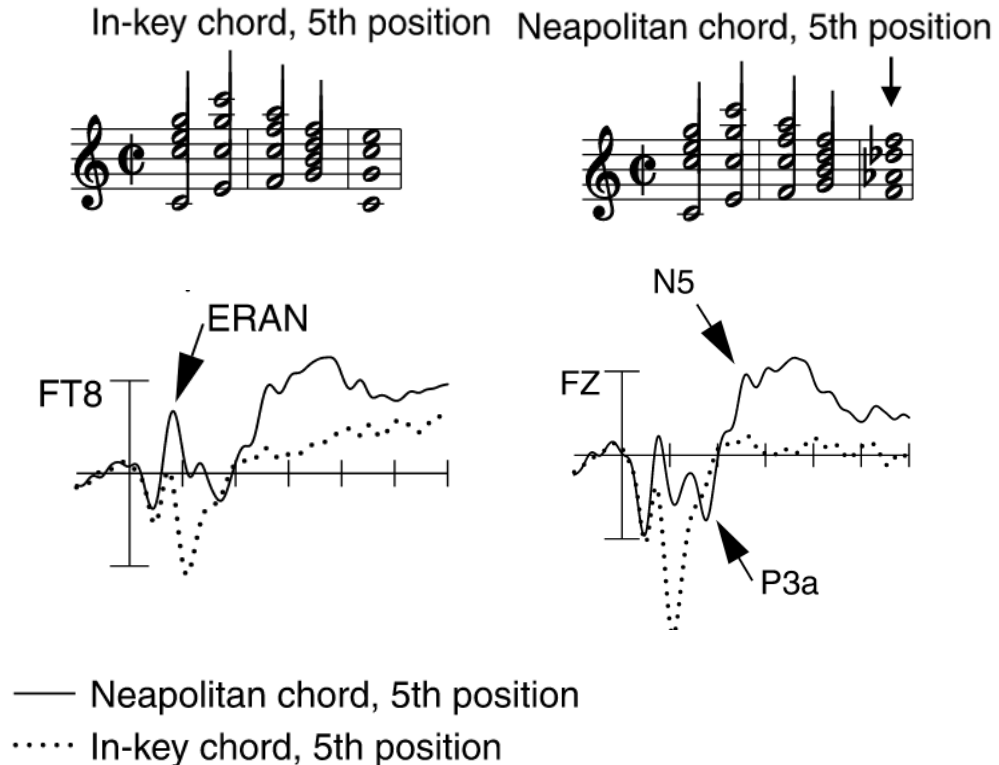
The background of the slide is a vibrant, abstract illustration. It features swirling, wavy lines in shades of blue, purple, and orange, creating a sense of movement and depth. Scattered throughout these swirls are various musical symbols, including treble and bass clefs, eighth and sixteenth notes, and small circles that resemble musical notes or sound waves. The overall color palette transitions from cool blues and purples on the left to warm oranges and yellows on the right.

Harmony Syntactic Function Emerging from Sequential Scale Notes in a Diatonic Mode: An Event- Related Potential Study

Shicheng Zhang, Takako Fujioka
Stanford University

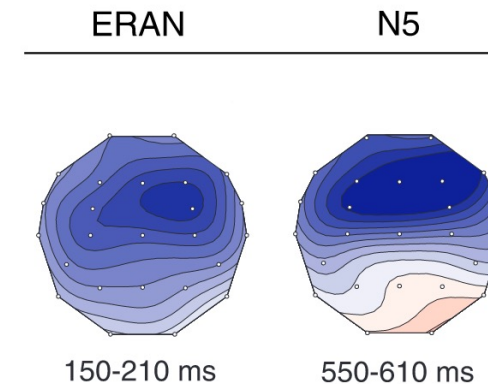


Auditory Evoked Potentials(AEPs) in Harmonic Syntax Perception: ERAN and N5



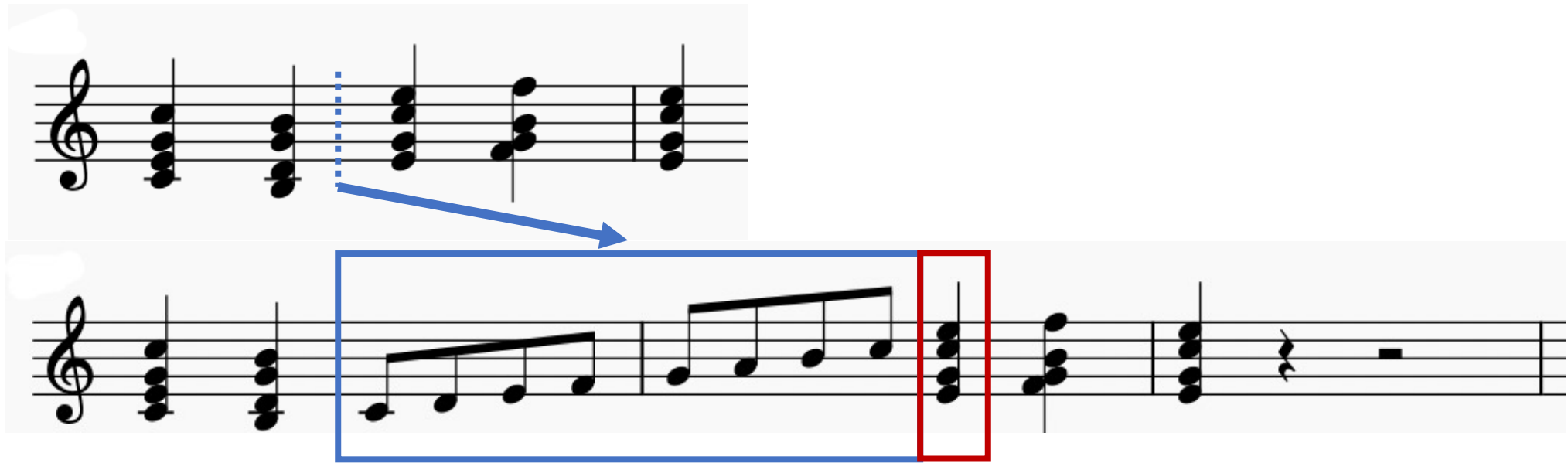
Early Right Anterior Negativity(ERAN): Early right-hemispheric preponderant-anterior negativity reflects the pre-attentive harmonic syntax violation. (maximal around 150 msec) (Koelsch et al. 2000, 2005; Loui et al., 2005; Leino et al., 2007)

N5: The N5 correlates to musical integration process which reflects current cognition on tonal schema and the hierarchy of harmonic stability. (Koelsch et al. 2000)



Reference:

Koelsch, S., Gunter, T., Friederici, A. D., & Schröger, E. (2000). Brain Indices of Music Processing: "Nonmusicians" are Musical. *Journal of Cognitive Neuroscience*, 12(3), 520–541.



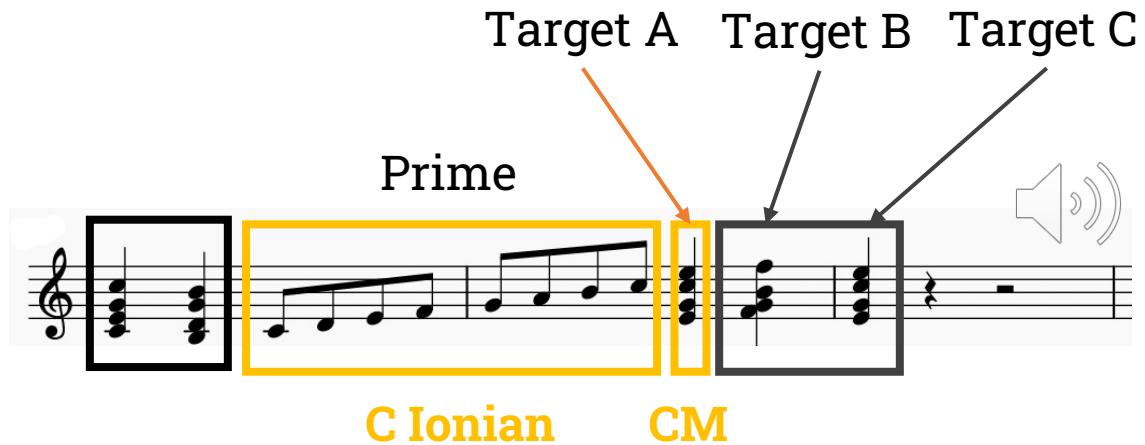
Can a scale insertion alter the subsequent chords harmonic syntax function?

(Likely yes, because that's what Jazz harmony uses)

Experiment #1: Modal Interchange

Hypothesis

Different interpretation of a borrowed chord (induced by a scale in [modal interchange](#)) affect the subsequent chords' harmonic expectancy differently.



Target A Target B Target C

Prime

C Ionian CM

This diagram shows a musical staff with a treble clef. It displays the C Ionian scale (C-D-E-F-G-A-B) and the C Mixolydian (CM) scale (C-D-E-F-G-A-Bb). The C Ionian scale is highlighted with a yellow box, and the CM scale is highlighted with a grey box. An orange arrow points to the F# chord (Target A) in the C Ionian scale. A black arrow points to the F# chord (Target B) in the CM scale. A black arrow points to the F# chord (Target C) in the CM scale. A speaker icon is located to the right of the staff.



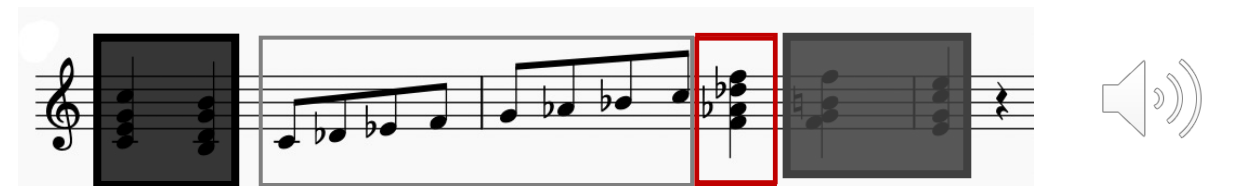
This diagram shows a musical staff with a treble clef. It displays the C Ionian scale (C-D-E-F-G-A-B) and the N6 chord (F#-C-E-G-A-B). The C Ionian scale is highlighted with an orange box, and the N6 chord is highlighted with a red box. A speaker icon is located to the right of the staff.

C Ionian N6



This diagram shows a musical staff with a treble clef. It displays the C Locrian scale (C-D-Eb-F-G-A-Bb) and the N6 chord (F#-C-E-G-A-B). The C Locrian scale is highlighted with a blue box, and the N6 chord is highlighted with a red box. A speaker icon is located to the right of the staff.

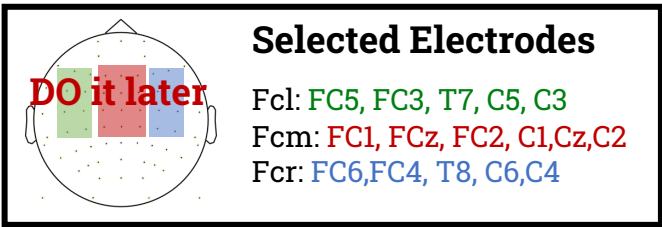
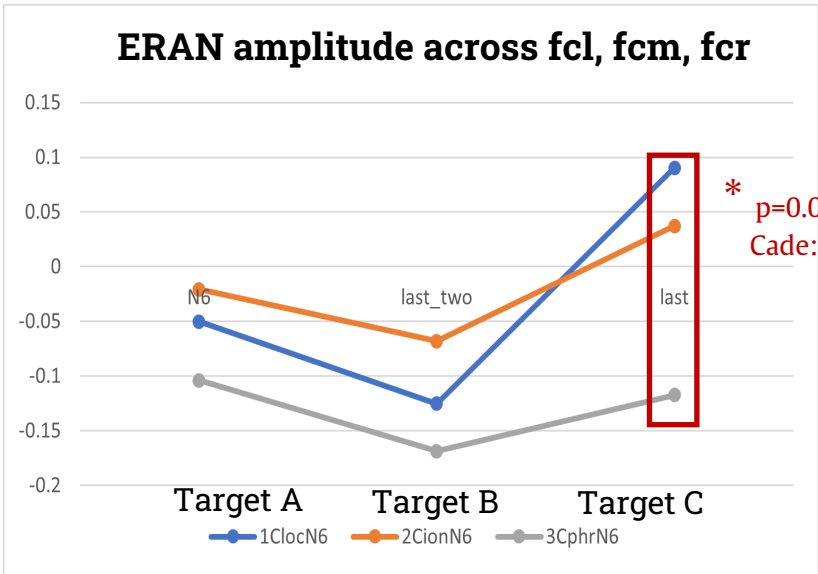
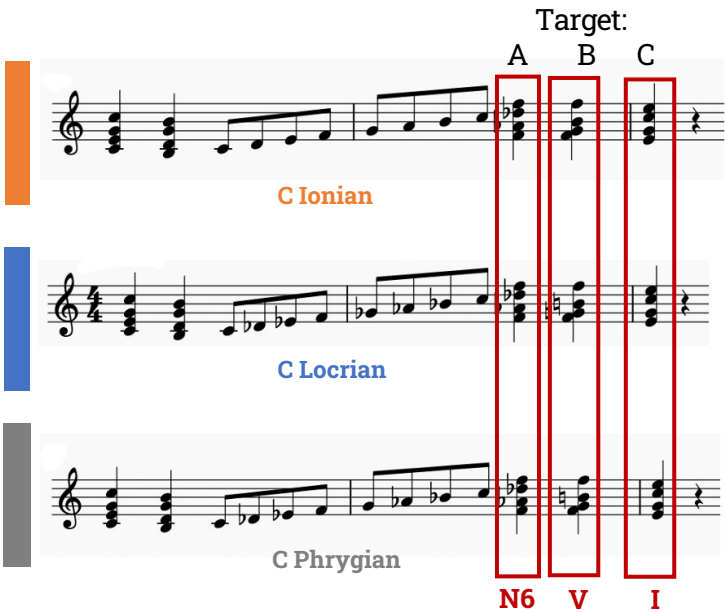
C Locrian N6



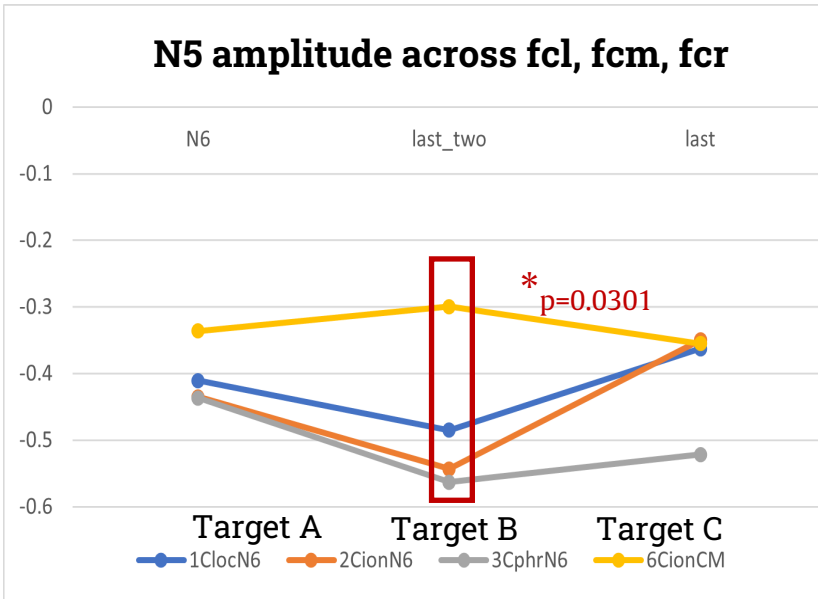
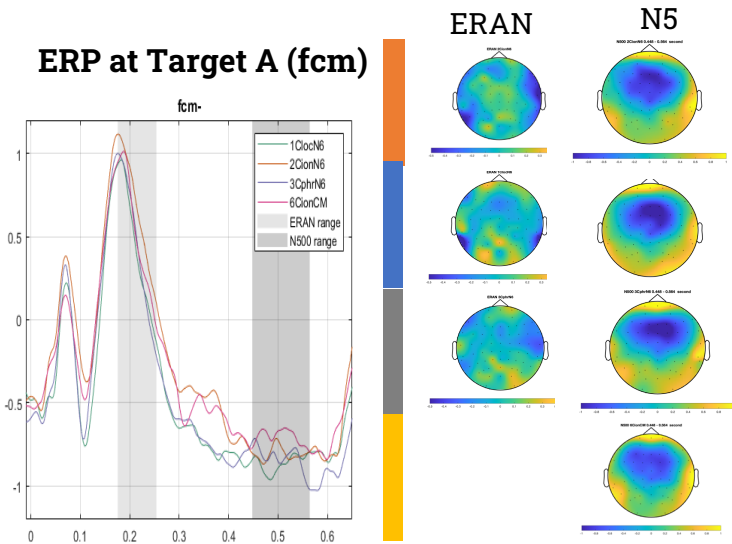
This diagram shows a musical staff with a treble clef. It displays the C Phrygian scale (C-D-Eb-F-G-A-Bb) and the N6 chord (F#-C-E-G-A-B). The C Phrygian scale is highlighted with a grey box, and the N6 chord is highlighted with a red box. A speaker icon is located to the right of the staff.

C Phrygian N6

Result #1: Modal Interchange



The C Phrygian condition evokes the significantly largest ERAN amplitude at the Target C position compared to other two conditions.



All the three conditions have significantly larger N5 amplitude at Target B position compared to C-Ionian-Cmajor control condition.

Experiment #2: Tonicization

Hypothesis

Different tonal center of **tonicization** (induced by a local perfect cadence) affect the subsequent chords' harmonic expectancy differently.

Target A Target B Target C

Prime

C Ionian CM

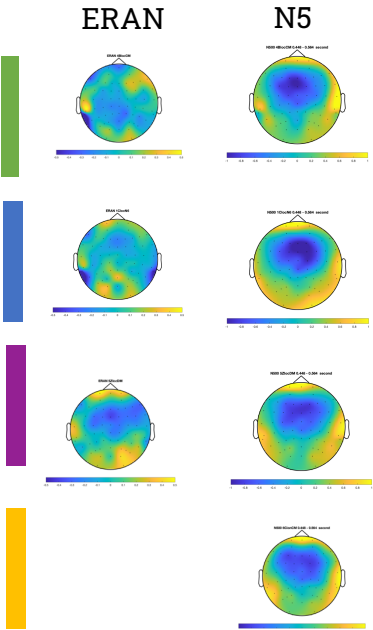
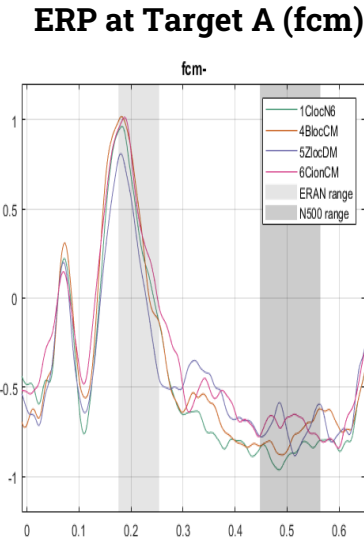
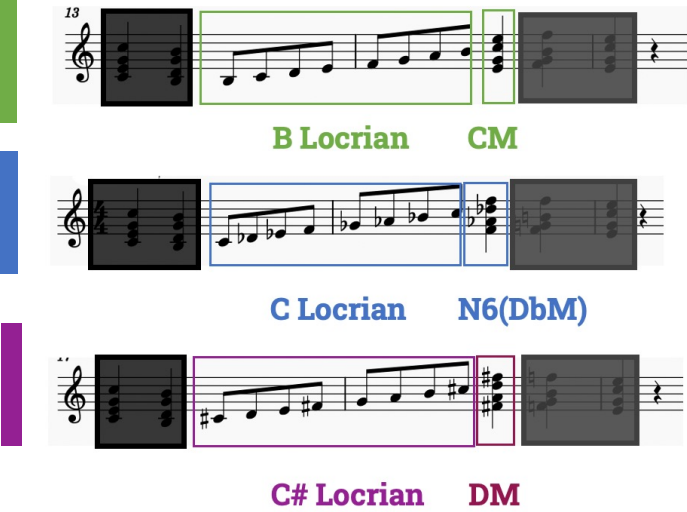
13

B Locrian CM

C Locrian N6(DbM)

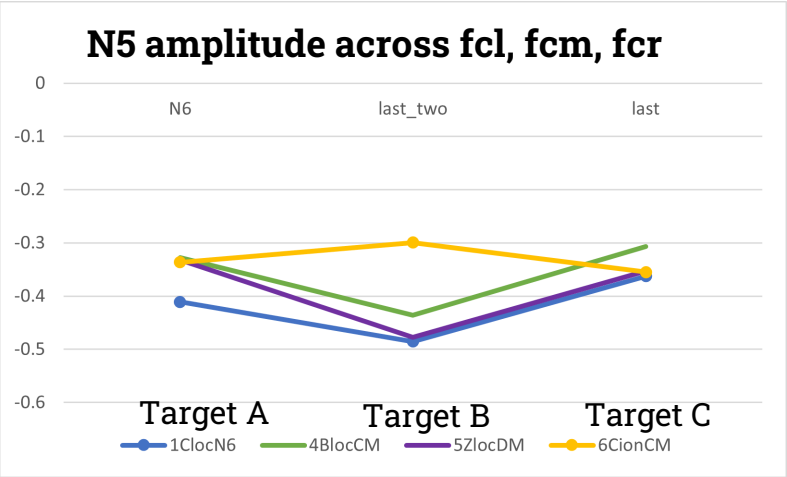
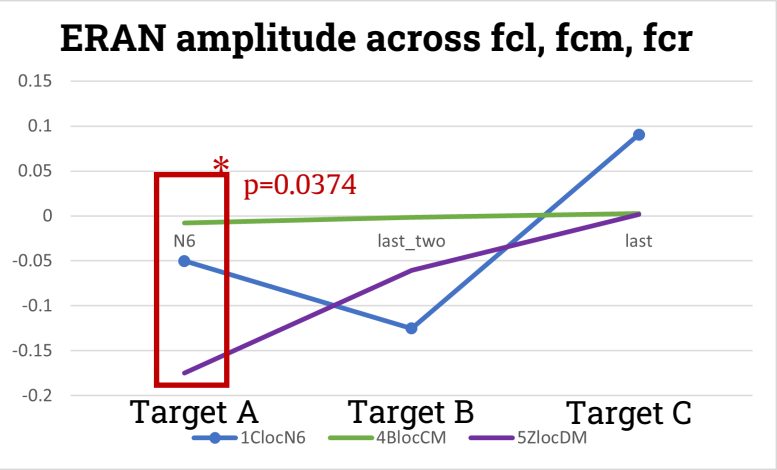
C# Locrian DM

Result #2: Tonicization



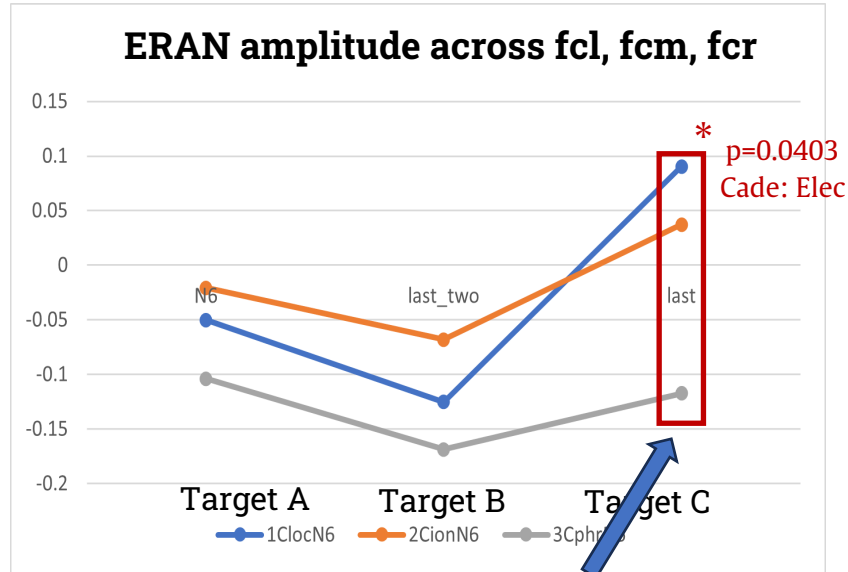
The C#locrian-Dmajor condition evokes the significantly largest ERAN amplitude at the Target A position compared to other two conditions.

Fcl: FC5, FC3, T7, C5, C3
Fcm: FC1, FCz, FC2, C1,Cz,C2
Fcr: FC6,FC4, T8, C6,C4

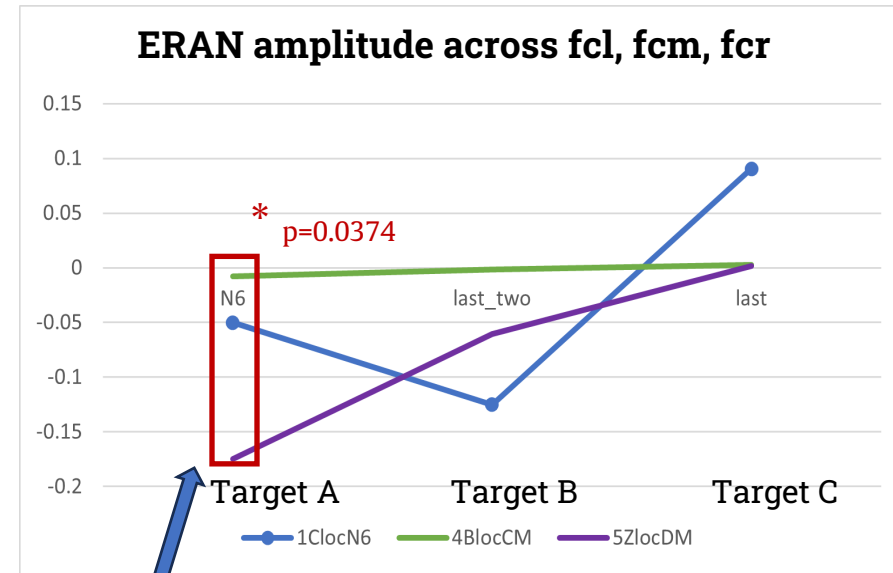


There is no significant difference of N5 amplitude for all condition at Target A, B, and C position.

What does ERAN Reflect?

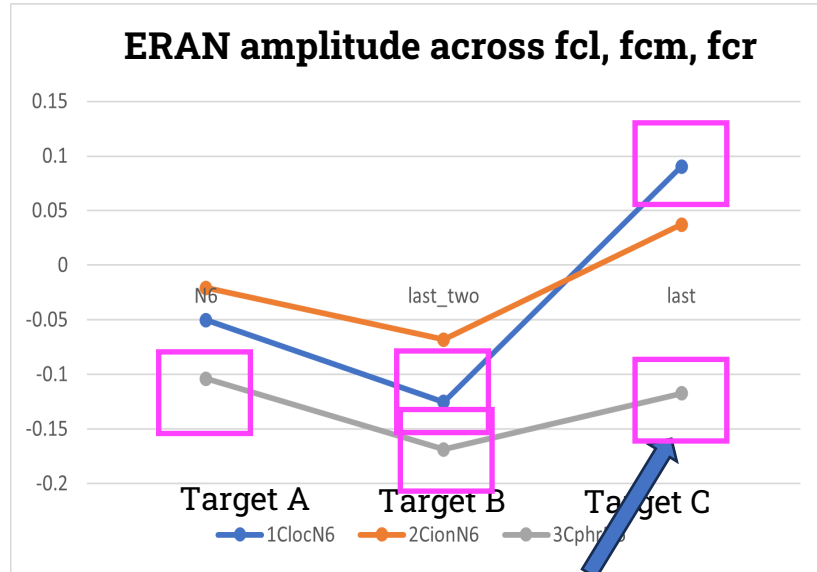


Target B → C
It solves local tonal ambiguity,
But that is influenced by the tonality established by the scale.

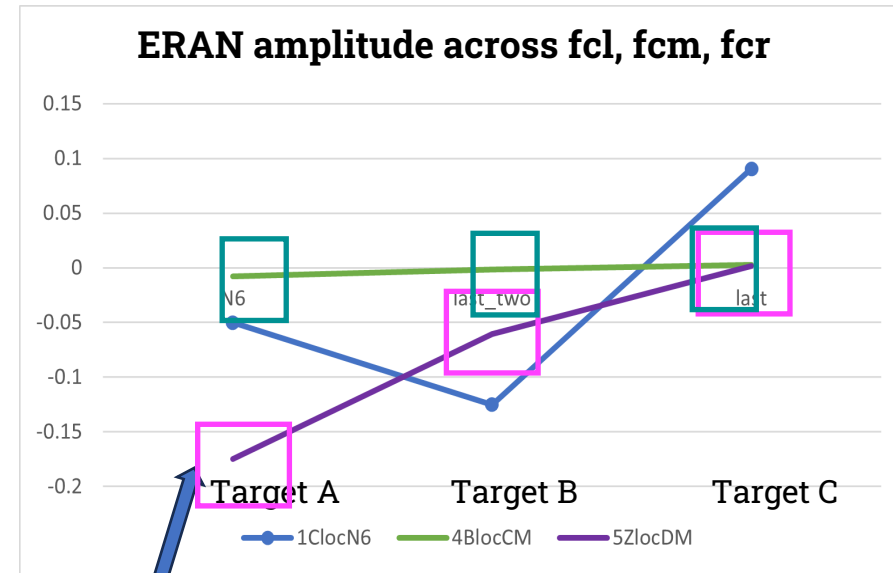


Locrian → Target A major chord
solves local tonal ambiguity, but that
is also influenced by the initially
established tonal center by the first
two chords.

What does ERAN Reflect?



Target B → C
It solves local tonal ambiguity,
But that is influenced by the tonality established by the scale.



Locrian → Target A major chord
solves local tonal ambiguity, but that
is also influenced by the initially
established tonal center by the first
two chords.

ERAN is dynamics.
Green line does
Not change at all.

2mins

Discussion

1. ERAN could reflect the momentary tonal ambiguity, induced by (1) an inserted scale (**mode interchange**) and (2) a local cadential motion (**tonicization**).
Tonal ambiguity is defined as the certainty whether the current pitch-class set implies a single tonality. (Temperley, 2007)
2. N5 seems to indicate the degree of resolution of a given chord in a chord sequence. Tonicization won't affect the resolution outside its local alteration range.
3. Not only a single chord altered the harmonic syntactical context in subsequent chords, but ascending mode also altered them.

Reference

Koelsch, S., Gunter, T., Friederici, A. D., & Schröger, E. (2000). Brain indices of music processing: “nonmusicians” are musical. *Journal of cognitive neuroscience*, 12(3), 520-541.

Koelsch, S., (2005). Neural substrates of processing syntax and semantics in music. *Curr. Opin. Neurobiol.* 15, 207–212.

Loui, P., Grent, T., Torpey, D., & Woldorff, M. (2005). Effects of attention on the neural processing of harmonic syntax in Western music. *Cognitive Brain Research*, 25(3), 678-687.

Leino, S., Brattico, E., Tervaniemi, M., & Vuust, P. (2007). Representation of harmony rules in the human brain: Further evidence from event-related potentials. *Brain research*, 1142, 169-177.

Temperley, D. (2007). The Tonal Properties of Pitch-Class Sets: Tonal Implication, Tonal Ambiguity, and Tonalness. *Computing in Musicology*, 15.

Discussion

1. Not only a single chord altered the harmonic syntactical context in subsequent chords, but ascending mode also altered them.
2. ERAN seems to not only indicating the out-of-key property of current chord, but its amplitude also correlates to the tonal distance between local tonal center and global tonal center. This is shown as Dmaj tonicization (2 accidentals) has a smaller number of accidentals compared to DbMaj tonicization (5 accidentals), but the former shows larger ERAN negativity than the latter.
3. N5 seems to indicate the degree of resolution of a given chord in a chord sequence. Tonicization won't affect the resolution outside its local alteration range.

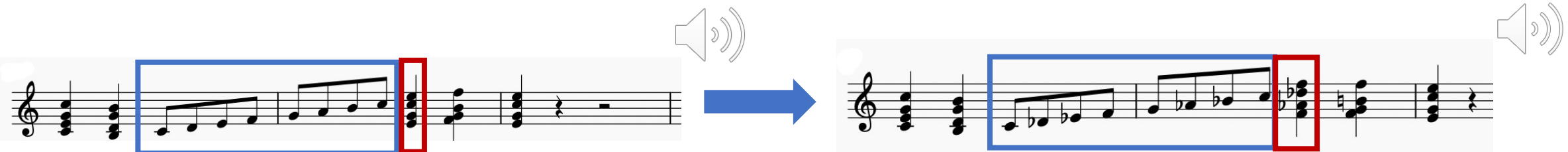
Qualitatively explain tonal ambiguity

1. Cadential moment ERAN come in → probability of certainty of tonal center
 2. Difference between two presented tonality
- Integrated these two
(ERAN difference between target A and B(not in this talk))

Modal Interchange

Definition:

An out-of-key chord can be primed by a preceding scale, thereby reducing the violation of the syntactic function of the chord under the initial tonality



The diagram illustrates modal interchange. On the left, a musical staff shows a sequence of chords: C Maj (I), V6, I (C Ionian), I6, V42, and I6. A blue box highlights the I (C Ionian) scale, and a red box highlights the I6 chord. A blue arrow points to the right, where the same sequence is shown, but the I6 chord is replaced by a C Phrygian mode chord (marked with a red box). The right side shows two possible interpretations for the C Phrygian mode chord: * (C Phrygian) and bII6(N6) for the C Maj (Ionian) perspective, and iii (C Phrygian) and IV6 for the Ab Maj (Ionian) perspective.

C Maj (Ionian): I V6 I (C Ionian) I6 V42 I6

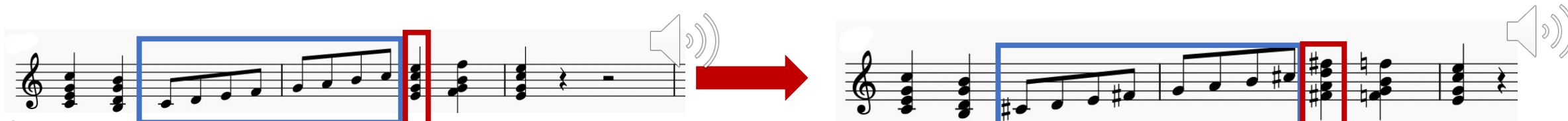
C Maj (Ionian): I V6 * (C Phrygian) bII6(N6) V42 I6

Ab Maj (Ionian): iii (C Phrygian) IV6 * *

Tonicization

Definition:

A chord in another key can be introduced as having a temporary tonic function.



The diagram illustrates tonicization. On the left, a musical staff shows a sequence of chords: C Maj (I), V6, I (C Ionian), I6, V42, and I6. A blue box highlights the I (C Ionian) scale, and a red box highlights the I6 chord. A red arrow points to the right, where the same sequence is shown, but the I6 chord is replaced by a C# Locrian mode chord (marked with a red box). The right side shows two possible interpretations for the C# Locrian mode chord: * (C# Locrian) and * for the C Maj (Ionian) perspective, and viio (C# Locrian) and I6 for the D Maj (Ionian) perspective.

C Maj (Ionian): I V6 I (C Ionian) I6 V42 I6

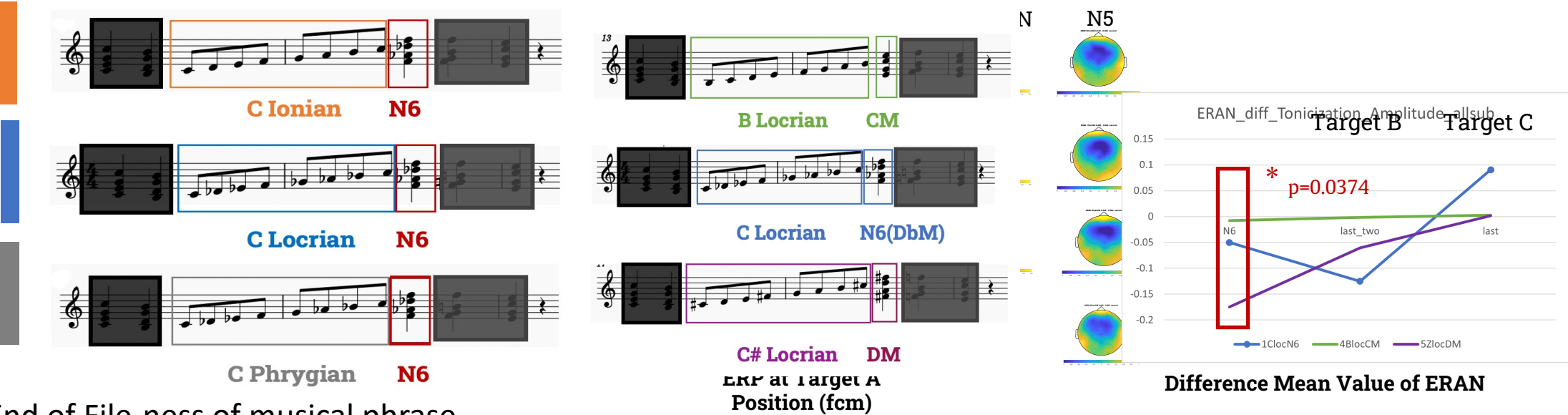
C Maj (Ionian): I V6 * (C# Locrian) * V42 I6

D Maj (Ionian): viio (C# Locrian) I6 * *

Hypothesis

Both **modal Interchange** and **tonicization** affect harmonic expectancy upon subsequent chords.

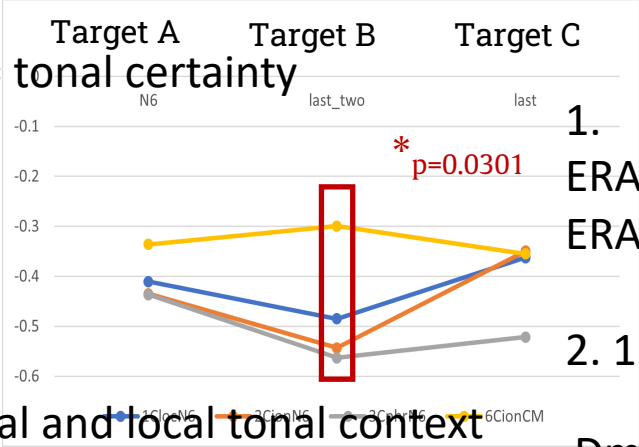
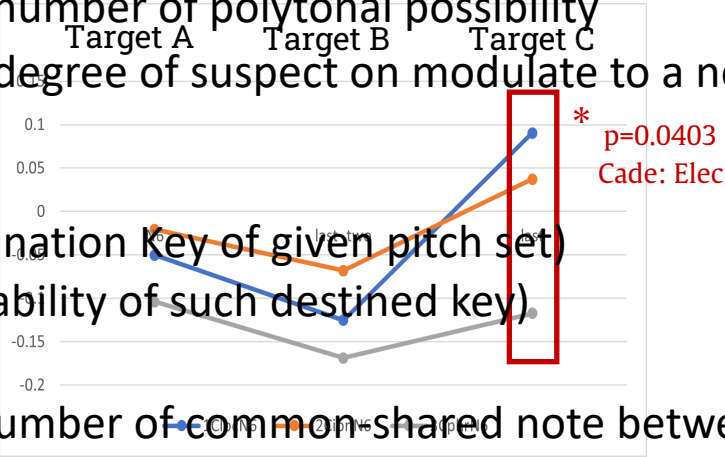
Result #1: Modal Interchange



ERAN rank the End of File-ness of musical phrase
ERAN correlates to the number of polytonal possibility

ERAN correlates to the degree of suspect on modulate to a new key = tonal certainty

David Temperley
Tonal implication (Destination Key of given pitch set)
Tonal Ambiguity (Probability of such destined key)



1. ERAN difference between:
ERAN(A)-ERAN(B),
ERAN(B)-ERAN(C)

2. 1 Big-ANOVA

Dm -> G7 -> CM
Chain of 2nd Dominant

ERAN reflect the number of common shared note between global and local tonal context

Both local perfect cadence and pitch set key implication manipulates tonal ambiguity.

ERAN is a consultant ERP that reflects the tonal ambiguity.

Local perfect cadence