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

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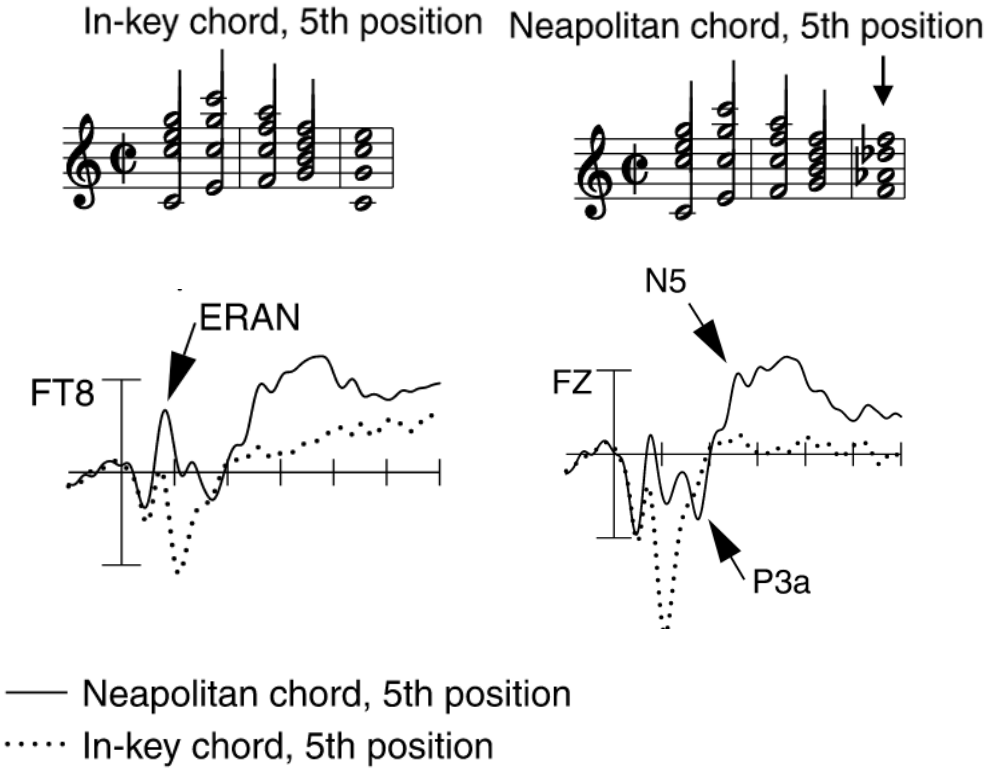
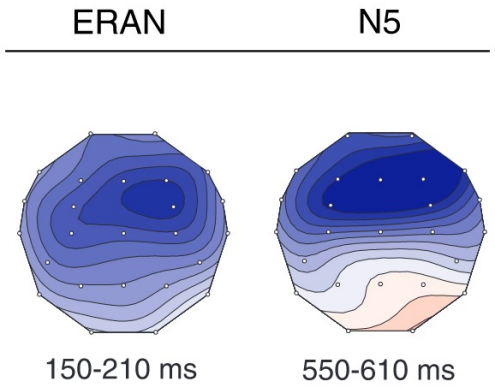
Auditory Evoked Potentials(AEPs) in Harmonic Syntax Perception: ERAN and N5

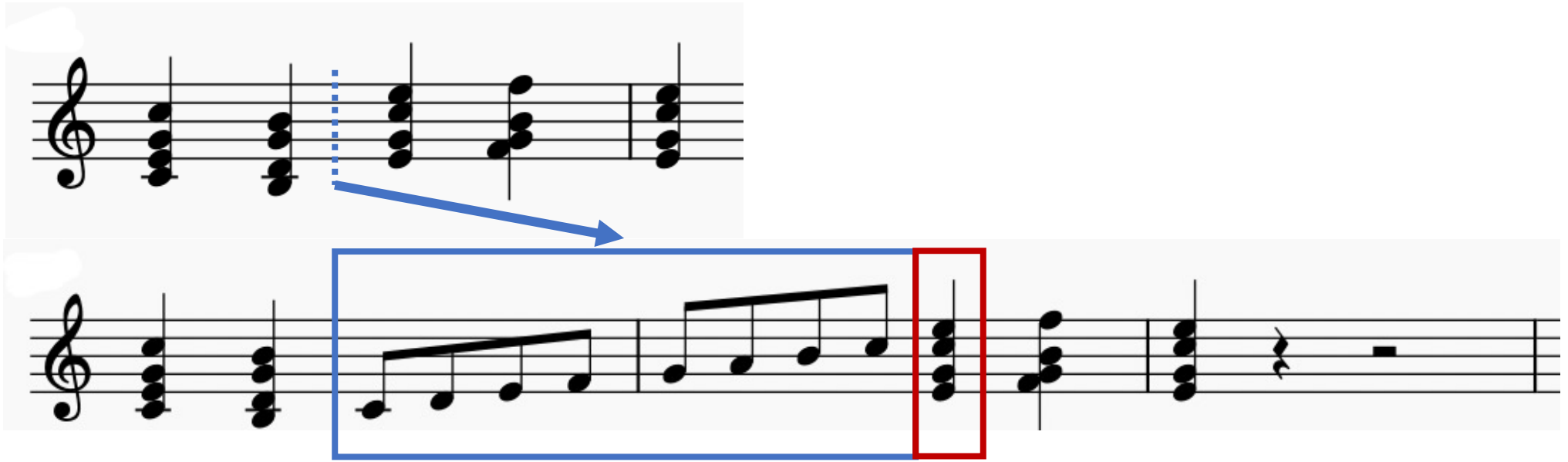


Early Right Anterior Negativity(ERAN):
Early right-hemispheric preponderant-anterior negativity reflects the pre-attentive harmonic syntax violation. (maximal around 150 msec) (Koelsch et al. 2000, 2005; Loui et al., 2005; Leino et al., 2007)

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.

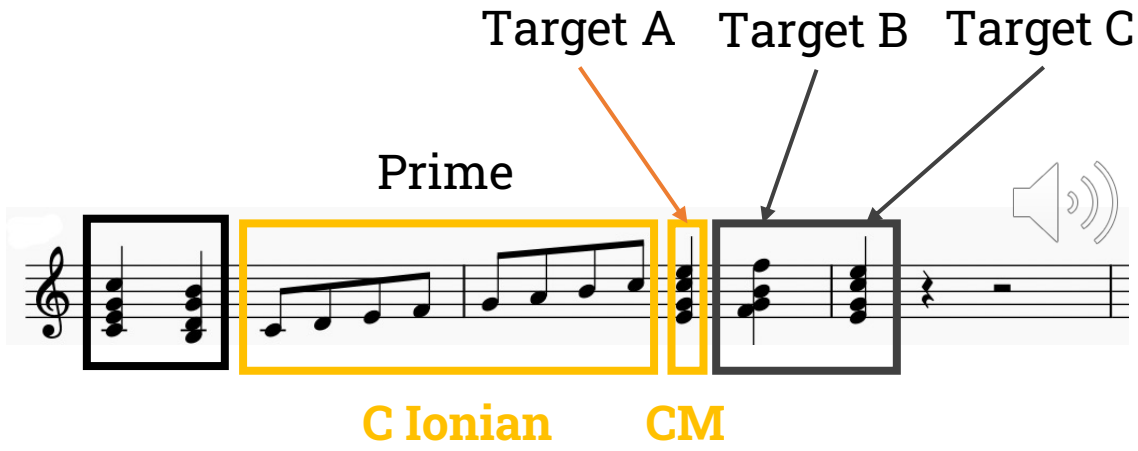


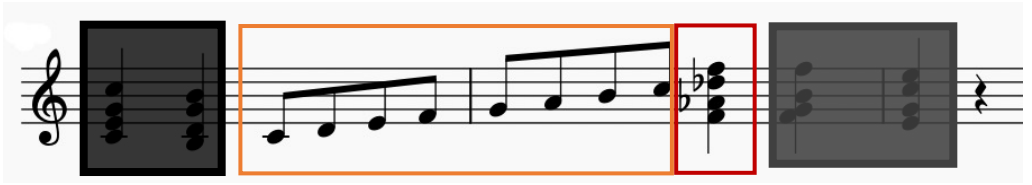
Can a scale insertion alter the subsequent chords harmonic syntax function?

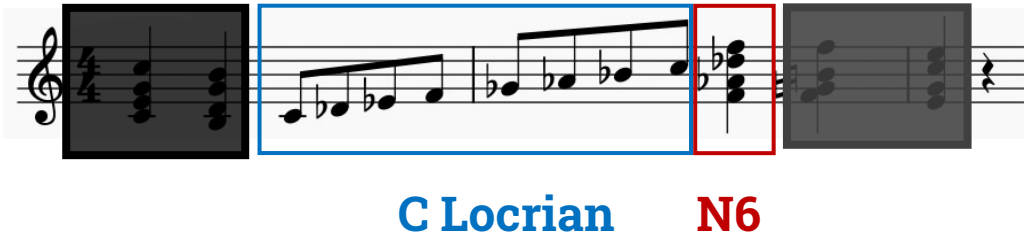
(Likely yes, because that’s what Jazz harmony uses)

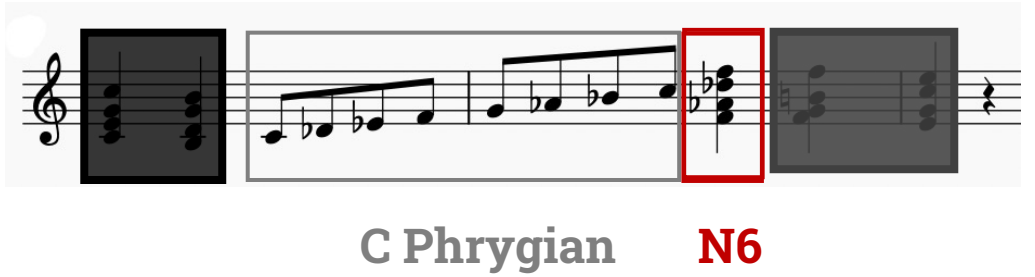
Experiment #1: Modal Interchange

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

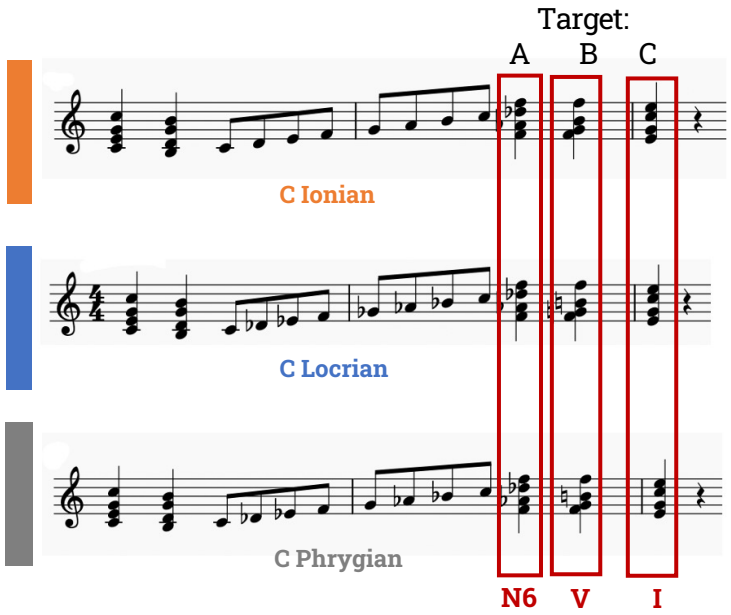


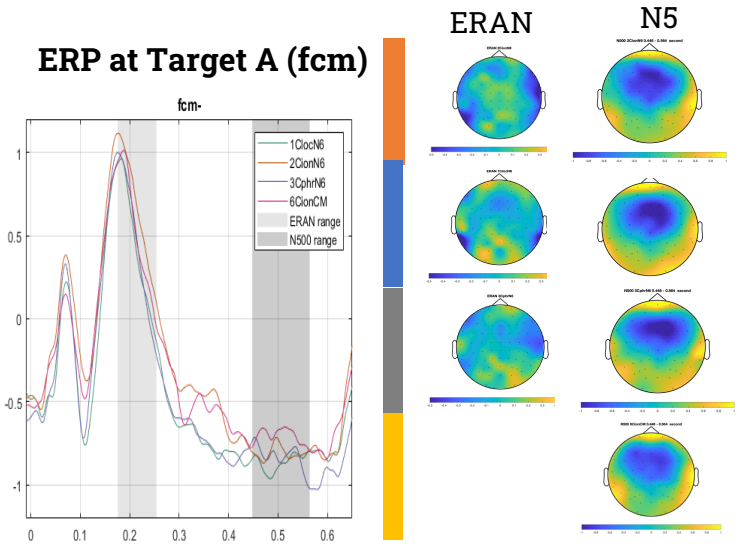


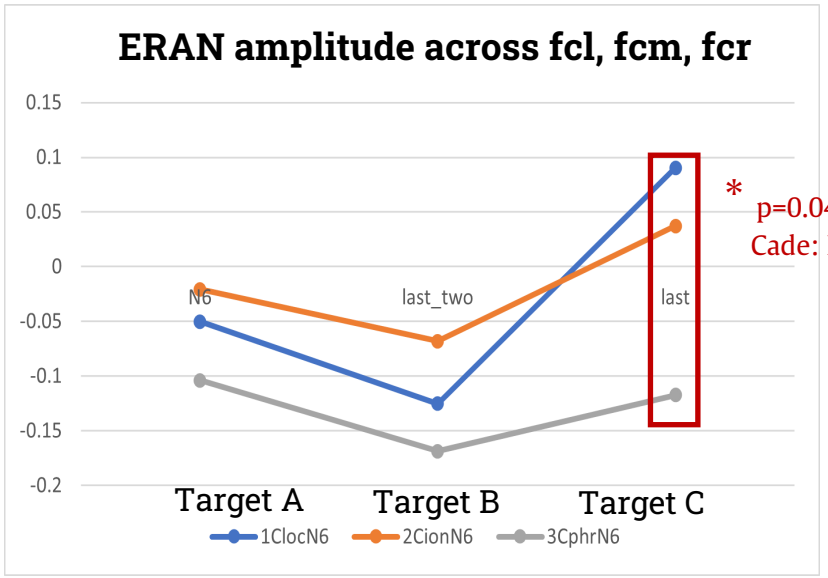


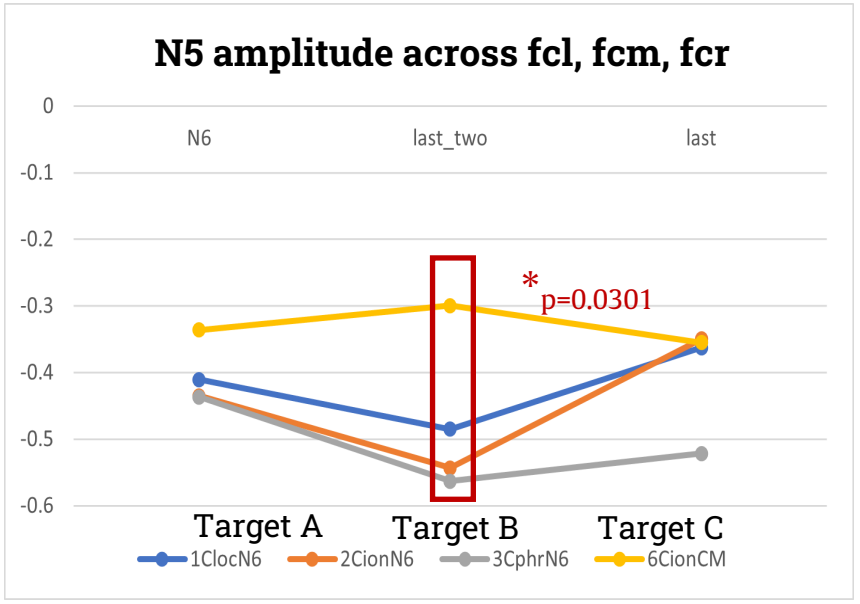


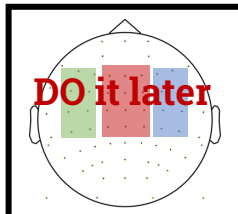
Result #1: Modal Interchange











Selected Electrodes

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

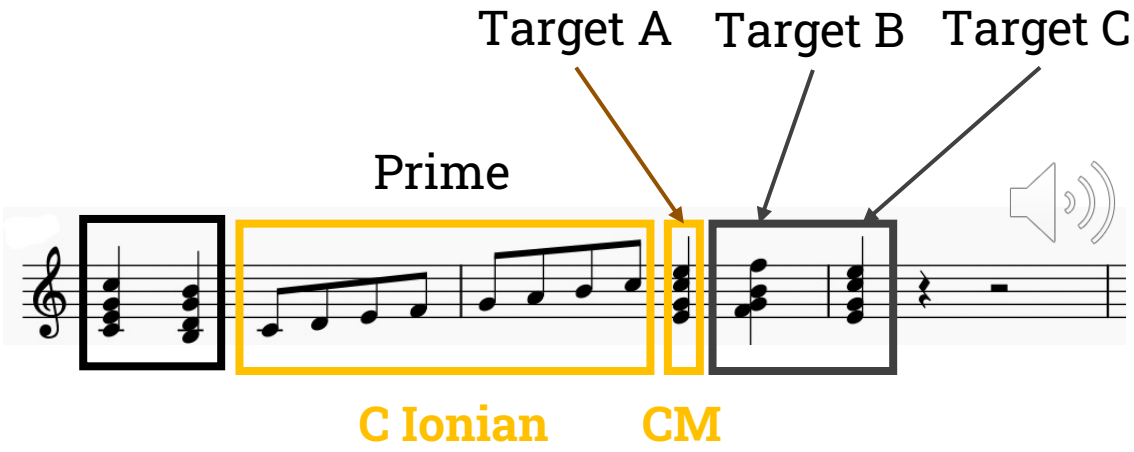
The C Phrygian condition evokes the significantly largest ERAN amplitude at the Target C position compared to other two conditions.

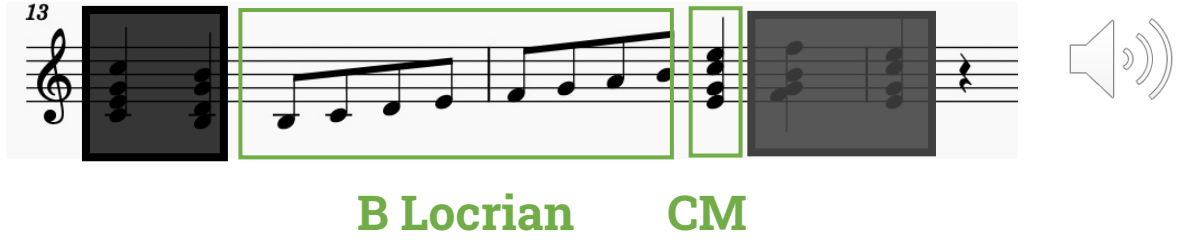
All the three conditions have significantly larger N5 amplitude at Target B position compared to C-Ionian-Cmajor control condition.

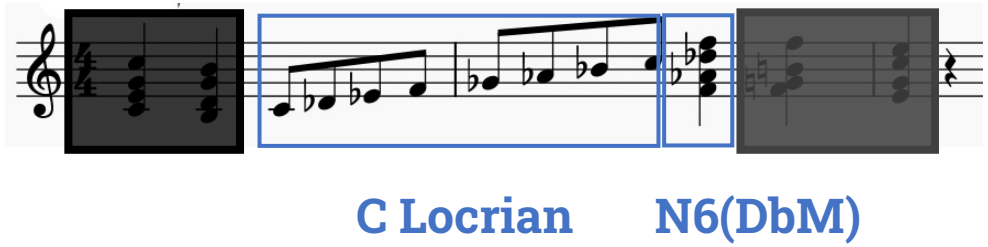
Experiment #2: Tonicization

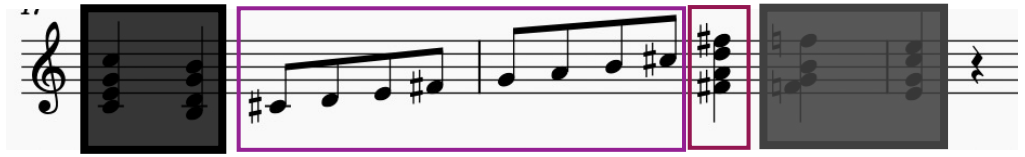
Hypothesis

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

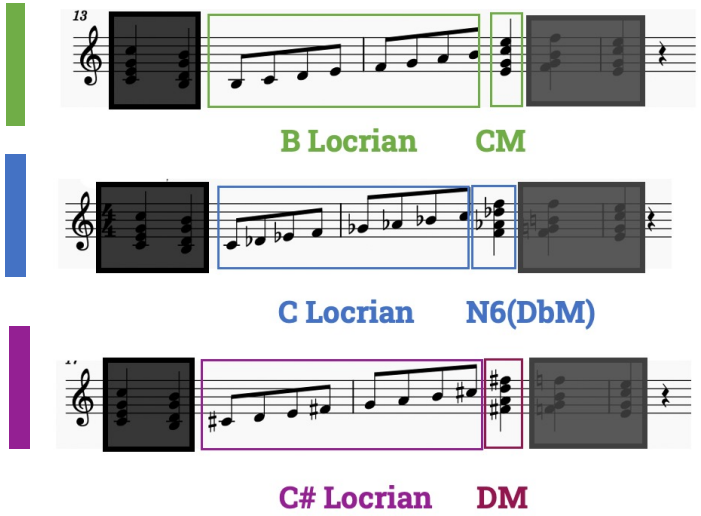


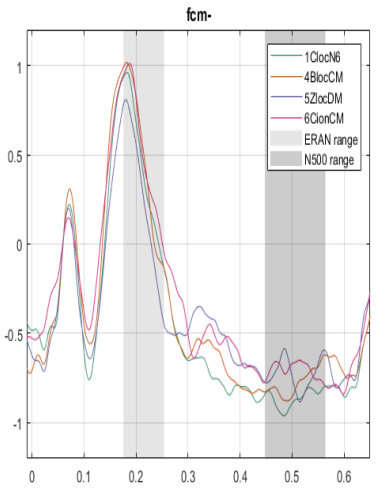


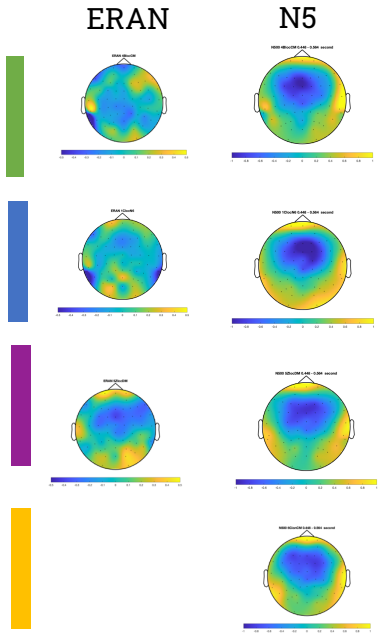




Result #2: Tonicization





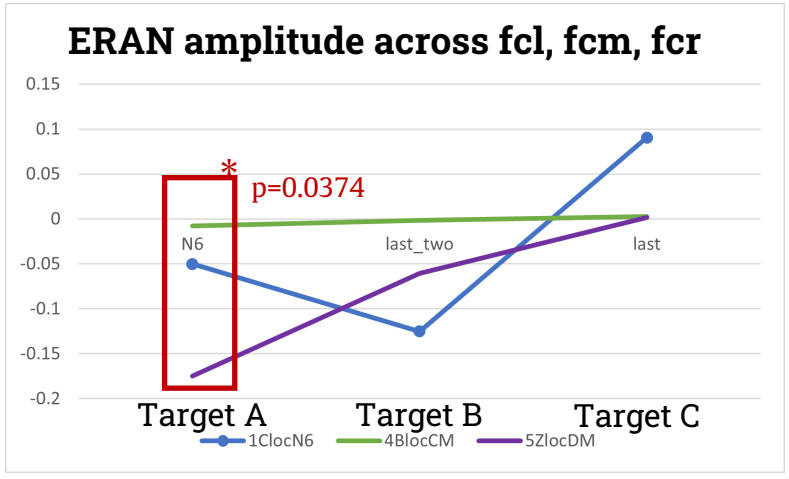


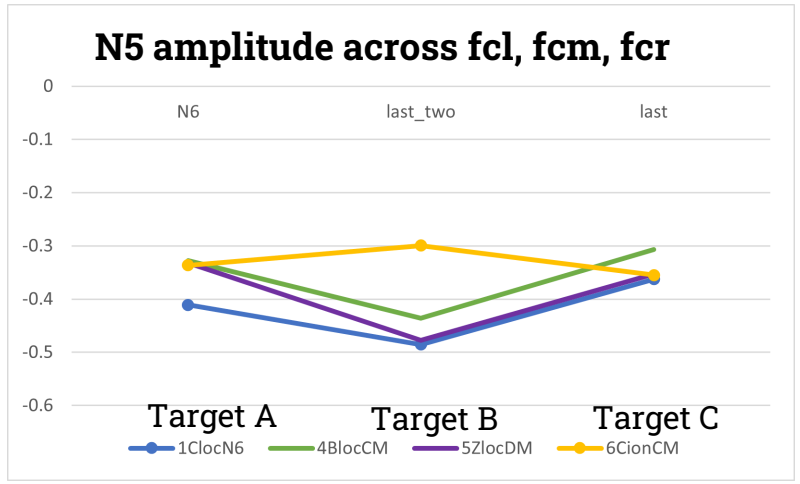
The C#locrian-Dmajor condition evokes the significantly largest ERAN amplitude at the Target A position compared to other two conditions.

Fcl: `FC5, FC3, T7, C5, C3`

Fcm: `FC1, FCz, FC2, C1,Cz,C2`

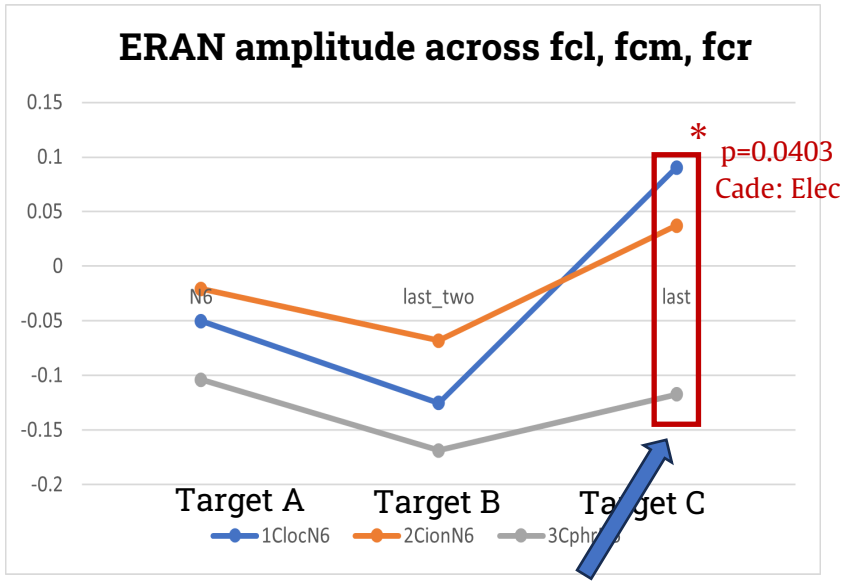
Fcr: `FC6,FC4, T8, C6,C4`



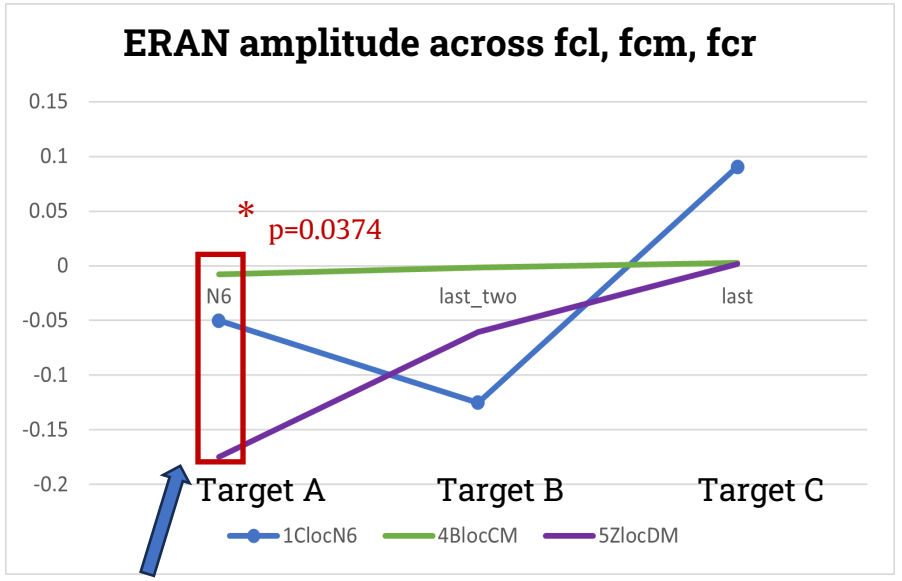


There is no significant difference of N5 amplitude for all condition at Target A, B, and C position.

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.

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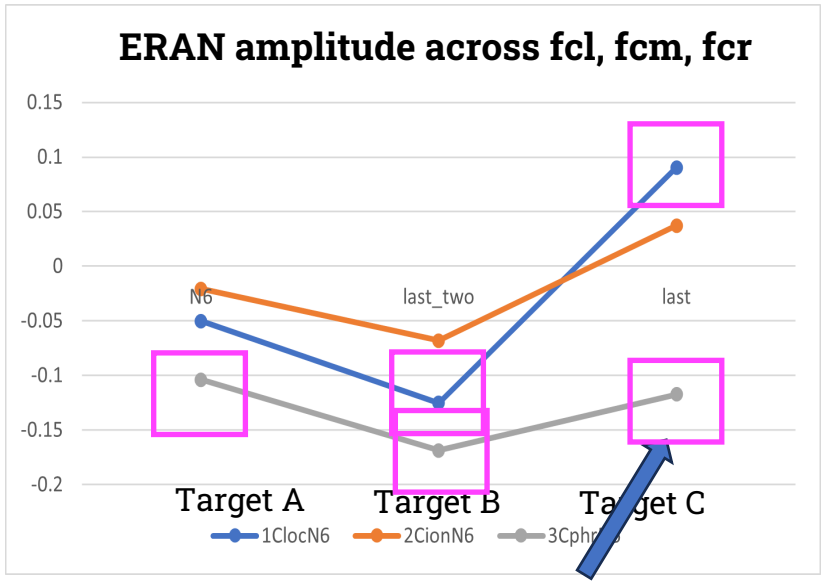

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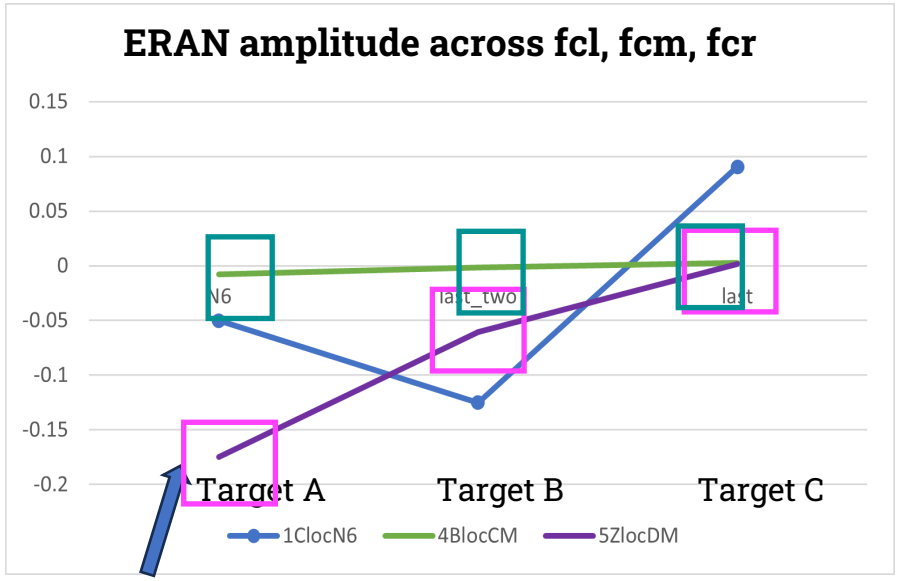


Locrian → Target A major chord solves local tonal ambiguity, but that is also influenced by the initially established tonal center by the first two chords.

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

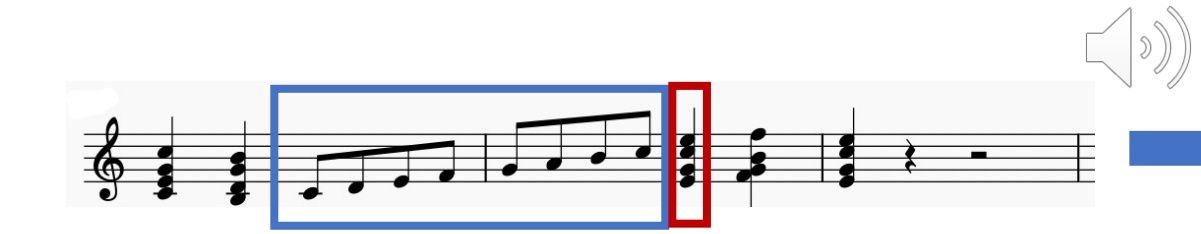
1. Cadential moment ERAN come in → probability of certainty of tonal center
2. Difference between two presented tonality

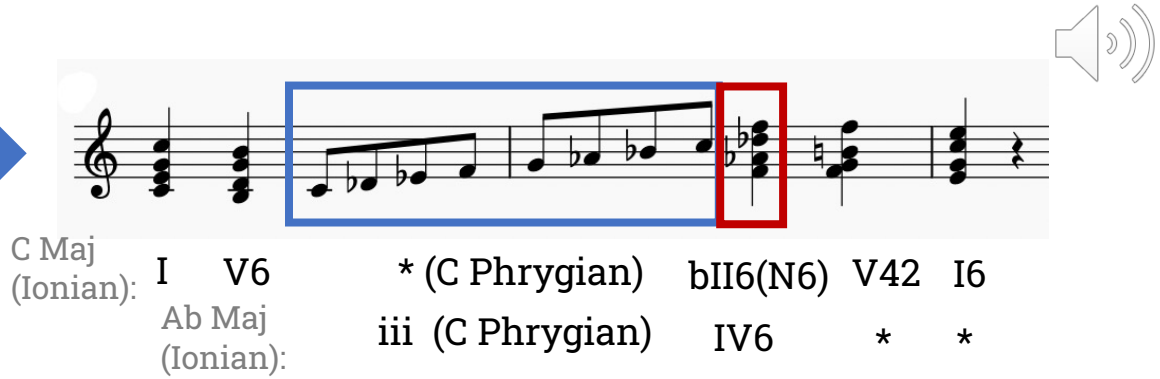
Integrated these two
(ERAN difference between target A and B(not in this talk))

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

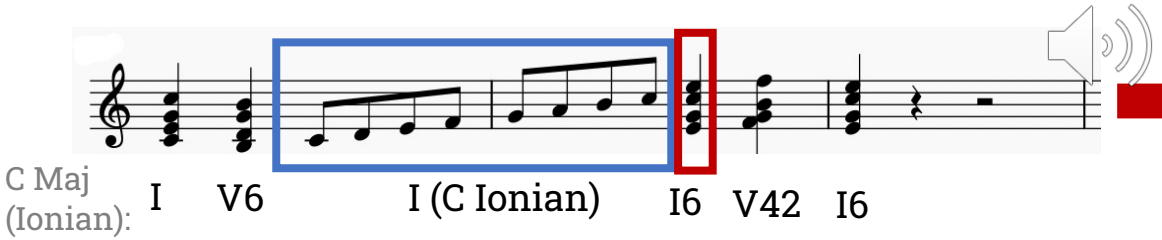


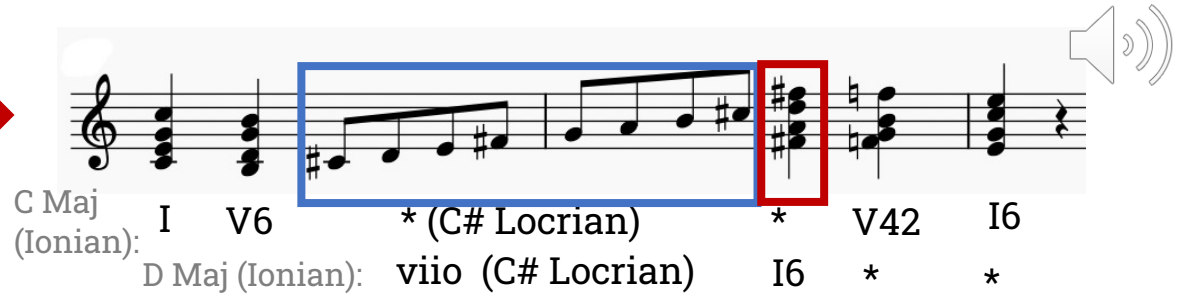


Tonicization

Definition:

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

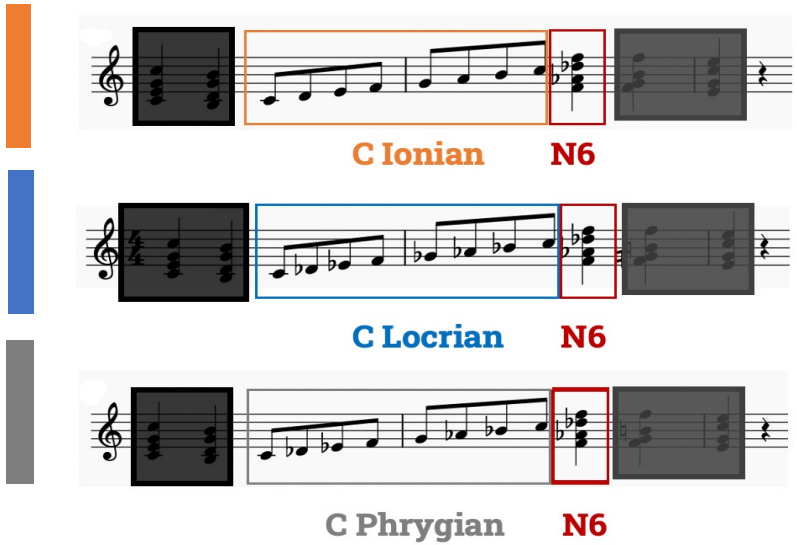


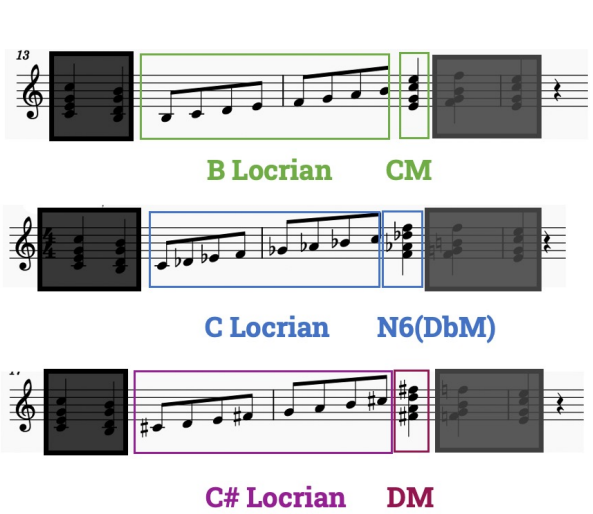


Hypothesis

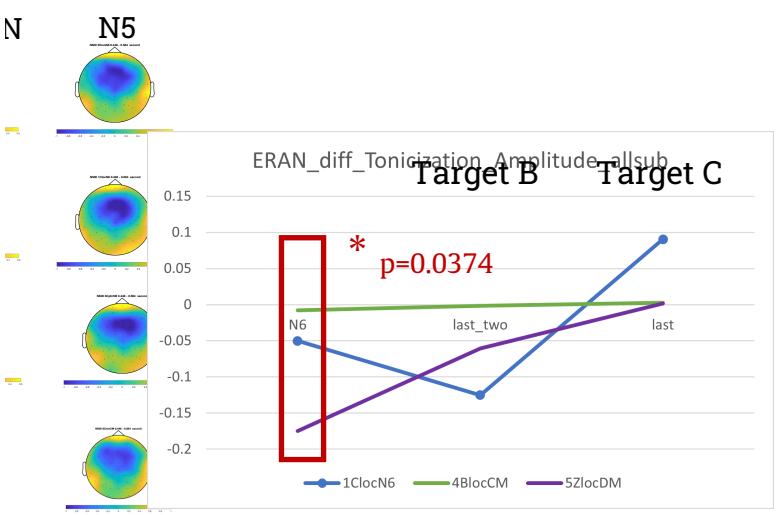
Both modal Interchange and tonicization affect harmonic expectancy upon subsequent chords.

Result #1: Modal Interchange





ERP at Target A
Position (fcm)

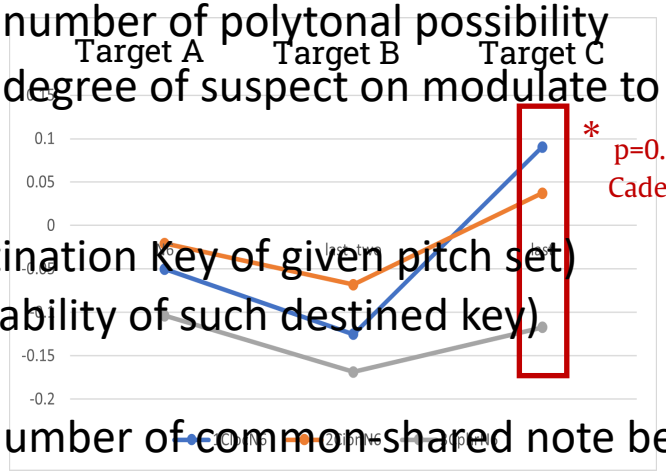


Difference Mean Value of ERAN

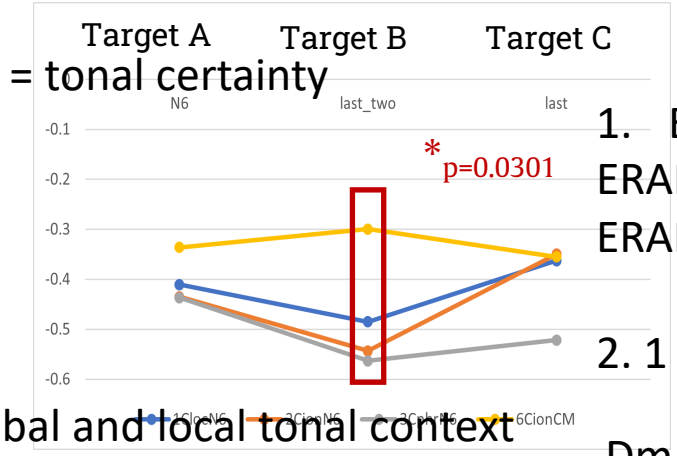
ERAN rank the End of File-ness of musical phrase

ERAN correlates to the number of polytonal possibility

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



Difference Mean Value of ERAN



Abs Mean Value of N5

David Temperley

Tonal implication(Destination Key of given pitch set)

Tonal Ambiguity (Probability of such destined key)

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

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

2. 1 Big-ANOVA

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

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