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A Comparison of the Accuracy of Two Models for Predicting the Behavior of "Soul Dominants" in the McGill *Billboard* Corpus

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ABSTRACT: The "soul dominant"—Mark Spicer's (2017) term for the dominant eleventh—poses challenges to harmonic theories of popular music, as evidenced by the diverse array of labels and functional categories applied to the chord. I created a dataset (n = 2033) of chords of the "soul dominant" quality across 153 songs in the McGill *Billboard* corpus (Burgoyne 2011), classifying them by their bass scale degree within the tonal context given by the transcription. For each chord, I recorded the root and bass of the previous and following chords, as well as the beat class (Cohn 1992) of the chord's onset and offset within four-measure units of quadruple meter. This article tests and compares some models designed to reflect theorists' intuitions regarding whether a "soul dominant" will resolve to "tonic" (if only locally), empirically demonstrating some shortcomings in conventional wisdom. The article finds that soul dominants are more likely to resolve conventionally when preceded by bass motion of a perfect fourth or perfect fifth, or when the chord transition happens on a relatively strong beat. In their relative simplicity, the models hold potential for capturing the experience of a stylistically educated listener; excerpts from the corpus furnish explanatory cases that demonstrate the models' true and false predictions. Findings are duplicated with a second, smaller corpus, showing consistency in soul-dominant harmonic practice. The article also reveals major-minor seventh chords to be less predictable in their behavior than eleventh chords, furthering recent theoretical revisions to the concept of "dominant function."

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1. Introduction

[1.1] Mark Spicer's 2017 article "Fragile, Emergent, and Absent Tonics in Pop and Rock Songs" begins with a thought-provoking analysis of the harmony in Daryl Hall and John Oates's 1973 song "She's Gone." In the song's verse, Spicer identifies "close position A major and B major triads

alternating over a B pedal" ([2]). Spicer terms the A-major triad over a B bass a "'soul dominant'—best thought of . . . as a close position IV chord over $\hat{5}$ in the bass, conflating subdominant and dominant functions" ([3]).[(1)] The "soul" qualifier owes to the sonority's prevalence in 1970s soul music.[(2)] Spicer supplies the Roman numeral label "V^{11}" and emphasizes the chord's dominant function, although his main point is the notable absence of tonic harmony in the verse, an absence underscored by the repeated use of dominant function chords. "She's Gone" provides a jumping-off place for this article's goal of better understanding the behavior of the soul dominant sonority.

[1.2] In Spicer's hearing, the soul dominant in "She's Gone" provokes an expectation of tonic—a $\hat{1}$ summoned by the bass voice's $\hat{5}$. Spicer is not alone in reacting to the sonority in this way. David Temperley, for instance, offers the following assessment: "V^{11} nearly always moves to I" (2018, 62). Nevertheless, corpus data—shown in **Example 1**—reveal some surprising statistics. The corpus (whose construction I explain below) includes not only instances of V^{11} in the Ionian mode (in other words, chords like the soul dominant in "She's Gone"), but also equivalent sonorities built on any scale degree. These equivalent sonorities arise in local tonicizations as well as in the context of other modes, such as the Mixolydian mode. To be sure, V^{11} moving to I is a frequent occurrence, although only a slight majority (53.8%) of V^{11} chords in the corpus do so. In Example 1, that particular resolution is located at the intersection of an antecedent bass note of $\hat{5}$ and a consequent bass note of $\hat{1}$, of which there are 537 such transitions. In this article, I show dependency between the bass voice's approach to what I agnostically call "an eleventh chord" and that eleventh chord's "resolution." By eleventh chord, I mean a four- or five-note chord featuring a bass note, an optional perfect fifth above the bass, and a minor seventh, a major ninth, and a perfect eleventh above the bass; the upper voices may occur in any registral ordering. For example, an eleventh chord built above the bass note G would necessarily include the notes F, A, and C (and optionally include the note D) in the upper voices. Furthermore, I also show dependency between an eleventh chord's offset beat (i.e., the moment in which the chord ceases to be in effect), the global scale degree of its bass voice, and its resolution. In practical terms, attention to one or two features concerning a given eleventh chord can improve the accuracy of an engaged listener's prediction regarding the chord's resolution.

[1.3] In section 2 of this article, I describe the dataset that I use in my research; I also elaborate on existing theoretical explanations of the soul dominant. I compare and contrast the efficiency of two models designed to reflect aspects of theorists' intuitions about the soul dominant in section 3; in section 4, I examine their application to specific songs from the corpus. In light of the observed dependency between various factors concerning eleventh chords and their musical contexts, I surmise that a stylistically educated listener might reasonably expect a particular resolution of these chords. In section 5, I test the validity of my findings by applying the two models to a second, smaller corpus; I also consider the models' application to another sonority to which music theorists often attribute dominant function: the dominant seventh chord. I conclude with some suggestions for further research in section 6.

2. Methods and Materials

[2.1] Given the high degree of subjectivity inherent in analyzing recorded popular music, I decided to use archival data from the McGill *Billboard* corpus ("MBC"). This publicly available dataset includes harmonic transcriptions for 1,084 randomly selected songs that charted between 1958 and 1991, transcribed by over a dozen jazz musicians (Burgoyne 2011, xvii–xviii, 130–31, 135). John Ashley Burgoyne, the corpus's creator, has stated that a goal of the corpus was "to represent an experience whereby a particular person in the United States listened to a particular song at a particular time in a particular week" (2011, 128).[(3)] I elect to use the MBC to study the V^{11} chord because the MBC's date range covers the periods before, during, and after the musical era that inspired Spicer to coin the term "soul dominant."

[2.2] I am committed to modeling a specific listener experience via models that take one or two distinctive features of eleventh chords' behavior overall and form a cognitive category around those specific behaviors. This follows the theories of Spicer and Temperley, who—each in their own

way—understand the "soul dominant" as exhibiting very specific behaviors: when an eleventh chord behaves along these lines, it *is* a soul dominant; when it does not, we may question the application of that categorical label.(4) In this way, I will frame the soul dominant as a category of event that includes a set of normal categorical expectations—a set of *rules*. Because these chords elicit single outcomes most of the time, I will therefore cast these rules in binary terms: either that expected categorical resolution happens, or it does not. Furthermore, we can imagine these rules as approximating listeners' expectations. If chords within the soul dominant category frequently adhere to these rules, it is reasonable to imagine that listeners will form expectations that these rules will be followed. Indeed, if we accept Burgoyne's premise that the songs in the MBC represent listening experiences, then it is possible that any emergent corpus behavior approximates a listener's expectations about eleventh chords' harmonic practice within that corpus, a stance that embraces notions of passive exposure and statistical learning (Saffran et al. 1999; Loui 2012; Brown 2020).(5)

[2.3] The variety of labels applied to eleventh chords in the MBC transcriptions reflects some of the challenges the chord poses to harmonic analysis, as well as disagreement between theoretical explanations of how the chord arises. The chord is mentioned in some of the corpus's documentation, specifically in directions that Jonathan Wild used to coach the corpus's transcribers. Wild groups the four labels C11, B♭/C, Gm7/C, and C9sus; he explains that these labels all "[equal] C,(G),B♭,D,F; the 'C11' notation is a pop music convention and basically means B♭/C, sometimes with a G thrown in too" (Burgoyne 2011, 202). In practice, the transcribers used numbers instead of letters to the right of slashes (e.g., "Bb:maj/9"); they used the label "C:sus4(b7,9)" instead of "C9sus"; and they also used "Bb:maj6/9," a label not mentioned by Wild. These labels are shown in **Example 2**. Philip Tagg lists "C11," "C9/7/4," "Bb6/C," and "Bb/C" as possible labels for the "eleven chord," a chord he classifies as an instance of "quartal harmony" on account of its absent third (2014, 306).(6) Trevor de Clercq classifies such chords under the broader label of "hybrid chords"— chordal sonorities "with a triad in the upper voices and a bass note that is not part of that triad" (2019, 274–75). Christopher Doll (2017, 64) and Drew Nobile (2020, 221), in their respective rock analysis monographs, both cite Spicer 2017 and are more likely to engage with the sonority when it features $\hat{5}$ in the bass voice, in which case they label it with the Roman numeral "V^{11}" or "V9/7/4." When the sonority does not feature $\hat{5}$ in the bass, the authors tend to label it in lead-sheet style only (e.g., B♭/C), without Roman numerals. I will maintain the transcribers' original labels in this article in my discussions and examples, and I will refrain from theorizing about why the transcribers may have labeled a sonority a particular way; I will focus instead on these sonorities' behaviors and how those behaviors interact with other musical factors.

[2.4] Regardless of this labeling difference, my corpus analysis treats the five labels shown in Example 2 as a single chord class—a generic "eleventh chord." The chord class can be transposed to each of the twelve relative pitch classes available in a key (Snyder 1990, 125). In other words, a key consists of twelve scale-degree classes, the seven diatonic scale degrees plus the five chromatic degrees with enharmonic equivalence ($\hat{1}$, $\sharp\hat{1}/\flat\hat{2}$, $\hat{2}$, $\sharp\hat{2}/\flat\hat{3}$, $\hat{3}$, $\hat{4}$, $\sharp\hat{4}/\flat\hat{5}$, $\hat{5}$, $\sharp\hat{5}/\flat\hat{6}$, $\hat{6}$, $\sharp\hat{6}/\flat\hat{7}$, and $\hat{7}$) and my corpus analysis will search for eleventh chords appearing on—and constructed with—any of these scale degrees. Of the 1,084 songs in the MBC, 153 contained eleventh chords. As may be inferred from the standard deviation found in **Example 3**, some songs use eleventh chords much more extensively than others.(7) I created a dataset of the resulting 2,033 eleventh chords and tracked the scale degree of their bass voice, using the key indicated within the MBC's annotations to orient those scale degrees.(8) For each chord, I also recorded the root and bass of the previous and following chords. Example 1 shows the counts of the transitions from an eleventh chord to the following chord.(9) (I additionally examined transitions between the scale degrees of the chord roots, something to which I will return in section 5.) The dataset also includes bass repetitions to account for static bass motion accompanied by a change in quality—for instance, 454 antecedent eleventh chords with $\hat{1}$ in the bass are followed by a consequent chord (of some contrasting quality) with $\hat{1}$ in the bass.(10)

[2.5] Spicer (2017, [27]) and Temperley (2018, 62) both assert that soul dominants are common at the ends of formal sections such as verses and bridges. To test this, I also recorded the beat class of the

onset (moment of initiation) and offset (moment of termination) of eleventh chords in the MBC within normative four-measure units of quadruple meter when possible. Also, when possible, I divided sections into multiple four-measure units (e.g., I divided eight-measure sections into two four-measure units).(11) **Example 4** shows the frequency of eleventh chords' metric placements in this corpus; I borrow the "dot notation" along the x-axis from Lerdahl and Jackendoff 1983 (19). **Example 5** shows the offsets of eleventh chords, which almost always coincide with the arrival of the consequent bass note (from Example 1). **Example 6** shows the onset and offset of an eleventh chord—labeled in the transcription as B♭sus4(♭7,9)—found within the first four measures of Roberta Flack's "Feel Like Makin' Love."(12) All chord symbols are taken from the MBC transcription; I have additionally shown the harmonies written on staff notation along with my own transcription of the vocal melody. As with most cases, the eleventh chord's offset coincides with the arrival of the following chord, E♭maj7.

3. Results

[3.1] I use the data I collected to test a few suppositions about the soul dominant: Temperley's claim that V^{11} usually resolves to I, Spicer's claim about the soul dominant's dominant function (a function associated with particular chord-to-chord successions, as I outline below), and—extrapolating from observations of both Spicer and Temperley—the idea that eleventh chords tend to resolve on strong beats. Consider first a simple model designed to test Temperley's claim that V^{11} usually moves to I. We can test this theory with a simple binary classifier that implements the following rule: if an eleventh chord has $\hat{5}$ in the bass, then it is predicted to resolve by descending perfect fifth in the bass; if an eleventh chord does *not* have $\hat{5}$ in the bass, then it is *not* predicted to resolve by descending perfect fifth. (Here, I'll use "descending perfect fifth" on account of the interval's historical legacy; in practice, the bass motion may also be realized as an ascending perfect fourth. For my purposes, the direction in pitch space is not important.) In the MBC, 537 V^{11} chords do indeed behave like "soul dominants," resolving to some chord with $\hat{1}$ in the bass. **Example 7** illustrates one such instance. By adding to those 537 V^{11} chords the 904 eleventh chords built on any of the eleven other scale degrees that do not resolve down by fifth, and dividing this sum by 2,033—the total number of eleventh chords in the MBC—the rule appears approximately 71% accurate.(13) I return to further issues surrounding this classification strategy, below.

[3.2] Given Spicer's claim about the soul dominant's dominant function, one question that arises concerns the role that chord-to-chord succession may play in this dominant function. To allow for the possibility of secondary soul dominants (e.g., V^{11}/IV resolving to IV, of which there are 59 instances in Example 1), I explore models that base their predictions on the interval with which the bass voice approaches the eleventh chord. If the soul dominant has dominant function, it is fair to wonder how often it is preceded by a pre-dominant—a harmony "whose primary purpose is to lead to the dominant" (Caplin 1998, 23). A rule that predicts an eleventh chord to be followed by bass motion of a descending perfect fifth if and only if it is itself preceded by descending-perfect-fifth bass motion (e.g., ii–V^{11}–I in the global key or any local key) is 69% accurate.(14) **Example 8** illustrates the rule's application, showing an eleventh chord built on $\flat\hat{6}$, preceded by a chord built on $\flat\hat{3}$, that tonicizes the following chord built on $\flat\hat{2}$ during the bridge of Phil Collins's "Two Hearts." Dominant-function chords need not be preceded by a pre-dominant, of course. Since Burgoyne found that $\hat{5}$ was the most common pre-tonic root and the second-most common post-tonic root in the MBC (Burgoyne 2011, 176, 178), I also investigated eleventh chords that participate in I–V^{11}–I progressions (within both global and local tonalities). Such a rule would predict resolution by descending fifth of an eleventh chord if and only if the chord is preceded by an ascending perfect fifth in the bass; the rule is 70% accurate. **Example 9** shows three successful predictions resulting from such a rule—with characteristic neighbor-note motion in two upper voices—in mm. 43–47 of Brother Jack McDuff's "Theme from Electric Surfboard." The most accurate combination of *two* possible intervals of approach in the bass voice is a perfect fourth *or* fifth (e.g., $\hat{5}$ approached from $\hat{1}$ or $\hat{2}$), at 72%.(15) This accuracy score offers validation for Spicer's characterization of the soul dominant's harmonic function.

[3.3] To test Spicer and Temperley's assertion that soul dominants commonly occur at the ends of formal sections—and thus the end of phrases and end of measures—I queried how many eleventh chords terminate on downbeats or hyperdownbeats.(16) A model that predicts conventional resolution of any eleventh chord if and only if the eleventh chord terminates on a strong beat is only 42% accurate.(17) **Example 10** revisits Flack's "Feel Like Makin' Love" to show strong-beat termination of an eleventh chord, B♭sus4(♭7,9), coinciding with resolution by descending fifth.(18) Weak-beat termination of an eleventh chord can be seen in Example 18, below.

[3.4] For the remainder of the article, I focus on two rule-based models that demonstrate aspects of eleventh-chord harmonic practice when applied to specific chords from the dataset, allowing us to further test Spicer and Temperley's theoretical intuitions. **Example 11** shows a flow-chart illustrating a binary classifier that I term Model A. Model A formalizes some of the above observations surrounding these chords' bass-motion behaviors, namely the tendency for soul dominants to be preceded by either a pre-dominant or by tonic. It predicts resolution by descending perfect fifth if and only if the bass voice of an eleventh chord is approached by perfect fourth *or* perfect fifth. That is: the model's rule is "satisfied" if an observed eleventh chord resolves down by fifth if it is preceded by bass motion of fourth or fifth; but, it is also satisfied if the chord does *not* resolve down by fifth if it is *not* preceded by a fourth or fifth. **Example 12** shows an "error matrix"—a useful table for scrutinizing the performance of a model. Eleventh chords approached by a perfect fourth or fifth in the bass are more than twice as likely as eleventh chords approached any other way to be followed by bass motion of a descending perfect fifth. **Example 13** provides a key for deciphering the statistics presented in the error matrix. Accuracy denotes the percent correctly classified overall; sensitivity denotes the percent of soul dominants correctly classified; specificity denotes the percent of non-soul dominants correctly classified.(19) A chi-square statistical test shows this categorization to significantly predict the corpus's behavior: $\chi^2(1, N = 2{,}033) = 251.35$, $p < .001$.(20) **Example 14** illustrates the model's performance with an area-proportional Venn diagram, showing that most eleventh chords approached by a perfect fourth or fifth in the bass voice resolve by descending fifth.

[3.5] The eleventh chord in the Roberta Flack excerpt shown in Example 7 adheres to Model A—its rules are satisfied—and also to what I term Model B. **Example 15** shows a flow-chart for Model B, a combination of the remaining two factors. Model B predicts resolution by descending perfect fifth if and only if an eleventh chord has $\hat{5}$ in the bass *and* terminates on a strong beat.(21) By "strong beat," I mean any event with some relatively large amount of metric accent, or "not any beat marked by a single dot in the dot notation of Example 5" (i.e., in a four-bar hypermeter, the second and fourth beats of quadruple measures would *not* be strong beats). **Example 16** shows an error matrix for Model B. Eleventh chords with $\hat{5}$ in the bass that terminate on strong beats are more than five times as likely to be followed by bass motion of a descending perfect fifth than eleventh chords that do not meet both of those criteria.(22) This again was significant according to a chi-square test: the chi-square (χ^2) value exceeded the tabled critical value because there were more observed successful predictions than expected successful predictions and fewer unsuccessful predictions than expected unsuccessful predictions: $\chi^2\ (1, N = 2{,}033) = 530.00$, $p < .001$.(23) **Example 17**'s area-proportional Venn diagram for Model B shows how the combination of factors from separate domains (bass scale degree and metric location of chord offset) describes the conventional resolutions with greater precision.

[3.6] Example 12 reveals a lack of independence between the bass's approach to and departure from an eleventh chord; Example 16 reveals a lack of independence between an eleventh chord's resolution, its bass scale degree, and its offset beat. For the engaged listener following along with the harmony in real time, the lack of independence between these factors may give rise to the appearance of cause and effect relationships.(24) For example, a stylistically educated listener, aware that a G11 chord was preceded by Dm7, might predict that G11 will behave as a dominant-function chord (Spicer's "soul dominant") and be succeeded by a C chord—a local or global tonic. If the chords in question are found in a song from the same repertoire as that sampled by the MBC, such a prediction will likely prove correct more often than it will prove incorrect.(25) That being said, a listener's response to an eleventh chord is likely mediated by not only the chord's immediate context, but also by the extent of the listener's experience with tonal and metric

hierarchies in music.[26] And, as will be shown in some of the song excerpts reviewed below, a broader view of a particular eleventh chord may reveal an explanation for its non-normative behavior.

4. Comparative Case Studies for Models A and B

[4.1] **Example 18** shows the musical factors that impact the outcomes of Models A and B applied to an eleventh chord found within the first four measures of the first verse of Earth, Wind & Fire's "After the Love Has Gone." With regards to the excerpt's penultimate chord, "B♭maj/9," both models classify it as a "rule satisfying" non-resolution by descending fifth. In other words, in musical situations like this, neither model would predict the eleventh chord to be followed by bass resolution by descending perfect fifth, and that bass resolution does not in fact happen. Model A classifies the eleventh chord as a rule satisfying non-resolution by descending fifth because its bass was not approached by perfect fourth or perfect fifth. Model B assigns the same classification—although $\hat{5}$ of F major is the bass of B♭maj/9, the chord's offset happens on a weak beat. A listener could reasonably expect B♭maj/9 to resolve to Fmaj, but not until a stronger beat, such as the ensuing downbeat. Model B's justification suits the transcription's close attention to surface-level harmonic detail.

[4.2] **Example 19** highlights the pertinent musical details of the last four measures of the first chorus of the Commodores' "Easy." This excerpt features two eleventh chords, both labeled "D♭maj/9"—one in each of the second and third measures of the example. Both models predict a leap of a descending perfect fifth in the bass across the excerpt's second and third measures, but that leap does not occur. These unfulfilled predictions reflect the aspect of surprise that accompanies the arrival of the "G♭maj" chord (♭VII of A♭ major), both in terms of its immediate musical context and the broader harmonic practice of popular music. Model B's criteria—$\hat{5}$ in the bass of the eleventh chord and an offset not on a weak beat—meet with success in their prediction of the second D♭maj/9 chord's resolution (see the final two measures of the excerpt).[27] Because this chord's bass voice is not approached by a perfect fourth or perfect fifth, however, Model A unsuccessfully predicts that the ensuing chord will not include $\hat{1}$ in the bass voice.

[4.3] Both models are equipped to handle tonic pedal points in modal contexts effectively. **Example 20** shows a tonic pedal point in the Aeolian mode in the introduction to Tina Turner's "What's Love Got to Do with It," an instance of what de Clercq refers to as "hierarchy divorce" between the bass and upper voices (2019, 271). Megan Lavengood (2020, [0.1]) identifies the bass guitar and electric guitar in this song as the "functional bass layer" and "harmonic filler layer," respectively. Above a stationary G♯ in the bass guitar, the electric guitar alternates G♯m7 chords and F♯-major triads; considered along with the pedal point, the latter sonority technically qualifies as an eleventh chord. For eleventh chords like this F♯maj/9 chord, both models would predict the bass to not resolve by descending perfect fifth. Model A would make such a prediction because of the bass's common tone with the previous chord; Model B would make this prediction because the bass voice features $\hat{1}$.

[4.4] On the other hand, Model B often makes inaccurate predictions when pedal points occur on the dominant scale degree.[28] In another example of de Clercq's hierarchy divorce, a dominant pedal point occurs during the chorus of Donna Summer's "Last Dance," shown in **Example 21**. Several apparent "B♭maj/9" chords are found in this passage. The first two "B♭maj/9" chords are succeeded by second-inversion F-major triads as part of the dominant pedal point. The third B♭maj/9 chord gives way to a statistically unlikely G9/3 chord.[29] This excerpt seems to treat dominant-eleventh chords as a potential source of musical drama—only the last eleventh chord is followed by descending fifth bass motion. The last eleventh chord—labeled as Csus4(♭7,9)—is also the only eleventh chord in the excerpt to be preceded by bass motion of a perfect fourth or fifth. Consequently, Model A successfully sorts the eleventh chord that behaves as a "soul dominant" from those that do not. Model B's inaccurate predictions owe to the fact that the model does not take account of eleventh chords' bass-line contexts: dominant pedal points may persist indefinitely,

and may not resolve as expected upon conclusion anyway. How the models perform in situations such as this plays a part in their diagnostic accuracy.

[4.5] The predictions of each of the models also illustrate interesting and conflicting facets of complex musical situations such as tonal ambiguity or harmonic-bass divorce (de Clercq 2019). **Example 22** shows an excerpt from the introduction to "Dial My Heart" by the Boys that elicits contrasting classifications from the two models considered in this article. The MBC transcription lists the song's tonic as A, even though the bass notes of Example 22's excerpt—B, E, and F♯—might more plausibly be heard as $\hat{1}$, $\hat{4}$, and $\hat{5}$ of B. With regards to the chord in m. 7—"Amaj/9," with B in the bass—Model A notices that the preceding bass note (as given by the transcription) is F♯—the ninth of "Emin9/9." Because the Amaj/9 chord is approached by a descending perfect fifth in the bass, Model A predicts further bass motion by a descending perfect fifth. The model therefore accurately predicts the resolution to the following "Emin9" chord (notwithstanding the surface detail shown in the staff notation in the example). Because the bass note of Amaj/9 is *not* $\hat{5}$, however, Model B inaccurately predicts that the ensuing bass note will *not* be E. These different predictions seem symptomatic of the harmonic-bass divorce latent within the passage, as the bass line seems removed from the overarching tonic of the song. But, even if the transcription had recognized B as the song's tonic (aligning more with the bass line's pitch content), however, the Amaj/9 chord would *still* not appear on $\hat{5}$, and therefore still not resemble a typical soul dominant as framed within Model B. Model A allows for the possibility of applied soul dominants (e.g., "V^{11}/iv"), but hearing the Amaj/9 chord as E's dominant seems incompatible with the bass line's prominent D♮s.(30) From a theoretical perspective, the harmony of "Dial My Heart" is complex and exceptional. I am skeptical that either model could plausibly represent the entirety of listeners' harmonic expectations within this excerpt. In my view, this musical situation highlights a deficiency in Model A's capacity to distinguish an actual tonicization (such as that shown in Example 8) from a tonally ambiguous progression, while Model B's scale-degree criteria may be misled altogether by such tonal ambiguity.

5. Further Explanation of Models A and B, and a Test

[5.1] Thus far, this article has focused on bass notes rather than chord roots. This is for two main reasons. First, there is clearly some debate between theorists—as well as the MBC's transcribers—over which note is the true root of chords within popular-music repertoires. A chord's bass note, however, is quite clear. Additionally, bass notes had greater predictive power than did chord roots in this corpus. Model A describes the behavior of 72% of my corpus when using bass motion, while the same model using root motion describes only 66%. (See **Example 23**.) Similarly, while Model B describes 76% of the corpus using bass notes, it falls to 73% when using chord roots (see **Example 24**). In both cases, predictions concerning the ensuing bass note were more accurate than predictions concerning the ensuing root.

[5.2] These discrepancies in accuracy owe to two factors. For one, 5.9% of the pre- and post-eleventh chords in this study are in inversion.(31) At least as far as tonic and dominant are concerned, whenever a chord's root and bass note differ, the bass provides a better explanation of the chord's behavior in more cases. Additionally, a bass-note only approach allows for eleventh chords to resolve to harmonically underdetermined moments. In particular, the MBC's transcribers recorded bass notes (without inferred harmonies) in those moments when the bass line was the only pitched accompaniment present, moments which ranged in duration from a single beat to several measures. For instance, the verse of Billy Joel's "Just the Way You Are"—shown in **Example 25**—concludes with an "Asus4(♭7,9)" chord. The MBC transcription observes that the ensuing interlude begins with a single note in the bass: D. Both Model A and Model B correctly predict this bass note. "A single note in the bass alone has the power to strongly convey chord function," de Clercq argues (2019, 273–74). Taking advantage of the potential ambiguity of this downbeat, the electric piano soon harmonizes D as the bass note of "Ehdim7/♭7" (i.e., $E^{\emptyset\frac{4}{2}}$), displacing the inferred tonic harmony's upper voices. A version of Models A or B that made predictions regarding root motion would produce incorrect predictions when applied to the eleventh chord in this particular excerpt.

[5.3] To test these models' generalizability, I test Models A and B on a separate corpus: Temperley and de Clercq's "Rolling Stone 200 Corpus" (2013, 187–88). Temperley and de Clercq's dataset includes two sets of harmonic analyses of two hundred songs from *Rolling Stone* magazine's 2004 article "The 500 Greatest Songs of All Time." Both authors independently analyzed each piece within this corpus, and I will focus specifically on Temperley's analyses, as they include more eleventh chords than de Clercq's. The Rolling Stone 200 ("RS200") corpus has fewer total songs and fewer total eleventh chords than the MBC—see **Example 26** for a comparison. As with the MBC, only a plurality of eleventh chords in the RS200 have $\hat{5}$ in the bass voice. Despite Temperley's pronouncement that "V^{11} nearly always moves to I," according to his transcriptions such a move happens only 54.8% of the time. **Example 27** reveals that Model A is slightly less accurate when applied to the RS200 corpus transcription data; **Example 28** shows Model B to be slightly more accurate. Eleventh chords approached by a perfect fourth or perfect fifth in the bass are more than twice as likely as eleventh chords approached any other way to be followed by bass motion of a descending perfect fifth ($\chi^2(1, N = 193) = 23.89$, $p < .001$). Eleventh chords with $\hat{5}$ in the bass and a chord offset not on a weak beat are more than three times as likely to be followed by bass motion of a descending perfect fifth than eleventh chords that do not meet both of those criteria ($\chi^2(1, N = 193) = 49.55$, $p < .001$).

[5.4] This alternate dataset also illustrates the potential problem of *overfitting*, or constructing a model whose complexities are specific to a single corpus but do not accurately describe events outside that specific dataset. We could, for instance, combine the three factors used across Models A and B—the bass scale degree, the interval with which the bass voice approaches the chord, and the metric offset—into a single model. Such a model would link together all the features useful within the MBC, but suffers when applied to the RS200. In this case, combining all three factors into one model mildly improves predictive accuracy when applied to the MBC-derived data to 78%, but such a model underperforms the simpler Model B when applied to the RS200 corpus (only 73%, compared to Model B's 77% accuracy).(32) This larger model would seem, then, to be overfitted to the MBC.(33)

[5.5] Overall, this suggests that the dominant function of an eleventh chord—the category of the *soul dominant*—seems to arise from a combination of overlapping but not necessarily co-occurring factors. Often, an eleventh chord preceded by a particular bass interval (such as a fourth or fifth) will proceed, in characteristic fashion, one position counterclockwise around the circle of fifths to the ensuing chord. Additionally, soul dominants tend to be chords with $\hat{5}$ in the bass that resolve to I on strong beats. Furthermore, my modeling shows that the "soul dominant" concept ought to include not only V^{11} chords, but also tonicizing dominants (as well as small-scale modulations subsumed into a song's tonal hierarchy).

[5.6] Remarkably, my models also show that V^{11} chords seem to behave in more predictable ways than the common-practice form of the dominant—the major-minor seventh chord, or "dominant seventh." Following the same procedure as before, I gathered data from the MBC transcriptions on major-minor seventh chords. **Example 29** shows an error matrix for Model A as applied to the 6,482 major-minor seventh chords in the corpus. As can be seen from the table, Model A is less accurate when applied to major-minor seventh chords than it is when applied to eleventh chords—in fact, major-minor seventh chords approached by a perfect fourth or perfect fifth in the bass voice are actually *less* likely to be followed by bass motion of a descending perfect fifth than major-minor seventh chords approached by any other interval.(34) I speculate that this owes to the influence of blues-based harmonic progressions: the model incorrectly predicts descending fifth bass motion between the latter pair of chords in a majority of the harmonic trigrams in a typical 12-bar blues (I^7–IV^7–I^7, IV^7–I^7–V^7, and I^7–V^7–IV^7). As **Example 30** reveals, Model B is also not as accurate when applied to major-minor seventh chords (although major-minor seventh chords that fulfill Model B's criteria are more likely to be followed by bass motion of a descending perfect fifth than those that do not).(35) In general, the behavior of major-minor seventh chords in the MBC may be characterized as less predictable than that of eleventh chords. This comparative lack of predictability may have played a role in motivating recent theoretical revisions of extant definitions of "dominant function" in rock and popular music, such as the separation of chord content from chord function (Nobile 2016, Doll 2017) or the introduction of new functional categories altogether

(White and Quinn 2018). If dominant function is a category of chords whose bass notes or roots resolve down by fifth to the tonic, eleventh chords seem to more predictably exhibit this function than their major-minor cousins.

6. Conclusion

[6.1] This article compared and tested the accuracy of two models' predictions regarding harmonic transitions from eleventh chords. Eleventh chords approached by a perfect fourth or perfect fifth in the bass voice are more than twice as likely than eleventh chords approached by any other interval (including a perfect unison) to be followed by bass motion of a descending perfect fifth—in other words, to behave as soul dominants. Eleventh chords with $\hat{5}$ in the bass that terminate on a strong beat are more than five times as likely to behave similarly. This behavior derives from the entire MBC, including songs from the soul music era, songs that pre-date the era, and songs from subsequent eras that were influenced by soul music.

[6.2] Spicer 2017 also discusses another facet of dominant chord usage in popular music that does not seem to be captured in the MBC's random sample of songs. He writes: "By the late 1970s [the soul dominant] sometimes operated as a coloristic sonority for its own sake, irrespective of its dominant function (not unlike, for example, the way in which Debussy often composed passages that utilized harmonic planing of non-functional dominant-seventh chords)" [27]. **Example 31** shows an excerpt from neo-soul musician D'Angelo's "Another Life" (2014) that illustrates this harmonic practice. The song's introduction features eleventh chords built on five different pitch classes. As **Example 32**'s inferential statistics suggest, bass departures of an ascending perfect fourth from an eleventh chord (e.g., B11 to EM7) are relatively common, though the "Another Life" introduction also features some rare bass departures (e.g., B11 to A♯m7). Depending on the extent of eleventh chord usage, passages like Example 31 can raise questions about the local (and global) tonality. Even if "B11 to EM7" is taken as a key-defining progression, the "resolutions" of the remaining eleventh chords all represent exceptional cases.(36) Further study is needed to determine the effect that extensive eleventh chord usage might have on key-finding strategies.(37)

[6.3] This article has used empirical testing to test conventional wisdom about eleventh chords and the "soul dominant." By operationalizing systems of rules and categorical expectations, these systems model musical expectations, especially one where a certain outcome is expected a majority of the time. Re-examining the behavior of the eleventh chords in this corpus also shows how harmonic function in popular music might be better understood through a lens of greater emphasis on chord context, rather than chord content. Finally, simple models may not only be used to test theoretical intuitions, but also as new listening strategies to tease out the surprising and satisfying moments in music.

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Footnotes

1. See also Spicer 2004, 38. Piston (1962, 262) refers to such a sonority as the “dominant eleventh.”
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2. Haralambos (1975, 154) locates the beginning of soul music as a style between 1960 and 1964 and observes that it became the foremost style of Black popular music by the middle of the 1960s (101). By the end of the 1970s, the term “soul” had undergone further development. Stephens (1984, 37) notes its blanket application to all Black popular music by that point, and Maultsby (1983, 58) finds that it also applied to any white performer who drew musical influence from blues and/or gospel music.
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3. As a measure of a song’s popularity, chart position and duration has been criticized, given that record labels sometimes paid radio stations to play songs they wanted to market (Burgoyne 2011, 129; Middleton 1990, 5–6).
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4. Thus, not all eleventh chords are soul dominants. I would explain the difference like this: if the bass note of an eleventh chord may be reasonably predicted to resolve by descending perfect fifth (and this criteria may be satisfied in more than one way), it is a soul dominant, regardless of how it actually resolves.
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5. Huron 2006 offers various “heuristics” that perform better than chance as explanation for listeners’ expectations.
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6. Tagg mentions Gm7 over C as another possible label.
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7. A future study might address how to control for the repetition of harmonic progressions in this dataset; such an undertaking is beyond the scope of this project.
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8. As the transcription for Milli Vanilli’s “Baby Don’t Forget My Number” did not match the song’s audio, I excluded its data from my study. The corpus also includes a handful of mislabeled eleventh chords in the following songs: Bing Crosby’s “White Christmas,” Color Me Badd’s “I Adore Mi Amor,” Milli Vanilli’s “Girl You Know It’s True,” and Bob Seger’s “Like a Rock.” After

aurally verifying the errors, I excluded those eleventh chords from my study.
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9. Thirteen of the corpus's eleventh chords were not followed by any chord or bass note, either because they were the last chord of the song, or they were followed by a passage that lacked harmony and/or a bassline (e.g., a drum solo).
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10. Example 1 therefore departs from aspects of the data collection approach used by Trevor de Clercq and David Temperley in their investigation on chord transitions in a one-hundred-song subset of *Rolling Stone* magazine's "500 Greatest Songs of All Time" list—the "RS 5 x 20 corpus." In that study, the authors counted changes of chord root, but not chord quality, in song transcriptions; consequently, they did not collect data on changes of quality with a constant root (2011, 61). Burgoyne's Table 4.10 and Table 4.11 (2011, 176, 178) take a similar approach to that of de Clercq and Temperley.
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11. In rock music, Temperley notes the "strong norm of duple (two-measure and four-measure) hypermeter" (2018, 143). Out of the 2,033 chords in this study's dataset, 1,752 (86.2%) were found in contexts with clear quadruple meter and hypermeter. This figure includes some compound meters (e.g., eight bars of $\frac{6}{8}$ treated as equivalent to four bars of quadruple meter). On the concept of beat classes, see Cohn 1992 (149).
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12. In Example 6, the onset of the eleventh chord ("B♭sus4(♭7,9)") is found in the fifth column from the left on Example 4; that chord's offset is found in the ninth column from the left on Example 5.
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13. Shea, White, Hughes, and Vuvan (2023, 21) similarly demonstrates how a tonal scenario involving several possible outcomes may be collapsed into a binary choice when investigating a first-level default.
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14. Successful predictions made by such a model exhibit Steve Larson's notion of "inertia": the bass voice approaches the soul dominant via a descending perfect fifth and continues, in pattern fashion, via another descending perfect fifth to the ensuing chord. On inertia, see Larson 2002 (352).
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15. Adding the possibility of the bass voice approaching the eleventh chord by ascending major second to the possibility of an approach by descending perfect fifth (e.g., $\hat{5}$ approached from $\hat{2}$ or $\hat{4}$) actually lowers the model's accuracy to 66%.
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16. The higher onset rate in the last measure of the hypermeasure—as well as the higher offset rate on the hypermetric downbeat—could be connected to Temperley's observation that V^{11} chords are common at cadences (2018, 62). Furthermore, Example 1, above, shows that a majority of eleventh chords (1,120/2,033, 55.1%) are followed by $\hat{1}$ in the bass voice. Together, Examples 1 and 5 lend support to Prince and Schmuckler's observations about the correlation between tonal and metric stability (2014, 261).
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17. Technically, the model filters out from its predicted resolutions any eleventh chord with a chord offset on a weak beat (i.e., all second and fourth beats in a passage of quadruple hypermeter). Eleventh chords in non-normative metric and hypermetric contexts are not filtered out, and are therefore predicted to resolve conventionally.
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18. Measures 3–4 of Example 10 provide a glimpse of how the MBC transcribers handled syncopation. The transcribers reduced-out syncopation, recording instead the "deep structure"

(Temperley 1999, 26) of the songs' harmonic rhythm. Thus, the transcription records "D♭7" as arriving on the downbeat of m. 4, when it can be heard on the recording that the bass guitar and electric guitar play the notes of this chord on the last eighth note of m. 3. The models explored in this article take the transcribers' practice into account, basing their predictions on eleventh chords' rhythmic deep structure.
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19. The binary data in the "Resolution ≠ ↓P5" row in Example 12 represent a compound event, encompassing the eleven other bass departure intervals (P1, ↓m2, etc.), as well as eleventh chords not followed by bass notes (e.g., as a song's final chord).
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20. Of the 648 eleventh chords with bass notes approached by perfect fourth or perfect fifth, 369 (56.9%) were followed by bass motion of a descending perfect fifth; of the 1,385 eleventh chords with bass notes not approached by perfect fourth or perfect fifth, 298 (21.5%) were followed by bass motion of a descending perfect fifth. The chi-square (χ^2) value, then, exceeded the tabled critical value on account of the differences between the observed and expected cell frequencies. In the error matrix for Model A (Example 12), the observed counts of successfully-predicted resolutions exceed the expected successfully-predicted resolutions, the observed unsuccessfully-predicted resolutions lag behind the expected unsuccessfully-predicted resolutions, and so on. Because the tabled critical value of $\chi^2 = 3.84$ was exceeded by the derived value of $\chi^2 = 251.35$, I reject the null hypothesis that the bass's departure from an eleventh chord is independent of its approach. It is important to clarify that there is no "ground truth" label of confirmed "soul dominants" used to assess the accuracy of the model's performance—accuracy hinges solely on the bass motion found after the eleventh chord.
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21. This model suggests that eleventh chords' resolution (as theorized by Temperley) more often than not occurs during moments where a listener's "attentional peak" is likely to be higher than a minimum threshold. On attentional peaks, see London 2004 (158).
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22. Of the 899 eleventh chords with $\hat{5}$ in the bass and a chord offset not on a weak beat, 537 (59.7%) were followed by bass motion of a descending perfect fifth; of the 1,134 eleventh chords that did not meet both of those criteria, 130 (11.5%) were followed by bass motion of a descending perfect fifth.
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23. Model B would explain why Spicer felt the introduction and verses of "She's Gone" produce "constant tension." Because those sections lack tonic chords entirely, the model's predictions about the resolution of the many V^{11} chords all prove false.
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24. Edward Tufte offers that "the reason we seek causal explanations is in order to *intervene*, to govern the cause so as to govern the effect" (1997, 28). I hesitate, however, to speculate on what the models compared herein say about how songwriters deploy eleventh chords in the act of songwriting. It is possible that a songwriter might structure the harmony of a song hierarchically—or work backwards from a terminal tonic chord in writing a chord progression. Model B reveals that global scale degree and meter are also important factors. Since tonic chords are common—both generally and on odd-numbered downbeats—it is also possible that the characteristics that Spicer and others have attributed to "soul dominants" owe to the chords' tendency to be deployed in the interstices (from both a metric standpoint as well as a pitch and pitch-class standpoint) between tonic chords.
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25. Theories of statistical musical learning suggest that listeners should be able to learn the musical norms illuminated in this article. On the conjectural connection between corpus studies and

statistical musical learning, see White and Quinn 2018 (317).
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26. On this expansive view of musical context, see Lewin 1986 (335).
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27. This chord illustrates Trevor de Clercq's notion of syntax divorce, a type of harmonic-bass divorce: "the harmonic layer and the bass share a structural or cadential goal [here, tonic] but approach that goal via different pathways" (2019, 271–72).
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28. This generalization assumes a regular harmonic rhythm of chords changing on the first and third beat of each measure—or slower.
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29. For eleventh chords built on $\hat{5}$, such a bass departure happens less than 1% of the time (9/999).
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30. Curiously, "Amaj/9–Emin7" in Example 22 is an exact transposition of mm. 94–95 from Example 8 ("D♭maj/9–A♭min7"), where an eleventh chord more obviously functions as an applied soul dominant. To reiterate a point made earlier, however, there is no ground truth label for soul dominants in the dataset; Model A has simply made a correct prediction regarding the bass note after an eleventh chord.
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31. Conversely, 94.1% of the pre- and post-eleventh chords are in root position. Compare these findings to those of de Clercq and Temperley, who observe that 94.1% of all chords in the RS 5 x 20 corpus are in root position (2011, 66).
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32. Such a model would predict conventional resolution of any II^{11} (i.e., V^{11}/V) *or* V^{11} chord approached by perfect fourth or fifth in the bass voice that terminates on a strong beat. As David Huron points out, there is a linear relationship between information content and reaction time (2006, 63). Increasing the complexity of a model may reduce the likelihood that the model reflects how listeners arrive at predictions in real time.
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33. The 153-song MBC subset includes one cover of a song in the 19-song RS200 subset (Jeff Beck's cover of The Impressions' "People Get Ready"), but the two recordings have non-trivial differences in their harmonic progressions.
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34. Of the 3,453 major-minor seventh chords with bass notes approached by perfect fourth or perfect fifth, 1,786 (51.7%) were followed by bass motion of a descending perfect fifth; of the 3,029 major-minor seventh chords with bass notes not approached by perfect fourth or perfect fifth, 1,815 (59.9%) were followed by bass motion of a descending perfect fifth.
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35. Of the 2,760 major-minor seventh chords with $\hat{5}$ in the bass and a chord offset not on a weak beat, 1,979 (71.7%) were followed by bass motion of a descending perfect fifth; of the 3,722 major-minor seventh chords that did not meet both of those criteria, 1,622 (43.5%) were followed by bass motion of a descending perfect fifth.
Return to text

36. The status of the first "B11 to EM7" progression as a key-defining progression may only be recognized after the fact. Upon hearing the first B11 chord, the listener has no way of predicting how—or when—it might "resolve."
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37. One possible direction would be to explore the effect of harmony in passages like Example 31 on the tonal pitch-class "center-of-gravity" (Temperley 2001, 125).
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