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Melodic Contour and Nonretrogradable Structure in the Birdsong of Olivier Messiaen

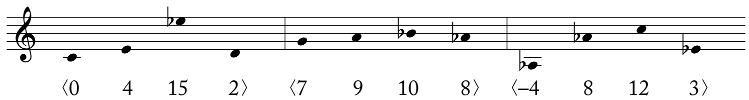
ROB SCHULTZ

Taking its cue from several highly suggestive remarks found in his interviews and two major theoretical treatises, this article investigates melodic contour structure in Olivier Messiaen's mature birdsong. Following some key refinements to Robert Morris's (1993) Contour-Reduction Algorithm and prime contour classification system, the algorithm is applied to various passages from Messiaen's *Réveil des Oiseaux* and birdsong transcriptions in Tome V of his *Traité de Rythme, de Couleur, et d'Ornithologie*, thereby revealing the existence of numerous nonretrogradable patterns, varying in both nature and degree of exactitude, at a deeper level of structure. The article then discusses the specific features that these patterns exhibit, and explores some of the major issues involved in carrying out an analysis of this kind. Finally, evidence is offered in support of the assertion that these contour symmetries represent a concrete manifestation of Messiaen's self-admitted tendency to unintentionally insert his own compositional voice and artistic sensibilities into his birdsong transcriptions.

Keywords: Messiaen, birdsong, melody, contour, algorithm, prime, symmetry

In the remarkably concise discussion of birdsong in his *Technique de mon Langage Musical*, Olivier Messiaen declares: "their [i.e. the birds'] melodic contours, those of merles especially, surpass the human imagination in fantasy" (Messiaen 1944/1956, 38). Although this remark unmistakably flows directly out of the previous chapter of the book, "Melody and Melodic Contours," it is nonetheless quite noteworthy that Messiaen draws specific attention to the melodic contours of birdsong. Indeed, in the aforementioned chapter on the subject, Messiaen reveals the crucial role that melodic contours occupy in his own compositional process, illustrating how various melodic passages from his works sprang forth from the melodic contours of passages from Mussorgsky's *Boris Godunov*, Grieg's *Chanson de Solveig*, and Debussy's *Reflets dans l'Eau* (32–34). This becomes even more explicitly apparent later in the chapter, when Messiaen discusses the "rare and expressive" melodic contours of plainchant, and subsequently declares: "We shall make use of them, forgetting their modes and rhythms for the use of ours" (36). Further evidence of Messiaen's regard for melodic contour, in both birdsong and plainchant, is also found throughout the decidedly more exhaustive treatment of birdsong presented in Tome V of his *Traité de Rythme, de Couleur, et d'Ornithologie*, where he frequently classifies melodic motifs from various birdsongs as being equivalent to certain types of neumes from the plainchant repertory—as though the birds themselves had also adopted his practice of adjusting the melodic contours of plainchant to his own pitch and rhythmic schemes.[1]

1 In Tome IV of the *Traité* (1997, 8–17), Messiaen outlines the various types of neumes using plainchant notation, and draws comparisons to melodies by Mozart, Wagner, and Debussy.



example 1. *Three equivalent realizations of the contour ⟨0231⟩ in pitch space (Morris 1993, 207)*

Given the significance that melodic contour has for Messiaen's compositional process and musical sensibility, an investigation into this aspect of his music utilizing some of the relatively recent advances in musical contour theory seems to be a rather pertinent and potentially fruitful endeavor.[2] Indeed, this approach seems especially justified for Messiaen's birdsong repertoire in light of his self-proclaimed conscious alterations of their pitch structure, as he describes in some detail: "I'm obliged to eliminate any tiny intervals that our instruments cannot execute. I replace those intervals, which are on the order of one or two commas, by semitones, but I respect the scale of values between the different intervals, which is to say that if a few commas correspond to a semitone, a whole tone or a third will correspond to a real semitone; all is enlarged, but the proportions remain identical, and as a result, what I restore is nevertheless exact" (1994, 95). While this last point clearly demonstrates that for Messiaen, these adjustments do not in any way invalidate the interval content, and thus, the authenticity of his birdsong transcriptions, the passage as a whole undoubtedly suggests an analytical and perceptual shift in emphasis, especially in connection with the importance Messiaen places on melodic contour in his theoretical writings, as described above.

As an initial step toward such an exploration of melodic contour in Messiaen's birdsong, this essay applies Robert Morris's Contour-Reduction Algorithm to several passages from Messiaen's *Réveil des Oiseaux* (1953), as well as a number of his birdsong transcriptions from Tome V of the *Traité*, thereby effectively revealing some of the essential structural and organizational principles at work therein, and exposing many of the critical issues involved in such an analysis.

the contour-reduction algorithm: an overview

For the present purposes, a contour will be defined as a temporally ordered set of pitches numbered in ascending pitch space order from 0 to (n–1), where n represents the cardinality of the set. By definition, then, the precise intervallic distances between the pitches are left undefined; thus identities lie solely in their relative positions within the contour. In this way, pitches in pitch space are transformed into contour pitches (c-pitches) in contour space (c-space).[3] The three melodies presented in Example 1 are thus all different realizations in pitch space of the same contour, ⟨0231⟩, since each begins with its lowest pitch, represented by the integer "0", followed by the second highest ("2"), highest ("3"), and finally, the second lowest ("1").[4]

The essence of Morris's Contour-Reduction Algorithm, shown in Example 2, is the delineation of local high and low

2 Marvin (1995) provides both an insightful summation and exhaustive bibliography of the relevant theoretical literature.

3 C-space was first defined by Morris (1987, 340) as "a pitch-space consisting of elements arranged from low to high disregarding the exact intervals between the elements." C-pitches are simply "the (pitch) elements of c-space."

4 The use of angle brackets in the standard notation of contour indicates that a contour is always by definition an ordered set.

The algorithm prunes pitches from a contour until it is reduced to a "prime."

Definition: *Maximum pitch:* Given three adjacent pitches in a contour, if the second is higher than or equal to the others it is a *maximum*. A set of maximum pitches is called a *maxima*. The first and last pitches of a contour are maxima by definition.

Definition: *Minimum pitch:* Given three adjacent pitches in a contour, if the second is lower than or equal to the others it is a *minimum*. A set of minimum pitches is called a *minima*. The first and last pitches of a contour are minima by definition.

Algorithm: Given a contour C and a variable N:

step 0: Set N to 0.

step 1: Flag all maxima in C; call the resulting set the *max-list*.

step 2: Flag all minima in C; call the resulting set the *min-list*.

step 3: If all pitches in C are flagged, go to step 9.

step 4: Delete all non-flagged pitches in C.

step 5: N is incremented by 1 (i.e., N becomes N+1).

step 6: Flag all maxima in max-list. For any string of equal and adjacent maxima in max-list, either: (1) flag only one of them; or (2) if one pitch in the string is the first or last pitch of C, flag only it; or (3) if both the first and last pitches of C are in the string, flag (only) both the first and last pitches of C.

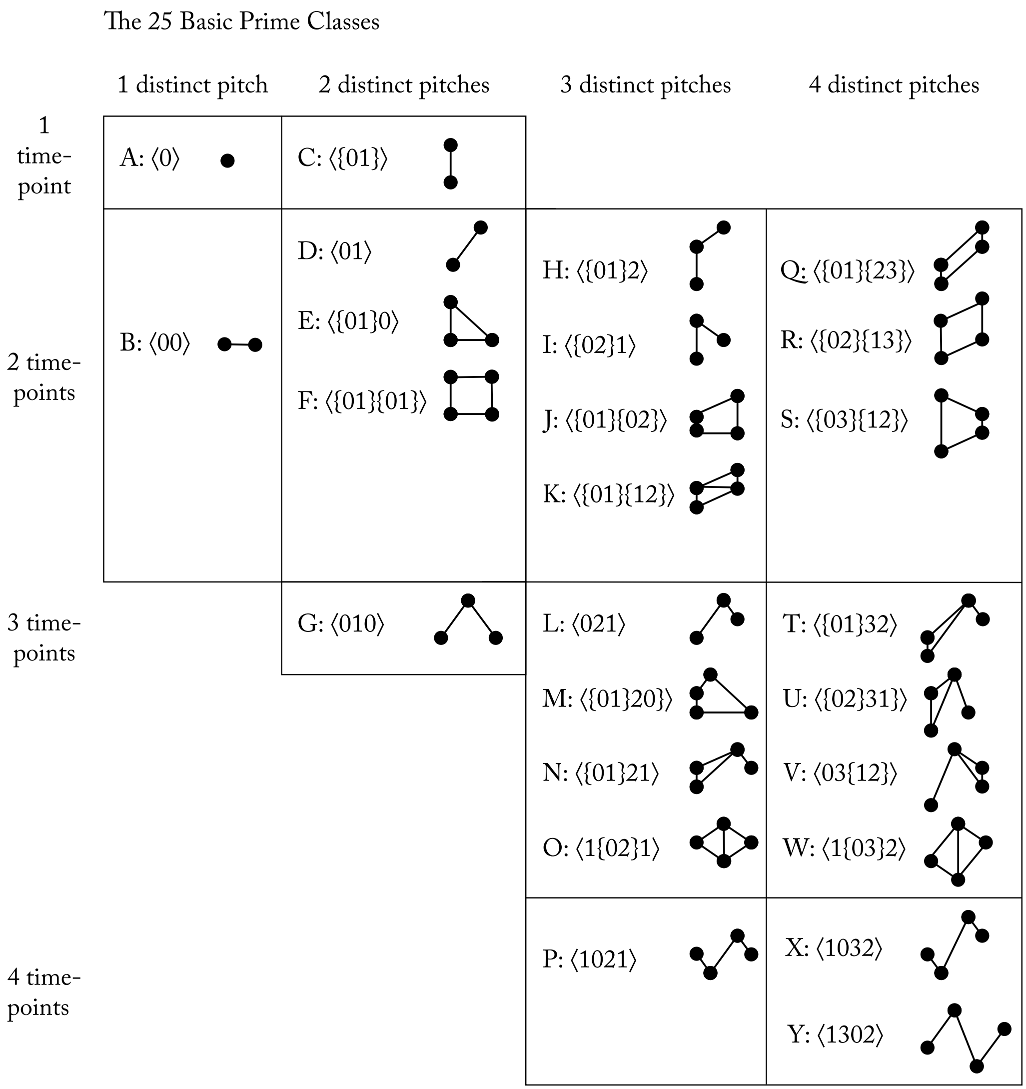
step 7: Flag all minima in min-list. For any string of equal and adjacent minima in min-list, either: (1) flag only one of them; or (2) if one pitch in the string is the first or last pitch of C, flag only it; or (3) if both the first and last pitches of C are in the string, flag (only) both the first and last pitches of C.

step 8: Go to step 3.

step 9: End. N is the "depth" of the original contour C.

The reduced contour is the prime of C; if N=0, then the original C has not been reduced and is a prime itself.

EXAMPLE 2. *The Contour-Reduction Algorithm (Morris 1993, 212)*



A, B, D, G, L, P, X, and Y are the "linear prime classes."

example 3. *Morris's prime contour classes (1993, 220–221)*

The secondary prime classes

	3 distinct pitches	4 distinct pitches	5 distinct pitches	6 distinct pitches
3 timepoints	a: ⟨{01}2{01}⟩	b: ⟨{01}3{12}⟩ c: ⟨{02}3{12}⟩ d: ⟨{12}{03}2⟩ e: ⟨{12}{03}{12}⟩ f: ⟨{13}0{23}⟩	j: ⟨{01}4{23}⟩ k: ⟨{02}4{13}⟩ l: ⟨{03}4{12}⟩ m: ⟨{12}{04}3⟩ n: ⟨{12}{04}{23}⟩ o: ⟨{13}{04}2⟩ p: ⟨{13}{04}{23}⟩	w: ⟨{12}{05}{34}⟩ x: ⟨{13}{05}{24}⟩ y: ⟨{14}{05}{23}⟩
4 timepoints		g: ⟨{12}032⟩ h: ⟨{12}302⟩ i: ⟨{12}03{12}⟩	q: ⟨{12}043⟩ r: ⟨{12}403⟩ s: ⟨{12}04{23}⟩ t: ⟨{13}042⟩ u: ⟨{13}04{23}⟩ v: ⟨{13}40{23}⟩	z: ⟨{12}05{34}⟩ aa: ⟨{13}05{24}⟩ bb: ⟨{14}05{23}⟩

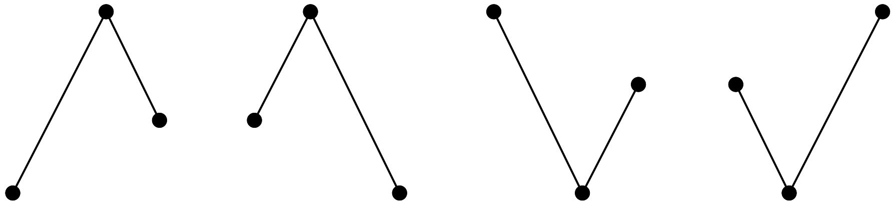
EXAMPLE 3. [*continued*]

points in a given contour, deemed “maxima” and “minima” respectively, and the subsequent elimination of c-pitches that do not fall into either category. The algorithm applies this procedure to a given contour recursively until no more c-pitches can be deleted, leaving a “prime” contour; a variable N tallies the number of times the procedure is applied, resulting in a “depth” value for the prime contour (Morris 1993, 212–13). Morris has organized such primes into 53 prime classes, which are subdivided into 25 “basic prime classes” and 28 “secondary prime classes,” given in Example 3; he also classifies the subset of (basic) prime classes that contain no simultaneities as “linear prime classes” (218–21).[5] It must be noted that each prime class is in fact an equivalence class consisting of its prime form representative, shown in the example, and all others related by identity, inversion, retrograde, and retrograde inversion.[6] By way of demonstration, Example 4 displays the four distinct members of prime class L. This prime class, and its status as an equivalence class based on these fundamental transformational operations, will prove highly apposite to the forthcoming analysis.

Example 5—again for demonstrative purposes—presents a step-by-step application of the Contour-Reduction Algorithm to the contour ⟨1312014⟩. Before proceeding with an explication of the procedure itself, a few words about the graphic representation of contours in this, and all other applications of the Contour-Reduction Algorithm throughout

5 Curly braces within contours denote simultaneous (i.e. unordered) c-pitches. Though not directly applicable to the present study, this ground-breaking inclusion of simultaneities represents a compelling move toward a more generalized theory of musical contour, the foundation of which is presented in the latter part of Morris’s article (222–28).

6 The inversion of a contour is obtained by subtracting the value of each c-pitch from that of the highest c-pitch in the contour.



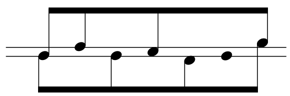
P = ⟨021⟩ R = ⟨120⟩ I = ⟨201⟩ RI = ⟨102⟩

example 4. *The four transformationally equivalent members of prime class L*

C = ⟨1312014⟩, N = 0

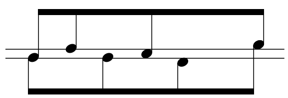
START

Steps 1 and 2: Flag all maxima upward and minima downward.



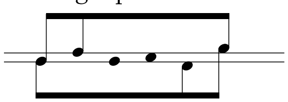
Step 3: Not all c-pitches are flagged.

Step 4: Delete non-flagged c-pitches.



Step 5: N = 1.

Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list; do not flag repetition in the min-list.

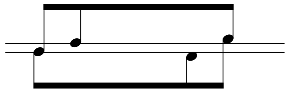


Step 8: Go to step 3.

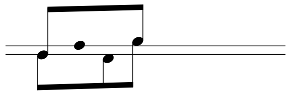
Step 3: Not all c-pitches are flagged.

Step 4: Delete non-flagged c-pitches.

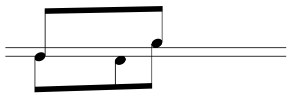
example 5. *A sample application of the Contour-Reduction Algorithm*



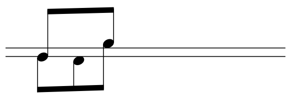
Step 5: N = 2.
Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list.



Step 8: Go to step 3.
Step 3: Not all c-pitches are flagged.
Step 4: Delete non-flagged c-pitches.

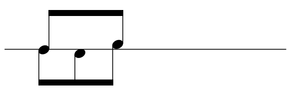


Step 5: N = 3.
Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list.



Step 8: Go to step 3.
Step 3: All c-pitches are flagged. Go to step 9.
Step 9: END.

Contour ⟨1312014⟩ has a prime of ⟨102⟩ and a depth of 3.



EXAMPLE 5. [*continued*]

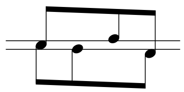
this article are in order. First, in order to enhance visual clarity and ease, a variable number of staff lines are employed. The cardinality of the contour in question determines the number of lines: only one is used for contours with three or fewer c-pitch members, two lines for contours of four or five members, etc. The bottom-most line always represents c-pitch 1, the space below it c-pitch 0, the space above it c-pitch 2, etc. Furthermore, following Morris (1993), flagged c-pitches, i.e. maxima and minima, are beamed together to more clearly delineate their membership in the max-list and min-list, respectively.

To begin, maxima and minima are defined according to the preliminary definitions given in Example 2 and flagged appropriately: the first and last c-pitches in the contour are double-flagged, c-pitch 3 is defined as a maximum and given an upward flag, since it lies higher than both the preceding and succeeding c-pitches (both 1s), the following c-pitch 1, being lower than both the preceding c-pitch 3 and the following c-pitch 2, is defined as a minimum, and therefore given a downward flag, and so on. Carrying this procedure to its conclusion, only one c-pitch, the penultimate c-pitch 1, remains without flag; the algorithm thus proceeds by deleting this c-pitch and adding one to the value of N per steps 4 and 5. Steps 6 and 7 then flag only the maxima and minima *within* the max-list and min-list, respectively. That is, rather than measuring c-pitch 3, for instance, against the immediately surrounding c-pitches, the measurement is now between the preceding upward-flagged c-pitch 1 and the next upward-flagged c-pitch, 2. Under this new set of criteria, c-pitch 3 retains its membership in the max-list, as evidenced by its upward flag, while c-pitch 2 does not. As for the min-list, the second instance of c-pitch 1 loses its downward flag per condition (2) of step 7, while c-pitch 0 remains a member of the min-list. After deleting the non-flagged c-pitches and incrementing N, the same procedure is again applied to the reduced four-element contour, and then once again to the resultant three-element contour, which finally yields an output for step 3 that is in the affirmative. As a result, the algorithm proceeds directly to step 9, which indicates that a prime form for the contour has been reached, in this case ⟨102⟩, the RI form of prime class L, which has a depth value of three. The algorithm thus effectively unearths the contour's underlying basic shape by progressively pruning c-pitches until only the first, last, highest, and lowest c-pitches of the contour remain. Note that the members of this prime form are renumbered from 0 to 2 in order to reflect the reduced cardinality of the set, a process called *translation* (Marvin and Laprade 1987, 228); the final c-pitch in the contour is shifted down to the space above the bottom line accordingly, and the upper line is thereby eliminated.

A REFINEMENT AND FURTHER SPECIFICATIONS

The foregoing tutorial effectively demonstrates how the Contour-Reduction Algorithm in fact applies its pruning procedure to two very different types of c-pitch sets within a contour: steps 1 and 2 apply it to the c-pitch content of the entire contour, whereas steps 6 and 7 apply it to the deeper-level subset of c-pitches contained in the max-list and min-list, respectively. As it turns out, however, this procedure must be applied to *both* types of c-pitch sets at least once in order to reliably produce a true prime. Example 6 illustrates why this is the case. Both contours of this example, ⟨2130⟩ and ⟨2415063⟩, feature a progressive outward expansion of c-pitches in c-space, thereby forming an overall wedge shape. In fact, in terms of general shape, the two differ only in their conclusion—the former leaves the wedge open at the end, while the latter closes it off with its final c-pitch. As the respective applications of the algorithm to these contours in Example 6 demonstrate, the progressive outward expansion and lack of repetition within each of them causes every c-pitch to be categorized as either a maximum or a minimum; hence, all c-pitches in each contour are flagged in steps 1 and 2. This results in step 3 proceeding directly to step 9, the end of the algorithm, entirely bypassing the application of the pruning procedure to the subset of c-pitches within the max-list and the min-list in steps 6 and 7. Thus, *a)* C = ⟨2130⟩, N = 0

START
Steps 1 and 2: Flag all maxima upward and minima downward.

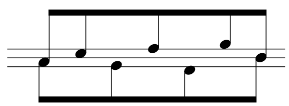


Step 3: All c-pitches are flagged. Go to step 9.
Step 9: END.

Contour ⟨2130⟩ has a prime of ⟨2130⟩ and a depth of 0.

b) C = ⟨2415063⟩, N = 0

START
Steps 1 and 2: Flag all maxima upward and minima downward.



Step 3: All c-pitches are flagged. Go to step 9.
Step 9: END.

Contour ⟨2415063⟩ has a prime of ⟨2415063⟩ and a depth of 0.

EXAMPLE 6. *Application of Contour-Reduction Algorithm to (a) open wedge-shaped contour ⟨2130⟩, and (b) closed wedge-shaped contour ⟨2415063⟩*

no c-pitches are pruned, and the original contour is itself deemed a prime form. Consulting the list of primes found in Example 3, however, indicates that neither of these contours are true primes. Closer examination reveals that certain c-pitches within their respective max-lists and/or min-lists that would have been pruned by steps 6 and 7—c-pitch 1 of the first contour and c-pitches 1, 4, and 5 of the second—indeed remain present. Step 3 thus engenders a premature ending to the algorithm, since steps 1 and 2 alone do not sufficiently prune these wedge-shaped contours into their proper prime forms.

Example 7 presents a modified version of Morris's Contour-Reduction Algorithm, which eliminates these anomalous results. Now, instead of skipping directly to the end of the algorithm when all c-pitches in C are flagged, step 3 proceeds to step 6; every input is thus subjected to the pruning procedure of steps 6 and 7, as well as that of steps 1 and 2, before a final output is attained. This algorithm also features a conditional incrementation of N in steps 10 and 11, which is needed in order to account for the shift to a deeper structural level that step 3 engenders despite not having deleted any c-pitches in C. Example 8 applies this new version

Algorithm: Given a contour C and a variable N:

step 0: Set N to 0.

step 1: Flag all maxima in C upwards; call the resulting set the *max-list*.

step 2: Flag all minima in C downwards; call the resulting set the *min-list*.

step 3: If all c-pitches are flagged, go to step 6.

step 4: Delete all non-flagged c-pitches in C.

step 5: N is incremented by 1 (i.e., N becomes N+1).

step 6: Flag all maxima in the max-list upwards. For any string of equal and adjacent maxima in the max-list, either: (1) flag only one of them; or (2) if one c-pitch in the string is the first or last c-pitch of C, flag only it; or (3) if both the first and last c-pitches of C are in the string, flag (only) both the first and last c-pitches of C.

step 7: Flag all minima in the min-list downwards. For any string of equal and adjacent minima in the min-list, either: (1) flag only one of them; or (2) if one c-pitch in the string is the first or last c-pitch of C, flag only it; or (3) if both the first and last c-pitches of C are in the string, flag (only) both the first and last c-pitches of C.

step 8: If all c-pitches are flagged, go to step 13.

step 9:: Delete all non-flagged c-pitches in C.

step 10: If N ≠ 0, N is incremented by 1 (i.e., N becomes N+1)

step 11: If N=0, N is incremented by 2 (i.e., N becomes N+2).

step 12: Go to step 6.

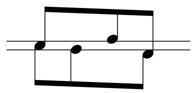
step 13: End. N is the "depth" of the original contour C.

The reduced contour is the prime of C; if N=0, then the original C has not been reduced and is a prime itself.

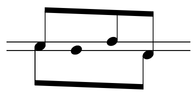
example 7. *Modified version of the Contour-Reduction Algorithm*

C = ⟨2130⟩, N = 0

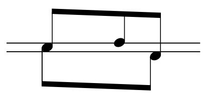
START
Steps 1 and 2: Flag all maxima upward and minima downward.



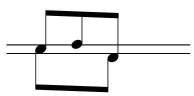
Step 3: All c-pitches are flagged. Go to step 6.
Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list.



Step 8: Not all c-pitches are flagged.
Step 9: Delete non-flagged c-pitches.

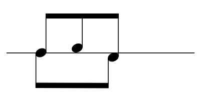


Step 10: N = 0
Step 11: N = 2.
Step 12: Go to step 6.
Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list.



Step 8: All c-pitches are flagged. Go to step 13.
Step 13: END.

Contour ⟨2130⟩ has a prime of ⟨120⟩ and a depth of 2.

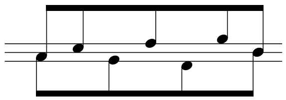


EXAMPLE 8(a). *Application of the algorithm from Example 7 to contour ⟨2130⟩*

C = ⟨2415063⟩, N = 0

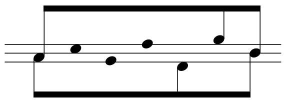
START

Steps 1 and 2: Flag all maxima upward and minima downward.



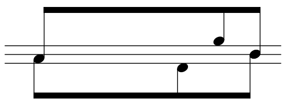
Step 3: All c-pitches are flagged. Go to step 6.

Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list.



Step 8: Not all c-pitches are flagged.

Step 9: Delete non-flagged c-pitches.

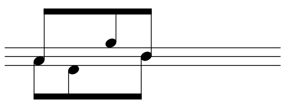


Step 10: N = 0

Step 11: N = 2

Step 12: Go to step 6.

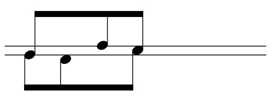
Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list.



Step 8: All c-pitches are flagged. Go to step 13.

Step 13: END.

Contour ⟨2415063⟩ has a prime of ⟨1032⟩ and a depth of 2.



EXAMPLE 8(b). *Application of the algorithm from Example 7 to contour ⟨2415063⟩*

of the algorithm to the wedge-shaped contours of Example 6. The results demonstrate the efficacy with which this minor modification remedies the problem caused by these rogue contours. A quick glance at Example 3 confirms that the primes obtained by this version of the algorithm are indeed true primes: ⟨120⟩ is the R form of prime class L, and ⟨1302⟩ is the P form of prime class Y.

Even in its presently modified form, however, the Contour-Reduction Algorithm remains not quite ready for "prime" time. Applying the algorithm to the contour ⟨2414043⟩, which is essentially the closed wedge contour of Example 6(b) with a flattened top, exposes another issue that requires further attention. Whereas the lack of repetition in the wedge-shaped contours of Example 6 was primarily responsible for the algorithm's anomalous results there, here it is actually the profuse repetition of c-pitch 4 within the contour that produces a problematic result of a different kind. As Example 9 demonstrates, the difficulty lies in the application of step 6 of the algorithm, which mandates that only one of the 4s in the max-list be flagged. Because conditions (2) and (3) do not apply, however, the algorithm provides no indication as to *which one* to flag in such a string of equal and adjacent maxima in the max-list. Indeed, Morris left this aspect of the algorithm ambiguous deliberately in order to allow for a greater degree of flexibility in its application. Thus, an added set of criteria regarding c-pitch repetition must be supplied, for while it is inconsequential whether one flags the first or second c-pitch of the string of repetitions in the contour presented in Example 9, since paths (a) and (b) lead to the same prime of ⟨1302⟩ (a member of prime class Y), flagging the last c-pitch produces a completely different prime of ⟨1032⟩ (a member of prime class X), as seen in path (c).[7] As it turns out, the root cause of this ambivalence is not the repetition of maxima itself, but rather the minima that intervene.[8] More specifically, here it is the minimum c-pitch 0 that lies between the second and third instances of c-pitch 4, since the c-pitch 1 between the first and second instances of c-pitch 4 is only a local minimum, and thereby deleted in step 9 of the algorithm.

Given this situation, it is entirely inappropriate to flag only one of these maxima, as dictated by condition (1) of step 6. Example 10 thus presents another version of the algorithm that incorporates these considerations into its flagging procedure for repeated c-pitches. Steps 6 and 7 now flag *all* c-pitches in a string of equal and adjacent maxima in the max-list and minima in the min-list, unless condition (1) or (2), both of which are retained from steps 6 and 7 of the original algorithm (there they are conditions (2) and (3)), obtains. Steps 8 and 9 then *remove* the extraneous flags from any string of maxima in the max-list for which no minima in the min-list intervene, and vice versa, before pruning all non-flagged c-pitches.

Example 11 presents the application of this version of the algorithm to contour ⟨2414043⟩ of Example 9. While there are no procedural ambiguities in terms of repetitions in the max-list, the resulting prime, ⟨13032⟩, or any transformationally related form thereof, does not appear in Example 3. Since one cannot prune any more c-pitches from this contour without destroying its fundamental identity, it must indeed be treated as a prime, unlike the pseudo-primes seen in Example 6. This new prime is, in effect, an assimilation of the two divergent primes obtained in Example 9. Although one could deem the prime of this contour a "split" ⟨1302⟩/⟨1032⟩ (Quinn 1997, 239), a less paradoxical solution certainly seems preferable.

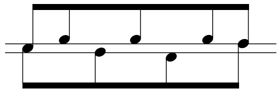
I thus instead propose that two prime classes be added to the list of basic prime classes in Example 3 to account for the

7 The modifications to the algorithm that follow are suitable to the general contour type that includes c-pitch repetitions, but no simultaneities (Morris 1993, 227). This category is particularly fitting for Messiaen's monophonic birdsong, which contains a plethora of repeated notes, unlike, the freely atonal and twelve-tone repertoire to which contour theory has been more commonly applied.

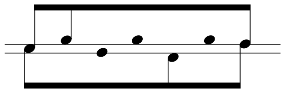
8 Charles R. Adams (1976, 197–200) presents contours with this feature as well, and makes similar observations, but avoids dealing with the issue directly by asserting that it only affects a contour's secondary attributes—its "shape"—rather than the primary features that constitute its "type".

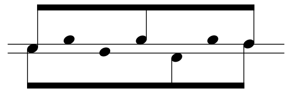
C = ⟨2414043⟩, N = 0

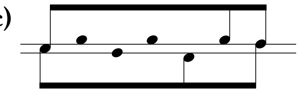
START
Steps 1 and 2: Flag all maxima upward and minima downward.



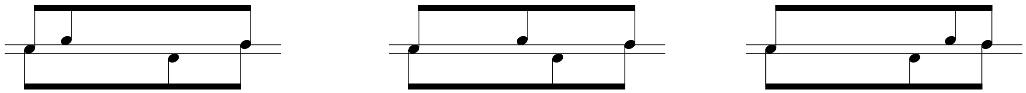
Step 3: All c-pitches are flagged. Go to step 6.
Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list; do not flag repetitions in the max-list.

a)


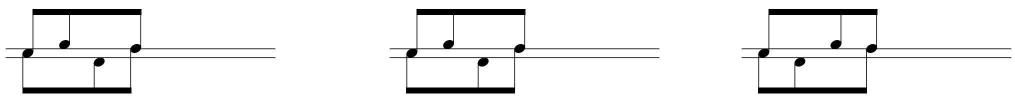
b)


c)


Step 8: Not all c-pitches are flagged.
Step 9: Delete non-flagged c-pitches.



Step 10: N = 0
Step 11: N = 2
Step 12: Go to step 6.
Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list.

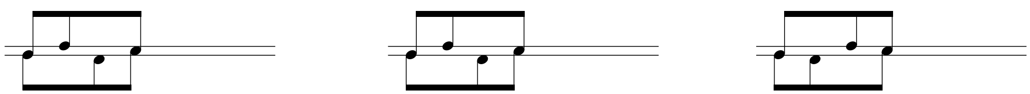


Step 8: All c-pitches are flagged. Go to step 13.
Step 13: END.

Contour ⟨2414043⟩ has a prime of ⟨1302⟩ and a depth of 2.

Contour ⟨2414043⟩ has a prime of ⟨1302⟩ and a depth of 2.

Contour ⟨2414043⟩ has a prime of ⟨1302⟩ and a depth of 2.



EXAMPLE 9. *Application of the algorithm from Example 7 to contour ⟨2414043⟩*

Algorithm: Given a contour C and a variable N:

step 0: Set N to 0.

step 1: Flag all maxima in C upwards; call the resulting set the *max-list*.

step 2: Flag all minima in C downwards; call the resulting set the *min-list*.

step 3: If all c-pitches are flagged, go to step 6.

step 4: Delete all non-flagged c-pitches in C.

step 5: N is incremented by 1 (i.e., N becomes N+1).

step 6: Flag all maxima in the max-list upward. For any string of equal and adjacent maxima in the max-list, flag all of them, unless: (1) one c-pitch in the string is the first or last c-pitch of C, then flag only it; or (2) both the first and last c-pitches of C are in the string, then flag (only) both the first and last c-pitches of C.

step 7: Flag all minima in the min-list downward. For any string of equal and adjacent minima in the min-list, flag all of them, unless: (1) one c-pitch in the string is the first or last c-pitch of C, then flag only it; or (2) both the first and last c-pitches of C are in the string, then flag (only) both the first and last c-pitches of C.

step 8: For any string of equal and adjacent maxima in the max-list in which no minima intervene, remove the flags from all but (any) one c-pitch in the string.

step 9: For any string of equal and adjacent minima in the min-list in which no maxima intervene, remove the flags from all but (any) one c-pitch in the string.

step 10: If all c-pitches are flagged, go to step 15.

step 11: Delete all non-flagged c-pitches in C.

step 12: If $N \neq 0$, N is incremented by 1 (i.e., N becomes N+1)

step 13: If N=0, N is incremented by 2 (i.e., N becomes N+2).

step 14: Go to step 6.

step 15: End. N is the "depth" of the original contour C.

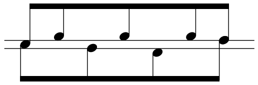
The reduced contour is the prime of C; if N = 0, then the original C has not been reduced and is a prime itself.

EXAMPLE 10. *Further-modified version of the Contour-Reduction Algorithm*

C = ⟨2414043⟩, N = 0

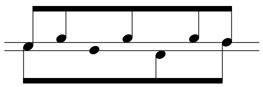
START

Steps 1 and 2: Flag all maxima upward and minima downward.

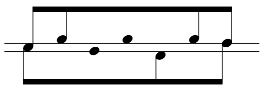


Step 3: All c-pitches are flagged. Go to step 6.

Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list; flag all repetitions in max-list.

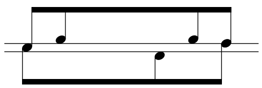


Steps 8 and 9: Remove flag from one of the maxima with no intervening minimum.



Step 10: Not all c-pitches are flagged.

Step 11: Delete non-flagged c-pitches.

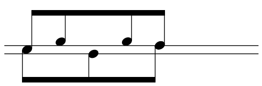


Step 12: N = 0

Step 13: N = 2

Step 14: Go to step 6.

Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list.

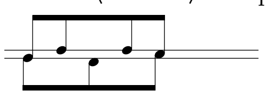


Steps 8 and 9: Both repeated c-pitches in the max-list have an intervening minimum; no adjacent repetitions in the min-list exist.

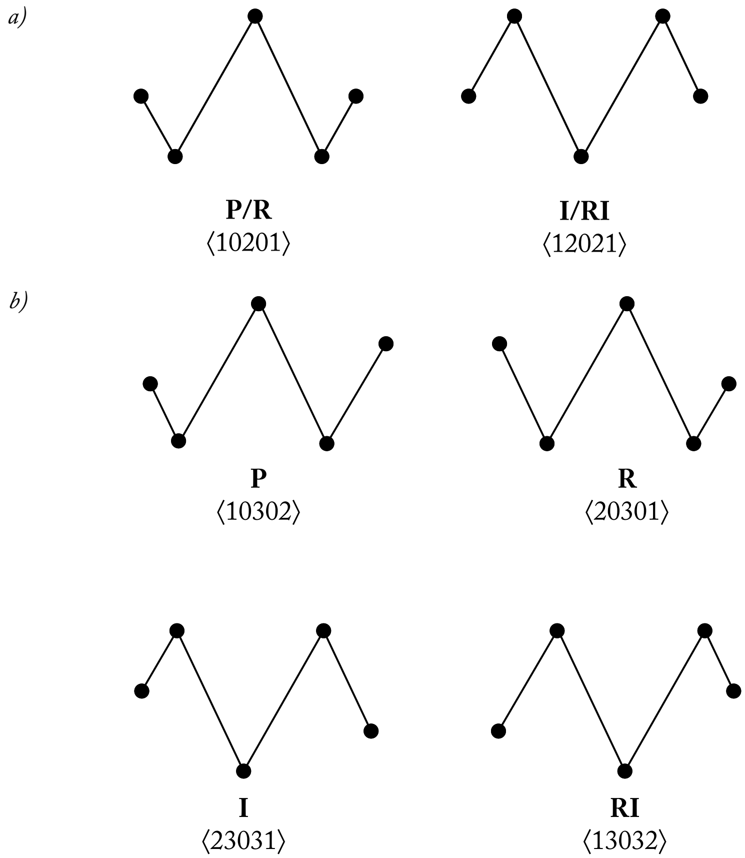
Step 10: All c-pitches are flagged. Go to step 15.

Step 15: END.

Contour ⟨2414043⟩ has a prime of ⟨13032⟩ and a depth of 2.



EXAMPLE 11. *Application of the algorithm from Example 10 to contour ⟨2414043⟩*



EXAMPLE 12. *Distinct members of (a) prime class ⟨10201⟩, and (b) prime class ⟨10302⟩*

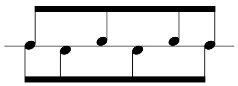
contours that exhibit this property: ⟨10201⟩ and ⟨10302⟩.[9] The former contains three distinct c-pitches while the latter contains four; both, however, contain five timepoints. Due to its retrograde-invariance, prime class ⟨10201⟩ contains only two distinct prime members, the traditional graphs of which are portrayed in Example 12(a).[10] Prime class ⟨10302⟩, on the other hand, contains four distinct prime members, shown in Example 12(b), which are related by inversion,

9 Thus, in Adams's terminology, I propose to promote this feature from "secondary" to "primary" status, i.e. from "shape" to "type."

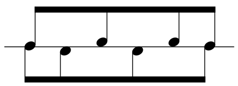
10 Prime classes A, B, and G are the other linear prime class that exhibit retrograde-invariance. Prime classes A and B, however, are also invariant under inversion, and thus contain only one distinct member, while prime class G contains the same two distinct members seen here: P/R and I/RI.

C = ⟨102021⟩, N = 0

START
Steps 1 and 2: Flag all maxima upward and minima downward.



Step 3: All c-pitches are flagged. Go to step 6.
Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list; flag all repeated c-pitches in the max-list and min-list.



Steps 8 and 9: Both repeated c-pitches in the max-list have an intervening minimum; both repeated c-pitches in the min-list have an intervening maximum.
Step 10: All c-pitches are flagged. Go to step 15.
Step 15: END.

Contour ⟨102021⟩ has a prime of ⟨102021⟩ and a depth of 0.

EXAMPLE 13(a). *Application of the algorithm from Example 10 to contour ⟨102021⟩*

retrograde, and retrograde inversion. These prime classes are hereby labeled "12(α)" and "12(β)," respectively.[11]

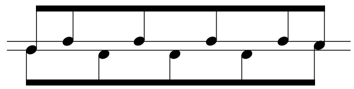
Although the updated version of the algorithm in Example 10 and the new prime classes in Example 12 effectively resolve one ambiguity in the deletion of a contour's repeated c-pitches, Examples 13(a) and 13(b) demonstrate that another still lingers. If a string of three or more equal and adjacent maxima in the max-list exist in a contour, and a minimum in the min-list intervenes between each of them, or vice versa, none of them are pruned, and an infinite number of new prime forms based on this repetition exists.[12] Example 14 thus presents a final version of the algorithm with added modifications (see steps 10, 11, and 12) that directly address this problem by eliminating all but the outermost c-pitches involved in any such repetitions. This not only effectively reduces these types of contours to a legitimate prime form, as proven by Examples 15(a) and 15(b),

11 I opt not to integrate these two prime forms into Morris's labeling system simply because it would set a large portion of the present contour labels askew, i.e. prime class ⟨10201⟩, having three distinct pitches and five timepoints, would hypothetically fall beneath prime class P in Example 3, and thereby receive the label "Q," while the contour that is currently labeled "Q," ⟨{01}{23}⟩, would become "R," etc. The same issue arises later with prime class ⟨10302⟩. Hence, to avoid creating added and unnecessary (at least for the present purposes) confusion, the new prime classes are labeled outside Morris's system as "12α" and "12β", respectively, and the original labels for all other prime classes are retained.

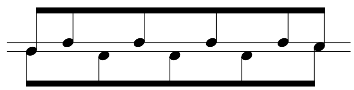
12 Morris (1993, 228) discusses a similar situation involving an infinite number of prime contours.

C = ⟨130303032⟩, N = 0

START
Steps 1 and 2: Flag all maxima upward and minima downward.



Step 3: All c-pitches are flagged. Go to step 6.
Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list; flag all repeated c-pitches in the max-list and min-list.



Steps 8 and 9: All repeated c-pitches in the max-list have an intervening minimum; all repeated c-pitches in the min-list have an intervening maximum.
Step 10: All c-pitches are flagged. Go to step 15.
Step 15: END.

Contour ⟨130303032⟩ has a prime of ⟨130303032⟩ and a depth of 0.

EXAMPLE 13(b). *Application of the algorithm from Example 10 to contour ⟨130303032⟩*

but it also remains true to the Gestalt spirit of the algorithm by retaining what Morris (1993, 215) describes as the "principle of boundary salience, that is, the perceptual prominence of the edges or outline of a percept." Indeed, it is this very principle at work in steps 11 and 12 of the final version of the algorithm that causes the contour of Example 15(a) to somewhat unexpectedly reduce to a prime of ⟨1021⟩ and not one of the new primes seen in Example 12.

ANALYSIS

Example 16 presents the opening Nightingale (Rossignol) solo from Messiaen's *Réveil des Oiseaux*. In the segmentation shown, eighth rests are inferred as boundary markers based on Messiaen's notational practice throughout Tome V of the *Traité* of delineating melodic segments, or what he calls "strophes" in his birdsong transcriptions in a similar manner.[13] The prime contours of these seventeen

13 Messiaen in fact more frequently utilizes measure lines, fermatas, quarter rests, two consecutive quarter rests, or some combination thereof as cues for strophe boundaries in the *Traité* (1999). The rare instances where he presents the original transcription of a birdsong found in one of his works, however, demonstrate that these boundary cues were often replaced by a variety of different notations, including lesser-valued rests such as eighth (1:100–04, strophes four and five) and sixteenth rests (1:100–04, strophes six and seven; 1:89–93), or even as ties (compare 1:105, strophes five, six, and seven to Messiaen

Algorithm: Given a contour C and a variable N:

step 0: Set N to 0.

step 1: Flag all maxima in C upwards; call the resulting set the *max-list*.

step 2: Flag all minima in C downwards; call the resulting set the *min-list*.

step 3: If all c-pitches are flagged, go to step 6.

step 4: Delete all non-flagged c-pitches in C.

step 5: N is incremented by 1 (i.e., N becomes N+1).

step 6: Flag all maxima in the max-list upward. For any string of equal and adjacent maxima in the max-list, flag all of them, unless: (1) one c-pitch in the string is the first or last c-pitch of C, then flag only it; or (2) both the first and last c-pitches of C are in the string, then flag (only) both the first and last c-pitches of C.

step 7: Flag all minima in min-list downward. For any string of equal and adjacent minima in the min-list, flag all of them, unless: (1) one c-pitch in the string is the first or last c-pitch of C, then flag only it; or (2) both the first and last c-pitches of C are in the string, then flag (only) both the first and last c-pitches of C.

step 8: For any string of equal and adjacent maxima in the max-list in which no minima intervene, remove the flag from all but (any) one c-pitch in the string.

step 9: For any string of equal and adjacent minima in the min-list in which no maxima intervene, remove the flag from all but (any) one c-pitch in the string.

step 10: If all c-pitches are flagged, and no more than one c-pitch repetition in the max-list and min-list (combined) exists, not including the first and last c-pitches of C, proceed directly to step 17.

step 11: If more than one c-pitch repetition in the max-list and/or min-list (combined) exists, not including the first and last c-pitches of C, remove the flags on all repeated c-pitches except those closest to the first and last c-pitches of C.

step 12: If both flagged c-pitches remaining from step 11 are members of the max-list, flag any one (and only one) former member of the min-list whose flag was removed in step 11; if both c-pitches are members of the min-list, flag any one (and only one) former member of the max-list whose flag was removed in step 11.

step 13: Delete all non-flagged c-pitches in C.

step 14: If N ≠ 0, N is incremented by 1 (i.e., N becomes N+1)

step 15: If N=0, N is incremented by 2 (i.e., N becomes N+2).

step 16: Go to step 6.

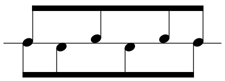
step 17: End. N is the "depth" of the original contour C.

The reduced contour is the prime of C; if N=0, then the original C has not been reduced and is a prime itself.

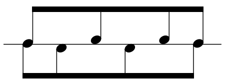
example 14. *Final version of the Contour-Reduction Algorithm*

C = ⟨102021⟩, N = 0

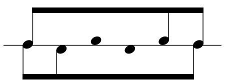
START
Steps 1 and 2: Flag all maxima upward and minima downward.



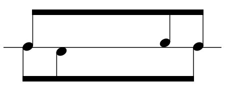
Step 3: All c-pitches are flagged. Go to step 6.
Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list; flag all repetitions in the max-list and min-list.



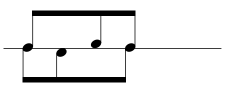
Steps 8 and 9: Both repeated c-pitches in the max-list have an intervening minimum; both repeated c-pitches in the min-list have an intervening maximum.
Step 10: All c-pitches are flagged. More than one repetition exists in the max-list and min-list combined.
Step 11: Remove the flags on all repetitions except those closest to the first and last c-pitches of C.



Step 12: The remaining flagged c-pitches from step 11 are not both in the max-list or the min-list.
Step 13: Delete non-flagged c-pitches.



Step 14: N = 0.
Step 15: N = 2
Step 16: Go to step 6.
Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list.



Steps 8 and 9: No adjacent repetitions in the max-list or min-list exist.
Step 10: All c-pitches are flagged. Go to step 17.
Step 17: END.

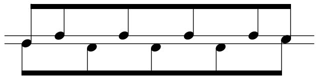
Contour ⟨102021⟩ has a prime of ⟨1021⟩ and a depth of 2.

EXAMPLE 15(a). *Application of algorithm from Example 14 to contour ⟨102021⟩*

C = ⟨130303032⟩, N = 0

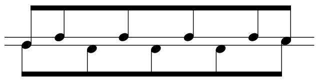
START

Steps 1 and 2: Flag all maxima upward and minima downward.



Step 3: All c-pitches are flagged. Go to step 6.

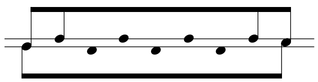
Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list; flag all repetitions in the max-list and min-list.



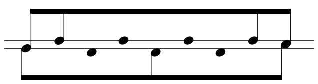
Steps 8 and 9: All repeated c-pitches in the max-list have an intervening minimum; all repeated c-pitches in the min-list have an intervening maximum.

Step 10: All c-pitches are flagged. More than one repetition exists in the max-list and min-list combined.

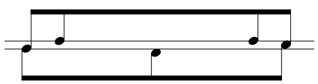
Step 11: Remove the flags on all repetitions except those closest to the first and last c-pitches of C.



Step 12: The remaining flagged c-pitches from step 11 are both in the max-list; flag any one former member of the min-list whose flag was removed in step 11.



Step 13: Delete non-flagged c-pitches.

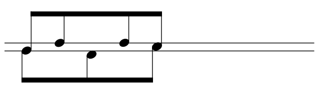


Step 14: N = 0.

Step 15: N = 2

Step 16: Go to step 6.

Steps 6 and 7: Flag all maxima in the max-list and minima in the min-list.

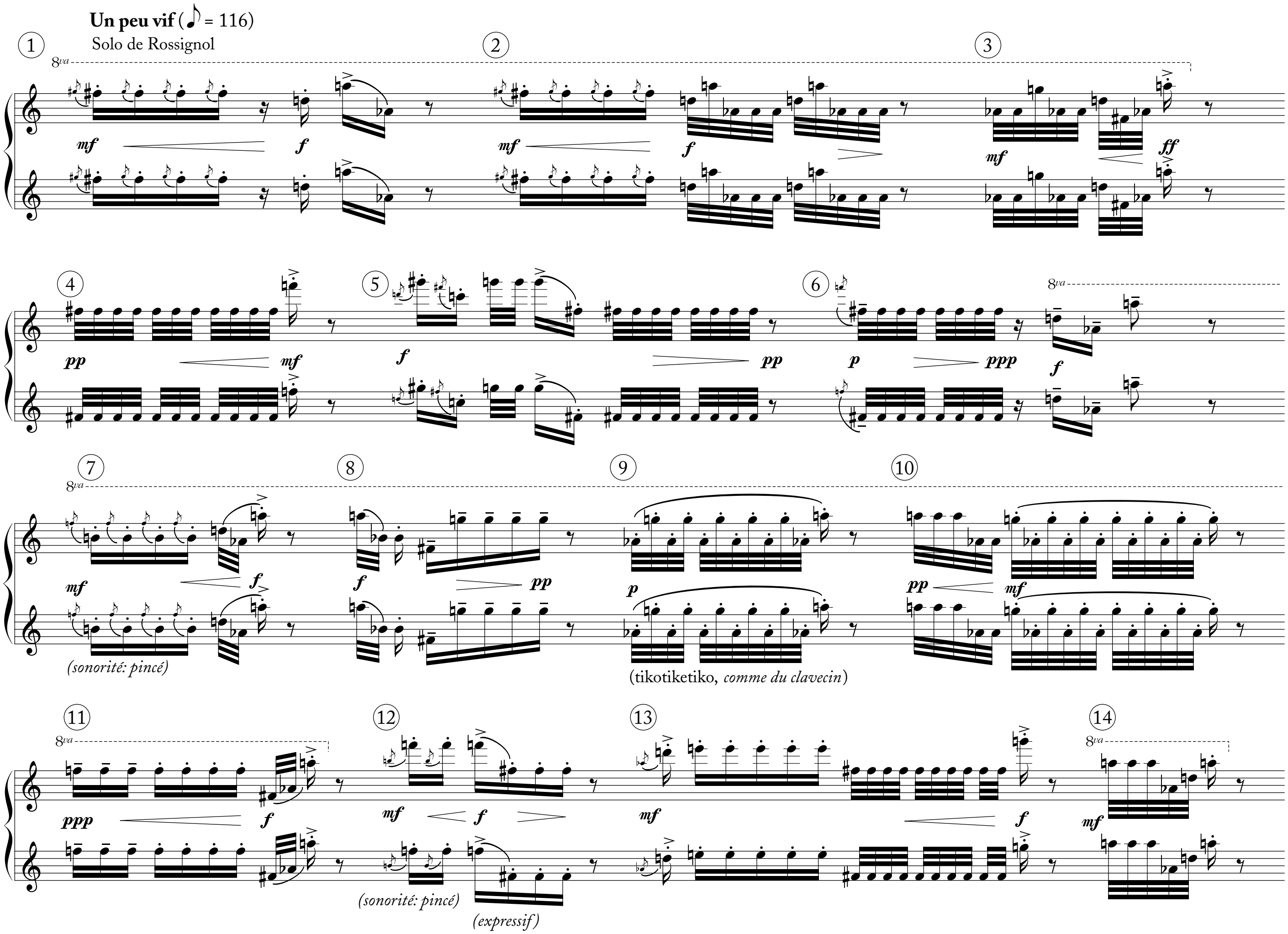


Steps 8 and 9: Flag both maxima with intervening minimum.

Step 10: All c-pitches are flagged. Go to step 17.

Step 17: END.

EXAMPLE 15(b). *Application of algorithm from Example 14 to contour ⟨130303032⟩*



EXAMPLE 16. *Opening Nightingale solo of* Réveil des Oiseaux

EXAMPLE 16. [*continued*]

strophes are displayed in Example 17.[14] As the arcs above the staff indicate, the succession of prime classes that results from the application of the algorithm to each strophe is arranged in an almost entirely symmetrical, or, using Messiaen's terminology, nonretrogradable pattern, with the prime class D contour of strophe 9 forming the "central common value" (Messiaen 1944/1956, 17). The lone discrepancy involves the only strophes in the passage whose contours are not members of prime class L.[15]

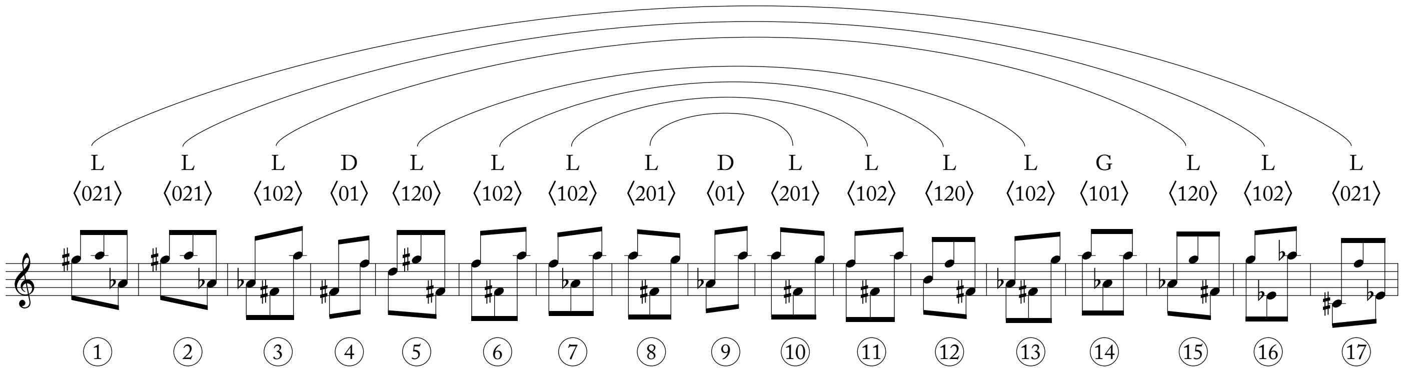
The existence of this nonretrogradable structure is, of course, entirely dependent upon the principle of contour equivalence based upon the four canonical transformational operations, as outlined at the beginning of this essay. That is, although the corresponding prime contours of each strophe are all members of the same prime class L, it does not necessarily follow that the internal structures of the contours themselves are nonretrogradable as well. The issue is more vividly illustrated by Example 18, which juxtaposes the prime form of prime class L with its identity, retrograde-, inversion-, and retrograde inversion-related forms, and evaluates each pair's capacity for reflectional symmetry about a central vertical axis. As the arcs in the example indicate, only the retrograde-related pair exhibits symmetry in this respect

1958, 9). These adjustments are not surprising considering the varying extent to which Messiaen altered the pitch content in these examples as well, a practice he considered to be entirely valid (1994, 94).

As for the term "strophe," Messiaen never offers a working definition in Tome V of the *Traité*, but there it for the most part seems to be equivalent to the conventional musical term "phrase" (as opposed to the entire movements that bear the names "Strophe" and "Antistrophe" in *Chronochromie* (1959–60), which refer specifically to the structural components of the classical Greek Ode (Messiaen 1994, 117; 132)). In the transcriptions found in the *Traité*, however, strophes can sometimes be a good deal longer than what might be comfortably considered a phrase, suggesting that the term's poetic connotations be taken a bit more literally. Indeed, strophes are often, but not always, capable of being subdivided into shorter melodic units or motifs, as made abundantly clear by the aforementioned references to plainchant neumes throughout. The term strophe does not, however, imply that birdsong is strophic, even though verbatim repetition may be present in a given song. Messiaen rather emphatically makes this point in his description of the song of the Song Thrush (Grive Musicienne): "These strophes are never identical, which is to say, the bird invents a strophe, repeats it three times, then invents another, also repeated three times, and the next day it'll invent another dozen of them . . ." (1994, 89).

14 In order to better facilitate cross-reference with the score, pitch content is preserved throughout Example 17, with the exception of the octave doublings. The same holds true in Example 24(a) for precisely this reason as well.

15 It is somewhat typical in Messiaen's birdsong for a solo to be restricted to just a few prime contour classes, although there are a number of exceptions, particularly in solos of greater length, as will be seen later in Example 32.



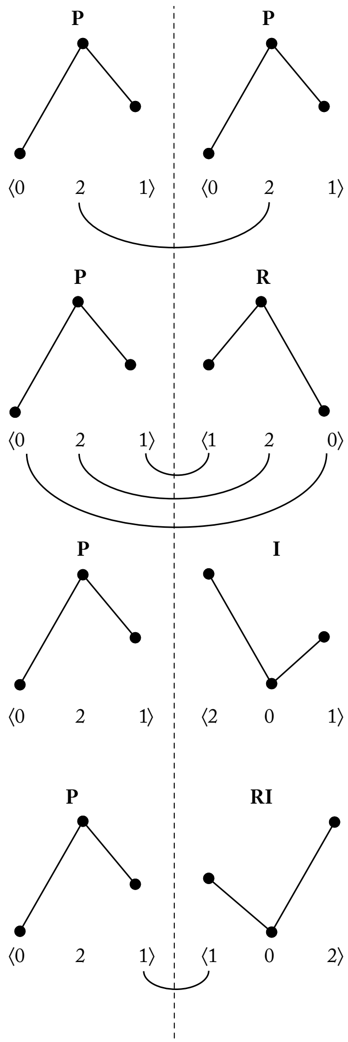
EXAMPLE 17. *Nearly symmetrical structure of the prime contour classes from Example 16*

between all of the contours' constituent c-pitches; the identity- and retrograde inversion-related pairs exhibit symmetry in only one-third of their constituent c-pitches, while the inversionally related pair exhibits no symmetry whatsoever.[16] Yet all four pairs are regarded as equally symmetrical in Example 17, since it does not differentiate between any of the four distinct forms of prime class L.

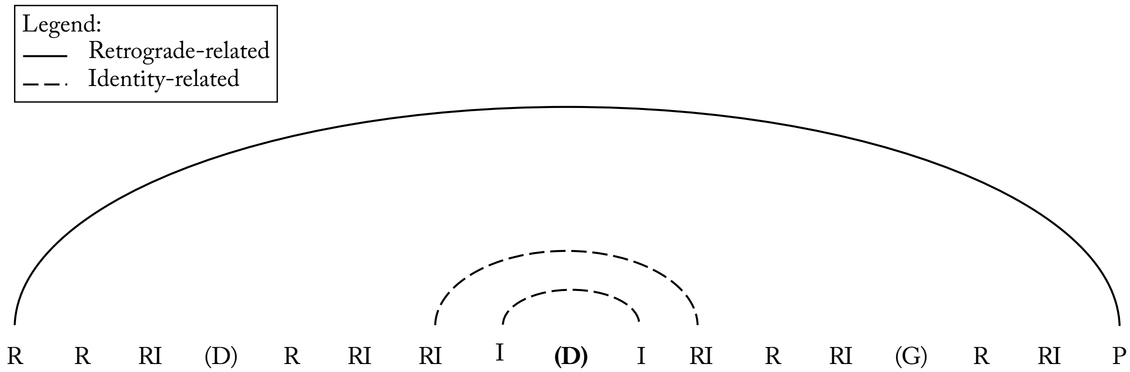
Example 19, on the other hand, specifies precisely which member of prime class L each strophe's prime contour form is, and thereby distinguishes between the various kinds of symmetry delineated in Example 18 between the corresponding contours. As the solid-lined arc in the example indicates, only the outermost pair of contours exhibits full retrograde-related symmetry; the two innermost pairs are one-third symmetrical by virtue of their identity relationships, while all those in between are inversionally related, and therefore possess no symmetrical properties whatsoever. The nonretrogradable structure in this solo thus remains quite heavily reliant on the concept of contour equivalence between transformationally related forms, since literal symmetry between the corresponding prime contours is the exception rather than the norm. To be sure, Example 19 does not completely nullify this nonretrogradable structure, but it does seem to indicate that it may actually reside at a deeper structural and perceptual level in the piece.

In Larry Polansky and Richard Bassein's (1992) discussion of the formal aspects of contour, however, we find the premises for an alternate view. The key lies in the distinction the authors draw between a *linear* description of contour and a *combinatorial* one: in the former, only adjacent c-pitches within a contour are considered, whereas the latter incorporates non-adjacent relationships as well. A linear description

16 This particular set of symmetrical properties is unique to prime class L; the symmetrical properties found in the nine remaining linear prime classes are summarized in Appendix I. Note that there is at least a 50 percent chance that two members of the same prime class will exhibit at least partial symmetry, and in some cases, i.e. prime classes A, B, P, and 12(α), it is in fact guaranteed. Generally speaking, then, the arrangement of prime contour classes in a nonretrogradable structure of this kind is more analytically significant than the internal symmetries that may be exhibited therein.



example 18. *Symmetries between the prime form of prime class L and its identity-, retrograde-, inversion-, and retrograde inversion-related counterpart*



EXAMPLE 19. *Identity- and retrograde-related symmetry in the Nightingale solo*

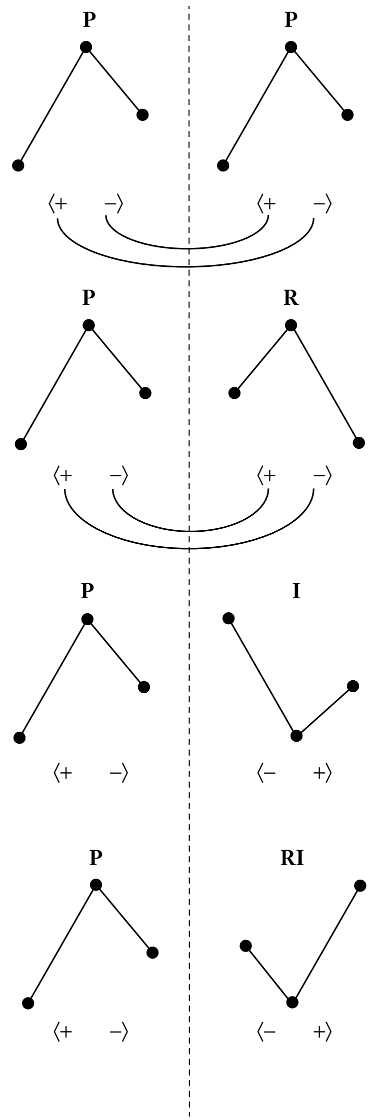
of the prime form of prime class L, for instance, involves simply comparing the relative position of the first and second c-pitches, and then the second and third, thereby arriving at the ordered series ⟨+,−⟩, indicating that the second c-pitch is higher than the first (resulting in an ascent), and that the third c-pitch is lower than the second (a descent); the relationship between the first and third c-pitches is simply not factored into this kind of measurement.[17] A combinatorial description, on the other hand, incorporates the positional relationships amongst all three c-pitches in the contour. The definition of contour employed here thus far is in fact based on this combinatorial description of contour; hence, the prime form of prime class L has been identified by the ordered integer string ⟨021⟩, which designates the first c-pitch as lower than both the second *and* the third c-pitches of the contour in addition to the linear relationships described above.

Although Polansky and Bassein acknowledge that a combinatorial description does in fact provide a more complete picture of a contour, they also note that the psychological literature actually tends to prefer the linear description of contour, since "listeners are often most sensitive to adjacency relations, and they tend to forget non-adjacent contour relationships quickly" (Polansky and Bassein 1992, 260).[18] This observation is particularly relevant to the current analytical and perceptual situation, for since we are dealing with prime contours, which are themselves already reductions of the contour structure found directly on the musical surface, it seems even less likely that listeners could accurately perceive and process the non-adjacent c-pitch relationships found therein.

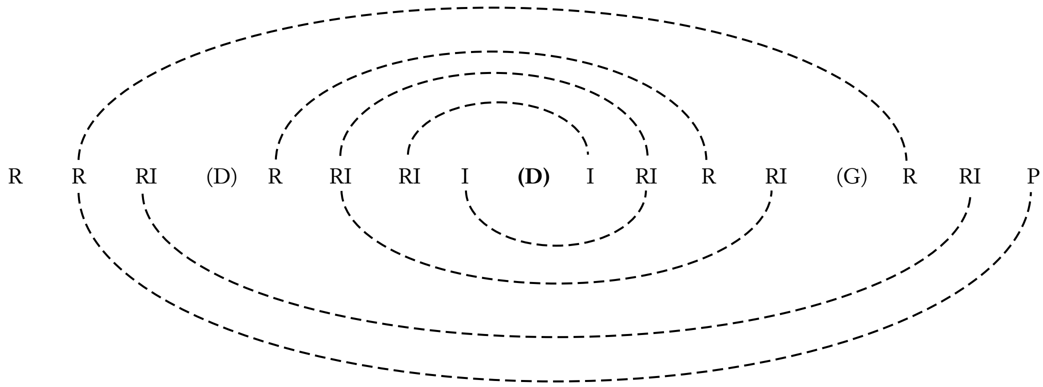
With this new perspective in mind, Example 20 displays the linear representations of the four members of prime class L,

17 Friedmann (1985) calls this ordered set the *Contour Adjacency Series* (*CAS*), while Marvin and Laprade (1987) refer to it as INT1.

18 This issue is directly addressed in a study conducted by Ian Quinn (1999). His findings are in agreement with this assertion, although they also indicate that non-adjacencies do have a role to play in contour perception as well.



example 20. *Linear description of the four members of prime class L*



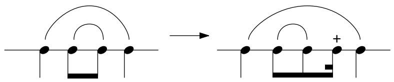
EXAMPLE 21. *Fuzzy symmetries with an offset value of one; arcs above the labels indicate a leftward displacement, and those below a rightward one*

and thereby reveals that under these conditions, these four forms reduce to two pairs of equivalent contours—the prime and retrograde forms both consist of an ascent followed by a descent, while the inversion and retrograde inversion forms consist of a descent followed by an ascent.[19] It therefore follows that the distinction between identity- and retrograde-related contours displayed in Example 19 disappears under these conditions as well, for as Example 20 demonstrates, both are in fact fully and equally symmetrical in this way, while the inversion- and retrograde- related contours are both entirely non-symmetrical.[20] (Note that because the linear measurements "+" and "−" represent a relation between two c-pitches, and not the c-pitches themselves, as in the combinatorial description, symmetry actually obtains between opposite, not equivalent signs, i.e. "+" is symmetrical with "−", not "+", and vice versa). Although the non-symmetrical contours still outnumber the symmetrical ones in the overall structure of the Nightingale solo under this description of contour, it is worth noting that the latter are placed in the most perceptually prominent positions possible, that is, the inner- and outer-most boundaries of each flank of the structure.

Still more observations of significant analytical import, however, may be gleaned from the non-symmetrical "mid-section" of each flank of the structure in Example 19, for each strophe therein participates in at least one slightly displaced symmetrical formation about the central prime class D, as indicated by the dashed arcs in Example 21; those above the contour form labels display symmetries that are offset by an "extra" strophe on the left-hand flank, while those below display symmetries offset by an "extra" strophe on the right-hand flank. Borrowing and adapting concepts and terminology employed by Joseph Straus (2003, 314–18) with regards to atonal

19 Friedmann (1985) would thus say that contours ⟨021⟩ and ⟨120⟩ have the same CAS, ⟨+,−⟩, while both ⟨201⟩ and ⟨102⟩ have a CAS of ⟨−,+⟩.

20 The symmetrical properties of the remaining linear prime classes under a linear description of contour are presented in Appendix II. Not only do certain members of the same prime class collapse into a single linear representation, as seen here with prime class L, but as comparison with Appendix I reveals, some prime classes themselves collapse in this manner as well. For instance, the P/RI forms of prime classes P, X, and Y all have the same linear description of ⟨−,+,−⟩, and are therefore, under these auspices, indistinguishable from one another.



Example 22. *Displaced symmetry resulting from the added rhythmic value, indicated by the "+" (Messiaen 1944/1956, 11)*

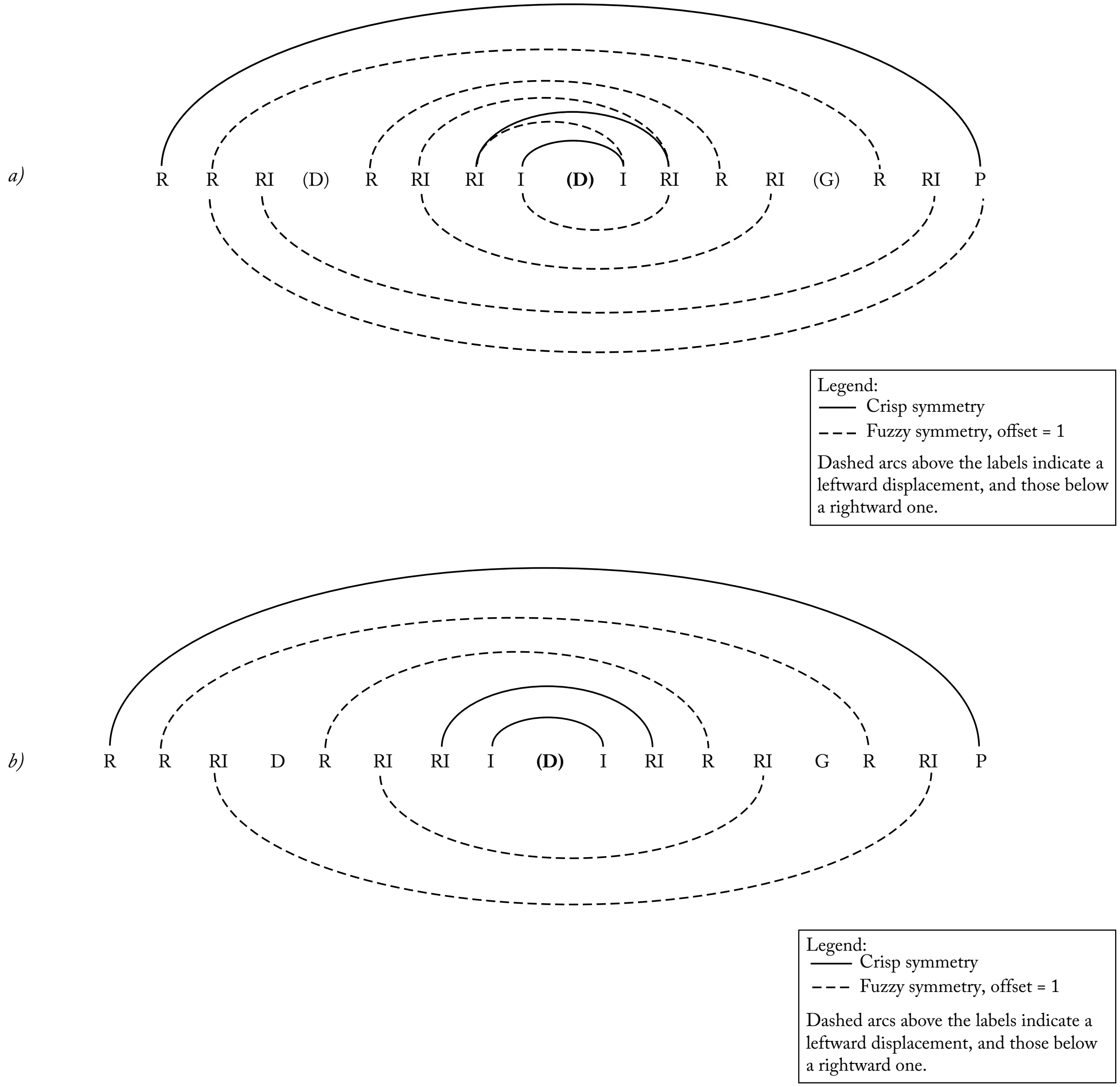
voice-leading, we may deem the precisely placed symmetries shown in Example 19 "crisp" symmetries, and the displaced symmetries of Example 21 "fuzzy" symmetries with an "offset" value of 1, since they are displaced by one position within the overall structure. Although these fuzzy symmetries may also be interpreted as crisp symmetries about different inversional axes—that of the arcs above the labels falling midway between the central D contour and the I form to its immediate left, and that of the arcs below the labels falling between the central D contour and the I form to its immediate right—regarding them as fuzzy with respect to the central D contour allows us to take special note of the striking resemblance in their overall effect to Messiaen's additive rhythm technique. This is demonstrated in Example 22, which is adapted from an example found in the chapter devoted to the subject in *Technique de mon Langage Musical* (11). As the arcs in the example indicate, the end result of the added value on the right flank of the nonretrogradable rhythm is a displaced symmetry highly comparable to those shown in Example 21.[21]

With the inclusion of these fuzzy symmetries in the linear interpretation of the Nightingale solo, we arrive at the structure shown in Example 23(a), which is simply a composite of Examples 19 and 21. Although the plentitude of symmetries in the figure undoubtedly strengthens the case for hearing a fuzzy nonretrogradable structure in the overall design of the solo, the contradictory participation of many strophes in two or more different symmetries is quite troubling, if not necessarily from a logical standpoint, certainly from a perceptual one. Establishing and enforcing a cognitive grammar rule that prefers crisp symmetry to any and all fuzzy symmetries in such ambivalent situations, however, results in the structure shown in Example 23(b). Here not only does each prime class L contour participate in precisely one symmetrical correspondence, but the pattern of fuzzy symmetries consistently alternates between leftward- and rightward-displaced ones throughout. The uniqueness and regularity that this structure exhibits no doubt considerably strengthens the viability of a nonretrogradable interpretation.

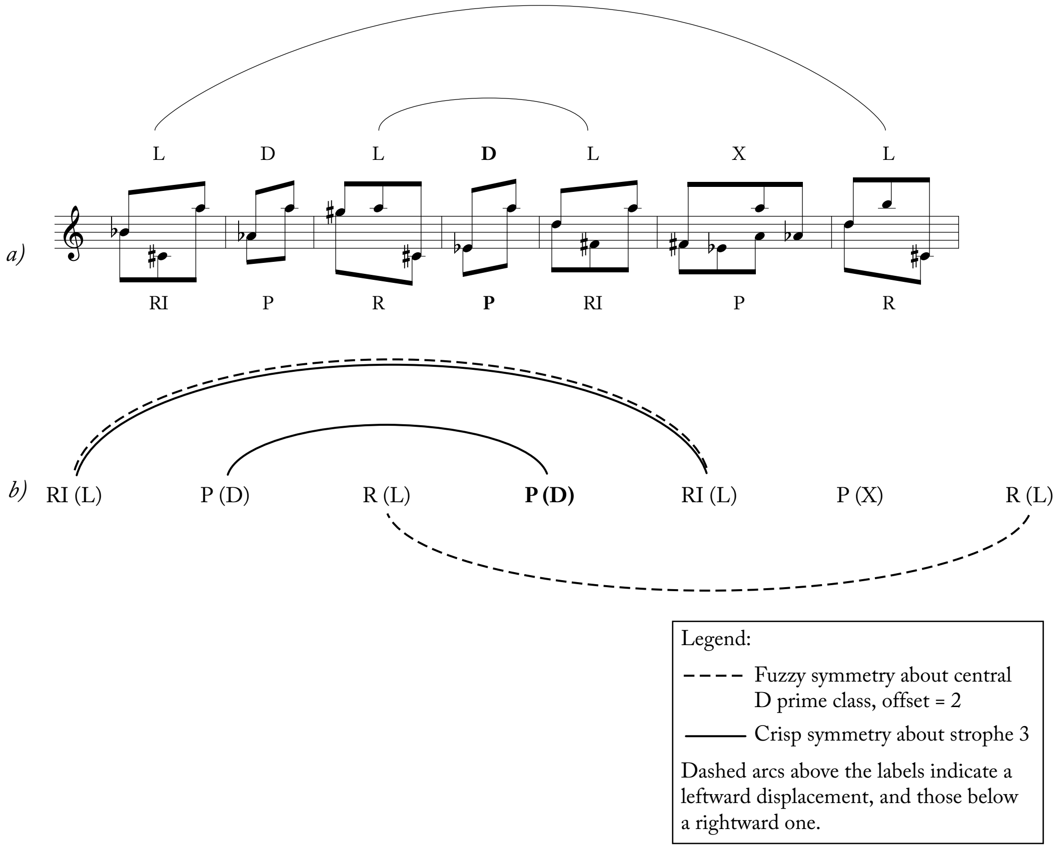
After an extended contrapuntal exchange between a second and third Nightingale immediately following the music displayed in Example 16 (more on that passage later), this initial Nightingale returns for a brief recapitulatory solo that exhibits some remarkably similar properties in terms of its prime class structure, as demonstrated in Example 24(a). Like that of Example 17, this structure is also symmetrical about a central prime class D contour but for one exception, which again involves the only two contours in the solo that do not belong to prime class L. The lone discrepancy here also occurs in the middle of each flank, with the symmetries placed at the most perceptually prominent positions in the structure, a feature also observed in Example 19.

Unlike the first Nightingale solo, however, a linear description of these contours is of little help in bringing this nonretrogradable structure closer to the musical foreground, for here the crisp prime class L symmetries involve two inversionally related forms about the central prime class D. Furthermore, as the dashed arcs in Example 24(b) demonstrate, any and all fuzzy identity- and/or retrograde-related symmetries have an offset value of two, which renders them rather dubious from a perceptual standpoint, particularly since the passage contains a total of only seven strophes. Indeed, the leftward-displaced fuzzy symmetry seems far

21 That the added value is of a different durational value than any of the others raises significant questions regarding the quantification of the offset value in this context that are too complex to explore in the present study.



EXAMPLE 23. *(a) Complete set of crisp and fuzzy identity- and retrograde-related symmetries in the Nightingale solo, and (b) symmetries resulting from the application of a crisp symmetry preference rule*



EXAMPLE 24. *(a) Nearly nonretrogradable structure of the prime classes in the first Nightingale's reprise solo, and (b) fuzzy symmetries with an offset of 2 about the central D prime class, and crisp symmetries about strophe 3*

more likely to be perceived in conjunction with the two prime forms of prime class D in the second and fourth strophes as crisp partial symmetries about the third strophe (R form of prime class L), as indicated by the solid arcs in the example. It is only in this way that symmetry remains a salient feature of this solo at a more foreground level, despite the fact that it does not coincide with that of Example 24(a).

SEGMENTATION RECONSIDERED

As Robert Morris (1993, 217–18) observes, and aptly demonstrates, the results of the Contour-Reduction Algorithm hinge entirely upon how one chooses to segment the given c-pitch data prior to its application. Fortunately, in the two Nightingale solos discussed thus far, the eighth rests in the score made it possible to establish a convincing segmentation in a fairly straightforward manner. Quite often, however, clear and consistent boundary cues of this kind are not available in Messiaen's birdsong scores, and other methods for segmentation must be sought.

The aforementioned "contrapuntal exchange" that intervenes between the two solo Nightingale passages discussed above provides a clear case in point, as the score, provided in Example 25, clearly demonstrates. In situations such as this, a new segmentation rule based on a combination of Messiaen's notation and the fundamental principle of the Tenney/Polansky (1980) algorithm (the segmentation method endorsed by Morris [1993]), which is illustrated in Example 26, may be employed: taking only rests of an eighth duration or greater as potential segment boundaries *a priori* (a nod to Messiaen's notational practices), strophe boundaries are demarcated at only those rests or series of consecutive rests whose total duration is greater than both the note that immediately precedes it and that immediately follows it.[22] Hence, in the song of the second nightingale (upper staff), for instance, the eighth rest at the start of the fourth measure delineates a phrase boundary, but the dotted-sixteenth, thirty-second, and sixteenth rests in that measure do not.

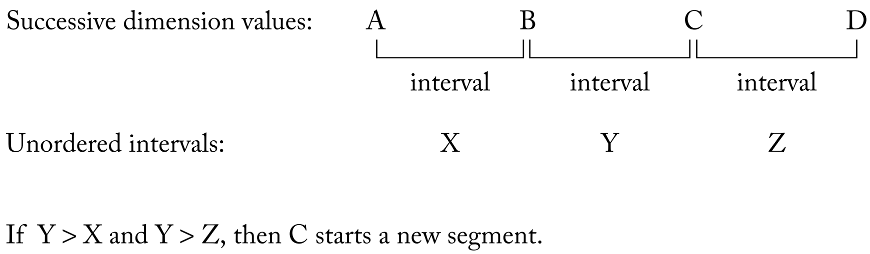
Example 27 displays the prime contour structure of both nightingale songs in this passage under the application of this segmentation rule. In both cases, only crisp symmetries are present, and all exhibit partial symmetry via their respective identity relations. As outlined above, this also signifies that they are fully symmetrical under the linear description of contour. The song of the second nightingale shown in Example 27(a), however, differs from those examined above in that its central common value, the P/RI form of prime class D, is bounded on the right by another prime class D contour of the same form, thereby rendering it somewhat less distinguishable as the central common value of a nonretrogradable structure. Furthermore, the song of the third nightingale in Example 27(b) contains an entirely different central common value, the P/RI form of prime class P. These points of divergence help distinguish these songs of the second and third Nightingales from the surrounding solos of the first Nightingale, and thereby enhance the sense of contrast and distinction that this passage strongly evokes, while maintaining at least some structural commonalities with them.

There is often, however, sufficient justification for overriding this segmentation rule in Messiaen's birdsong. Perhaps the most obvious situations are those in which orchestration is a factor, such as the excerpt from *Réveil* presented in Example 28, a brief dialogue between three separate Nightingales.[23] The segmentation shown is based entirely on orchestration, with the exception of the strophe boundary in the first measure, which stems from the segmentation rule, and the fifth measure, in which the flute's fluttertongued F♯ is interpreted as an extension of the B♭ clarinet's (concert) F♯, with which it overlaps, and not as a separate strophe in its own right. Note that the exclusive application of the segmentation rule to this passage would produce a drastically different result, as the length of rest separating strophes two from three, three from four, six from seven, eight from nine, nine from ten, and ten from eleven would eliminate these points as segment boundaries.

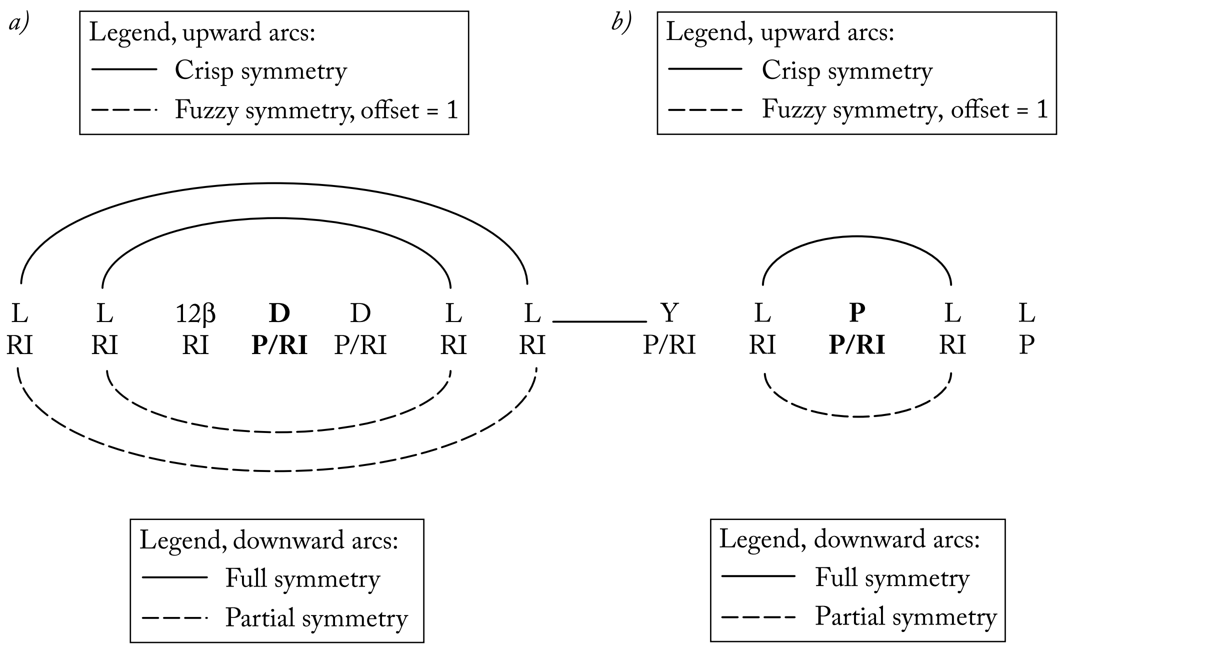
22 The Tenney/Polansky algorithm is customarily applied to attack point distances and/or pitch intervals, and thus, often marks phrase segments where no rest is present. For instance, in the succession eighth note–half note–eighth note, a new phrase would begin at the onset of the second eighth note. The stipulation regarding notated eighth rests thus precludes this kind of segmentation from occurring here. Furthermore, the decision to set the eighth rest as the minimum value is entirely context-driven; in other passages, a greater or lesser minimum value may be more appropriate.

23 I am indebted to *Spectrum* Reader A for pointing out the nonretrogradable contour features of this passage.

EXAMPLE 25. *Rehearsals 1–2 of* Réveil des Oiseaux



EXAMPLE 26. *Principle of Tenney/Polansky algorithm (Morris 1993, 221).*

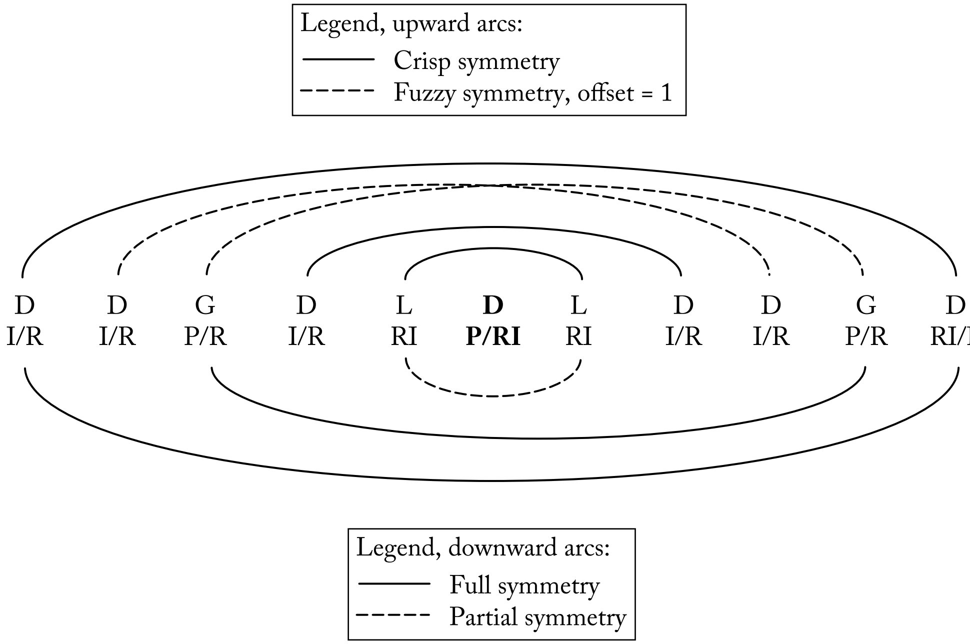


EXAMPLE 27. *Nearly nonretrogradable structures of the prime classes in the solos of (a) the second, and (b) the third nightingales, and the types of symmetries involved therein.*

EXAMPLE 28. *Rehearsals 8–9 of* Réveil des Oiseaux

Example 29 displays the nonretrogradable features that obtain from incorporating orchestration into the segmentation of the passage, as shown in Example 28. The similarities of these features to those observed in the previous analyses are indeed quite striking. The central common prime class D is itself common to all but one of these structures—the one given in Example 27(b)—as is the presence of crisp symmetries at the inner and/or outer boundaries of each flank, and the relegation of the fuzzy symmetries, where present, to the less prominent midsections. This passage also features two instances of full symmetry, and one of partial symmetry, all three of which hold true under the linear description as well.

Many of Messiaen's birdsongs are more motivic than strophe- or phrase-oriented in their construction, such as that of the Song Thrush (Grive musicienne) contained in the excerpt



EXAMPLE 29. *Nearly nonretrogradable structures of the prime classes in Example 28*

from *Réveil* displayed in Example 30. The delineation of the first two strophes in this passage is straightforward, not only in terms of rest values, but also in that they involve two different species, the Greenfinch (Verdier) and the Blue Tit (Mésange bleue), respectively. With the entrance of the aforementioned Song Thrush, however, the criteria for segmentation employed thus far are of no avail, as they would produce no segmentation whatsoever for the remainder of the passage. Segmenting the passage according to motivic content, however, despite the fact that none of the individual motifs are separated by a long enough duration of rest according to the segmentation rule (indeed, some lack any intervening rest or rests whatsoever), produces a highly satisfactory result, one that is in fact confirmed by Messiaen's own discussion of this passage (1999, 1:110–11), in which he asserts precisely the same segmentation.

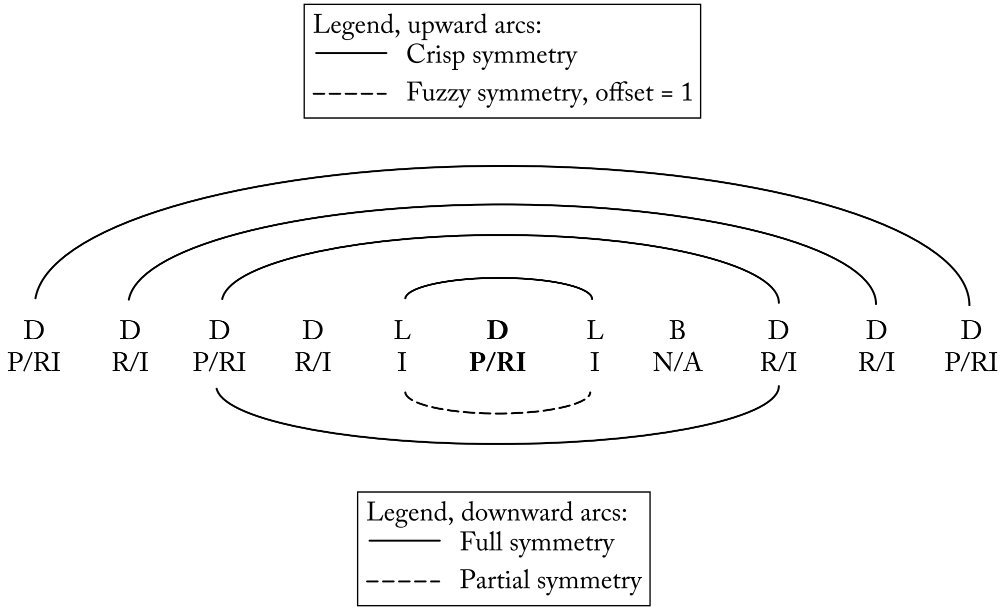
Example 31 displays the nonretrogradable features that result from this segmentation.[24] Here, unlike most of those

24 Despite the presence of harmony in the first two strophes, for simplicity's sake, each is represented as ⟨01⟩, not because the uppermost voice in each strophe has a prime of ⟨01⟩—as the *Traité* (1999, 1:89–93 and 95–104) reveals, the uppermost voice in a birdsong harmony is not necessarily the original birdsong—but rather because *all* the voices in each strophe have a prime of ⟨01⟩. While Morris's article (1993) does provide the foundation for contour study that incorporates harmony,

example 30. *Rehearsals 39–40 of* Réveil des Oiseaux

found in the preceding passages, the symmetries are all crisp, although only half of them exhibit any internal symmetry whatsoever, and thus, remain symmetrical under the linear description of contour. Hence, the nonretrogradable construction of the passage is most strongly projected under a combinatorial description that admits transformational contour equivalence.

whereby the first strophe would be represented by the prime ⟨{0245}{1367}⟩ (G♯$_3$ = 0, C$_4$ = 1, C♯$_4$ = 2, etc.), and likewise, the second by ⟨{023}{145}⟩, and this approach would almost certainly yield a plethora of interesting results and raise a host of further questions, particularly given Messiaen's penchant for adding harmony to his birdsongs as a means of conveying timbre, resonance, and (visual) color, the intricacies of both contour and voice-leading methodology demand a more extensive treatment than is possible within the confines of the present study.



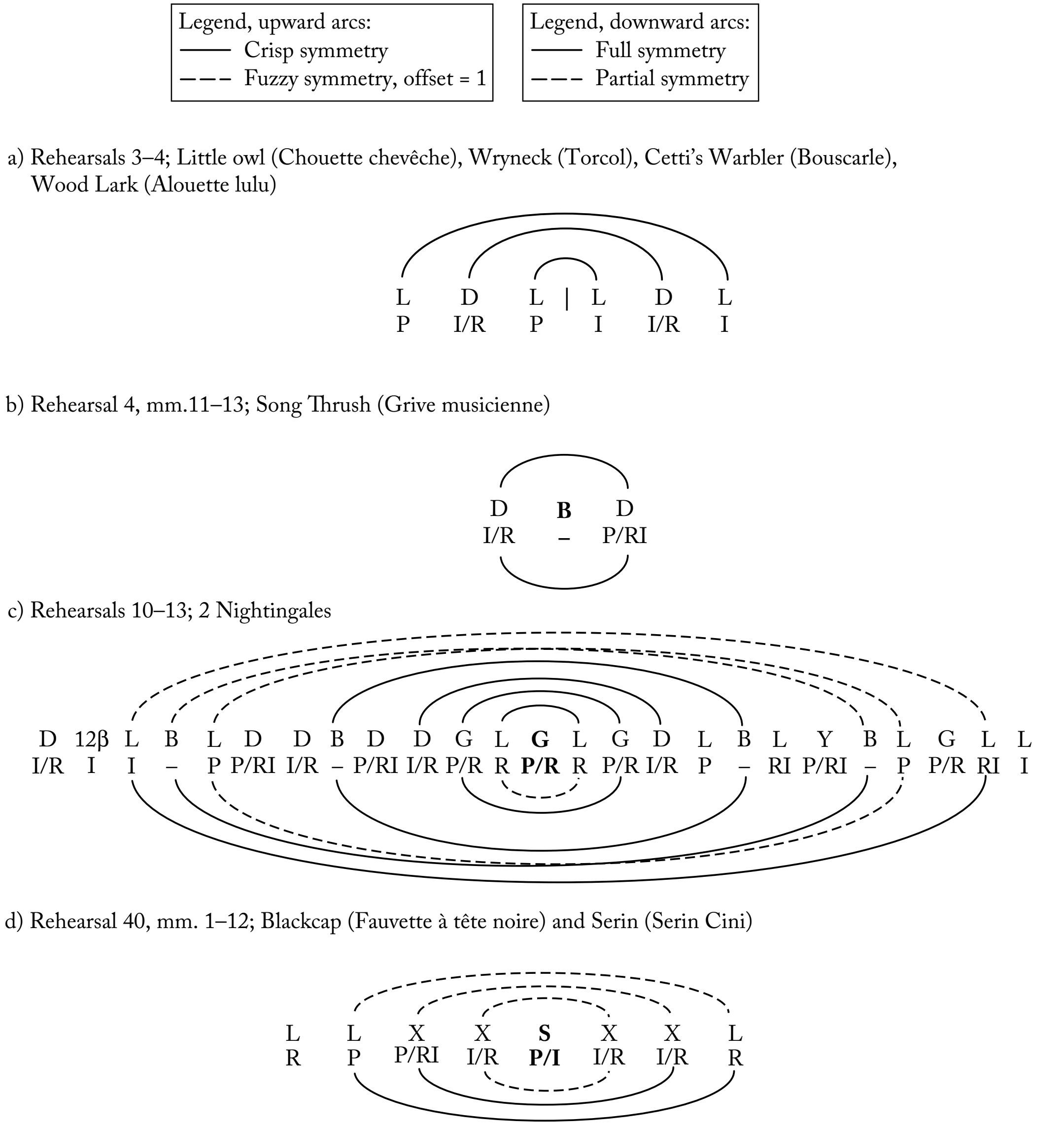
EXAMPLE 31. *Nearly nonretrogradable structures of the prime classes in Example 30*

FURTHER OBSERVATIONS AND CONCLUSIONS

Example 32 provides a list of several more prominent nearly nonretrogradable contour structures found in both *Réveil* and throughout Tome V of the *Traité* that obtain under the segmentation methods outlined above.[25] In addition to the notable variety of species involved, wide-ranging chronology,[26] and variable length of the structures presented, we may also observe how many of them exhibit several distinctive features not seen in any of the passages discussed above. First, the structures at (a), (d), (e), (f), (g), and (i) have no central common value, while the rest possess a variety of central common values outside of the D and P prime classes

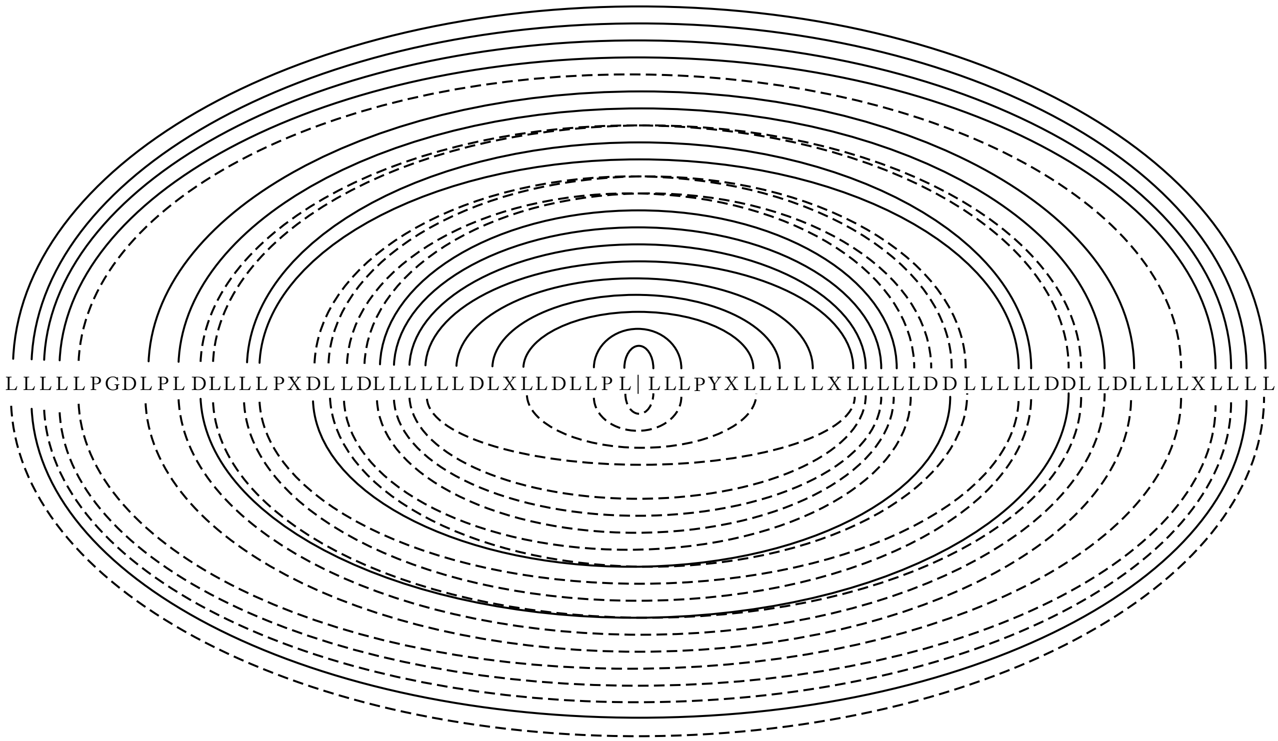
25 I have restricted the content of Example 32 to these two sources in order to bypass the aforementioned complexities regarding harmony (cf. n22), which permeates Messiaen's post-*Réveil* birdsong music.

26 Messiaen began seriously notating and cataloguing birdsong in the early 50s, and continued to do so for the rest of his life. Regarding the songs shown at (k) and (l), the *Traité* does not specify the dates these were notated; those shown are extrapolated from the known dates of Messiaen's foreign travels to the native countries of the birds in question, Japan and New Caledonia, respectively. Messiaen traveled to Japan in 1962, 1978, and 1985, but the earliest of the three trips seems to be the most likely source of this song, as it is the only one in which Hill and Simeone (2005, 245–51; 319–20; 353–54) document any birdsong activity on Messiaen's part. Messiaen visited New Caledonia only once, in the autumn of 1975 (306–10).

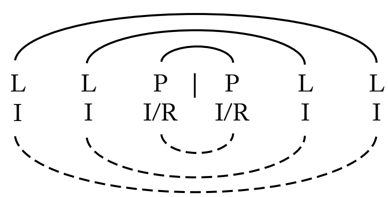


EXAMPLE 32. *Nearly nonretrogradable structures in various passages from* Réveil *and Tome V of the* Traité

e) Volume 1, pp. 145–46; Mistle Thrush (Grive draine), April 9, 1991

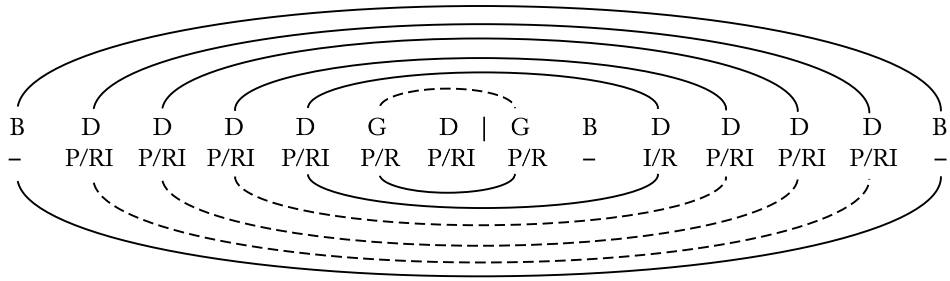


f) Volume 1, pp. 206–7; Willow Warbler (Pouillot Fitis), April 7, 1955

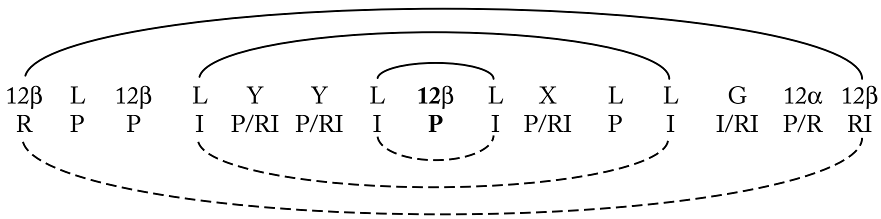


EXAMPLE 32. [*continued*]

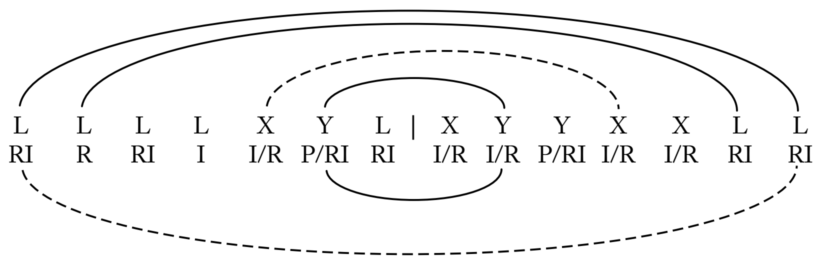
g) Volume 1, pp. 234–35; Tengmalm's Owl (Chouette de Tengmalm), April 3, 1964



h) Volume 1, pp. 316–17; Blackcap, June 29, 1980

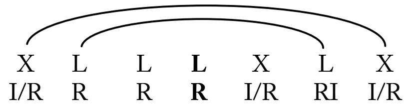


i) Volume 1, pp. 371–72; Garden Warbler (Fauvette des jardins), June 25, 1978

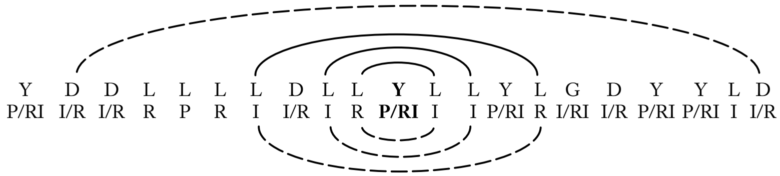


EXAMPLE 32. [*continued*]

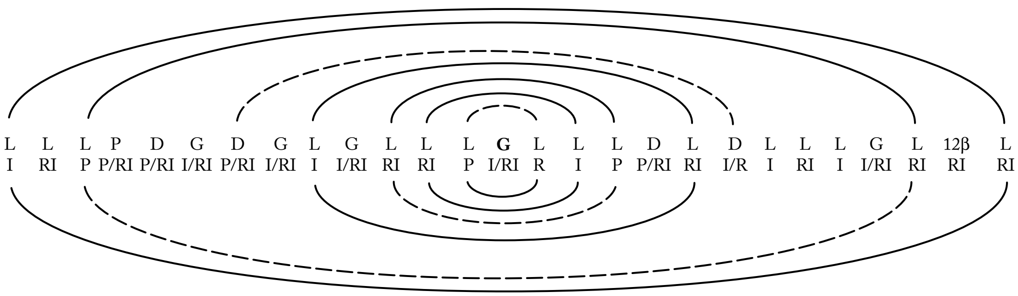
j) Volume 1, p. 522; Black-eared Wheatear (Traquet Stapazin), April 14, 1971



k) Volume 2, pp. 19–21; Narcissus Flycatcher (French: Gobemouches Narcisse; Japanese: Kibitaki), 1962 (?)



l) Volume 2, pp. 336–37; Silvereye (Zostérops à dos gris) or Green-backed White-eye (Zostérops à dos vert) (?), Autumn, 1975



EXAMPLE 32. [*continued*]

contained in the structures previously examined.[27] Furthermore, the structure at (d) is entirely fuzzy; the uniformity of its offset and the high degree of full symmetry it exhibits, however, render it quite prominent nonetheless. In addition, in the structures at (a) and (j), the symmetries reside exclusively under the auspices of the transformational equivalence class under a combinatorial description of contour, as none of them exhibit even partial internal symmetry. Finally, the structure at (b) is categorically fully symmetrical. The passages presented in Example 32 thus exhibit symmetries that vary significantly in both their nature and degree, but undoubtedly remain a substantial structural feature in each case.

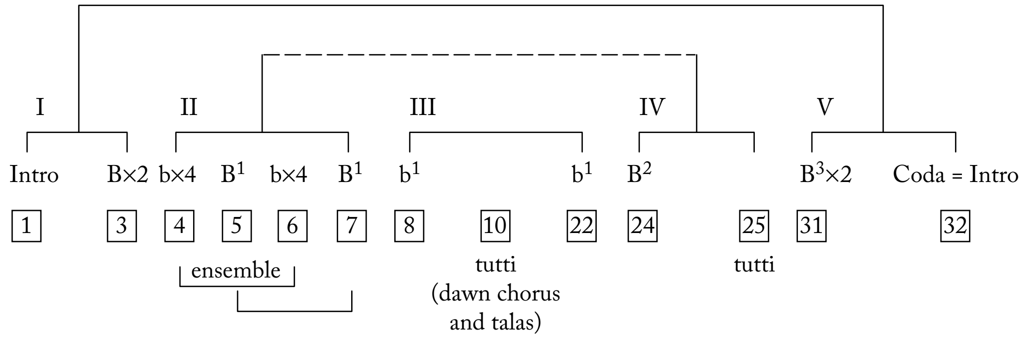
It must be acknowledged, however, that while Example 32 indeed provides only a representative sample of structures that contain these symmetrical properties, they are in fact by no means ubiquitous in Messiaen's birdsong output—several prominent and substantive solos in *Réveil*, as well as a significant portion of the transcriptions contained in the *Traité*, exhibit very little or none of these nonretrogradable properties.[28]

Before addressing this issue, however, it is necessary to first turn to the question of just how such a fundamental hallmark of Messiaen's own compositional practice emerged from these supposedly authentic transcriptions of naturally occurring phenomena in the first place. While it is certainly possible that these structures are indeed simply innate characteristics of the birdsongs themselves, a more probable (and more appealing, for reasons explained below) explanation may be found in the following confession Messiaen made to Claude Samuel with regard to his birdsong: "I assure you that everything is real; but, obviously, I'm the one who hears, and involuntarily I inject my reproductions of the songs with something of my manner and method of listening" (Messiaen 1994, 94). Indeed, evidence of this unconscious creative impulse crops up in the pitch content of some of Messiaen's birdsongs: a song of the Fan-tailed Cuckoo (Coucou à éventail) "rather curiously" (Messiaen's words) occurs entirely within an incomplete mode 3^4 (Messiaen 1999, 2:305), while the Blue Rock Thrush (Merle bleu) frequently employs the A Major pentatonic collection; A Major, for Messiaen, happens to correspond synaesthetically to the color blue via its close resemblance to mode 3^3 (Bernard 1986, 48). It is thus entirely plausible that the nearly nonretrogradable contour structures revealed in the analyses above could represent yet another manifestation of this unconscious impulse.

Highly suggestive in this regard is Malcolm Troup's formal analysis of the work written immediately after *Réveil*, *Oiseaux exotiques* (1955–56). Troup's interpretation, reproduced in Example 33, features a nonretrogradable structure that is remarkably similar to those examined in the present study, but one that emerges under decidedly different pretenses. Troup (1995, 406) asserts that "there is reason enough for seeking to construe the thirteen sections, with their five punctuating piano cadenzas, in terms of those palindromic structures so dear to Messiaen (see [Ex. 33]). Certainly the central and closing sections would seem to support such an arch-wise interpretation but there is enough asymmetry to leave room for doubt. . . ." Troup's "arch-wise interpretation" refers to the centrally located dawn chorus, designated as section III in the diagram, which functions as the central common value of a five-part symmetrical structure, and the outer sections I and V, the contents and inner organization of which correspond to a nonretrogradable design (Intro. $-$ B $\times$ 2 / $B^3 \times 2$ $-$ Coda = Intro). The asymmetry occurs in sections II and IV, which are highly dissimilar in this regard.

27 The small vertical line "|"marks the structural midpoint of those passages in the example with no central common value. Note also that the individual forms of the prime classes in (e) are omitted due to space limitations.

28 The uneven distribution between volumes one and two of the *Traité* in Example 32 is intended to reflect that the former is more heavily populated with these structures than the latter.



B mynah (India); red-billed mesia (China); wood thrush and veery (N. America)
B^1 cardinal (N. America)
b lesser green leafbird (Malaysia); Baltimore oriole; red-billed mesia; California thrasher
b^1 prairie chicken
central tutti: songs of 32 birds
B^2 catbird and bobolink
closing tutti (in order of appearance):
shama (India), Western tanager, Carolina wren, red-eyed vireo, horned lark, brown thrasher, purple finch, warbling vireo, yellow-throated vireo, lazuli bunting, blue-headed vireo (all of N. America)
B^3 ($B + B^1$) wood thrush and cardinal
*B = piano cadenza; b = ensemble

EXAMPLE 33. *Malcolm Troup's formal diagram of* Oiseaux Exotiques *(1995, 410)*

The parallels between this imprecise nonretrogradable structure and those examined in this study are quite readily apparent; the circumstances under which the structure of Example 33 is made manifest, however, are entirely different, as the passages from *Réveil* were transcribed directly from nature, while the entirety of *Oiseaux exotiques* was assembled and directly manipulated by Messiaen himself. Regarding the latter work, Messiaen (1994, 131) declares: "there's a blend of strictness and freedom, and, all the same, a certain element of composition in the 'bird-song material,' since I've randomly placed side by side the birds of China, India, Malaysia, and North and South America, which is to say, birds that never encounter each other." In *Réveil*, however, "the presentation is much more accurate . . . the birds singing are really found together in nature; it's a completely truthful work. It's about an awakening of birds at the beginning of a spring morning; the cycle goes from midnight to noon. . . ."[29] That the inexact

29 Thus, if we are to take Messiaen at his word, the passages shown in Examples 25, 28 and 30 are to be considered a transcription in the

nonretrogradable structure displayed in Example 33 emerged from a compositional environment in which Messiaen clearly exerted a substantial amount of conscious decision-making lends a good deal of credence to the idea that the nonretrogradable features of the Nightingale solos from *Réveil* do indeed stem from his unintentional participation in the transcription process.

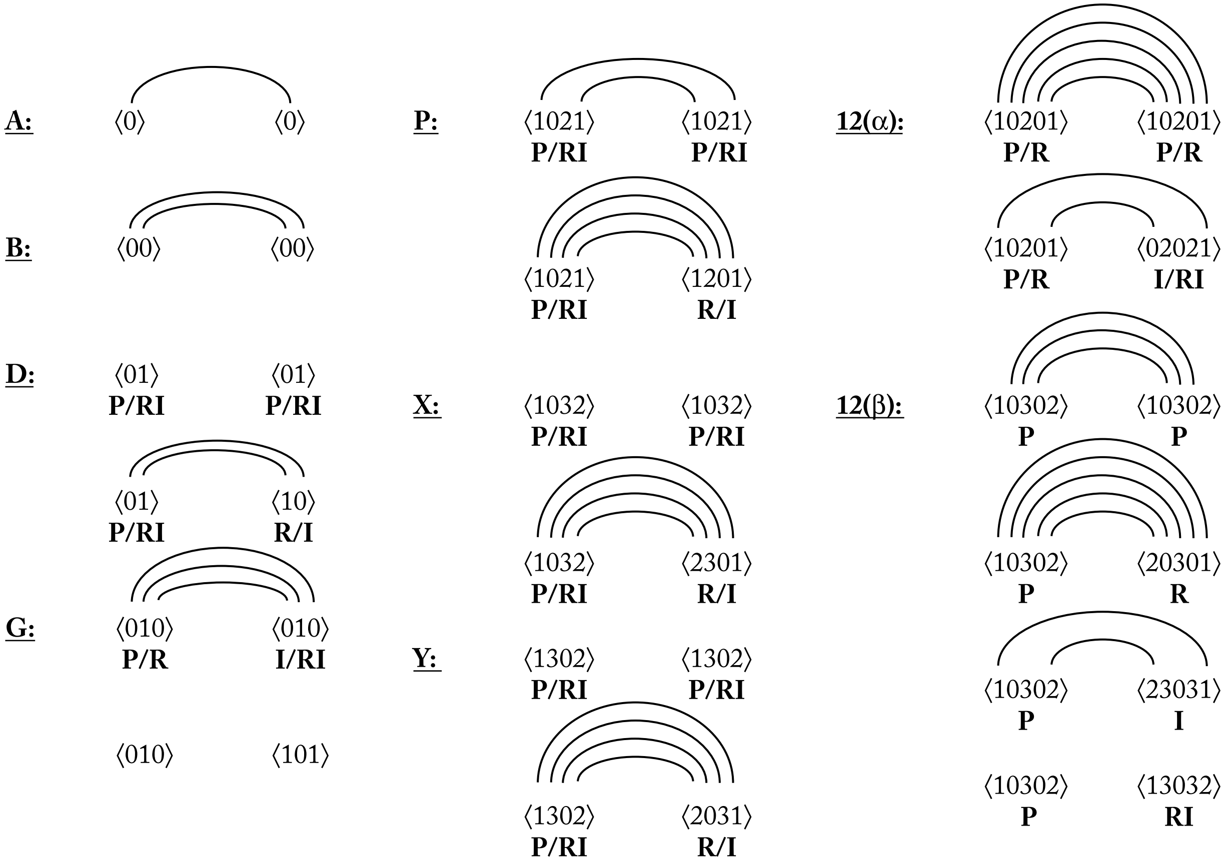
As for the lack of ubiquity of these structures noted above, it in no way diminishes this assertion, but rather strengthens it, for a more sporadic distribution is a far more likely byproduct of an *unconscious* compositional process than a fully consistent distribution. Also worth noting in this regard is the overwhelmingly greater number of nearly nonretrogradable contour structures in the first volume of Tome V of the *Traité*, which deals exclusively with European birds, than in the second volume, which contains only the birds Messiaen encountered in his travels abroad. This suggests that perhaps his greater familiarity with the birds of his native land granted him on some level in his psyche more freedom to "inject" his compositional will into the transcription process to a greater degree. Again, such a pattern is indicative of an unconscious, rather than fully intentional phenomenon.

The nonretrogradable and nearly nonretrogradable structures that the Contour-Reduction Algorithm has unearthed in this study, and the idea that they represent an unconscious manifestation of Messiaen's compositional voice in his birdsong, speak strongly to not only the Messiaen scholar seeking to unravel the mysterious process by which Messiaen's birdsong gets from the beak to the page, but also to the Messiaen analyst/listener who may feel shortchanged that he/she in most cases has no access to the original source of this musical material,[30] and thus, can never truly comprehend, or even appreciate it, for here we find considerable evidence that Messiaen's birdsong is still unabashedly *Messiaen's* music, and may in fact be understood as such, in strictly musical terms. As Messiaen (1994, 96) himself once remarked, "If [the listener] knows birds in general, it must make an impact. If he doesn't know them, he'll take pleasure in the music purely for itself and—well—perhaps that won't be so bad."

same sense as each of the Nightingale solos, despite the fact that each consists of material from separate individual birds, and in the case of Example 30, different species as well.

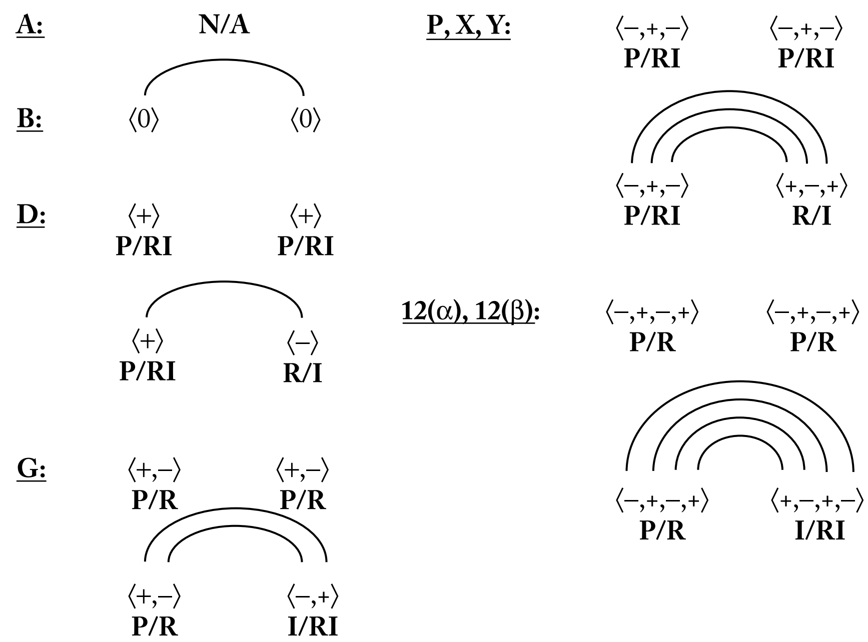
30 Robert Fallon (2007) discusses a very interesting exception—Messiaen's use of commercial birdsong recordings in the composition of the aforementioned *Oiseaux Exotiques*. An interactive multimedia demonstration that compares five songs from these recordings and Messiaen's renditions thereof can be found at http://www.oliviermessiaen.org/birdsongs.html.

Symmetrical Properties of Remaining Prime Classes (Combinatorial)



APPENDIX 1

Symmetrical Properties of Remaining Prime Classes (Linear)



APPENDIX II

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