

elements of

Harmony

Augusto Sarti

Computer Music Representations and Models

M.Sci. Music and Acoustic Engineering



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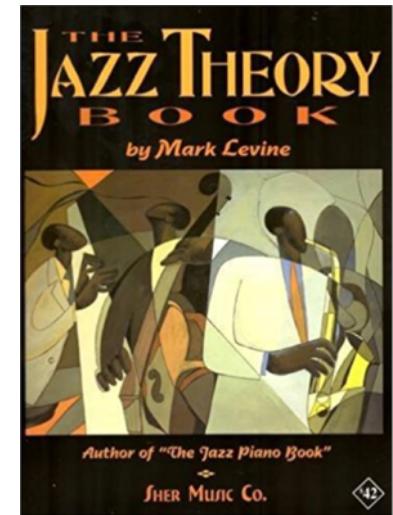
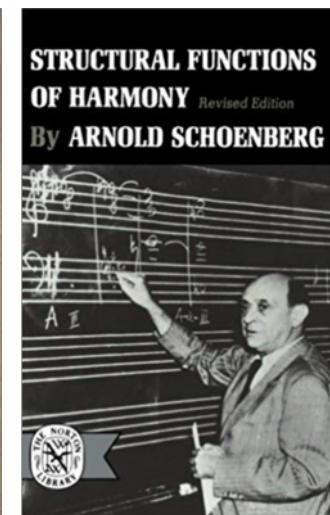
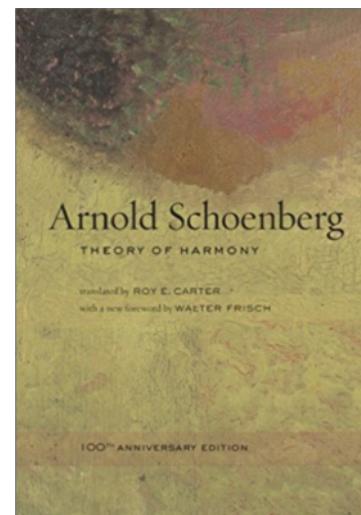
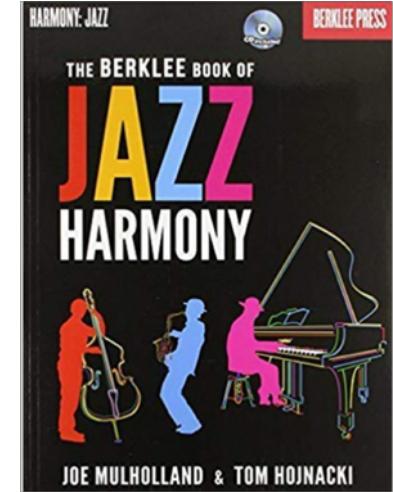
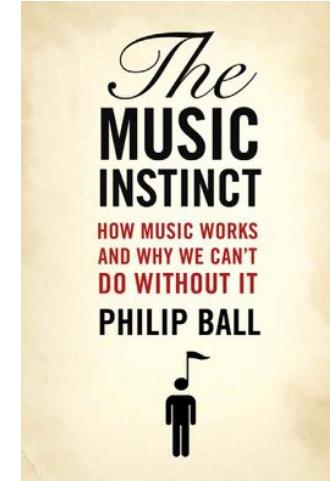
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Harmony readings

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- Mark Levine, "The jazz theory book", Sher Music 1995.**
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Basic theory

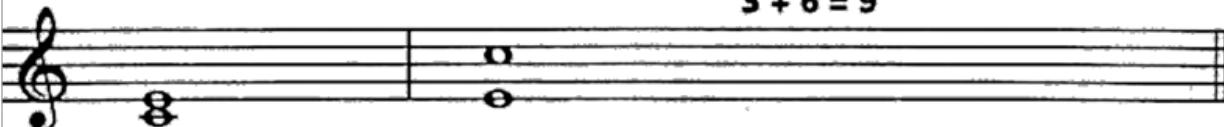
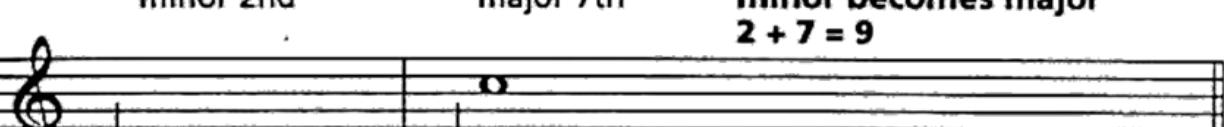
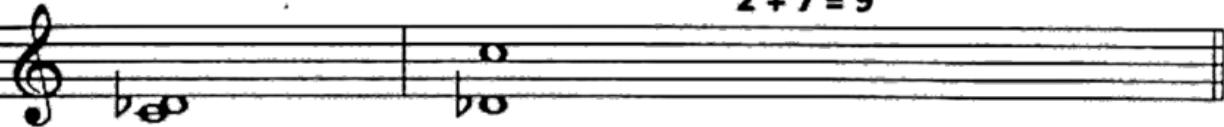
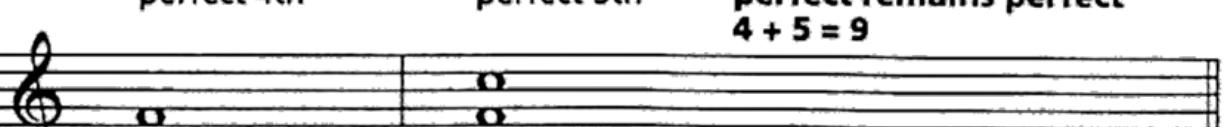
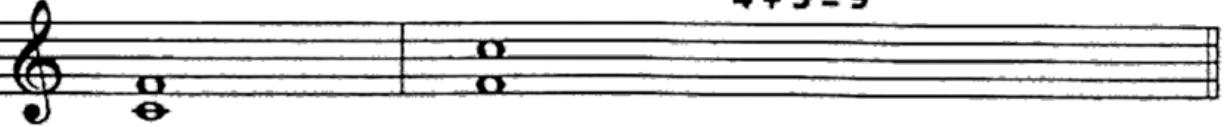
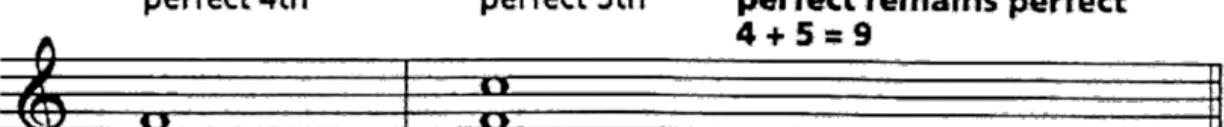
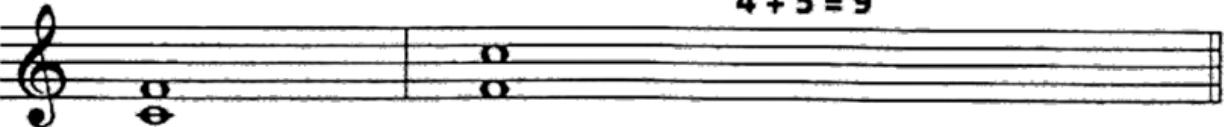
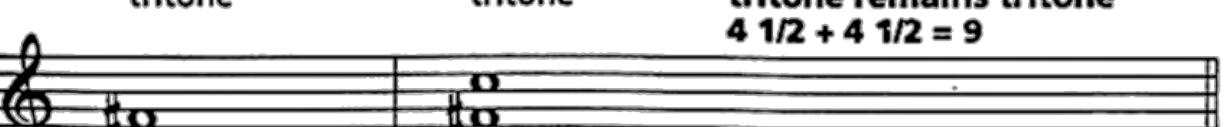
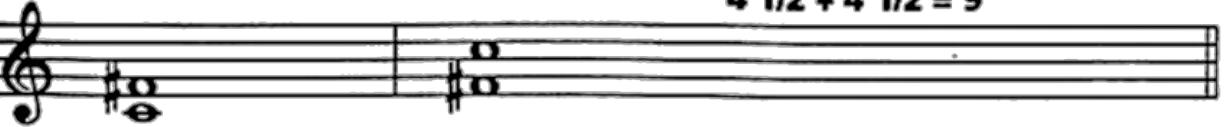


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Intervals and inversions

- Intervals and their inversions add up to 9
- Majors become minors and vice-versa
- Perfect intervals remain perfect through inversion
- A tritone interval remains tritone through inversion

major 3rd	minor 6th	major becomes minor $3 + 6 = 9$
		
minor 2nd	major 7th	minor becomes major $2 + 7 = 9$
		
perfect 4th	perfect 5th	perfect remains perfect $4 + 5 = 9$
		
perfect 4th	perfect 5th	perfect remains perfect $4 + 5 = 9$
		
tritone	tritone	tritone remains tritone $4 \frac{1}{2} + 4 \frac{1}{2} = 9$
		

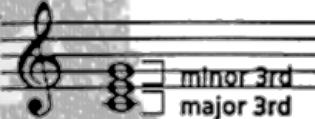
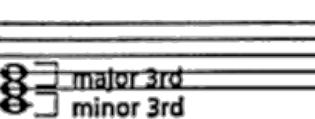
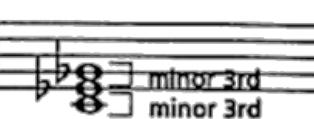
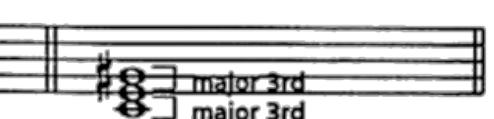


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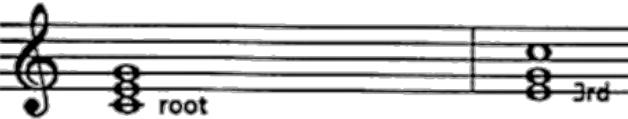
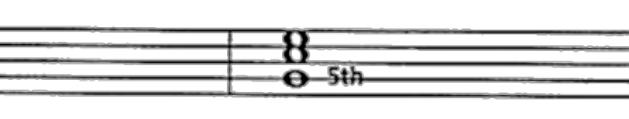
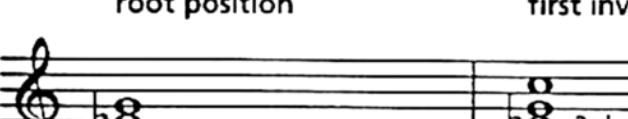
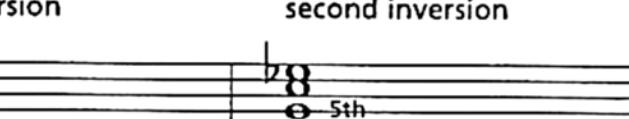
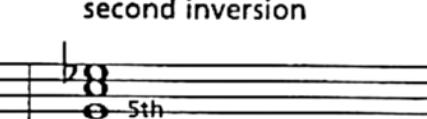


Triads and inversions

- Triads are two thirds stacked on top of one another
 - Four possible combinations of major/minor thirds:

C major triad	C minor triad	C diminished triad	C augmented triad
			
Happy Strong Triumphant	Sad Pensive Tragic	+ Tension Agitation	+ Floating Misty qual.

Inversions
of triads

root position	first inversion	second inversion
		
root position	first inversion	second inversion
		

The Major Scale and the II-V-I Progression

- Modes generated by the major (ionian) scale
- Roman numerals denote the degree of the scale

The diagram illustrates the seven modes generated by the major (Ionian) scale, arranged vertically from top to bottom:

- I C Ionian: The standard major scale.
- II D Dorian: Starts on D.
- III E Phrygian: Starts on E.
- IV F Lydian: Starts on F.
- V G Mixolydian: Starts on G.
- VI A Aeolian: Starts on A.
- VII B Locrian: Starts on B.

Each mode is shown on a single-line staff with a treble clef. The notes are represented by vertical stems. The mode names are written to the right of the staves.



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The Major Scale and the II-V-I Progression

- *From the modes come seventh chords*
- *We construct seventh chords by playing every other note of each mode*
 - *The Ionian Mode and the Major 7th Chord*

The diagram illustrates the C Ionian mode scale and its corresponding major 7th chord. The top part shows the C Ionian mode scale on a staff with a treble clef. The notes are: C (root), D (2nd), E (3rd), F (4th), G (5th), A (6th), B (7th), and C (octave). The 5th, 6th, and 7th notes are highlighted with boxes. The bottom part shows the construction of a major 7th chord from the scale. The notes are: C (root), E (major 3rd), G (5th), and B (7th). Arrows point from the labeled scale degrees to their corresponding notes in the chord.

C Ionian mode

root 2nd 3rd 4th 5th 6th 7th octave I

Chord tones

CΔ

major 3rd 5th major 7th



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The Major Scale and the II-V-I Progression

- *The Dorian Mode and the Minor 7th Chord*

D Dorian mode

D-7

root 2nd 3rd 4th 5th 6th 7th octave II

D-7

minor 3rd perfect 5th minor 7th

This block contains two musical examples. The top example shows the notes of the D Dorian mode on a treble clef staff, with each note labeled by its name and its position relative to the root. The bottom example shows the notes of the D-7 chord, also on a treble clef staff, with labels for the minor 3rd, perfect 5th, and minor 7th.

- *The Mixolydian Mode and the Dominant 7th Chord*

G Mixolydian mode

G7

V root 2nd 3rd 4th 5th 6th 7th octave V

G7

major 3rd perfect 5th minor 7th

This block contains two musical examples. The top example shows the notes of the G Mixolydian mode on a treble clef staff, with each note labeled by its name and its position relative to the root. The bottom example shows the notes of the G7 chord, also on a treble clef staff, with labels for the major 3rd, perfect 5th, and minor 7th.



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The Major Scale and the II-V-I Progression

- The I, II, and V chords often occur as a II-V-I *chord progression*, the most common chord progression (most often played in pop and jazz)
 - The second, fifth, and first notes of the F major scale are G, C, and F. The II chord is always a minor 7th chord, the V chord is always a dominant 7th chord, and the I chord is a major 7th chord
 - II-V doesn't have to end with I, as in the II-V changes in the first four bars of Richard Rodgers' "I Didn't Know What Time It Was"

F#-7 B7 3
E-7 A7
F#-7 B7 3
E-7 A7

II V in key of E II V in key of D II V in key of E II V in key of D

Example

Music staff 1:

G7 CΔ C-7 F7 GΔ

V I II - - - V I
in C in B♭ in G

Music staff 2:

B♭-7 E♭7 A-7 D7

II - - - V II - - - V
in A♭ in G

Music staff 3 (labeled 1.):

B-7 E-7 A7 A-7 D7 D-7 G7

II II - - V II - V II - V
in A in D in G in C

Music staff 4 (labeled 2.):

F#-7 B7 E-7 A7 A-7 D7 GΔ (D-7 G7)

II - V II - - V II - V - I II - V
in E in D in G in C

A speaker icon is located at the bottom center.



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JUST FRIENDS - KLEINER / LEHRS

Handwritten musical score for 'Just Friends' by Kleinert / Lehrs, featuring two staves of music with lyrics and chords.

Staff 1 (Top):

G7 Cmaj7 2 - 3 - C-7 F7

Gmaj7 2 - 3 - B♭-7 E♭7

A-7 D7 B-7 E-7

A-7 2 - 3 - A-7 D7 D-7 D7

Cmaj7 2 - 3 - C-7 F7

Gmaj7 2 - 3 - B♭-7 E♭7

A-7 D7 B-7 E-7

A-7 A-7 D7 D-7 D7

Staff 2 (Bottom):

2 - 3 - C-7 F7

Gmaj7 2 - 3 - B♭-7 E♭7

A-7 D7 B-7 E-7

A-7 A-7 D7 D-7 D7

G6 D-7 G7

Functions of II-V-I: voice leading

- As you go from the II chord to the V chord to the I chord, *the 7th of each chord resolves down a halfstep and becomes the 3rd of the next chord*
- Voice leading is the direction a particular note wants to go. It's an attractor that pulls on the 7th, urging it to resolve down a half-step

- Example: «Round midnight» (Thelonious Monk)



D-7 G7 CΔ

7th 3rd

7th 3rd

7th resolves down a half step, becomes 3rd of next chord

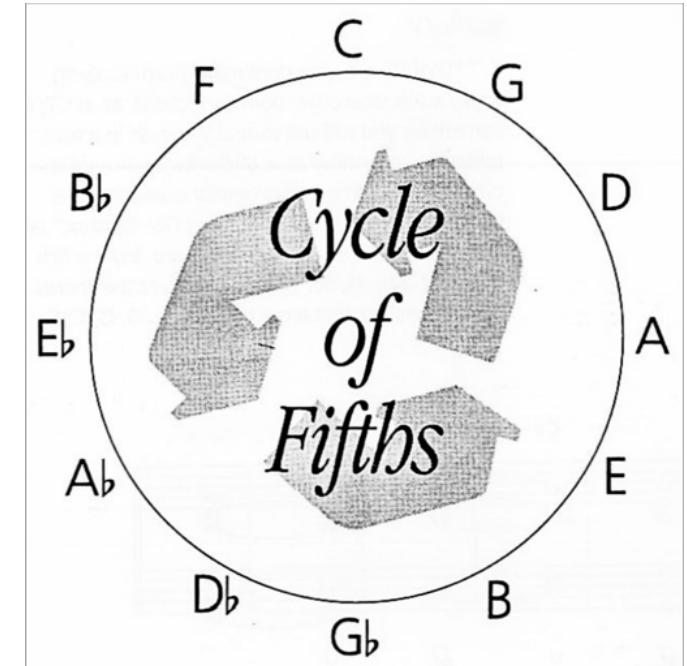
II V I

E♭-7 A♭7 B-7 E7 B♭-7 E♭7

7th 3rd 7th 3rd 7th 3rd

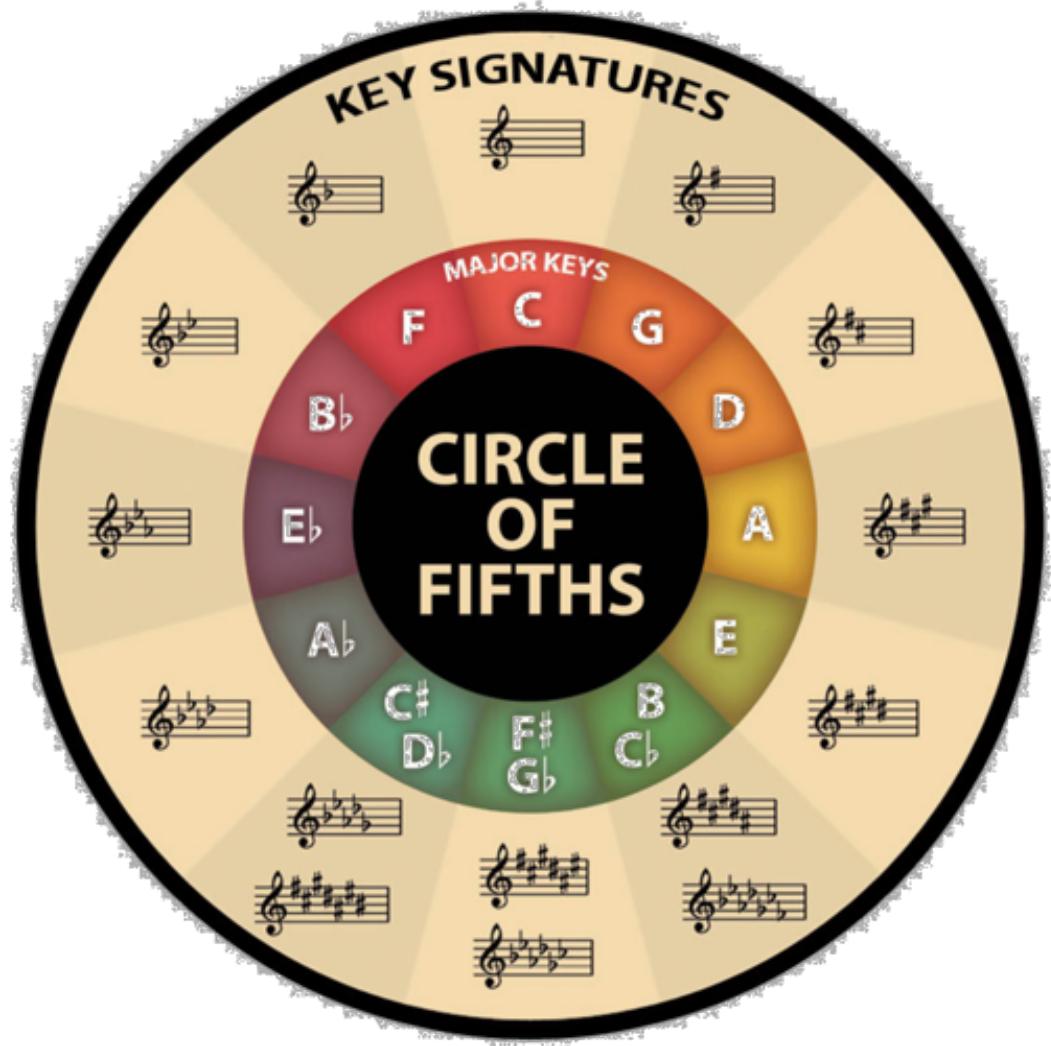
The Cycle of Fifths

- The cycle (or circle) of fifths is an arrangement of all 12 notes of the chromatic scale, each note a 5th lower than the preceding one.
- As you go around the cycle, think of each note as representing a key, i.e. a tonal reference
- Most chord movements within tunes follow portions of the cycle
 - E.g. the roots of a II-V-I progression follow the cycle counterclockwise around the cycle



The Cycle of Fifths

- The cycle of fifths as a method to count how many sharps or flats the signature will have
 - Moving clockwise adds one sharp (or removes one flat)
 - Moving counterclockwise adds one flat (or removes one sharp)



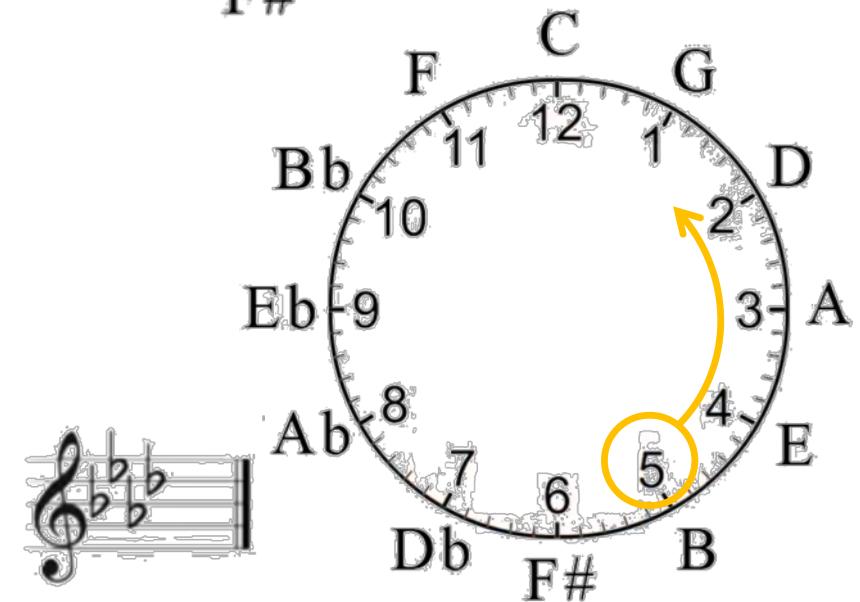
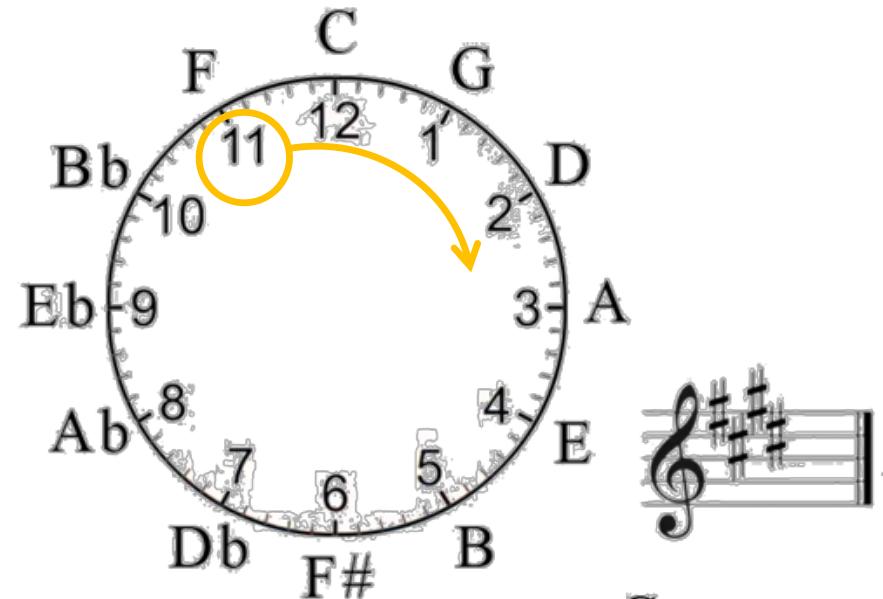
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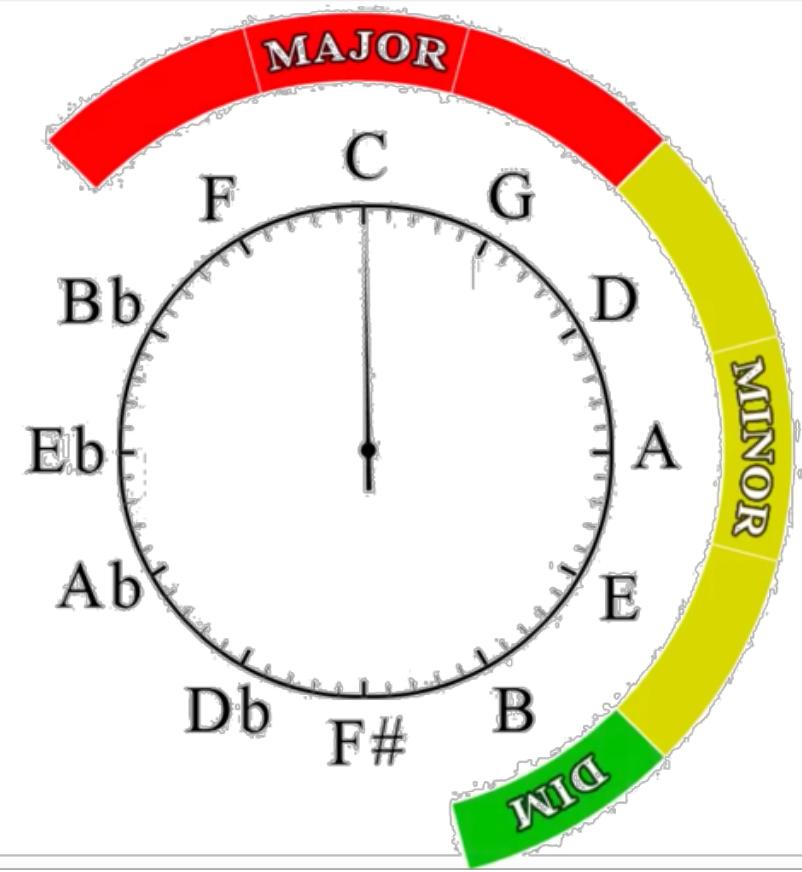
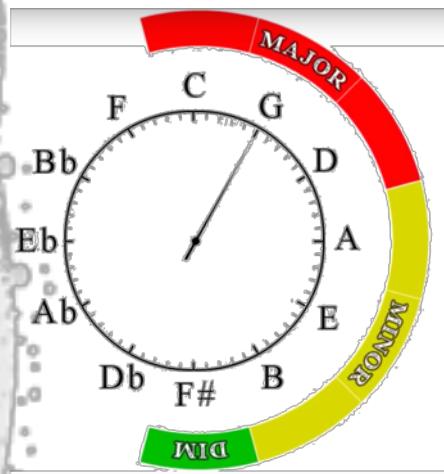
The Cycle of Fifths

- It also helps find which sharps or which flats are in the signature
 - To count sharps start from 11 and move clockwise
 - To count flats start from 5 and move counterclockwise



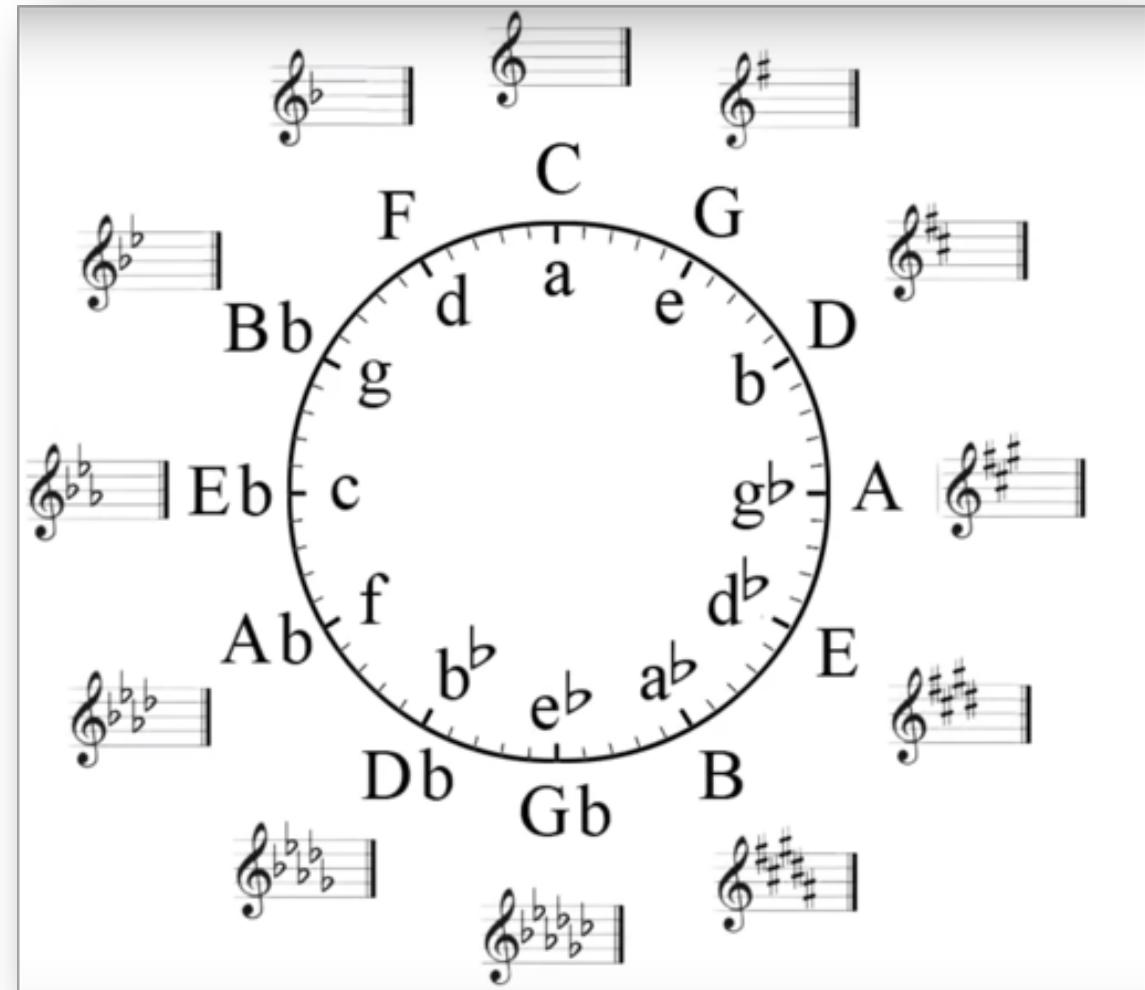
The Cycle of Fifths

- It can be used to identify which modal scales relative to the ionian C are major, minor or diminished
- The same holds true by rigidly rotating the wheel (i.e. using a different tonal reference)



The Cycle of Fifths

- Major and relative minor share the same signature



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The Cycle of Fifths

- In order to modulate a key to another it could be helpful to pass through a **pivot chord**, which is a chord shared by both keys
- For example: modulating from C to G

Key of C:



Key of G:



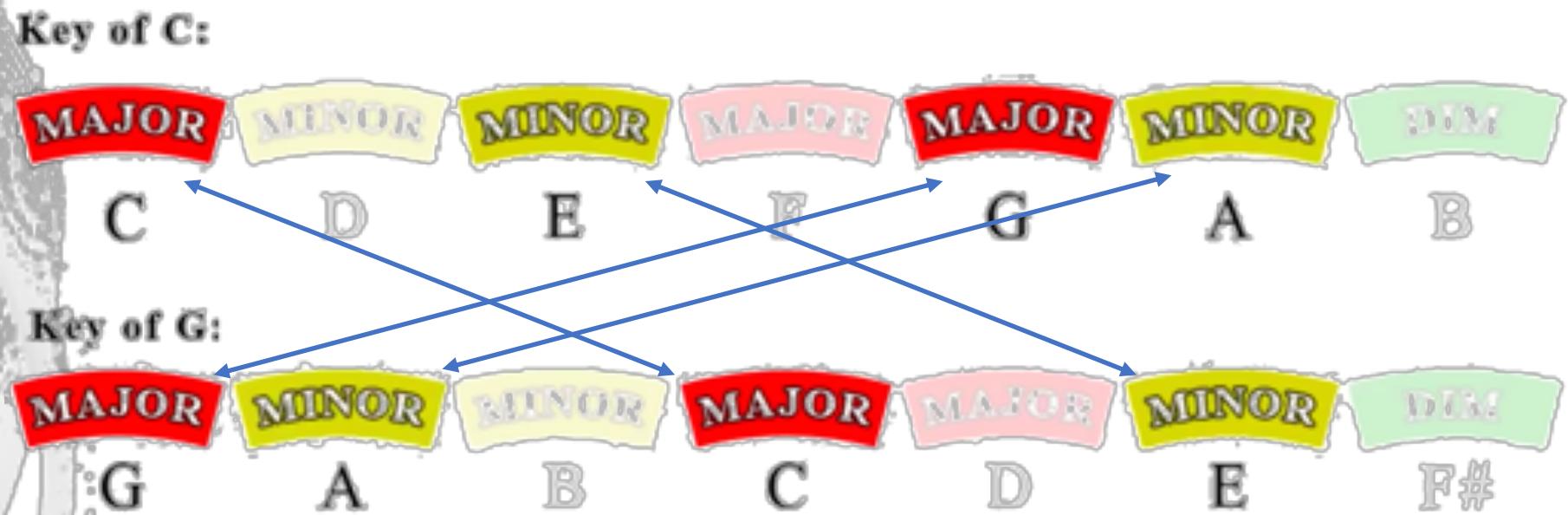
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The Cycle of Fifths

- In order to modulate a key to another it could be helpful to pass through a **pivot chord**, which is a chord shared by both keys
- For example: modulating from C to G can be done through the pivot chords



Other Common Chord Progressions

- «V of V» means a dominant chord resolving down a 5th to another dominant chord, as in C7, F7
 - Usually this happens several V chords in a row, following each other counterclockwise around the cycle of fifths
 - George Gershwin's "I've Got Rhythm," with four V chords in a row, each resolving down a 5th (figure 2-22). Notice how the roots of the chords go counterclockwise around the cycle: D, G, C, F.

D7 G7 C7 F7

v of v of v of v



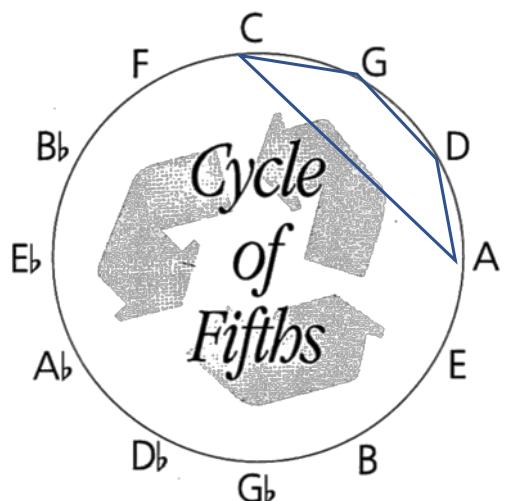
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Other Common Chord Progressions

- «I-VI-II-V», one of the most common chord progressions in any musical genre
 - The original first four chords of George Gershwin's "I've Got Rhythm" are a I-VI-II-V



Other Common Chord Progressions

- «I-VI-II-V», one of the most common chord progressions in any musical genre
 - It introduces a new mode, the Aeolian one:



- The VI chord derived from the Aeolian mode has a minor 3rd, a perfect 5th, and a minor 7th. Structurally, it is identical to the II chord derived from the Dorian
- There is, however, a great difference between the Dorian and Aeolian modes
 - Today's players usually play a dominant 7th chord rather than a minor 7th chord as the VI chord in a I-VI-II-V. They would play I-VI-II-V in the key of C as CΔ, A7, D-7, G7
 - Playing A7 instead of A-7 gives the progression a stronger sense of resolution going to D-7, and there are far more opportunities to alter dominant 7th chords than here are to alter minor 7th chords

A musical score in 4/4 time shows the progression I-VI-II-V. The top staff is in treble clef and the bottom staff is in bass clef. The chords are: CΔ, A7, D-7, G7. The bass line consists of eighth notes. Below the staff, the Roman numerals I, VI, II, V are written under their respective chords.



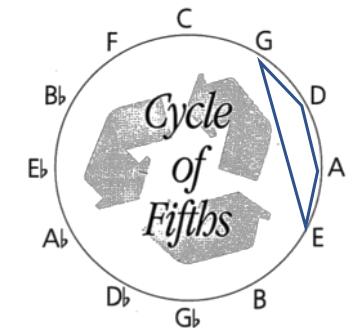
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Other Common Chord Progressions

- «III-VI-II-V», a common variation of I-VI-II-V
 - It introduces a new mode, the Phrygian one:



E Phrygian mode
E-7

The musical staff shows the notes of the E Phrygian mode. The notes are: root, 2nd, 3rd, 4th, 5th, 6th, 7th, octave, and III. The 7th note is labeled "5th root" and the 3rd note is labeled "7th 3rd". The staff has a treble clef and a key signature of one flat.

- The III chord derived from the Phrygian mode is structurally identical to the II and VI chords derived from the Dorian and Aeolian modes. All three are minor 7th chords
- however, the Phrygian mode is played most often on an entirely different chord-one that isn't even a minor 7th chord
 - As in the I-VI-II-V progression, the VI chord in a III more often played as a dominant chord, as on bars 7 and 8 of "Polka Dots And Moonbeams"

Oscar Peterson and Dexter Gordon
– Polkadots and moonbeams



D-7 G7 E-7 A7 D-7 G7

II V III VI II V

The musical score consists of two staves. The top staff is in treble clef and the bottom is in bass clef. The chords shown are D-7, G7, E-7, A7, D-7, and G7, corresponding to the harmonic progression II, V, III, VI, II, V. The score is in 4/4 time.

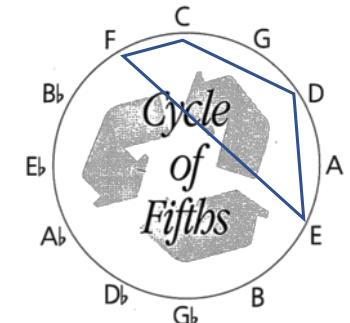


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Other Common Chord Progressions

- «I-II-III-IV»
 - It introduces a new mode, the Lydian one:



F Lydian mode

A musical staff in treble clef. The notes are: IV (F), root, 2nd, 3rd, ♯4, 5th, 6th, 7th, octave, 5th root, 7th, 3rd. The 7th note is highlighted with a box.

- The chord tones of the Lydian form a major ($F\Delta$) chord

John Coltrane - Moment's Notice

Coltrane deceptively used a I-III-III-IV progression to modulate from E^b into another key. The expected IV chord would be $A^b\Delta$, but Coltrane played A^b-7 instead, resolving it to D^b7 , the II-V in G^b



A musical score for piano or keyboard. The top staff shows the melody with chords labeled above the notes: $E^b\Delta$, $F-7$, $G-7$, A^b-7 , D^b7 . The bottom staff shows the bass line.

The Locrian Mode and the Half-Diminished Chord

B Locrian mode
Bø

VII

root 2nd 3rd 4th \flat 5 6th 7th octave VII

3rd 5th 7th

root 3rd

- Locrian is the only mode with a flattened 5th
Instead of B-7b5 most musicians today use BΦ
(read as «B half-diminished»)
 - "Half-diminished" means "a minor 7th chord with a flattened 5th"
 - often used as «passing mode» in minor harmony (see later)



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Chord-Scale theory



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Duality between chords and scales

- There is a duality btw scales and chords, though scales are often easier to remember
- As there seems to be a large number of chords, we tend to think that there is an even larger number of scales. We will see, however, that we can interpret almost all chord symbols using just these four scales
 - The major scale
 - The melodic minor scale
 - The diminished scale
 - The whole-tone scale
- As we're going to be thinking of scales and chords as two forms of the same thing, let's review the rules for the three basic chords: major 7th, minor 7th, and dominant 7th. The same rules will apply for most scales.
 - The major 7th chord has a major 3rd and a major 7th
 - The minor 7th chord has a minor 3rd and a minor 7th
 - The dominant 7th chord has a major 3rd and a minor 7th
- All three chords-major 7th, minor 7th, and dominant 7th-have a perfect 5th



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Major scale harmony

- We know that chords are derived from scales through 2:1 subsampling
- So far we only checked out the root, 3rd, 5th, and 7th of each mode to discover what chord is derived from each mode
- In fact, all seven notes of each mode contribute to chord formation
- To do so, we need to cover two octaves

D-7

A musical staff with two staves: treble and bass. The top staff starts with a treble clef, and the bottom staff starts with a bass clef. The notes are: Root (D), 3rd (F#), 5th (A), 7th (C#), 9th (E), 11th (G), and 13th (B). The notes are grouped into pairs by vertical lines, representing the two octaves of the chord.

The diagram shows eight musical staves, each representing a mode of the major scale:

- I: Ionian (CΔ) - No specific notes highlighted.
- II: Dorian (D-7) - No specific notes highlighted.
- III: Phrygian (Esus^{b9}) - No specific notes highlighted.
- IV: Lydian (FΔ^{#4}) - No specific notes highlighted.
- V: Mixolydian (G7) - An "avoid" note is shown at the 11th position.
- VI: Aeolian (A-^{b6}) - An "avoid" note is shown at the 11th position.
- VII: Locrian (Bø) - An "avoid" note is shown at the 9th position.
- VIII: Mixolydian (Gsus) - An "avoid" note is shown at the 5th position.

In the Mixolydian mode (VIII), there is a note labeled "no 'avoid' note" at the 11th position.



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Major scale harmony

- Take every other notes of a D dorian scale covering two octaves and rearrange these notes in the same octave without changing the numbering

D -7 D Dorian mode

A musical staff in G clef. At the top left is a D7 chord symbol. To its right is a vertical stack of seven notes labeled from bottom to top: 7th, 5th, 3rd, root, 9th, 11th, and 13th. Below the staff, the notes are labeled: root, 9th, 3rd, 11th, 5th, 13th, 7th, and root. The notes are represented by black dots on the staff.

- This can be confusing because extensions (9th, 11th, 13th), when wrapped back onto the same octave, correspond to even notes of the scales (2nd, 4th, 6th)
- We need extensions to **visit all notes of the scale** using chords, because chords are built with intervals of thirds → now chords and scales contain the same information (duality)
- Alterations are obtained by altering extensions: *b9, #9, #11, b5, b13*
- Extensions and alterations are used for generating «tension» in the harmonic progressions



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Major scale harmony

The *Ionian Mode and the Major 7th Chord*

A musical staff in G clef shows the notes of the Ionian mode scale. The notes are: CΔ, D, E, F, G, A, B. The note F is labeled "4th". The note B is labeled "avoid note". The mode is identified as "Ionian" at the end of the staff.

- Because it has a major 3rd and a major 7th, it is the mode for a CΔ chord



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Major scale harmony

The Ionian Mode and the Major 7th Chord

«Hocus pocus»
Lee Morgan



A musical score in 4/4 time with a treble clef. It features five chords: FΔ, D-, G-7, C7, and FΔ. The notes are represented by vertical stems with dots at the top, and the chords are shown as groups of three notes each. The word "majestic" is written below the final chord.

«Lynn's Tune»
Booker Ervin



playful

«My romance»
Bill Evans



romantic



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Major scale harmony

The *Dorian Mode and the Minor 7th Chord*

A musical staff in G clef and common time. The notes are: B (D7), A, G, F, E, D, C, B. The label "D-7" is above the staff, and "Dorian" is to the right.

- Because it has a minor 3rd and a minor 7th, it is the mode for a D-7 chord
- The *Mixolydian Mode and the Dominant 7th Chord*

A musical staff in G clef and common time. The notes are: E (G7), D, C, B, A, G, F, E. The label "G7" is above the staff, and "Mixolydian" is to the right. A note in the middle of the staff is labeled "avoid note". Below the staff, the label "11th" is centered.

- Because it has a major 3rd and a minor 7th, it is the mode for a G7 chord



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Major scale harmony

- To sum up, these are the modes to play over the II-V-I progression in the key of C: D-7, G7, CΔ
 - On a D-7 chord, play the D Dorian mode
 - On a G7 chord, play the G Mixolydian mode
 - On a CΔ chord, play the C Ionian mode
- So... *Why* bother with modes?
Why not just think "play in C major" on D-7, G7, CΔ?

CΔ

4th

the 4th or "avoid" note

CΔ

4th

OK (passing note)

Major scale harmony

- Sometimes «avoid notes» are played on purpose (creative use of dissonance)

The image shows a musical score for the song "Stella by Starlight" by Victor Young. The score consists of two staves. The top staff is for the piano, showing chords and bass notes. The bottom staff is for the vocal part. A red circle highlights a specific note in the vocal line, which is a dissonant note (likely a 7th or 9th) used for effect. An arrow points from this circled note down to a smaller inset at the bottom left, which shows a piano keyboard diagram with the note labeled "BbΔ". Below the piano keyboard, it says "4th 3rd".

STELLA BY STARLIGHT -VICTOR YOUNG

E-7 b5 A7 14 C-1 F7

F-7 Gb7 Ebmin7 Ab7

Bbmaj7 E-7 b5 A7 14 D-7 Bb-7 Eb7

Fmaj7 E-7 b5 A7 A-7 b5 D7 14

BbΔ
4th 3rd



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Major scale harmony

- Before the bebop era, most jazz musicians played the 4th of a major chord as a passing note only
- Charlie Parker, Bud Powell, Thelonious Monk, and other pioneers of bebop often *raised* the 4° in their improvising, chord voicings, and original tunes
 - used especially when improvising over an «outside» (e.g. a long stretch of a major chord)
 - the raised 4th was a very controversial note during the 1940s
 - People actually wrote letters to *Down Beat* magazine about it, saying things like "the beboppers are ruining our music" and "jazz is dead"
 - In classical music the raised 4th was a forbidden note (tritone or *diabolus in music*)
 - Today used very often in progressive rock
- It characterizes the Lydian mode, denoted with Major 7th^{#4}

A musical staff in G clef (soprano) shows the notes of the C Lydian mode. The notes are: C, D, E, F#, G, A, B. The key signature has one sharp, indicating F# (the 4th degree). The staff is labeled 'C Lydian mode' at the top right. The first note is labeled 'CΔ#4'. The fourth note is labeled '#4' and the fifth note is labeled '5th'. The Roman numeral 'IV' is on the left.



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Major scale harmony

- Lydian mode - Major 7th^{#4}

- C Lydian mode is the same as a G major scale, except that it starts on C
- Even though the chord symbol reads $C\Delta^{#4}$ you're actually playing in the key of G (*think key, not chord!*)
- The symbol #4 is often omitted (optional)
- Used also in earlier times:
 - 1926 - «Someone to watch over me» (first chord)
 - 1893 - «Happy Birthday» (6th bar)

- Joe Henderson
«Black Narcissus»



C Lydian mode

IV $C\Delta^{#4}$

$\sharp 4$ 5th

melody

piano



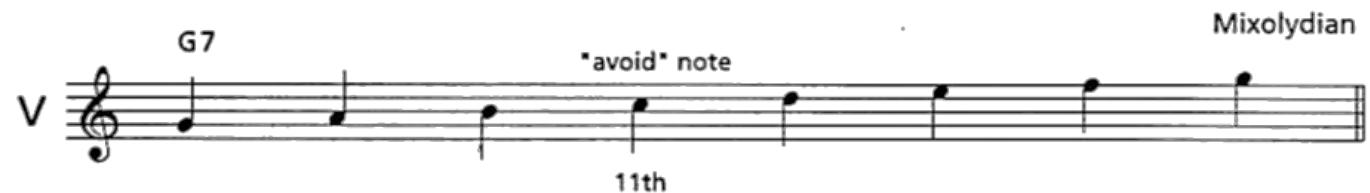
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Major scale harmony

- Mixolydian mode – Dominant scale



- root position G7 chord
- avoid note is the the 4th (or 11th)
- most pre-bebop jazz musicians played the 4th on a dominant 7th chord strictly as a passing note
- bebop musicians often raised the 4th on a dominant chord ($G7^{#11}$ or $G7^{#4}$)
- The $G7^{#11}$ or $G7^{#4}$ scale is also known as «Lydian b7» or «acoustic scale» (scale of the overtones)



Thomas Hojnacki – Ass. Chair of Harmony @ Berklee - <https://youtu.be/-X2HNQPdWWg>

Major scale harmony

- Mixolydian mode and the Sus chord

A musical staff in G major (one sharp) with a treble clef. It starts with a 'V' symbol followed by a note on the A line. The next note is on the G line, labeled 'G sus'. The third note is on the F line, labeled 'no "avoid" note'. The fourth note is on the E line, labeled '11th'. The fifth note is on the D line, and the sixth note is on the C line. The seventh note is on the B line, and the eighth note is on the A line.

- This is again a mixolydian mode, but a new chord symbol: Gsus
- G7 and Gsus share the same mixolydian mode but Gsus is voiced so that the 4th doesn't sound like an "avoid" note
- "sus" in the chord symbol refers to the *suspended 4th* of the chord (the note C)
 - In traditional harmony, the 4th of a sus chord usually resolves down a half step to become the 3rd of a dominant chord
 - In contemporary music, the 4th often doesn't resolve, which gives sus chords a floating quality

A musical staff in G major (one sharp) with a treble clef. It shows two chords side-by-side: Gsus (G-B-D) and G7 (G-B-D-F#). An orange arrow points from the text "In traditional harmony, the 4th of a sus chord usually resolves down a half step to become the 3rd of a dominant chord" to the Gsus chord, highlighting the open 4th (D) and 3rd (C) notes.

- Play to hear the difference:

A piano keyboard diagram showing two chords side-by-side: G7 (G-B-D-F#) and Gsus (G-B-D). The G7 chord has a black dot on the 4th key (F#), while the Gsus chord has an open 4th (D).



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Major scale harmony

- Mixolydian mode and the Sus chord: examples

- «Why Was I Born», Art Tatum



Musical notation for a Gsus chord in 4/4 time. The top staff shows a treble clef, a key signature of one sharp (F#), and a common time signature. The bottom staff shows a bass clef and a common time signature. The notation consists of two vertical stacks of three notes each, representing the Gsus chord. A fermata is placed over the top note of the second stack.

- Typical voicings of a sus chord

Musical notation showing a Gsus chord followed by a CΔ chord in 4/4 time. The top staff has a treble clef and a key signature of one sharp (F#). The bottom staff has a bass clef and a common time signature. The Gsus chord is shown with a standard voicing (G-B-D). The CΔ chord is shown with a standard voicing (C-E-G).

Musical notation showing a Gsus chord followed by a CΔ chord in 4/4 time. The top staff has a treble clef and a key signature of one sharp (F#). The bottom staff has a bass clef and a common time signature. The Gsus chord is shown with a standard voicing (G-B-D). The CΔ chord is shown with a standard voicing (C-E-G).

Musical notation showing a Gsus chord followed by a CΔ chord in 4/4 time. The top staff has a treble clef and a key signature of one sharp (F#). The bottom staff has a bass clef and a common time signature. The Gsus chord is shown with a standard voicing (G-B-D). The CΔ chord is shown with a standard voicing (C-E-G).

Major scale harmony

- Mixolydian mode and the Sus chord: examples

- 1944: Leonard Bernstein
"Some Other Time"
(Bill Evans, 1958)



- ...compare with «Peace Piece»,
Bill Evans, 1958



- ...and with «Flamenco Sketches»,
Miles Davis, 1959
again, with Bill Evans



Major scale harmony

- *The Phrygian Mode and the Sus^{b9} Chord*

A musical staff with a treble clef and three measures. The first measure is labeled "III" above the staff and "E sus^{b9}" above the notes. The second measure shows a single note. The third measure shows a single note. The staff ends with a repeat sign and the label "E Phrygian mode" above it.

- This mode and its chord are very deceptive because it has a minor 3rd and a minor 7th
- this mode appears as though it would be played over an E-7 chord
- C, the ^{b6} of E-7, sounds very dissonant against the chord, which is why it is usually played in III-VI-II-V progressions as a passing note
- The Phrygian mode is usually played, not over minor 7th chords, but over *sus^{b9} chords*
- The notes most often played on a sus^{b9} chord are

A musical staff with a treble clef and two measures. The first measure shows an E-7 chord with a bass note. The second measure shows an E-7 chord with a bass note. The staff ends with a repeat sign and the label "E -7" above it.

A musical staff with a treble clef and one measure. The notes are labeled: "root", "4th", "7th", and "5th". The note labeled "root" is the lowest note, followed by the "4th", then the "7th", and finally the "5th" above the 7th. The label "E sus^{b9}" is above the staff.



Major scale harmony

- *The Phrygian Mode and the Sus^{b9} Chord*

Kenny Barron «Golden lotus»

Dsus^{b9}

Booker Ervin «Gichi»

Esus^{b9}



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Major scale harmony

- *The Aeolian Mode*



- Often called the *natural minor scale*
- Rarely played
- Bridge of Miles Davis' «Milestones» is all in A aeolian



- What constitutes an Aeolian chord? when is an Aeolian scale played?
 - sometimes played over the VI chord in a I-VI-II-V or a III-VI-II-V progression
 - modern jazz musicians play the VI chord as a dominant chord (CD, A7, D7, G7) most of the time
 - the aeolian mode is often played on a VI chord because it allows the musician to stay in the same key over all four chords of I-VI-II-V



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Major scale harmony

- *The Locrian Mode and the Half-Diminished Chord*

A musical staff in G clef. The notes are: B \circ , VII, B \flat 9, B, B \flat 5, B, B, B. The label "B Locrian mode" is at the top right.

- This mode has a minor 3rd and a minor 7th, so it goes with a B-7 chord ...with a difference: it also has a flattened 5th (F is a \flat 5 above B) and it is the only major mode to have it
- The chord symbol for this mode is B \circ , shorthand for B-7 \flat 5, and called B half-diminished (*half-diminished means a minor 7th chord with a flattened 5th*)

C is the \flat 9 of the chord
The \flat 9 of a half-diminished chord is
an "avoid" note

A musical staff in G clef. The notes are: B \circ , B, B, B, B, B, B. The label "B \circ *avoid* note" is above the 9th note. An orange arrow points from the text "dissonant" to the 9th note. The bass staff shows a bass line of eighth notes.



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Major scale harmony

- *Summary*
 - *All the chords from the key of C major*

CΔ, D-7, Esus^{b9}, FΔ^{#4}, G7, Gsus, A-^{b6}, Bφ

share the same C major scale



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Melodic minor scale Harmony

- Seven-note scale with seven modes
 - Differs from the C major scale in that it has an Eb, a minor 3rd
 - Yet, melodic minor harmony *sounds* much darker and more exotic than major scale harmony
 - The melodic minor scale has greater melodic and intervalic possibilities than the major scale

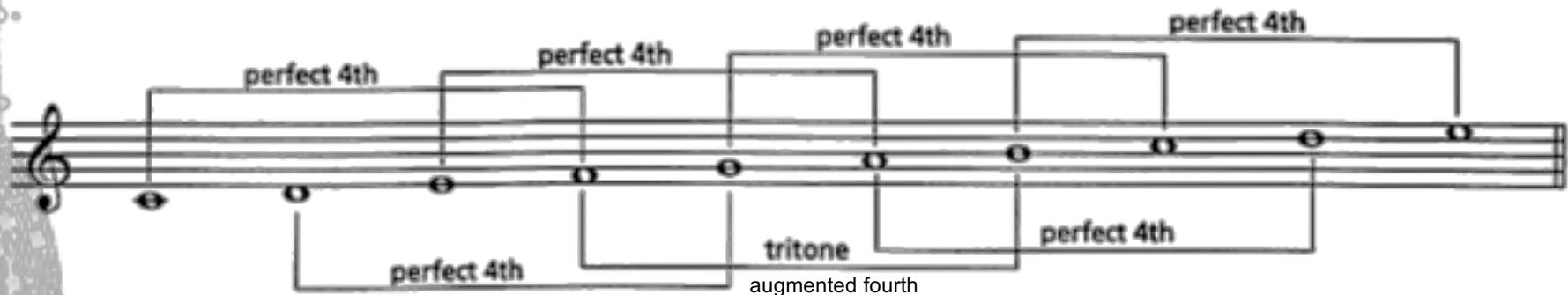


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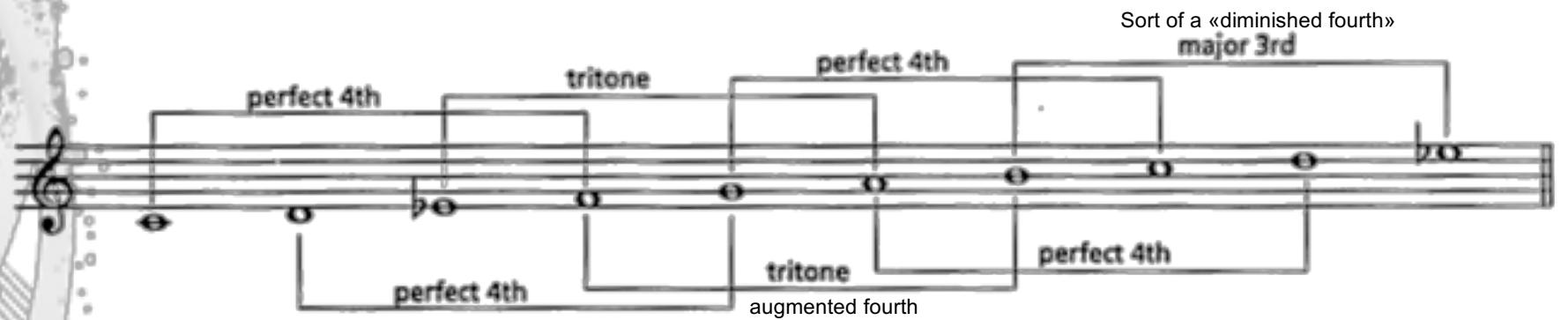


Melodic minor scale Harmony

- A *diatonic 4th* is the interval between every 4th note within a key
 - Diatonic fourths in a major scale (two different types)



- Diatonic fourths in a melodic minor scale (three different types)



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Melodic minor scale Harmony

- The *Minor-Major Chord*

- First mode has a minor 3rd and a major 7th, hence the name *minor-major chord*
- Common symbols: C-D and C-#7 and C-maj7

A musical staff in G clef and common time. The key signature is one sharp, indicating F# major. The notes are: C, A, G, F#, E, D, C. The first note is labeled 'C' above the staff, and the last note is labeled 'C minor-major' to its right.

Unlike a minor 7th chord, which functions as a II chord, a minor-major chord functions as a *minor I chord*, also called a *tonic minor chord*

«Minority» Gigi Gryce



A musical score for piano in 4/4 time. The treble clef is F# and the bass clef is B. The score consists of two staves. The first measure shows a C major chord (F# A C) followed by a G minor chord (B D F#). The second measure shows a C minor-major chord (F# A C) followed by a G minor chord (B D F#). The third measure shows a C major chord (F# A C) followed by a G minor chord (B D F#). The fourth measure shows a C major chord (F# A C) followed by a G minor chord (B D F#).



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Melodic minor scale Harmony

- The *Minor-Major Chord*

- Minor-major chords are often played as a substitute for minor 7th chords
 - The clue for when you can do this is very simple: If a II chord is not part of a II-V progression, you can usually substitute a minor-major chord for a minor 7th chord

- Summertime (minor)



- Summertime (minor-major)



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Melodic minor scale Harmony

- *The second mode and the Sus^{b9} Chord*

- has a minor 3rd and a minor 7th, suggesting that you would play it over a D-7 chord

II

Dsus^{b9}

D-7^{b9}

b9 of the D-7 chord
(sounds dissonant)

second mode. C melodic minor

F#sus^{b9}

F# Phrygian mode, D major

two scales played over
the same Sus^{b9} chord

...just one note of difference

This block contains musical notation for two scales over a Sus^{b9} chord. On the left, a treble clef staff shows a Dsus^{b9} chord followed by a bass staff with a D-7^{b9} chord. A red arrow points from the text 'b9 of the D-7 chord (sounds dissonant)' to the b9 note in the bass staff. To the right, two staves show the second mode of C melodic minor (notes: A, B, C, D, E, F#, G) and the F# Phrygian mode (notes: D, E, F#, G, A, B, C). The text 'two scales played over the same Sus^{b9} chord' is centered between them, and '...just one note of difference' is at the bottom.

F#sus^{b9}

F# Phrygian mode, D major

second mode, E melodic minor

6th

This block contains musical notation for two scales over a Sus^{b9} chord. It features two staves: the top staff shows the F# Phrygian mode (notes: D, E, F#, G, A, B, C) and the bottom staff shows the second mode of E melodic minor (notes: B, C, D, E, F#, G, A). The text 'F#sus^{b9}' is above the top staff, 'F# Phrygian mode, D major' is to its right, 'second mode, E melodic minor' is below the bottom staff, and '6th' is at the bottom right.



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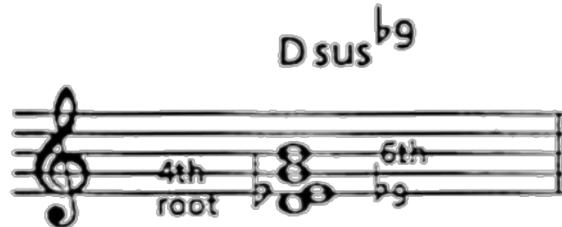


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Melodic minor scale Harmony

- *The second mode and the Sus^{b9} Chord*

- The most important notes in a chord, the ones that distinguish one chord from another, are often the 3rd or 7th
- The most important notes of the melodic minor Sus^{b9} chord, however, are the root, ^{b9}, 4th, and 6th



Anthony Newley
«Who Can I Turn To»
“The roar of Greasepaint”



Musical score showing two chords: F-7 and B^bsus^{b9}. The score is in 4/4 time. The F-7 chord is shown with a bass line and three upper notes. The B^bsus^{b9} chord is shown with a bass line and three upper notes, including the b9 note. The chords are labeled "F-7" and "B^bsus^{b9}" respectively.



Melodic minor scale Harmony

- *The third mode and the Lydian augmented chord*

- Because it has a major 3rd and a major 7th, it suggests an EbΔ chord. Normally, if you saw an EbΔ chord symbol, you'd think of the Eb major scale, except this has both a raised 4th (A natural), and a raised 5th (B natural)
- The complete chord symbol would be EbΔ^{#4 #5}, shortened to EbΔ^{#5}

The image shows two musical staves. The top staff is in treble clef, key signature of Eb (two flats), and time signature of common time (indicated by 'III'). It starts with a note on the fourth line, followed by a sharp sign indicating a raised 4th (A natural). The next note is on the fifth line, followed by another sharp sign indicating a raised 5th (B natural). The staff ends with a sharp sign above the staff line, indicating a raised 7th (D natural). Above this staff, the text 'EbΔ^{#5} (G/E♭)' is written. To the right of the staff, the text 'E♭ Lydian augmented' is written. The bottom staff is in bass clef, key signature of G (no sharps or flats), and time signature of common time (indicated by '4'). It shows a G major triad (G, B, D) with a bass note on the fourth line. Above this staff, the text 'G/E♭' is written twice. A brace groups the two staves.

E♭Δ^{#5} (G/E♭)

E♭ Lydian augmented

G/E♭ G/E♭

The 3rd, #5, and 7th of this EbΔ^{#5} chord form a G major triad, which explains why it is sometimes notated as a *slash chord*, in this case G/Eb

Melodic minor scale Harmony

- *The fourth mode and the Lydian dominant chord*

A musical staff in G clef and common time. It shows a sequence of notes: a quarter note, a eighth note, a eighth note, a quarter note, a eighth note, a eighth note, a half note, and a eighth note. Above the staff, the label "F7 #11" is positioned above the first note, and "IV" is positioned below the first note. To the right of the staff, the label "F Lydian dominant" is positioned above the last note.

- Lydian dominant harmony in «Stella by Starlight»

«Stella by Starlight»
Miles Davis (Kind of blue)



A musical score for two staves. The top staff is in treble clef and the bottom is in bass clef, both in common time. The score shows a harmonic progression: C7 (with a circled 3), followed by a measure of chords, then A♭7 #11. The score includes various rests and dynamic markings like 'p' (piano).



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Melodic minor scale Harmony

- *The fifth mode*

- rarely played, which shows the limitations of the traditional theory
- chord tones are G-B-D-F (root, major 3rd, perfect 5th, and minor 7th) which suggests a G7 chord
- The E^b in the scale would be the ^b13 of the chord, suggesting a chord symbol of G7^{b13}

C Δ/G

5th mode, C melodic minor

G7 G7

G Δ/D

Because D is the 5th of G melodic minor, this creates a chord based on the fifth mode of G melodic minor (defined as *tonic minor chord*)



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Melodic minor scale Harmony

- *The fifth mode*

Kenny Barron playing
«Spring is here»



A musical score for piano or guitar. The top staff is in treble clef and 4/4 time, with a key signature of one sharp (F#). It shows a chord progression from GΔ to CΔ/G. The bottom staff is in bass clef and 4/4 time, with a key signature of one sharp (F#). It shows harmonic bass notes corresponding to the chords above.

- Because it is so rarely played, the chord of the fifth mode of the melodic minor scale has no universally accepted chord symbol
- In C melodic minor, it is usually notated as a slash chord C-Δ/G



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Melodic minor scale Harmony

- *The sixth mode and the half-diminished chord*

- it has a minor 3rd and a minor 7th, which suggests a minor 7th chord: A-7
- However, It has a $\flat 5$ ($\flat E$), and a $\flat 6$ (F), which suggests a chord symbol of A- $7^{5s \ \flat 6}$
- Usually denoted as Aø (half-diminished), also A Locrian #2 (differs from Locrian in the second note)

Because it has a minor 3rd and a minor 7th, the half-diminished chord functions as a II chord

The image shows four musical staves. The top staff is labeled "VI" and "Aø". The second staff is labeled "A Locrian, 7th mode of B-flat major" and includes notes Aø, B-flat, C, D-flat, E-flat, G-flat, and B-flat. The third staff is labeled "A Locrian #2, 6th mode of C melodic minor" and includes notes Aø, B-flat, C, D-flat, E-flat, G-flat, and A. The bottom staff shows two measures of Aø chords in G major (Aø, C, E) and Aø chords in A melodic minor (Aø, C-sharp, E). Red arrows point from boxes labeled "Avoid note" and "Sounds good" to the B-flat and C-sharp notes respectively.

A half-diminished (A Locrian #2)

VI

Aø

A Locrian, 7th mode of B_b major

Aø b9

A Locrian #2, 6th mode of C melodic minor

Aø 9th

Aø Aø

Avoid note

Sounds good

Melodic minor scale Harmony

- *The sixth mode and the half-diminished chord*

- Mccoy Tyner's «Search for peace»



- «Stella by starlight»



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Melodic minor scale Harmony

- *The seventh mode and the altered dominant chord*

A musical staff in G clef. Above the staff is the label "B7alt". Below the staff, the notes are labeled: VII, b9, #9, #11, b5, b13, #5. The notes correspond to B, D, E^b, G, B, D, F# respectively.

- It has a minor 3rd (D), but the note after D in the scale (E^b), is a major 3rd above B (root)
- E^b is the true 3rd (major), while D is something else
- It also has a minor 7th (A), so it must go with some kind of B7 chord. If you saw the chord symbol B7, you would normally think of the B Mixolydian mode, the fifth mode of the E major scale (not possible because it doesn't have 4 sharps)
- compare it with B the seventh mode

b13
b11
b9
B7b9

Two musical staves are shown side-by-side. The top staff is labeled "B7" and "B Mixolydian, 5th mode of E major". The notes are labeled: root, 9th, 3rd, 11th, 5th, 13th, 7th, root. The bottom staff is labeled "B altered, 7th mode of C melodic minor". The notes are labeled: root, b9, #9, 3rd, #11, b13, 7th, root. A red box highlights the notes b13, b11, b9, and B7b9 from the first staff, and a red arrow points from this box to the "B7alt" label on the second staff.

Melodic minor scale Harmony

- *The seventh mode and the altered dominant chord*

- «I Thought About You»
Miles Davis

Bø E7alt A7 D7alt G7



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Melodic minor scale Harmony

- The *Interchangeability of Melodic Minor Chords*
 - All seven modes of the minor harmony share the same melodic minor scale
 - This is similar to major scale harmony, where (in the key of C), CΔ, D-7, Esus^{b9}, FΔ^{#4}, G7, and G7 all share the same major scale
 - However, there is a very big difference between major and melodic minor harmony
 - there are no "avoid" notes in chords from melodic minor harmony
 - The lack of "avoid" notes means that almost everything in any melodic minor key is interchangeable with everything else in that key
 - Anything you play on C-Δ will work as well on Dsus^{b9}, E^bΔ^{#5}, F7^{#11}, Aø, and B7alt

A musical staff with two staves (treble and bass) and a common time signature (C). The top staff has a treble clef and the bottom staff has a bass clef. The staff is divided into six measures by vertical bar lines, labeled I, II, III, IV, VI, and VII below them. Above the staff, the chords are labeled: FΔ, Gsus^{b9}, A^bΔ^{#5}, B^b7^{#11}, Dø, and E7alt. The chords are represented by vertical stacks of three notes each. Measure I contains a C major chord (C, E, G). Measure II contains a D minor chord (D, F, A). Measure III contains an E minor chord (E, G, B). Measure IV contains a G major chord (G, B, D). Measure VI contains an A minor chord (A, C, E). Measure VII contains a B minor chord (B, D, F#).



Observation 1

F Δ Gsus $^{\flat}9$ Ab $\Delta^{\#}5$ B $\flat7^{\#}11$ Dø E7alt

I II III IV VI VII

the F-Δ voicing sounds just as good as Gsus $^{\flat}9$, Ab $\Delta^{\#}5$, Bb $7^{\#}11$, Dø, and E7alt

Aside from the root *there is no difference between any of the chords* (all of the roots are also from the F melodic minor scale)

Any idea you play on F-Δ will work with any other chord from F melodic minor



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Observation 2

A musical score consisting of two staves. The top staff is in treble clef and the bottom staff is in bass clef. Both staves are in 4/4 time. The first measure contains a F7^{#11} chord (F, A, C, E, G, B) followed by an EΔ chord (E, G, B, D). The second measure contains a B7alt chord (B, D, F#, A) followed by another EΔ chord (E, G, B, D).

F7^{#11} and B7alt are the only dominant 7th chords from C melodic minor and their roots are a tritone apart

The two dominant 7th chords from melodic minor harmony are a tritone apart

because of the lack of "avoid" notes, F7^{#11} and B7alt are essentially the same chord, and tend to resolve to the *same* chords



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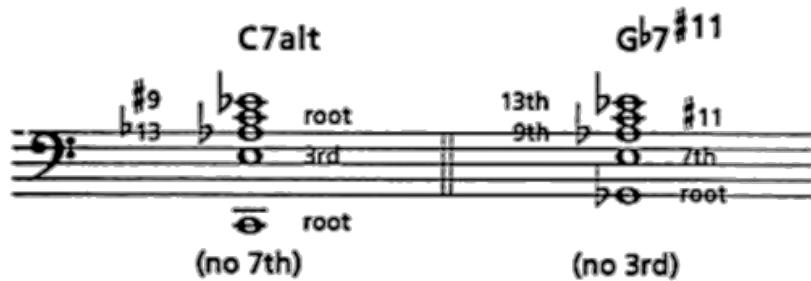
Observations 3-4

- **The interchangeability doesn't work in chords from the major scale**
 - For example: although both D-7 and CΔ are from the key of C, a voicing for D-7 won't work for a CΔ chord because D-7 has an F, the "avoid" note of a CΔ chord
- **In traditional theory, the 3rd and 7th are considered essential notes on dominant 7th chords. When you play dominant chords from melodic minor harmony, the 3rd or 7th may not have much importance at all**

The image shows two musical staves. The left staff is labeled $B_{\flat}7\#11$ and the right staff is labeled $E7\text{alt}$. Both staves are in treble clef and common time. The $B_{\flat}7\#11$ staff has a bass clef and contains notes B, G, D, and A. The $E7\text{alt}$ staff also has a bass clef and contains notes E, C, G, and B. Blue arrows point from boxes containing text labels to specific notes in the chords. One arrow points to the D note in the $B_{\flat}7\#11$ chord with the label "no 3rd (D)". Another arrow points to the B note in the $E7\text{alt}$ chord with the label "no 7th (D)".

Observation 5

- Because there are no "avoid" notes in melodic minor harmony, the resulting interchangeability of all the chords means that you're playing the whole melodic minor «key» much more than any individual chord within it



The voicing lacks the 7th when played as C7alt, and lacks the 3rd when played as Gb7^{#11}

because of the lack of "avoid" notes, you are
really playing the entire key, not just the chord
→ **Think key, not chord**



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The Minor II-V-I and II-V Progressions

A musical score for a piano or keyboard instrument. It consists of two staves. The top staff is in treble clef and the bottom staff is in bass clef. The time signature is common time (indicated by '4'). The progression is labeled above the staff as Dø, G7alt, and CΔ. The notes are played sequentially, with each chord's notes connected by a horizontal line. The Dø chord has three notes: D, F, and A. The G7alt chord has four notes: G, B, D, and F. The CΔ chord has three notes: C, E, and G.

- A minor II-V-I usually consists of a half-diminished chord, an alt chord, and a minor-major chord
- unlike the major II-V-I, in which all three chords are derived from the same key (D-7, G7, and CΔ are all from C major)

the three chords in a minor II-V-I are derived from three different melodic minor scales

- The notes played over the Dø chord are from F melodic minor
- The notes played over the G7alt chord are from Ab melodic minor
- The notes played over the C-Δ chord are from C melodic minor



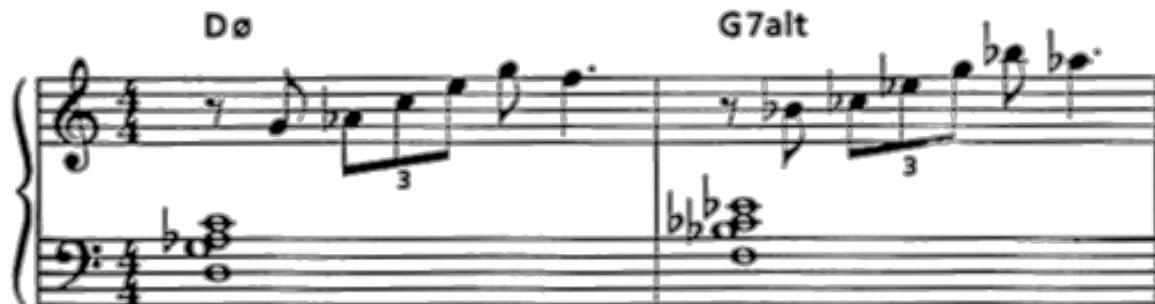
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The Minor II-V-I and II-V Progressions

Observation 1

- The harmonic minor scale is often mentioned in theory books as being "a scale played over a minor II-V-I
If this were true, we would hear it played often, but **it is not true**



Example of minor II-V: both the $D\phi$ phrase in the treble clef and the chord voicing in the bass clef are repeated a minor 3rd up on the $G7\text{alt}$ chord

- A melodic figure repeated at a different pitch is called *a sequence*
- Repeating a chord at a different pitch is called *parallelism*

On a minor II-V, anything you play on the half-diminished chord can be played up a minor 3rd on the alt chord (the two chords come from melodic minor keys a minor 3rd apart)



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The Minor II-V-I and II-V Progressions

Observation 2

- A minor II-V doesn't necessarily have to resolve to a minor chord
It can resolve beautifully to a major 7th chord as well

«What's new»

Musical score for "What's new" in G major (key signature of one sharp). The progression is Gø - C7alt - FΔ. The bass line consists of eighth-note patterns. The melody line includes a three-note figure over the Gø chord.

«Stella by starlight»

Musical score for "Stella by starlight" in C major (key signature of no sharps or flats). The progression is Cø - F7alt - B♭Δ. The bass line consists of eighth-note patterns. The melody line includes a three-note figure over the Cø chord.



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Other interesting topics

- Diminished scale harmony
 - *The Half-Step/Whole-Step Diminished Scale and the V7^{b9} chord*
 - *The Whole-Step/Half-Step Diminished Scale and the Diminished Chord*
- *Whole-Tone Scale Harmony*



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Slash chords

«What the World Needs Now is Love» - standard harmonization

A musical score for three chords: C6, A-7, and D7. The score consists of two staves. The top staff is in treble clef, 3/4 time, and has a key signature of one sharp. The bottom staff is in bass clef, 3/4 time, and has a key signature of one sharp. The first measure shows a C6 chord with a bass note. The second measure shows an A-7 chord with a bass note. The third measure shows a D7 chord with a bass note.

«What the World Needs Now is Love» - reharmonization with slash chords

A musical score for piano in 3/4 time. The top staff shows the treble clef and the bottom staff shows the bass clef. The score consists of seven measures. Measures 1-4 are grouped by a brace under the first four measures, with a '4' above it, indicating a four-measure phrase. The first measure contains a chord of F/Dflat. The second measure contains a chord of Eflat/B. The third measure contains a chord of F/Dflat. The fourth measure contains a chord of C/Aflat. The fifth measure contains a chord of Eflat/A. Measures 6-7 are grouped by a brace under the last two measures, with a '2' above it, indicating a two-measure phrase. The sixth measure contains a chord of C/B. The seventh measure contains a chord of D7.

- Definition of slash chord: "**a triad over a bass note**"



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Slash chords

- Which scale goes with which slash chord?

- None of the slash chords go with whole-tone scale harmony, because the triads in all these slash chords are major triads (they don't exist in whole-tone scale harmony)
- Most of the scales shown above are "C" scales, but
 - since F/C is just an F major triad in second inversion, you should play an F major scale
 - since A♭/C is an A♭ major triad in first inversion, you should play an A♭ major scale

C/C ¹⁸	C major and C Lydian
D♭/C	C Phrygian and C Locrian
D/C	C Lydian
E♭/C	C Dorian
E/C	C Lydian augmented
F/C	F major
G♭/C	C altered and C half-step/whole-step diminished
G/C	C major
A♭/C	A♭ major
A/C	C half-step/whole-step diminished
B♭/C	C Mixolydian
B/C	C whole-step/half-step diminished



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What have we learnt?

- Basic Theory
 - Intervals (minor, major, perfect, tritone, diminished, augmented) and inversions
 - Stacking intervals: triads and inversions
 - Modal scales and their role
 - Cadenzas and II-V-I and voice leading
 - Circle of fifths (determining signatures, identifying minors and majors, finding pivot chords...)
 - Other turnarounds: V of V; I-VI-II-V; III-VI-II-V; I-II-III-IV.
- Major Scale Harmony (MSH)
 - Duality between chords and scales (extensions and alterations)
 - Revising modes and related chords
 - Regular distribution of diatonic 4ths in a major scale (all perfect fourths except btw 4th and 7th, which is a tritone)



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What have we learnt?

- Melodic Minor Scale Harmony (MMSH)
 - More complex harmony: irregular distribution of diatonic 4ths in a major scale (four perfect fourths, two tritones, one major third)
 - Role of modes in MMSH is very different from that of major scale harmony
 - I → *Minor-major mode*
 - II → *Sus^{b9} chord*
 - III → *Lydian augmented chord*
 - IV → *Lydian dominant chord*
 - V → not used (slash chord)
 - VI → *half-diminished chord*
 - VII → *altered dominant chord*
 - *Interchangeability of Melodic Minor Chords (not applicable to MSH)*
 - No avoid notes in MMSH
 - MMSH has two dominant chords a tritone apart that resolve to the same chord
 - 3rd and 7th are not so important (unlike in MSH)
 - *Minor II-V-I and II-V progressions*
 - the chords of a minor II-V-I are derived from three different melodic minor scales!
 - A minor II-V can also resolve to a major 7th (Δ) chord

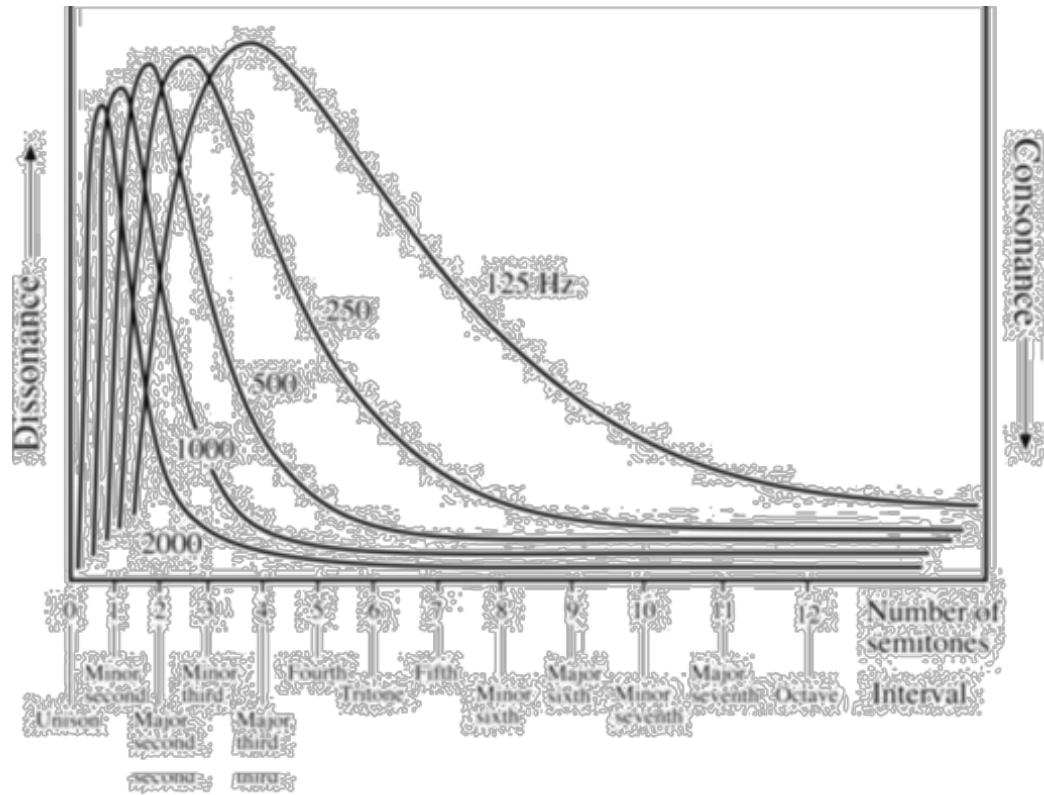
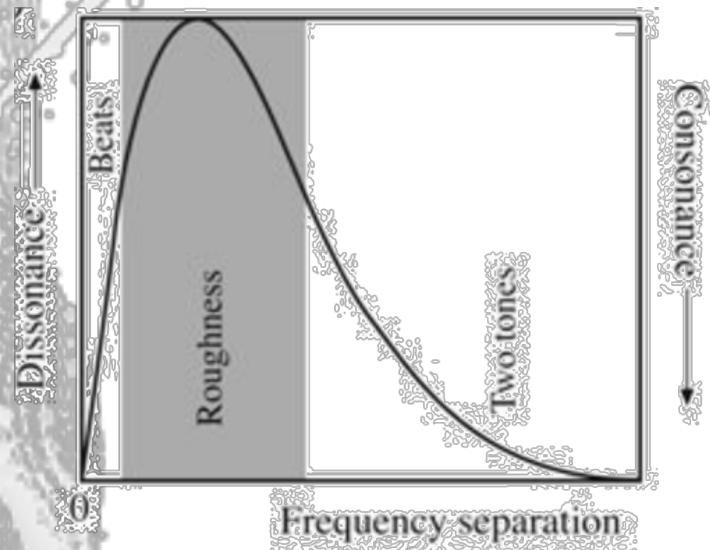


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Consonance and dissonance

Dissonance in the critical bandwidth



When the rate of musical beats exceeds about 20 Hz, they create an audible sensation of roughness. Once the frequency separation is large enough, we perceive two separate tones (left). The width and the position of the peak in the band of sensory dissonance depends on the absolute frequencies of the tones (right).

Consonance and dissonance

- This means that an interval that might be consonant in a high register, high up on the piano keyboard, may become dissonant in a lower register
- In other words, *there is no such thing as a tonally dissonant interval* – it all depends on where you play it, using high notes or low
 - In the mid-range of the piano, intervals of a minor third (three semitones) generally lie beyond the band of roughness, evading sensory dissonance. For high notes, even a semitone (minor second) interval does not create roughness. But in the bass, rather wide intervals can become rough, and even an interval like a perfect fifth that is considered highly musically consonant becomes dissonant in sensory terms. This explains the ‘gruffness’ of chords sounded low down with the left hand, and helps us understand why Western music almost universally shows voicings (combinations of notes) that become more widely spaced the lower they are sounded.
 - The left hand of a pianist will typically play voicings spanning almost an octave or more when the lowest note is around the octave below middle C, while it might include some fourths and fifths if this note is higher than the E below middle C. The right hand, meanwhile, merrily bangs out chords containing thirds and even seconds.



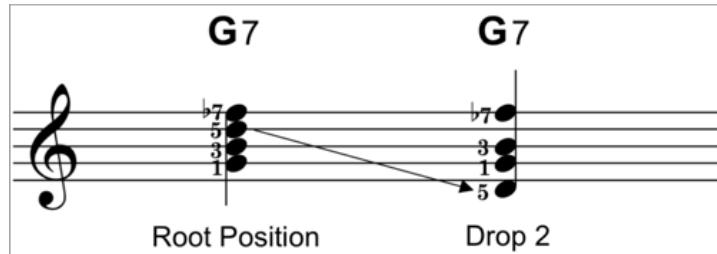
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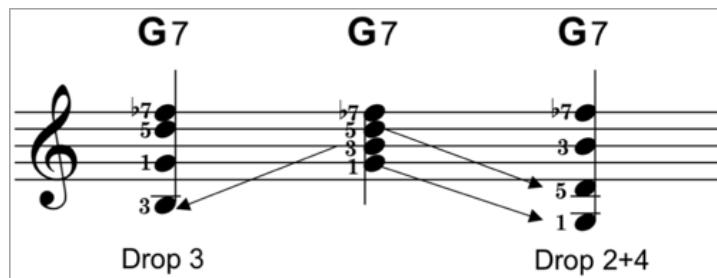
Voicings

Vertical spacing and ordering of the pitches in a chord is called voicing

- Simply stacking thirds is not a satisfying chord building method
- Former discussion on consonance and dissonance suggests to increase the spacing btw notes as you go lower on the keyboard
- Some well-known techniques
 - Drop 2:



- Drop 3 / Drop 2+4:



Voicings

Vertical spacing and ordering of the pitches in a chord is called voicing

- Simply stacking thirds is not a satisfying chord building method
- Former discussion on consonance and dissonance suggests to increase the spacing btw notes as you go lower on the keyboard
- Some well-known techniques
 - Leave out some of the chord tones (keep the chord recognizable)

The diagram illustrates two ways to voice a G9 chord. The first, labeled "G9", shows a standard stack of thirds: G (1), B (3), D (5), F# (7), and A (9). The second, labeled "G9(no 5th)", omits the fifth note (D) and instead includes the ninth note (A) as the lowest note, creating a more open sound.

often the tonic is left out along with the fifth (especially when the bass player is already taking care of that)





Digging deeper...

Substitutions



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Secondary Dominants, Extended Dominants, and the "II V" Progression

- You often hear about *chromaticisms*, which are non-diatonic tones added to music in the prevailing key
 - They are aural "outsiders"
 - They add strong colors to the music
 - They exhibit a tendency to resolve to diatonic neighbor tones
- How do chromatic notes create harmonic forward motion?



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Secondary Dominants, Extended Dominants, and the "II V" Progression

Consider each of these three phrases

The image shows three musical phrases, labeled a), b), and c), in G major. Each phrase consists of two measures. The first measure contains a G major chord (G-B-D) and a D major chord (D-F#-A). The second measure contains a G major chord (G-B-D) and an E major chord (E-G#-B). The bass line is simple, showing quarter notes on the D string.

if we change a single note in the second chord, our expectations change dramatically

The image shows three musical phrases, labeled a'), b'), and c'), in G major. The first two measures are identical to the original phrases. In the third measure, the second chord is changed: a) changes the G to a G#, b) changes the G to a G, and c) changes the G to a G. This creates a secondary dominant chord (E7) which provides a strong sense of resolution back to the primary dominant (G7).

This has a strong sense of resolution

By changing the G to a G#, we change the interval structure of the E7 chord

The interval between D and G# is now an augmented fourth (a tritone), so E7 has an interval structure identical to the primary dominant of the key, G7



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Secondary Dominants, Extended Dominants, and the "II V" Progression

By changing the G to a G#, we change the interval structure of the E-7 chord

The interval between D and G# is now an augmented fourth (a *tritone*), so E7 has an interval structure identical to the primary dominant of the key, G7

The diagram shows three musical examples (a), (b), and (c) on a staff. A brace on the left indicates 'E7 as a Secondary Dominant'. The staff has a treble clef and a common time signature.

- a)** Shows an E7 chord (B,D,G,B) followed by a III-7 chord (C,E,G,B) and a VI-7 chord (A,C,E,G). An arrow points from the B of the E7 to the G of the III-7, labeled 'P4' (Perfect Fourth).
- b)** Shows an E7 chord (B,D,G,B) followed by a chord labeled '???'. An arrow points from the B of the E7 to the G# of the '???' chord, labeled 'Tritone'.
- c)** Shows an E7 chord (B,D,G,B) followed by a V7 chord (G,B,D,F#) and an I chord (C,E,G,B). An arrow points from the B of the E7 to the F# of the V7, labeled 'Tritone'.

- That dominant quality, with G# as a leading tone, creates an expectation of resolution to A-7
- E7 functions as a secondary dominant, the V7 chord of the VI-7 chord
- It is referred to as the V7/VI
- Secondary dominants are dominant chords that create an expectation of resolution down a fifth to a diatonic target other than the tonic**



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Secondary Dominants, Extended Dominants, and the "II V" Progression

- The momentary focus that secondary dominants bring to their diatonic target chords gives those chords a heightened priority in a progression
- **Secondary dominants are strongly key-related.** Their function is to draw the listener's attention to a diatonic chord by advertising its arrival
- Their use does not mean we have left the key, even temporarily. If anything, the sense of relief associated with the normal resolution of a secondary dominant only reaffirms the original key identity



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Secondary Dominants, Extended Dominants, and the "II V"

Progression

- it is helpful to think of secondary dominants as chromatically altered diatonic chords
- This focuses the attention on how the temporary leading tone resolves to the target chord

Diatonic Progression

VI-7 Altered to become the V7/II:
A-7 becomes A7

- The new chord functions as V7/II ("V7 of II"): the V chord of the II-7 chord.
- Changing the tonic function VI-7 chord into a dominant-quality chord destabilizes the harmony.
- The A7 chord creates a stronger sense of forward motion to II-7 on the downbeat of measure 2.



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MAJOR KEY SECONDARY DOMINANTS

- **V7/II**

- The VI-7 chord is altered by raising the minor third

A musical staff in G clef and common time. It shows four chords: VI-7, IMaj7, V7/II, and II-7. The first chord has a bass note on the A string and a G7-like upper structure. The second chord has a bass note on the D string and a C major-like upper structure. The third chord has a bass note on the G string and a B7-like upper structure. The fourth chord has a bass note on the C string and an A7-like upper structure. An arrow points from the V7/II chord to the II-7 chord.

- **V7/III**

- The VII-7 \flat 5 chord is altered by raising the minor 3 and diminished 5

A musical staff in G clef and common time. It shows four chords: VII-7 \flat 5, IMaj7, V7/III, and III-7. The first chord has a bass note on the E string and a D7-like upper structure. The second chord has a bass note on the A string and a C major-like upper structure. The third chord has a bass note on the D string and a B7-like upper structure. The fourth chord has a bass note on the G string and an A7-like upper structure. An arrow points from the V7/III chord to the III-7 chord.



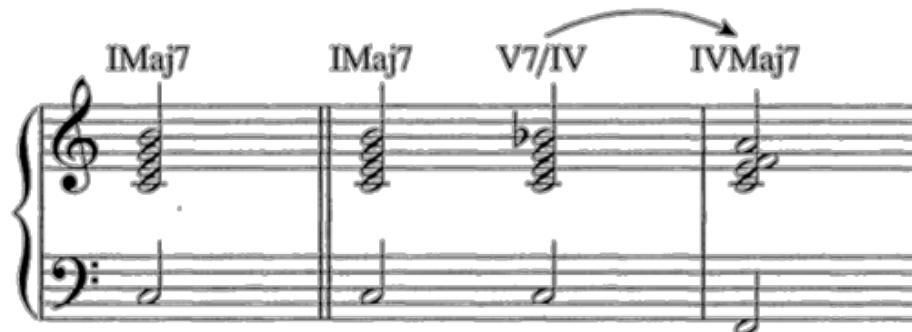
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MAJOR KEY SECONDARY DOMINANTS

- **V7/IV**

- The IMaj7 chord is altered by lowering its 7



- **V7/V**

- The II-7 chord is altered by raising its minor 3



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MAJOR KEY SECONDARY DOMINANTS

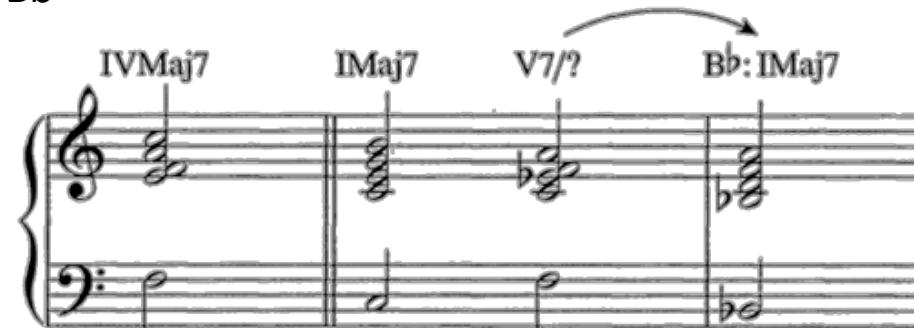
- **V7/VI**

- The III-7 chord is altered by raising its minor 3
 -



- **V7/bVII?**

- If we lower degree 7 of IVMaj7 to create a dominant seventh chord, the resulting resolution would take us to the key of Bb



despite its diatonic root, the alteration does not result in a secondary dominant!



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Extended Dominants

- **Extended Dominant:** A string of three or more dominant chords that start on a strong harmonic stress point, and progress, one to the next, by descending perfect-fifth root motion

F#7 B7 E7 A7 D7 G7 CMaj7

S W S W S W S

Ex.: «I got rhythm» - Gershwin



(3) D7 G7 C7 F7



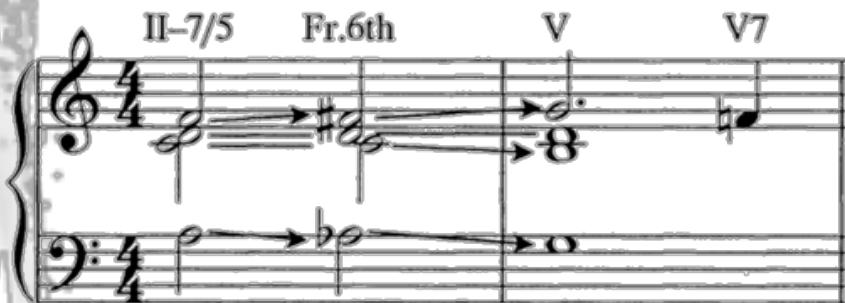
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Substitute Dominants: «SubV's»

- *tritone substitution*: replace one dominant chord with another dominant chord that shares the same tritone
 - The chord that replaces the original is called a *substitute dominant*, or simply a *subV*
- The substitute dominant originates from the augmented sixth chords of classical music. There are three different types of augmented sixth chords: Italian, French, and German. The sound of the French sixth is the closest to the jazz substitute dominant



- The tritone targets the root and 3 of the V7
- The bass slips downward by a half step to the root
- The interval between the bass and soprano of the French sixth is an augmented sixth:
 - Ab to F#
- The root is a common tone with the 5 of the V chord



Substitute Dominants: «SubV's»

- In music rooted firmly in the diatonic scale, the chromaticism of augmented sixth chords created an exotic sounding link to the V chord. Eventually, composers in the early 19th century began to use them as a colorful alternative to secondary dominants targeting functions other than V

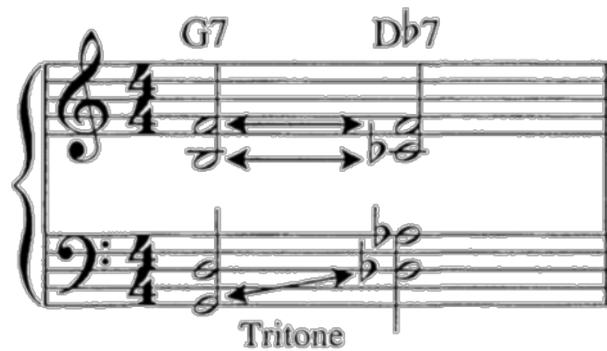
II-7 V7 IMaj7 II-7 Fr.6th V7b5/b5 IMaj7

French Sixth Chord as Secondary Dominant

Substitute Dominants: «SubV's»

- **Tritone equivalence or invariance:** *every dominant chord has a potential mirror image that shares the same tritone but has a different root*
 - Tritone equivalence allows us to freely replace one root with the other, as long as the tritone remains invariant
 - The distance between the root notes of each of these pairs is also a tritone
 - This has major implications for introducing a new level of chromatic freedom and color into a progression:

Any dominant function chord-primary, secondary, or extended-can be replaced by a substitute dominant



Db7 as the SubV of G7



SUBSTITUTE SECONDARY DOMINANTS AND THEIR RELATED II'S

- Each major key has six subV's: one for the primary dominant and each of the five secondary dominants
 - Just as the subV resolves down a half step to the target, it is preceded by a related II a half step higher
 - This creates a descending chromatic root motion from inside the key-out of the key-back into the key

The diagram illustrates a musical progression across two staves. The top staff is in G major (G-C-E-G) and the bottom staff is in C major (C-E-G-C). The progression is as follows:

- II-7 (D7) in G major
- subV (Db7) in G major, connected by a dashed bracket to the II-7 above it.
- IMaj7 (Cmaj7) in G major, indicated by a dashed arrow pointing to the subV chord.
- D-7 (D7) in C major
- Db7 (Dbb7) in C major, connected by a dashed bracket to the D-7 above it.
- CMaj7 (Cmaj7) in C major, indicated by a dashed arrow pointing to the Db7 chord.

Dashed brackets connect the II-7 and subV in G major, and the D-7 and Db7 in C major. A dashed arrow points from the IMaj7 in G major to the Db7 in C major, and another dashed arrow points from the CMaj7 in C major back to the Db7 in C major.

- the dashed bracket shows the relationship between related II and subV
- The dashed arrow indicates resolution to the expected target chord



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SUBSTITUTE SECONDARY DOMINANTS AND THEIR RELATED II'S

- **SubV/II**

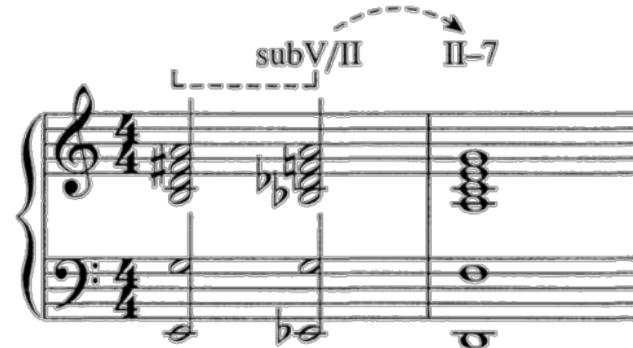
- B7 is the substitute secondary dominant of A7, the V7/II in the key of C

Eb7 as SubV/II



B7 introduces not just one, but three chromatic tones into the phrase, dramatically increasing the amount of color and harmonic tension

III-7 SubV/II II-7 with Tensions



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SUBSTITUTE SECONDARY DOMINANTS AND THEIR RELATED II'S

- SubV/IV

G_b7 as SubV/iV

A musical staff in G clef and common time. It shows two chords: G_b7 (G, B, D, G_b) and G major (G, B, D). A dashed arrow points from the G_b7 chord to the label "subV/IV". Another dashed arrow points from the G major chord to the label "IVMaj7".

Related II, SubV/IV, IVMaj7 with Tensions

A musical staff in G clef and common time. It shows three chords: G_b7 (G, B, D, G_b), G major (G, B, D), and G major (G, B, D). The first G major chord has a flat sign below it, indicating it is a tensioned second inversion chord. The second G major chord has a sharp sign below it, indicating it is a tensioned dominant chord.



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SUBSTITUTE SECONDARY DOMINANTS AND THEIR RELATED II'S

- SubV/V

Ab7 as SubV/V

Musical staff in G major (4/4 time). The progression is: VI-7 (Dm7), subV/V (Ab7), and V7 (E7). The Ab7 chord is highlighted with a dashed bracket under the staff, labeled "subV/V". A dashed arrow points from the Ab7 chord to the V7 chord.

VI-7, SubV/V, V7sus4, V7 with Tensions

Musical staff in G major (4/4 time). The progression is: VI-7 (Dm7), subV/V (Ab7), V7sus4 (E7sus4), and V7 (E7). The chords are shown with various voicings and tensions indicated by different note heads and stems.



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SUBSTITUTE SECONDARY DOMINANTS AND THEIR RELATED II'S

- **SubV/III**

- In the key of C, B7 (V7/III) can be replaced by F7: subV/III

F7 as SubV/III

- The substitute secondary dominant for V7/III is potentially confusing because:
 - It is the only major key substitute dominant that has a diatonic root. (Secondary dominants all have diatonic roots; based on that characteristic, subV/III might appear to belong to that functional group.)
 - It is superficially identical to the IV7 chord found in the blues
 - In its triadic form, it is the subdominant chord of the key
- These factors create a strong prejudice toward hearing subdominant function for dominant chords built on scale degree 4. Nevertheless, it *is* a half step above III-7, and can resolve there



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SUBSTITUTE SECONDARY DOMINANTS AND THEIR RELATED II'S

- **SubV/VI**

- In the key of C, Bb7 is generally used as a modal interchange chord from the parallel minor key. It performs a subdominant function that most often leads back to IMaj7 in the majority of chord progressions
- Although subV/VI has a non-diatonic root, it is similar to subV/III in that it functions most clearly when it is:
 1. prepared by a diatonic related II chord
 2. has a shorter duration compared to that of the prevailing progression
 3. is interpolated between a secondary dominant and the target chord
- So when this chord is preceded by VII-7b5, the descending chromatic root motion causes us to expect VI-7

Bb7 as SubV7/VI

Sub V7/VI and Related II with Tensions



Chord substitution

- A **chord substitution** consists of replacing a chord with another one so that it functions like the original one
- Chord substitutions are used to create variety and add interest to a piece
 - The substitute chord must have some harmonic quality and degree of function in common with the original chord, and often only differs by one or two notes
 - Usually substituted chords possess two pitches in common with the triad that they are replacing
 - E.g. Tritone substitution preserve third and seventh
 - in the simple chord progression I-ii-V-I, which in the key of C Major would be the chords C Major - D minor - G Major - C Major, a musician could replace the I chords with "tonic substitutes", the most widely used of which are iii and vi (in a Major key), which in this case would be the chords e minor and a minor.
 - This simple chord progression with tonic substitutes could become iii-ii-V-vi or, with chord names e minor - d minor - G Major - a minor



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Chord substitution types

- The **ii-V substitution** is when a chord or each chord in a progression is preceded by its supertonic (ii7) and dominant (V7), or simply its dominant
 - E.g. a C major chord would be preceded by Dm7 and G7



The notation illustrates the ii-V substitution. In the first progression, a C major chord (I) is followed by an F major chord (IV). In the second progression, the C major chord (I) is preceded by a Dm7 chord (V/IV), and the F major chord (IV) is preceded by a G7 chord (V7/I).

The final two chords in the first progression are each preceded by their dominants in the second progression

- **Chord quality substitution** is when the quality of a chord is changed, and the new chord of similar root and construction, but with one pitch different, is substituted for the original chord
 - E.g. the minor sixth for the major seventh, or the major seventh for the minor



The notation shows a progression of chords: D7, D_b7, CM7, and C6. This represents a substitution where a major seventh chord (D7) is replaced by a minor sixth chord (D_b7), and a minor seventh chord (CM7) is replaced by a major sixth chord (C6).

*ii7-subV7-IM7-I6
progression*

Chord substitution types

- The **diminished seventh chord** is often used in place of a dominant 7th chord
 - In the key of A Major the V chord, E dominant 7th (which is made up the notes E, G#, B, and D) can be replaced with a G# diminished seventh chord (G#, B, D, F). If the diminished seventh chord (G#) is followed by the I chord (A), this creates chromatic (stepwise semitonal) root movement, which can add musical interest in a song mainly constructed around the interval of the fourth or fifth
- The **diminished seventh chord on the sharpened second scale degree, $\sharp\text{II}^07$** , may be used as a substitute dominant
 - E.g. in C: $\sharp\text{II}^07 = \text{D}\sharp-\text{F}\sharp-\text{A}-\text{C}\natural \leftrightarrow \text{B}-\text{D}\sharp-\text{F}\sharp-\text{A} = \text{VII}^7$

A musical staff in G major (one sharp) shows three chords: D-7 (D, F, A, C), B°7 (B, D, F, A), and CΔ (C, E, G, B). The chords are stacked vertically.

vii⁰7 as dominant substitute

A musical staff in G major (one sharp) shows three chords: D-7 (D, F, A, C), G7 (G, B, D, F), and CΔ (C, E, G, B). The chords are stacked vertically.

#II⁰7 as dominant substitute



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Chord substitution types

- **Tritone substitution:** the substitute chord only differs slightly from the original chord. If the original chord in a song is G7 (G, B, D, F), the tritone substitution would be Db7 (Db, F, Ab, Cb)
 - Note that the 3rd and 7th notes of the G7 chord are found in the Db7 chord (albeit with a change of role)



Play ii-subV-I in C, which creates the chromatic root movement D - Db - C



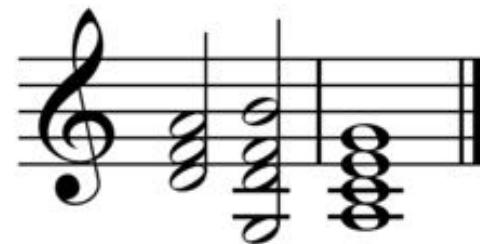
Contrast with the original ii-V-I progression in C

Chord substitution types

- **Tonic substitution** is the use of chords that sound similar to the tonic chord (or I chord) in place of the tonic
 - In major keys, the chords iii and vi are often substituted for the I chord, to add interest



iii⁷ as tonic substitute



vi⁷ as tonic substitute

Chord substitution types

- ***Relative major/minor substitution*** shares two common tones and is so called because it involves the relation between major and minor keys with the same key signatures, such as C major and A minor
 - The augmented triad on the fifth scale degree may be used as a substitute dominant, and may also be considered as $\flat\text{III}^+$
 - E.g. in C: $V^+ = G-B-D\sharp$, $\flat\text{III}^+ = E\flat-G-B\sharp$, and since in every key: $D\sharp = E\flat$
 - The chord a minor third above, $\flat\text{VII}^7$, may be substituted for the dominant, and may be preceded by its ii: iv7
 - Due to common use the two chords of the backdoor progression ($\text{IV}^7-\flat\text{VII}^7$) may be substituted for the dominant chord
 - In C major the dominant would be G7: GBDF, sharing two common tones with B \flat 7: B \flat DFA \flat . A \flat and F serve as upper leading-tones back to G and E, respectively, rather than B \sharp and F serving as the lower and upper leading-tones to C and E



$\flat\text{III}^+$ as dominant substitute

A musical staff in treble clef showing three chords. The first chord is D7 (D-A-F-D). The second chord is G7 (G-B-D-F) with an F7 (F-C-G-F) underneath it, indicated by a brace. The third chord is C major (C-E-G-C). The G7 chord is underlined with a brace.

Backdoor ii-V in C: $\text{IV}^7-\flat\text{VII}^7-\text{I}$

Role of chord substitutions

- Chord substitutions are used by composers and arrangers
 - Composers may use chord substitutions when they are basing a new jazz tune on an existing chord progression from an old jazz standard or a song from a musical
 - Arrangers may use chord substitutions in their arrangement of a tune, to add harmonic interest or give a different "feel" to a song
 - Instrumentalists may use chord substitutions in their performance of a song to personalize it or react to other musician's stimuli



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Modeling harmonic surprise



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Modeling harmonic surprise

- Repetition is often pointed out as the main process governing music production and perception
 - “Repetition breeds content”, as the proverb says, and experimental psychology has long shown the importance of repetition in musical cognition, since the early stages of musical development (Deliege & Sloboda, 1995)
 - However, purely repetitive music also brings boredom, and surprise plays as central a role in musical perception as repetition.
 - It is our ability and desire to be surprised that drives us to listen to music, and also pushes us to discover new musical styles
 - Both composers and listeners look for some compromise between repetition and surprise
 - there seems to be an “ideal” position between prototypicality and deviance, similarity and difference, repetition and surprise



Modeling harmonic surprise

- Understanding surprise is a key to musical cognition
- Surprise may occur at all levels of musical structures: rhythm, melody, harmony, and even timbre
- For surprise to occur, there needs to be strong expectations built and deceived
 - strong expectations are the result of long exposure to musical material in a given style
 - How do we model the mechanisms by which expectations are created, fulfilled, disappointed or surpassed? How do we «achieve» surprise?
- We focus here on harmonic surprise
 - there is something specific to harmonic surprise because harmony involves high-level combinatorial structures



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Modeling harmonic surprise

- Models in the literature are usually based on classical harmony involving only triads
- Although Jazz harmony comes from Classical harmony from an evolutionary viewpoint, the harmonic functions of chords are much more complex than in classical four-part chorals, because of the underlying combinatorial “game” at play
 - in the context of C major, classical theories would consider a F# chord as the most “distant” possible tonal context, while in Jazz a C(7) and F#(7) are closely related and often interchangeable (tritone substitution)
 - Another distinction made in Classical four-part choral music is between a pure C major chord (playing a role of, say, a stable first degree) and a C7 chord (playing the role of an unstable dominant seventh tending to resolve to F). In Jazz CΔ and C7 are clearly distinguished while in Classical music the difference is often a bit blurred



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Jazz Chord Sequences

- chords allow the accompanists to play along, by giving the necessary harmonic information,
- chords are also useful for the soloist, as they give indications on which scales may be used for improvisation
- chords are so important that often, this is the only information shared by the different players
- This is why they are gathered in special collections such as the Real Book (1981), the Fake book (1983) containing over 2000 Jazz chord sequences
- Chords can be easily encoded

bluesForAlice

F | E halfDim7 / A 7 | D min / G 7 | C min / F 7 | Bb 7 | Bb min / Eb 7
| A min | Ab min / Db 7 | G min 7 | C 7 | F 7 | G min / C 7 |

Blues For Alice

By Charlie Parker

The score is for three voices: soprano saxophone, alto saxophone, and bassoon. The key signature changes throughout the piece, indicated by handwritten markings above the staff. The tempo is 125 BPM.



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Notation

- Chords are represented as a couple {pitch class, structure}
 - Pitch classes are one of the possible pitch classes (e.g. A, B, C, ..., A#, B#, etc.)
 - The structure is a string representing the harmonic content of the chord
 - The structure allows a musician to infer exactly the list of notes making up the chord
 - Typical structures are:
 - min (a minor chord)
 - maj7 (a major seventh chord)
 - 7 (a dominant seventh chord)
 - aug5 7 9 (a seventh chord with augmented fifth and perfect ninth)
 - ...
- Temporal sequences of chords
 - We assume that we have only 4/4 tunes, and each measure contains either 1, 2, 3 or 4 chords
 - Temporal information is represented by the following separators:
 - "," indicates the separation between the first and second beat
 - "/" between the second and third beat
 - ";" between the third and fourth beat
 - "|" separates two 4 beat measures



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Notation

bluesForAlice

F | E halfDim7 / A 7 | D min / G 7 | C min / F 7 | Bb 7 | Bb min / Eb 7
| A min | Ab min / Db 7 | G min 7 | C 7 | F 7 | G min / C 7 |

Marmaduke

G min 7 | G min | G min | G min / C 7 | F | G min / C 7 | F | A min / D
| G min | G min | G min | G min / C 7 | F | G min / C 7 | F | F |
C min | F 7 | Bb | Bb | G 7 | G 7 | G min | C 7 | G min | G min |
G min | G min / C 7 | F | G min / C 7 | F | A min / D 7 |

NowsTheTime

F 7 | F 7 | F 7 | F 7 | Bb 7 | Bb 7 | F 7 | D 7 | G min | C 7 | F 7
| C 7 |

ornithology

G 7 | G | G min | C 7 | F | F | F min | Bb 7 | Eb 7 | A halfDim7 / D
| G min | D 7 aug9 | B min | E 7 | A min | D 7 | G | G | G min |
C 7 | F | F | F min | Bb 7 | Eb 7 | A halfDim7 / D 7 | G | G | G | B
min / E 7 | A min / D 7 | G / E 7 | A min / D 7 |

Examples of Jazz chord sequences (all by Charlie Parker)



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Patterns of Chord Sequences

- Jazz Chord sequences exhibit regularities which create deep expectations of continuations
- Many of these regularities come from classical music, and are governed by the mechanism of resolution: a seventh chord creates an expectation of its resolution
- This expectation is even stronger when the seventh chord is duly prepared. For instance, a sequence such as : C / A min 7 | D min 7 / G 7 (I-VI-II-V) will most probably create an expectation of a C major chord to occur next, in a trained western tonal ear



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Patterns of Chord Sequences

- Jazz music also includes a multitude of musical structures of its own
 - II-V-I structure: indicates a sequence of three chords such as (D min 7 / G 7 | C) which is typical of Jazz standards
 - So-called *turnarounds* such as I-VI-II-V (C / A 7 | D min 7 / G 7) are other examples of typical pattern of chords
 - Tritone pattern such as C | F#7 | F are also very frequent in Jazz (much less in Classical music)



Chord Substitution Rules

- One important characteristic of Jazz harmony consists in twisting an existing piece to make it sound different, within certain limits, so that it is still recognizable, without being always the same
- This is based on a set of chord substitution rules, such as:
 - **Repetition:** C → C / C
repeated the same chord multiple times in the same time slot
 - **Enrichment of chords**
replace simple chords by more complex chords, built by adding extra notes to basic chords.
For instance, a C seventh chord will often be replaced by a more complex C 7 9 11.
Similarly, a C minor triad will be often replaced by a C min 7 9 (5 notes)



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Chord Substitution Rules

- Examples of chord substitution rules:
 - **Relative minor**
It reflects the equivalence between major and relative minor chords, which share almost the same note set
E.g. C → A min
 - **Tritone Substitution**
This rule is probably the most characteristic rule of Jazz. It states an equivalence between seventh chords and their tritone. The rule can be explained in terms of classical harmony (although, these two chords are opposed in the circle of fifths, they share the same third and seventh)
C 7 → F# 7
 - **Preparation**
allows one chord to be replaced by two or more chords
Preparation by Seventh: C → G 7 / C
Here the rule allows any chord to be prepared by its seventh chord. This increases the feeling of progression, without creating new harmony
Another but somewhat equivalent kind of preparation is with a minor seventh chord:
Preparation by Minor Seventh: G 7 → D min 7 / G 7



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Chord Substitution Rules

- Examples of chord substitution rules:

- **Transition to Fourth chord**

This rule introduces fourth chords in sequences. Fourth chords are stable chords which stress the tonality of the replaced chord. The rule can be stated as follows: C7 → C7 / F

- **Back propagation of seventh**

This is a more complex rule dealing with back-propagation of seventh chords. The rule does not modify the sequence *per se*, but only its temporal structure. It states that a seventh chord can somehow move backward in time, thereby stressing its role of preparation by anticipating its occurrence: X X C7 Y → X C7 Y Y

- **Left Deletion**

Finally, some chords may be occasionally deleted, once again without changing the harmonic content. This is typically the case after the preceding rule has been applied

Left Deletion of Seventh: X C7 → X X

- These represent just a set of the most important chord substitution rules needed to create chord sequences and it is not exhaustive

Chord Substitution Rules

- these rules can be combined in a recursive and combinatorial fashion

Example #1: Chromatic descent from a basic Blues structure

C | F | C | C7 | F

This simple sequence can be modified by using chord substitution to create a much more harmonically interesting sequence (a chromatic descent with alternating minor seventh and seventh chords):

C | B min 7 / A# 7 | A min 7 / G# 7 | G min 7 / F# 7 | F ...

C | F | C | C7 | F ...

with (Preparation by Minor Seventh):

C | F | C | G min 7 / C7 | F ...

with rule (Tritone Substitution):

C | F | C | G min 7 / F#7 | F ...

with rule (Preparation by Seventh):

C | F | C | D 7, G min 7 / F#7 | F ... with rule (Back Propagation of Seventh):

C | F | C / D 7 | G min 7 / F#7 | F ... with rule (Left Deletion):

C | F | D 7 | G min 7 / F#7 | F ...

The same sequence of rules is applied on the D7 chord, with rules (Preparation by Minor Seventh), (Tritone Substitution), (Preparation by Seventh), (Back Propagation of Seventh) and (Left Deletion), to yield:

C | F / E 7 | A min 7 / G# 7 | G min 7 / F#7 | F ...

Finally the same rules are applied on the E 7 chord to obtain the target chord sequence

Chord Substitution Rules

Example #2: *Turnarounds*

A *turnaround* is a typical short Jazz sequence of chords, whose function is to replace a first degree chord followed by its seventh (e.g. C | G 7)

The simplest turnaround is probably the following:

(Turnaround #1) C / A 7 | D min 7 / G 7

This turnaround may be obtained simply by applying the following chord substitution rules, starting from C | C| C (3 measures):

C | C | C
C | G 7 / C | C
C | D min 7 / G7 | C
C | A7, D7 / G 7 | C
C / A 7 | D min 7 / G 7 | C

with rule (Preparation with Seventh):
with rule (Preparation with Minor):
with rule (Preparation with Seventh):
with rule (Back Propagation of Seventh):
QED.

Chord Substitution Rules

Example #2: Turnarounds

A variations of this turnaround, proposed by Bill Evans is:

(Turnaround #2) C / Eb 7 | Ab 7 / Db maj7

In this case it is impossible to obtain it from our chord substitution rules. The best approximation we can get is the following:

C		C		C
C		C		G7 / C
C		G7		C
C		D7 / G7		C
C		A7, D7 / G7		C
C	/	A7		D7 / G7 C
C	/	D#7		D7 / G7 C
C	/	D#7		G#7 / G7 C
C	/	D#7		G#7 / C#7 C
C	/	Eb7		Ab7 / Db7 C

with rule (Preparation with Seventh):
with rule (Back Propagation of Seventh):
with rule (Preparation with Seventh):
with rule (Preparation with Seventh):
with rule (Back Propagation of Seventh):
with rule (Tritone Substitution):
with rule (Tritone Substitution):
with rule (Tritone Substitution):
which is equivalent to:



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Chord Substitution Rules

Example #2: *Turnarounds*

Bill Evans' turnaround cannot be cleanly obtained by applying the rules: one needs to polish by hand by replacing the last chord (Db 7) by a Db maj 7 chord

The problem could be solved by adding a rule such as

$$C\ 7 \rightarrow C\ \text{maj}7$$

but doing so would create a lot of sequences which do not make sense in the context of Jazz

A more proper way to solve the problem is to introduce a “2 by 2” rule such as:

$$G\ 7 / C \rightarrow D\flat\ \text{maj}7 / C$$

which does make sense musically



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Chord Substitution Rules

Example #2: Turnarounds

With such a rule, the derivation would be quite different:

c | c | c
c | c | G7 / c

c | G7 | c

c | Db maj7 | c

c | Ab 7 / Db maj7 | c

c | Eb 7; Ab 7 / Db maj7 | c
c / Eb 7 | Ab 7 / Db maj7 | c

with rule (Preparation with Seventh):
with rule (Back Propagation of Seventh):
with rule (Neapolitan Sixth):
with rule (Preparation with Seventh):
with rule (Preparation with Seventh):
with rule (Back Propagation of Seventh):

However, although such a rule makes sense, this shows the limit of a manually built rule set: how can one be sure that the set of rules is consistent, sound, or complete?

What is surprising here is the appearance of a C# min 7 chord in the context of C 7, which is, harmonically, quite out of the scope of the traditional harmonies supported by C 7 (i.e. in Jazz, either F, G or C). However, the “surprise” is relative to the knowledge of the underlying chord substitution rules, and the ability to combine them in various ways

Chord Substitution Rules

Observations:

- an ear trained only by detecting patterns, i.e. recurring subsequences of data, would take much longer to accept this kind of sequence than an ear able to learn and use chord substitution rules
- This shows that learning Jazz harmonies involves more than learning simple patterns. The combinatorial aspect of Jazz harmony, formalized here as chord substitution rules, accounts for a large part in the perception of Jazz chord sequences



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Extracting Patterns from Chord Sequences

- **Lempel-ziv applied to chord sequences**

- The Lempel-Ziv (LZ) data compression algorithm uses an efficient one-pass pattern detection mechanism in order to build a dictionary of substrings
- We can use its pattern detection and representation scheme for the purpose of sequence generation. We can do so by using only chord sequences as input (ignore time evolution)
- The LZ parsing algorithm parses a sequence sequentially into distinct phrases, such that *each phrase is the shortest string which is not a previously parsed phrase*. From the Lempel-Ziv dictionary we derive the LZ-tree, whose nodes represent possible substrings. The sons of the nodes represent the possible continuations of the substring. By construction, the inverse of the number of sons is the probability of occurrence of the substring.
- In order to use this scheme to make prediction and model surprise, we can design the following procedure:
 - at each step, the sequence being built is compared to the tree.
 - First the whole sequence is considered, and possible continuations are looked for.
 - Then the process is iterated with the subsequence starting from the second element, and so forth until the last one.
 - The result is a list of possible continuations sorted according to two criteria:
 1. length of the subsequence
 2. weight of the continuations



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Extracting Patterns from Chord Sequences

- ***Expectation and surprise***

- Information theory yields a good **definition of expectation**: the most expected item is obtained by taking the longest possible subsequence for which there is a possible continuation, and choosing the continuations with the highest probability.
- However, there is **no such a simple canonical definition for surprise**. There are several ways to define surprise in the context of our sequences:
 - simplest way is to define surprise: “the least expected item considering the shortest substring, i.e. the last element”
 - Alternate definition: “the least probable item for the longest substring”
 - Pachet opted to choose the last item of the list, i.e. the least expected element considering the shortest substring. By definition, this element is not a possible continuation of any longer substring, so it yields a surprise which is unrelated to the past. He called the first element of this list called “E” (as most expected), and the last element “S” (as most surprising)



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Extracting Patterns from Chord Sequences

- ***Learning chord changes instead of chords***

Instead of learning chord sequences, we choose to learn sequences of chord changes.

This allows us to bypass the problem of transposition:

the two following sequences are equivalent, once transposed:

C | F maj7 | D min 7 / G 7

E | A maj7 | F# min 7 / B 7

However, it is difficult to normalize chord sequences, as this would require knowing the tonality (which requires complex harmonic analysis)



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Extracting Patterns from Chord Sequences

- ***Learning chord changes instead of chords***

To solve this problem, we can focus on learning sequences of **chord transitions** (pairs of chords whose first chord is in C)

e.g. the chord transition sequence corresponding to:

E | A maj7 | F# min 7 | B 7

is:

(C : F maj7) | (C maj7 : A min 7) | (C min 7 : F 7)

The Lempel-Ziv tree represents therefore the possible continuations of a given chord transition, or chord transition subsequence



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Extracting Patterns from Chord Sequences

- ***Learning chord changes instead of chords***

LZ tree of chord transitions

consider the starting sequence: C min | F 7

list of sorted possible continuations

given by the sorted LZ-tree for this sequence

```
-- past size = 1
C 7:F min
C 7:F 7
C 7:F
C 7:F# min 7
C 7:G min
-- past size = 0
C 7:C 7
C 7:C min
C 7:G 7
C 7:F# halfDim7
C 7:F# min
C 7:D min
C 7:A 7
```

```
C :C
---C :C min
-----C min:F 7
C :C min
---C min:F 7
C min:F 7
---C 7:F 7
---C 7:F min
-----C min:F 7
-----C 7:F 7
-----C min:C min
---C 7:F
-----C :D min
-----C min:F 7
-----C :E min
-----C :C
-----C :A 7
---C 7:G min
---C 7:F# min 7
C 7:F
---C :C
-----C :E min
---C :A 7
---C :D min
---C :E min
C 7:F# halfDim7
---C halfDim7:F 7
C halfDim7:F 7
---C 7:F min
C 7:F min
---C min:F 7
-----C 7:F 7
C min:G aug9
C aug9:A min
C 7:F 7
---C 7:D min
C min:C min
---C min:C min
-----C min:F 7
-----C min:C min
C :G min
C 7:C 7
---C 7:C 7
---C 7:F 7
---C 7:G 7
C 7:C min
---C min:F 7
C 7:A 7
C 7:G 7
C :B halfDim7
C 7:F# min
C min:Cb min
C min 7:F 7
```

Extracting Patterns from Chord Sequences

- ***Surprise and expectation***

- produce sequences according to two different schemes of surprise and expectations from the starting sequence and the learned LZ-tree
 - The first one is a series of “most expected” chords only (represented as the sequence “eeeeee”)
 - The second one is a series of “most expected” with two surprises inserted (“eseese”)

Example #1, only most expected chords:

C min 7 | F 7 | Bb min | Eb 7 | Ab 7 | Bb min | Eb 7 | Ab min
e e e e e e e

Example #2, introducing surprise:

C min | F 7 | D 7 | G min | C 7 | A 7 | D min | G 7
e s e e s e e

Extracting Patterns from Chord Sequences

- ***Surprise and expectation***

- The corresponding harmonic progressions effects are indeed quite satisfactory, musically speaking: the system has “learned” about *two-five-one* transitions, and is able to complete sequences by resolving seventh chords. The surprise (transition from F 7 to D 7) is of course not very surprising for a trained ear but quite novel considering this stage of learning
- After learning the whole corpus of chord sequences, the results are the following:

Example #1:

C min F 7 Bb C min F 7 F min Bb 7 Eb
e e e e e e e

Example #2:

C min F 7 F# min 7 B 7 E 7 F min 7 Bb 7 Eb
e s e e s s e



Applications

Harmony and harmonization



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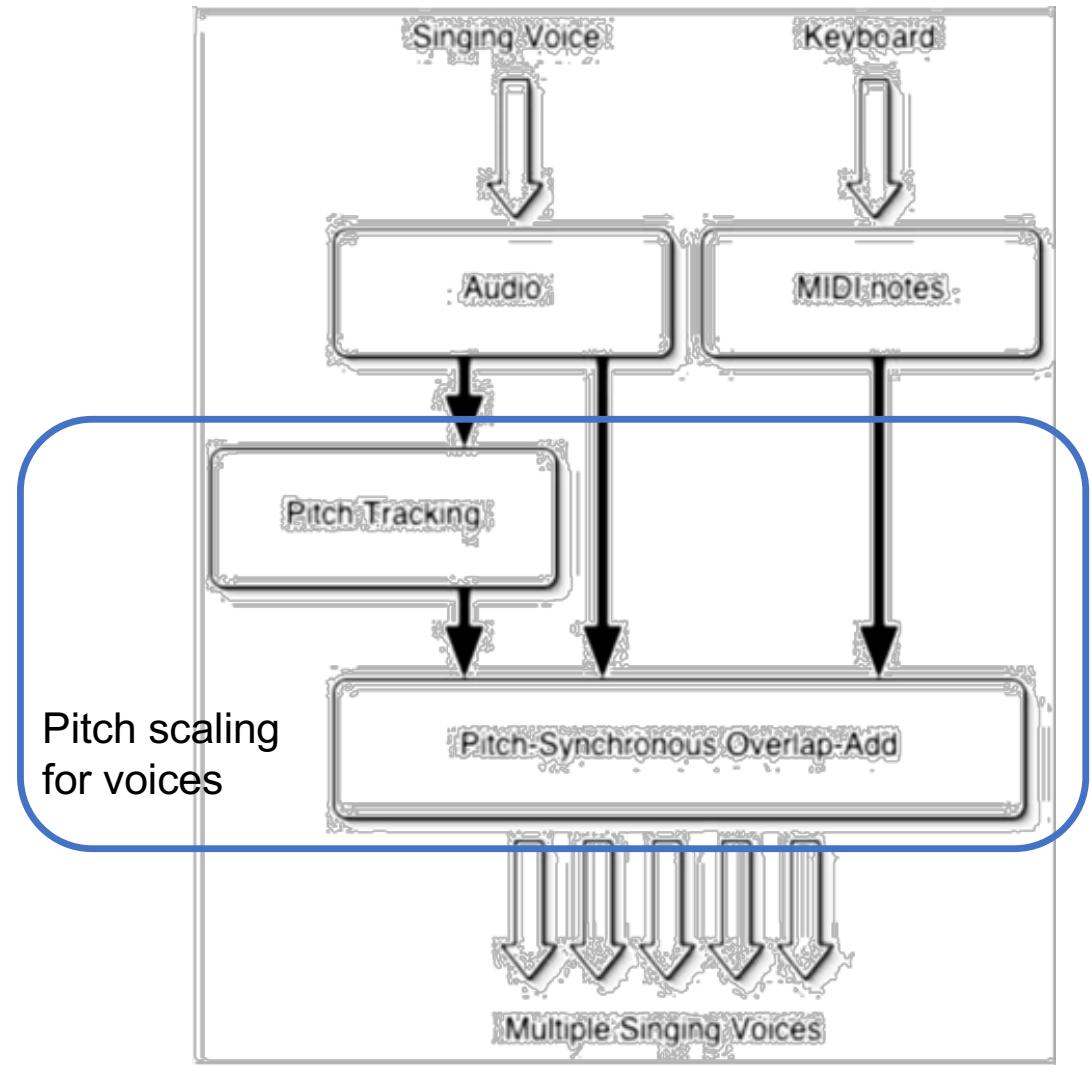


Applications: harmonizer

<https://youtu.be/eqY3FaZmh-Y>

Applications: harmonizer

- *Multiple pitch-scaled replicas of the original voice are controlled via MIDI controller*
- *Each voice is pitch scaled using a PSOLA (Pitch-Synchronous Overlap and Add) algorithm*
 - Suitable for voice, as it preserves original formants
- Can harmonization be controlled by an algorithm instead of a MIDI controller?
 - Harmonizing a woodwind or a lead guitar (both hands are busy)



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Harmonizer: simple suggestions

- *Single voice harmonization*
 - **MSH, with harmonizing voice at an interval of fourth**
 - Quite straightforward: we can keep a distance of a perfect fourth (5 HT) almost always (except for the fourth note of the scale, which calls for a tritone)
 - **MSH, with harmonizing voice at an interval of fifth**
 - Also straightforward: always keep a perfect fifth except for the 7th note, which calls for a augmented fourth
 - With MSH, in general, we need to keep a constant number of steps from main melodic line (within the correct current scale), and adapt as scale changes
 - With 3 steps we will have to keep switching from minor to major third
 - We don't necessarily need to worry about identifying the tonic, as long as we know is the scale
- *Multiple voice harmonization*
 - MSH: combine interval handling as explained in the single-interval case



Harmonizer: simple suggestions

- *With MMSH, harmonic complexity generally increases*
 - *Intervals of fourths cannot rely on a majority of perfect fourths (perfect fourths alternate with diminished fourths/major thirds and tritones), and similar considerations hold true for fifths*
 - *Scales change more often: e.g. minor II-V-I uses three different melodic minor scales!*
 - *Interchangeability of Melodic Minor Chords helps simplify the problem but calls for a different approach: instead of keeping a constant number of steps from melodic line, it is easier to harmonize with voicings (chords that tend to follow the melodic contour through rolling inversions)*



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