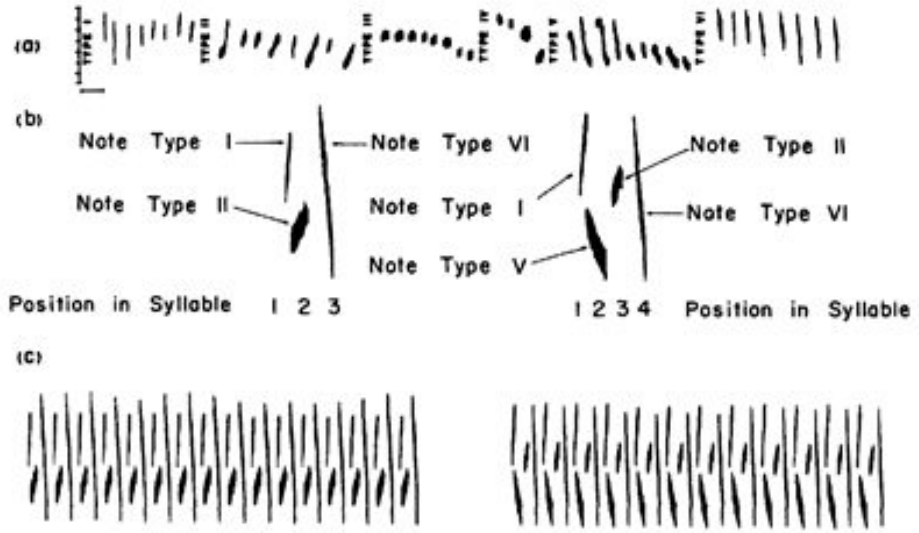


Figure 5.1 Swamp sparrow song organization. (a) Examples of the six categories of minimal acoustic elements (notes) that make up swamp sparrow songs. Scale at the left represents frequency (1–8KHz); time scale bar on the bottom is 100 ms. (b) From two to six (most commonly three or four) notes are put together to form syllables. Two syllables from two different New York songs are shown. Birds in a given geographic location have preferences for placing certain notes in certain positions in a syllable; this constitutes the syntax of a song. (c) Swamp sparrow syllables are repeated to form a ~2-sec song. The two songs depicted here consist of repetitions of the two syllables detailed in (b). From Balaban, 1988.

I. Multiple levels of organization

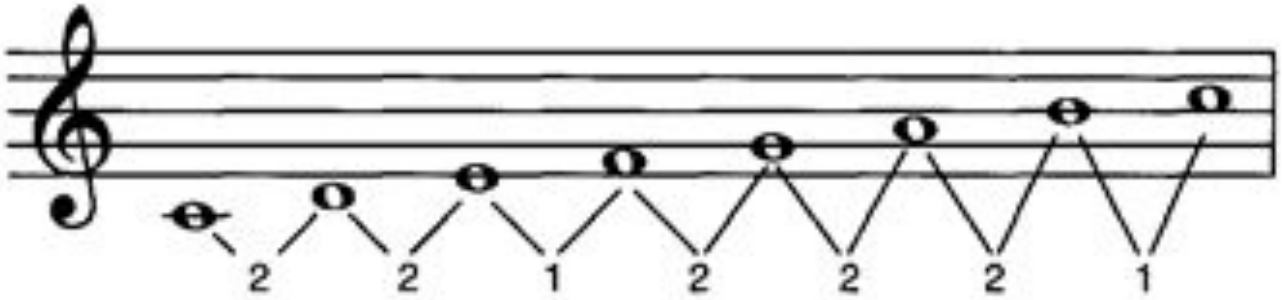
- Scale structure.
- Chord structure.
- Key structure.

- Each octave (doubling in frequency) contains 12 notes, each a constant frequency apart (6% of the octave: one semitone).
- Each pitch class is given a distinctive name, according to the chromatic scale:
  - A A#(B♭)B C C#(D♭)D D#(E♭)E F F#(G♭)G G#(A♭)
  - Octave equivalence: A3 (220 Hz), A4 (440 Hz).

Scale structure

- Scale: 7 tones (scale degrees) per octave with an asymmetric pattern of pitch spacing (intervals) between them.
- The different tones take on different roles in the fabric of music, with one tone being the most central and stable (the tonic).
  - Diverse musical traditions make use of a tonic.
  - Such organization may be congenial to the human mind, perhaps reflecting the utility of psychological reference points in organizing mental categories.

Scale structure



Note name	C	D	E	F	G	A	B	C′
Scale degree	1	2	3	4	5	6	7	1

Figure 5.2 The C-major musical scale. The small numerals between the notes on the musical staff indicate the size of pitch intervals in semitones. (2 st = a major second, 1 st = a minor second.) The interval pattern [2 2 1 2 2 2 1] defines a major scale. C′ is the pitch one octave above C. Modified from Cuddy et al., 1981.

Scale structure

- There is a hierarchy of stability between scale degrees.
  - 2^{nd}: supertonic, 7^{th}: leading tone.
  - Frances 1988: listeners were less sensitive to upward mistunings of the leading tone when it appeared in an ascending melodic context.
  - Krumhansl 1979: listeners heard an ascending or descending scale, and then judged how closely related two tones were to each other; multidimensional scaling revealed a three dimensional cone shape.
    - Scale degrees 1, 3, and 5 are perceived as closely related, then other tones in the scale, then tones outside the scale.
    - The contrast between physical and psychological proximity is part of what animates tonal music.

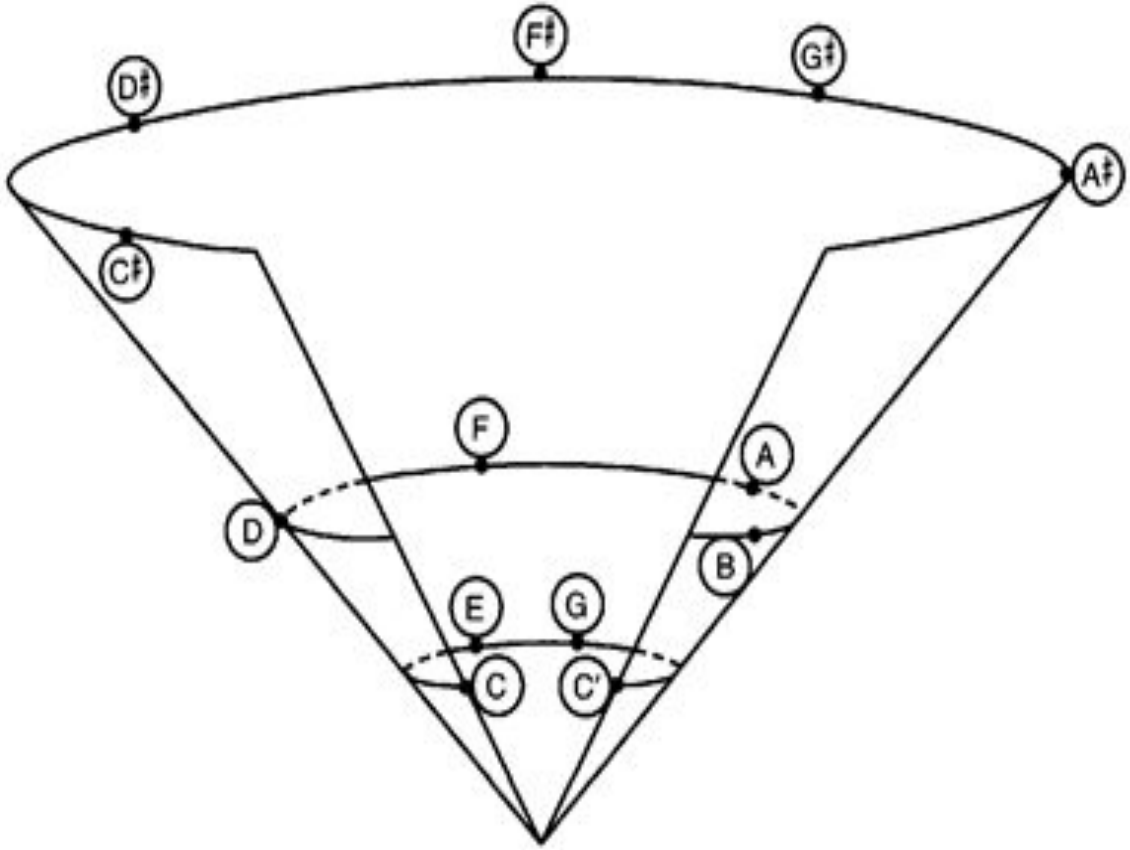


Figure 5.3 Geometrical representation of perceived similarity between musical pitches in a tonal context. The data are oriented toward the C major scale, in which C serves as the tonic. C′ is the pitch one octave above C. From Krumhansl, 1979.

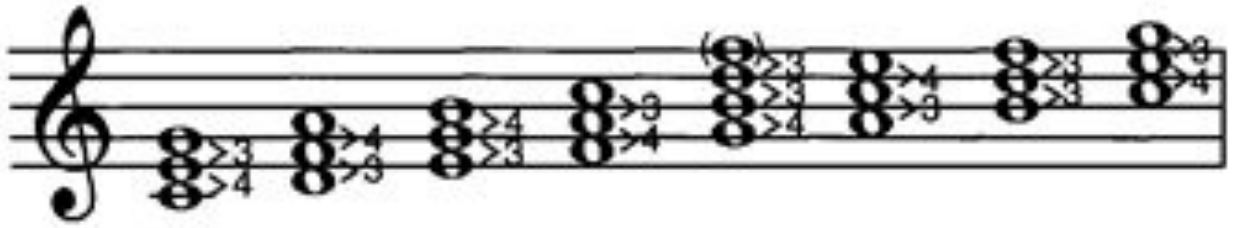
Scale structure

- Listeners are very sensitive to scale structure
  - Sour notes are very salient.
  - Trainor & Trehub 1992: nonmusician adults were sensitive to notes in a melody that were changed by one semitone (outside of the scale) compared to four semitones (inside the scale), but 8-month-old-infants were not.
  - Trainor & Trehub 1994: 5-year-old children with no formal training in music were sensitive to out-of-scale alterations.

Chord structure

- A very important part of tonal music's syntax is the simultaneous combination of scale tones into chords, creating harmony.
  - Basic "triads" are built from scale degrees separated by a musical third.
    - Major third: four semitones
    - Minor third: three semitones
    - Major triad: 4+3
    - Minor triad: 3+4
    - Diminished triad: 3+3

Chord structure



Chord names	C	d	e	F	G	a	b°	C′
Harmonic labels	I	ii	iii	IV	V	vi	vii°	I

Figure 5.4 Basic triadic chords of the C-major musical scale. Small numbers between the notes of a given chord indicate the interval in semitones between notes. Major, minor, and diminished chords are indicated in the "chord names" and "harmonic labels" lines by fonts: uppercase = major, lower case = minor, lower case with "°" superscript = diminished. The musical note in parentheses at the top of the V chord, if included in the chord, creates a seventh chord (V7, or G7 in this case). Modified from Cuddy et al., 1981.

Chord structure

- One tone acts as its "root" or structurally most significant pitch and gives the chord its name.
  - Root of C-major chord: **C**-E-G, harmonic label I.
- Even when the notes of a triad occur in different vertical ordering, the root and harmonic label remain the same, and the chord is treated as having the same harmonic status.
  - Inversions: G-**C**-E, E-G-**C**, …
- A fourth tone can be added to the triad, to create a "seventh" chord.
  - G7 (V7): **G**-B-D-F
  - Imply forward motion toward a point of rest that has not yet been reached.

Chord structure

- There is also horizontal patterning of chords.
  - Norms for how chords follow one another play a role in governing the sense of progress and closure in musical phrases.
    - A “cadence” is a harmonic resting point in music.
    - “Authentic cadence”: Movement from a V or V7 to a I chord leads to a sense of repose.
    - Other chord progressions are typical also:
      - I-V-I, I-IV-V-I, I-ii-V-I
  - Smith & Melara 1990: even musical novices are sensitive to the prototypicality of chord progressions.
  - Cuddy et al. 1981: melodic sequences that imply prototypical chord sequences are better remembered.
  - Trainor & Trehub 1994: musically unselected adults are more sensitive to melodic changes that violate implied harmony than to physically larger changes that obey implied harmony.

Chord structure

- The tonic (I) chord is the most central, followed by the dominant (V) chord and the subdominant (IV) chord.
  - Many popular and folk songs can be played with just these three chords as the underlying harmony.
  - Krumhansl et al. 1982 tested how well one chord followed from a second in a context of an ascending scale.
    - Multidimensional scaling reveals that IV and V are most closely related to I.

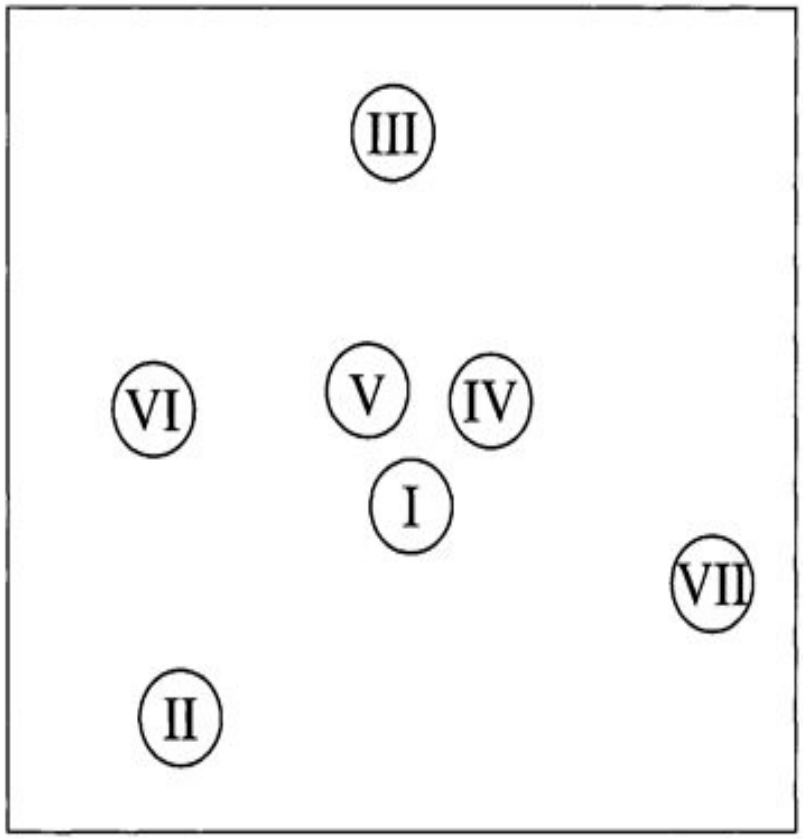
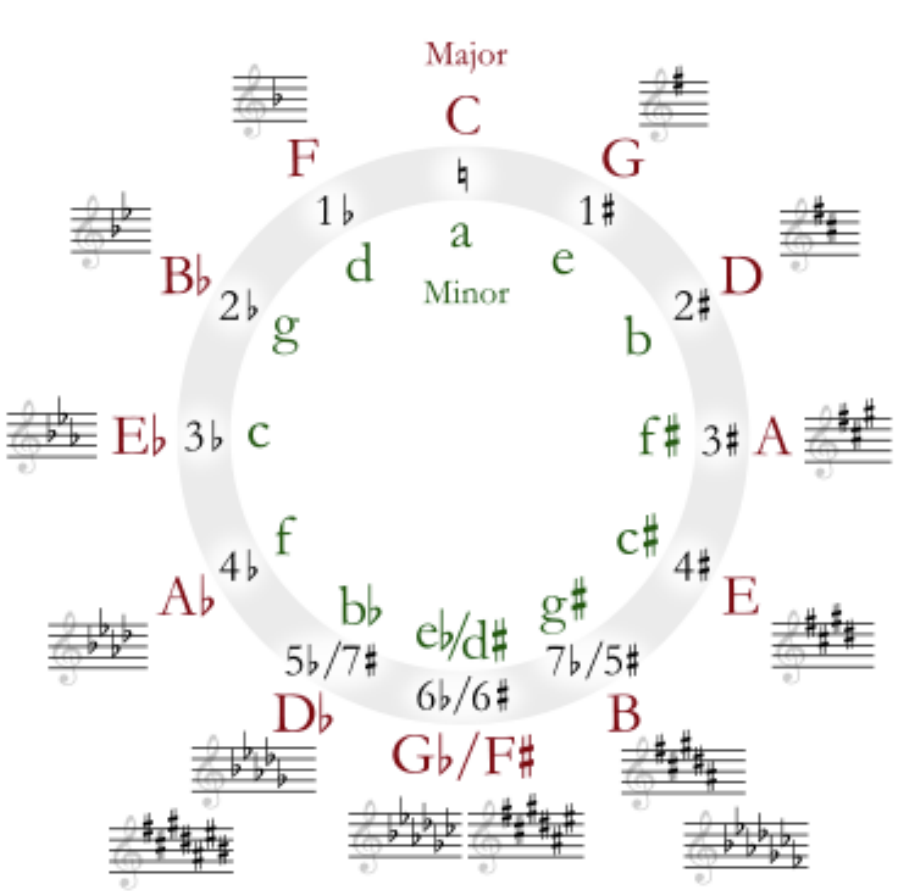


Figure 5.5 Psychological relatedness of different chords in a musical context. Chords are indicated by their harmonic labels, with uppercase Roman numerals used in a generic fashion (i.e., major, minor, and diminished chords are not distinguished). From Krumhansl et al., 1982.

Key structure

- A scale and its tonal hierarchy, plus its system of chords and chord relations defines a “key” or tonal region in Western European music.
- Each pitch class can serve as the tonic of a scale, and there are two common scale structures: major and minor.
    - There are 24 keys. Named for their principal note and scale structure: C major, B minor.
- A great deal of tonal music moves between keys during the course of a composition.
  - Such “modulations” tend to occur between related keys.
  - Two keys are more related if they share more basic scale tones.
    - As determined by the circle of fifths.

Key structure



Key structure

- Each major key is closely related to two minor keys.
  - The “relative minor” shares the same notes (key signature) but has a different tonic.
    - E.g. C major and A minor.
  - The “parallel minor” shares the same tonic but has different scale tones.
    - E.g. C major and C minor.
- Krumhansl & Kessler 1982
  - Propose a two-dimensional diagram showing the relatedness of keys.
  - Based on perceptual experiments.
  - The top and bottom edges are equivalent and the left and right edges.
    - So the map is an unfolded torus, reflecting the circular nature of perceptual key relations.

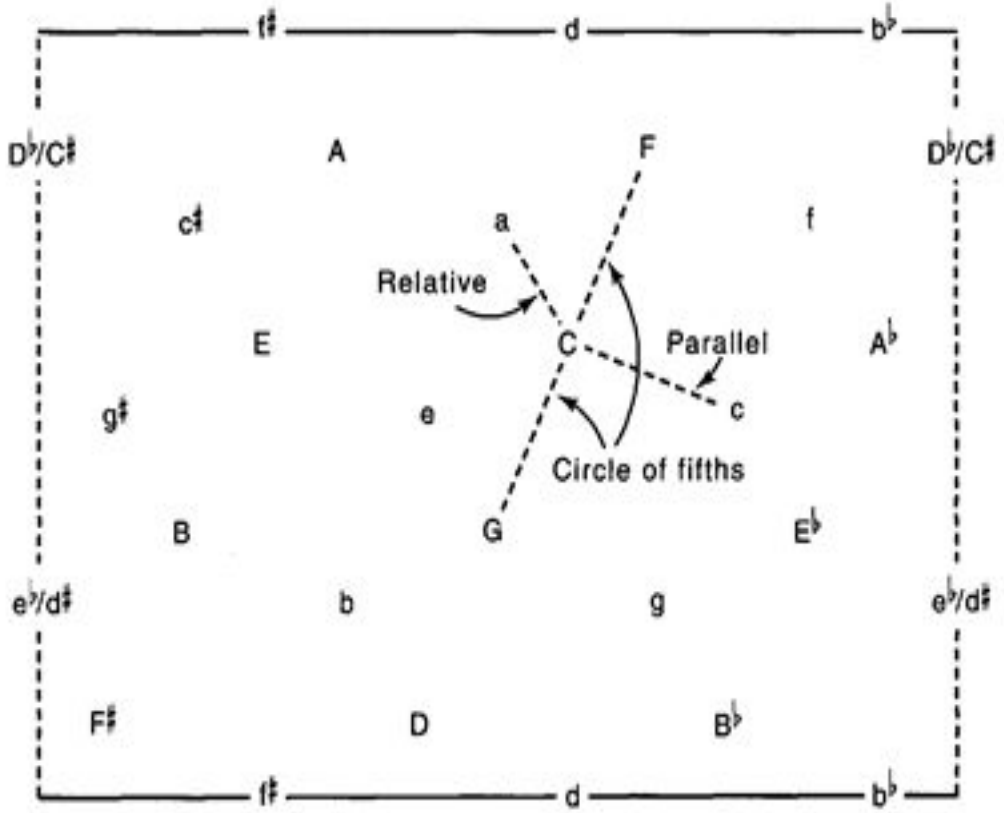


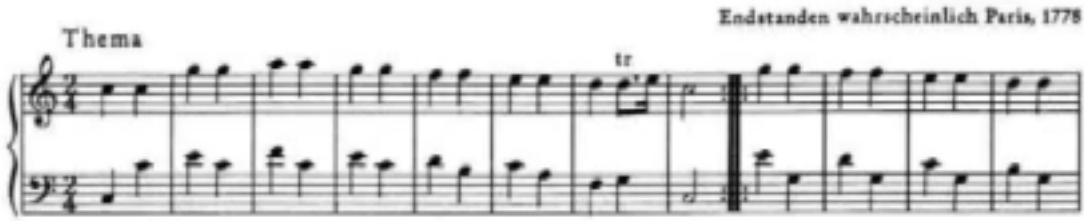
Figure 5.7 A map of psychological distances between musical keys. Major keys are indicated by uppercase letters and minor keys by lowercase letters. Dashed lines extending from the key of C major indicate related keys: two adjacent major keys along the circle of fifths (G and F; cf. Figure 5.6) and two related minor keys (see text for details). Modified from Krumhansl & Kessler, 1982.

Key structure

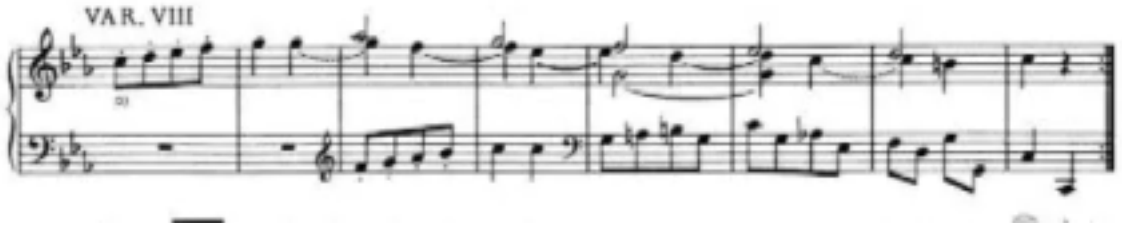
- Cuddy et al. 1981, inter alia: judgments of whether two melodies are the same are more accurate when the melody is transposed to a nearby key.
- Patel, Gibson et al. 1998: an alien chord from a distant key gives rise a larger P600 ERP (Event Related Potential) than an alien chord from a nearby key.
- Janata et al 2002: fMRI (functional magnetic resonance imaging) provided evidence for maps of key distance in the brain.

Key structure

- Mozart's theme and variations KV 265 in C major.

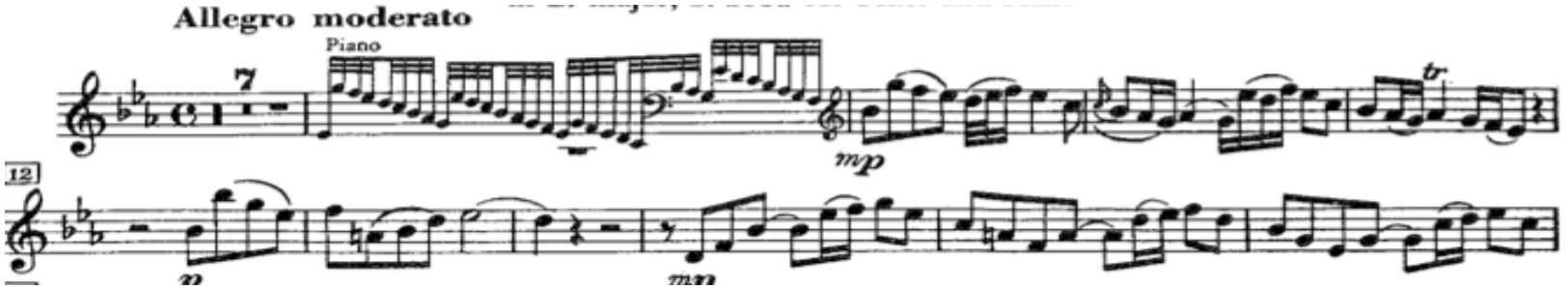


- Variation VIII in C minor



Key structure

- Bach's flute sonata in E-flat major first movement: E-flat major



- Second movement: G minor

II. The Hierarchical Structure of Sequences

- Syntactic structure
  - When a sentence unfolds in time it gives rise to a hierarchical syntactic structure.
- Event structures in music
  - When music unfolds in time it gives rise to hierarchical event structures.
  - These are different from the atemporal hierarchies like the tonal hierarchies just discussed.
  - They have been the focus of study in cognitive music theory (e.g. Lerdahl & Jackendoff 1983).
    - Time span reduction
    - Prolongation reduction

Language: Syntactic structure

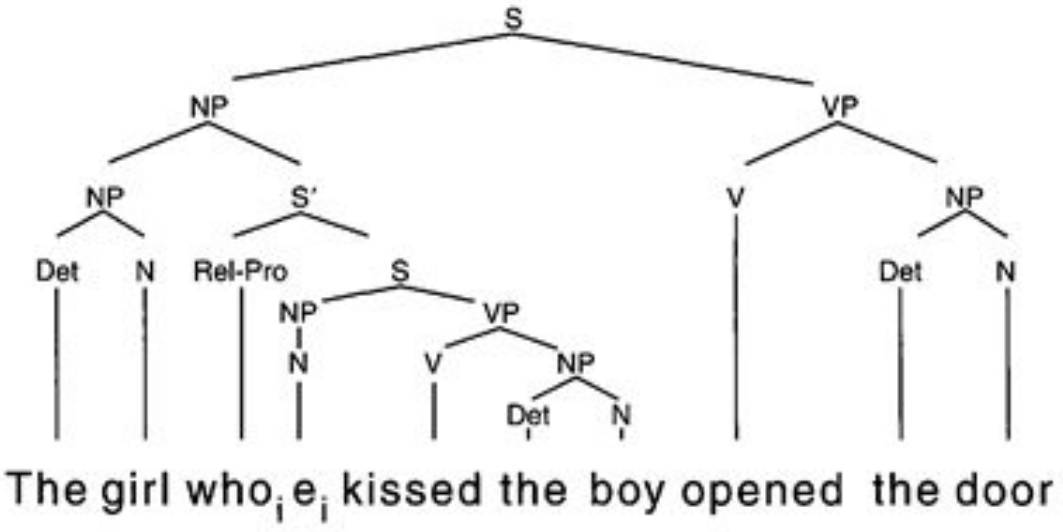


Figure 5.8 The hierarchical syntactic structure of an English sentence. (S = sentence; NP = noun phrase, VP = verb phrase, S′ = sentence modifier [relative clause], N = noun; V = verb; Det = determiner; Rel-Pro = relative pronoun.) Within the clause, the relative pronoun "who" is referred to as a filler and is interpreted as the actor for the verb "kissed." This relationship is identified by the presence of a coindexed empty element e_i in the subject position of the relative clause. Modified from Patel, 2003b.

Musical event hierarchies I: Structure and ornamentation

- The concept that some pitches serve to elaborate or ornament others is central to music theory.
  - We can recognize a melody in a richly ornamented jazz rendition.
  - Some event are heard as more important than others.
- Time span reduction
  - Lerdahl & Jackendoff 1983.
  - Shorter branches terminate on less important pitches, and longer branches terminate on more important pitches.
  - Such choices are influenced by tonal hierarchies but also take rhythmic and motivic information into account.
  - The trees are meant to model the experienced listener's intuitions about levels of relative structural importance of tones.

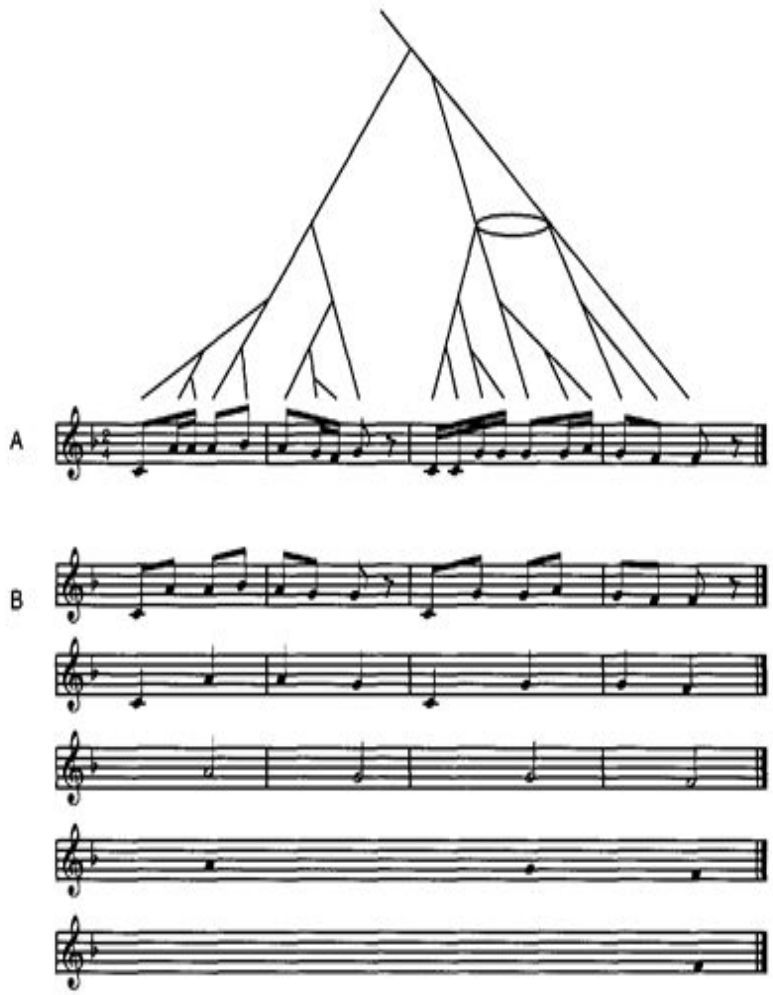


Figure 5.9 (A) A time-span reduction of the first two phrases of the children's song "Hush Little Baby." Shorter branches terminate on less important pitches, whereas longer branches terminate on more important pitches. (B) The lower staves show the dominant events at successively higher levels of tree structure. Modified from Large et al., 1995.

Musical event hierarchies I: Structure and ornamentation

- Large et al. 1995
  - Pianists played 5 improvisations on a children's melody.
  - The pattern of pitch retention was based on the basis of the pitch hierarchy of different scale degrees, note duration, and degree of metrical accent on a given note.
  - All of these are involved in Lerdahl & Jackendoff's time-span reduction.
- Bharucha 1984
  - An unstable note that is immediately followed by a stable note (e.g. B-C in a C major context) is less prominent (detectable in a memory experiment) than an unstable note that is not "anchored" in this way.
  - Demonstrates that the tonal hierarchy is involved in perceived elaboration relations.

Musical event hierarchies II: Tension and resolution

- Central to the experience of tonal music is a listener's sense of tension and relaxation as a piece unfolds in time.
  - Tension can be conveyed by surface features such as loudness and tempo.
  - But an important source is harmonic structure: its underlying sequence of chords and keys.
  - These contribute to the pattern of "tonal tension" that arises from relations between harmonic elements in a structured cognitive space.
- Prolongation reduction
  - Lerdahl & Jackendoff 1983.
  - Local tensing and relaxing motions are embedded in larger scale ones.
  - Right branching indicates an increase in tension, and left branching a decrease: a longer branch is more relaxed.

Recording

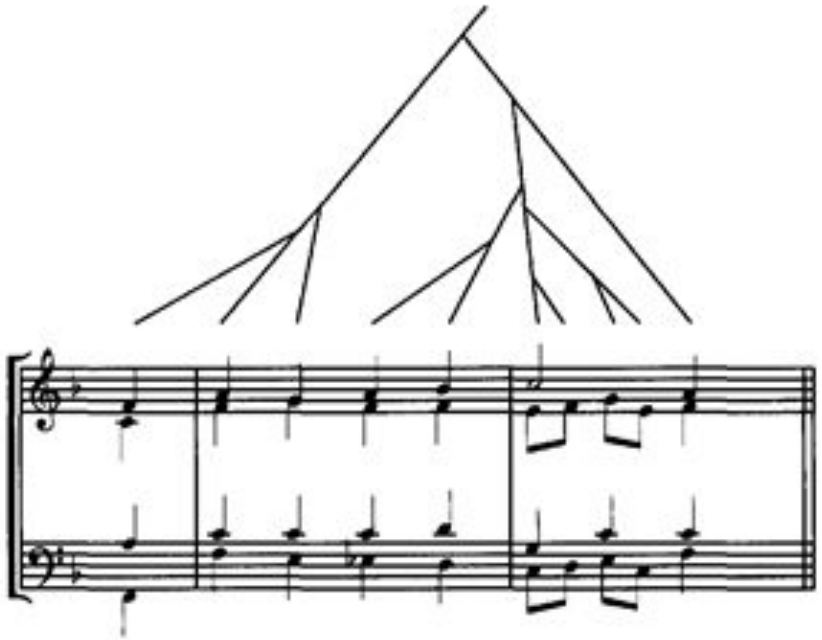


Figure 5.10 A prolongation reduction of a phrase from a composition by J. S. Bach (*Christus, der ist mein Leben*). In this type of tree, right branching indicates an increase in tension and left branching a decrease in tension (i.e., a relaxation). The tree shows how local tensing and relaxing motions are embedded in larger scale ones. Modified from Lerdahl, 2001:32.

Musical event hierarchies II: Tension and resolution

- Figure 5.10:
  - The first chord locally relaxes into the second.
  - The second chord locally tenses into the third.
  - The fourth chord is the point of maximum tension, and is the first event originating from a right branch that attaches high in the tree, and represents an increase in tension at a higher level.
  - Local relaxations into chords 5 and 6 are followed by a more global relaxation, indicated by the left branch connecting chord 6 with the final chord.
- The construction of such trees relies on time-span reduction but is not determined by it.
- Prolongation reduction is another kind of event hierarchy that relates events (chords) to each other in ways that are more complex than nearest-neighbor relations.

Musical event hierarchies II: Tension and resolution

- Evidence that tension is actually perceived in a hierarchical fashion comes from studies in which listeners rate perceived tension as they listen to musical passages.
  - Some studies favor a purely sequential structure:
    - "Stop tension" task where listeners rate tension after increasingly long fragments.
    - Bigand & Parncutt 1999.
    - The unnatural listening situation may encourage local rather than global listening.
  - Other studies favor a hierarchical structure:
    - "Continuous tension" task where listeners move a slider while listening to a piece.
    - Lerdahl & Krumhansl 2007; Smith & Cuddy 2003.

Order and meaning

- Musical syntax, like linguistic syntax, exhibits a strong structure-meaning link.
  - In language, changing the order of elements can result in a sequence with very different meanings.
    - This doesn't happen in birdsong or whale song.
  - If the pattern of tension and relaxation in music is taken as one kind of musical meaning, then it is clear that changing the order of musical elements (e.g. chord sequences) will have a strong impact on meaning.

Formal differences and similarities between musical and linguistic syntax

- Formal differences
  - Music doesn't have parts of speech or subjects and objects.
  - Syntactic trees in music are not constituent structure trees.
  - Long-distance dependencies in language are perceived by every listener, but the relations embodied in tension-relaxation trees are better viewed as hypotheses subject to empirical test.
  - There is a much greater tolerance for ambiguity in music.
    - In modulations, a chord may be heard simultaneously in its multiple roles in different keys.

Formal differences and similarities between musical and linguistic syntax

- Formal similarities: Hierarchical structure
  - Both linguistic and prolongation reduction trees relate grammatical categories in a hierarchical fashion.
  - The same grammatical categories can be filled by different members of the same category:
    - Different nouns and verbs.
    - Different inversions of the same chord or different chords if the key is changed.
  - Musical structure, like linguistic structure, exhibits recursion.
    - Small scale patterns of tension and relaxation can be embedded in larger tension-relaxation patterns.

Formal differences and similarities between musical and linguistic syntax

- Formal similarities: Logical structure
  - Both domains recognize a distinction between "structural" and "elaborative" elements in sequences.
    - Adverbs and adjectives in language.
  - Both exhibit context-dependent grammatical functions involving interdependent relations between elements.
    - The same NP can serve as subject or object in language.
    - Harmonic functions in music: The same chords G-B-D and C-E-G are V and I in the key of C major, but I and IV in the key of G major.
      - In C, these chords play the role of an authentic cadence, but in G, they act as a I-IV progression and leave the phrase sounding unfinished. Sound example.