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Transformation in Post-Tonal Music

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Abstract and Keywords

Post-tonal music (loosely, most Western art-music compositions since the turn of the 20th century) manifests many organizational techniques but not the processes of harmony and counterpoint that direct and articulate time in tonal music. Of the diverse theories for explaining this music, the theory of musical transformations is especially productive. Not only does its notion of a transformational graph offer a powerful, hierarchical view of musical relationships, but it also embraces a processive attitude toward musical form that has broad applicability. This article identifies four specifically temporal aspects of transformational theory that have been neglected in the recent literature and demonstrates how they can inform understanding of a variety of post-tonal music much more recent than the modernist works to which the theory has mostly been applied. The demonstrations proceed through detailed analytical consideration of compositions by Kurtág, Adams, Adès, Sheng, Haas, and Saariaho.

Keywords: post-tonal music, temporality, form, process, transformational theory, graph, Kurtág, Adams, Adès, Sheng

Orientation

The descriptor “post-tonal” hinders appreciation of a vital musical repertoire. If “tonal” is construed, as usual, to denote the special synergy of pitch and rhythm processes that shape 18th- and 19th-century Western art music, then “post-” seems to conflate and depreciate many highly crafted works of the last century as vestiges of a bygone era. Yet to the extent that we value those works, this inadequate label provokes productive questions, especially about their temporal qualities. How, in the absence of tonal harmony and counterpoint, do post-tonal compositions create a sense of progression, of directed change? How do they organize time into memorable experiences, so that listeners form expectations and sense their fulfillment or denial? In some pieces, perhaps, how do moment-to-moment changes coordinate into a coherent temporal experience to which every event seems necessary?

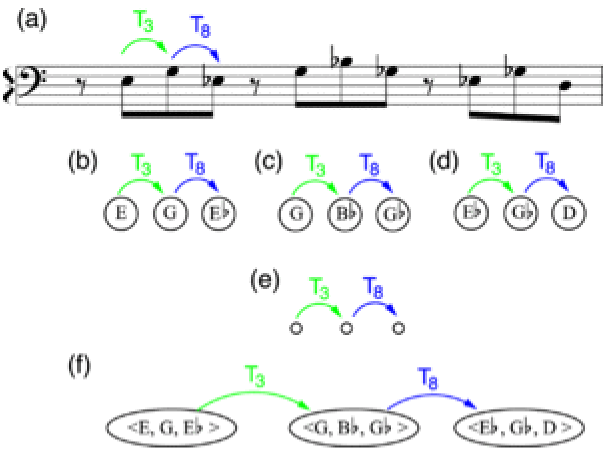
Serial composition takes a radical approach to these technical but ultimately artistic questions. Its instantaneous continuity does not arise from tendencies that pitches have as members of scales and harmonies but is established contextually, by the order of elements in the basic series, sometimes supported by basic rhythmic processes such as pulse. It articulates longer time spans by the completion of series or by shifts from one series combination to another. Its chords, on which listeners might focus for a sense of progression and change, are often difficult to categorize and distinguish. In integral serial works, features of the series may even determine larger-scale form. Although serial techniques can thus be quite demanding on listeners, mathematics facilitates a comprehensive appreciation of their possibilities, an opportunity not lost on composers and theorists so inclined.[1]

However, since most post-tonal pieces are not serial compositions, analytical surveys of post-tonal music must embrace a farrago of not entirely compatible theories and idiosyncratic compositional methods, including pitch-class-set theory (an offshoot of serial theory that classifies collections of notes and describes relationships among them), theories of melody and voice leading that privilege pitch change by small intervals, and quasi-harmonic theories (such as Hindemith's) that attribute special sonic and progressive properties to certain intervallic structures.[2]

In these accounts the reader may encounter a diagram like Example 1(a): labeled arrows connecting symbols that represent musical "objects," in this case the notes of the principal motive of the song "Nacht" from Schoenberg's *Pierrot Lunaire*. The diagram is shorthand for a transformational network, represented more completely by Example 1(b). The circles are nodes of the network, each filled with a symbol that denotes a particular quality of the corresponding event (in this case its pitch class). Pairs of nodes are connected by directed arrows, each labeled by the transformation (in this case a transposition) that changes the object at the arrow's tail into the object at the arrow's head. For a given network, the objects must be all of the same sort of percept, but the wealth of options—individual pitches or pitch classes, pitch-class sets or series, rhythms, orderings of instruments, and many others—makes it possible to represent a variety of musical processes. The objects and transformations, though, must comprise a coherent system in the following senses: Every transformation must be a function, meaning (informally) that it acts on every object of the system and that the transformation that changes object s_1 to another object s_2 is not the same as the transformation that changes s_1 to a different object s_3; every transformation must combine with every other; and the family of objects is closed under the transformations in the sense that no combination of transformations can produce an object not in the family. There are other constraints on the arrow labels as well. "Transformation," in this sense, then, has a rather precise technical meaning. Originated in the 1980s by the composer and theorist David Lewin, transformational theory has since undergone further exposition, development, and application to a variety of music.[3]

Although there are some fairly nontechnical introductions to the theory,[4] it is not always fully deployed in musical analysis. Networks are sometimes presented merely as concise representations of distances or relations among entities rather than as changes—for example, with arrows signifying intervals rather than transpositions.[5] Such a conflation is understandable, considering that Lewin explicated transformations in tandem with a generalized interval theory[6] and that both theories have been applied intensively to the same early-20th-century repertoire and its direct legacy.[7] But the explanatory power of transformational theory emerges fully only when the analyst mobilizes its key concepts, which have no counterpart in relational theories.

Most fundamentally, as many commentators have noted, transformational theory treats music as intentional process.[8] Each directed arrow asserts a temporal, or at least conceptual, order,[9] and its label focuses attention on the particular action that alters one object into another.[10] Lewin's writings show concern for the "phenomenological presence" of his arrows, focusing on the characteristic audible effects, or "signatures," of the transformations they represent.[11] Also, the notion of action implies the existence of an agent who chooses and effects the changes and to whom the listener may attribute meaningful intent.[12] Thus transformational networks represent music as dynamic communication rather than as static design.[13]



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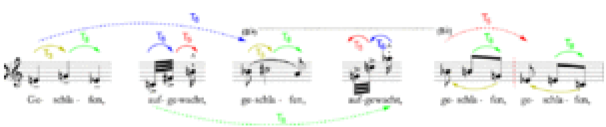
Example 1 . Networks and isography in a brief excerpt from Schoenberg's "Nacht," Op. 21, No. 8.

Four further aspects of transformational theory, all contingent on this temporal orientation, seem especially distinctive and valuable: its concept of isography as both a source of compositional unity and a principle of large-scale progression; its interpretation of transformations as "structuring forces" that drive musical continuity and development; and its two views of form, as a manifestation of the systematic properties of transformations and as a manifestation of objects as members of a structured space of possibilities. To explain each of these aspects completely would require the kind of formal exposition that the curious reader may easily pursue in the technical literature. Instead, this article demonstrates them more pragmatically in four brief analyses. It shows how fundamental they are and how they offer the possibility of much deeper readings than do plain network representations. The music analyzed here is more recent than the works featured in the literature and includes contrasting examples not just by the clear inheritors of early 20th-century modernism but also by minimalists and by eclectic artists who draw, in the postmodern spirit, on Western classical and world music traditions. The variety of examples demonstrates how the theory provides a common language for explaining the temporality of post-tonal compositions and asserts surprising connections between apparently divergent styles.

Isography, Contextual Progression, and "Composing out"

For some works, transformational theory links larger-scale and local musical processes through the concept of isography. This property is apparent in the networks of Examples 1(b), 1(c), and 1(d): They have the same node-arrow structure, and their corresponding arrows are labeled with the same transformations. That is, disregarding the specific objects they involve, each manifests the same graph, namely the labeled node-arrow system in Example 1(e). Since the objects in these networks are all pitch classes, their isography manifests on the same small scale of note-to-note change. Yet the transpositions that structure the family of pitch classes in this system also define other families, such as classes of transpositionally equivalent pitch-class series. Hence, the graph in Example 1(e) is also manifested by the network of pitch-class sets in Example 1(f).[14] Since each of those series itself comprises a network of pitch classes, as in Examples 1(b) to 1(d), we can hear those distinctive transformations, established contextually by the local, event-to-event continuity of the motive, directing the larger-scale progression of motives belonging to the same set class. The recursion unifies the composition and gives it hierarchical depth, somewhat analogous to the "composing out" of motives in tonal music.[15]

Isography is by no means confined to music of the Second Viennese School, and it can also manifest in more elaborate ways involving networks of different object families. Consider "Berceuse II" from György Kurtág's *Kafka Fragmente* for soprano and violin, Op. 24 (1985–87). This brief song alternates the words "geschlafen" (slept) and "aufgewacht" (woke up) several times, then concludes abruptly with the outburst "elendes Leben!" (miserable life!). Focusing on each utterance independently, the listener may notice the contrasting ways the first two words are set musically. As shown in Example 2, each "aufgewacht" is set mimetically by rapidly rising fourths and fifths, while each "geschlafen" features thirds, an arch contour, and a sedate rhythm (in a postmodernist allusion typical of Kurtág, its first two instances echo the *Kopfmotiv* of Schoenberg's "Nacht," Example 1a).



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Example 2 . Transformational interconnections of motives in Kurtág's "Berceuse II" from *Kafka Fragmente*, Op. 24.

However, by interpreting the intervals as the result of transpositional actions, the listener can hear the whole passage directed by a process that vividly portrays an interplay between the two states of consciousness. Example 2 uses labeled arrows to indicate the relevant transformations, which are pitch-class transpositions applied to pitch classes (solid shafts) or to members of two different types of pitch-class series (dashed shafts). It shows that the second "geschlafen" is the first "geschlafen" transformed by a transposition T_6 that is characteristic of the pitch-class network of "aufgewacht", and that the fourth "geschlafen" is the third "geschlafen" transformed by the other transposition T_5 that is characteristic of the pitch-class network of "aufgewacht." In other words, the sleep motives change by the same succession of transformations that produce the waking motive, T_6 then T_5 (the succession is made more apparent by the common pitch, B<flat>4, on which the second and third "geschlafen"s both begin). Similarly, a characteristic transformation, T_8, of "geschlafen" links the two statements of "aufgewacht" (the second statement presents its characteristic transformations T_6 and T_5 in retrograde). Thus, through isography, the same transformations not only direct local continuity and larger-scale progression in the song but also construct a reading of the text—of sleeping and waking as completely entangled—that motivates the despair of its final outburst.[16]

Structuring Forces

Even for music lacking isography, a transformational approach can underwrite concise and vivid explanations. The opening of John Adams' orchestral foxtrot *The Chairman Dances* (1985) builds up an ostinato by the staggered entrance and repetition of brief ideas, shown on the upper grand staff in Example 3, which shift abruptly to a series of chord progressions, shown on the lower grand staff. Although the components of the ostinato may be heard subsumed into a single, static harmonic entity (a B^{11} chord), the order of their appearance, and the changes that some of them undergo, encourage conceiving of them as the result of a more dynamic expository process in which each new idea or change is motivated by, or in some way expands on, the previous ones.

Transformational theory offers a distinctive way of characterizing such a process. As each new event appears, we consider what transformation(s) could have produced it from earlier events. To the extent that specific transformations can be heard to recur—that is, to the extent that new events appear to result from the consistent operation of a few distinctive transformations on previous events—we may regard those transformations as "structuring forces" that may be expected to produce further events, so that future developments in the music may be understood as the realization or denial of such expectations.[17]

Recognizing such structuring forces helps explain not only how the ostinato of *The Chairman Dances* develops but also how it prepares the chord progressions. The top of Example 3 summarizes this hearing by connecting events with distinctively colored arrows indicating distinctive, recurring transformations. The first idea, in the violas and bassoons, alternates a dyad {E4, A4} with a single pitch D4, suggesting that we hear the D as a transformation of both the other notes. Of the various possible transformational systems, let us consider one that regards the objects as the family of twelve pitch classes and that regards their transformations as the familiar pitch-class transpositions and inversions. Accordingly, let us conceive of E as T_7 of A, as indicated by the labeled red arrow connecting them on the example. A is the same transformation of D, or, more consistently with their temporal order, D can be generated from A by T_{-7}, the inverse of the transformation that generates E. This implies that D is the inversion-around-A of E, a transformation labeled I on the example. When the piccolos enter in measure (m.) 5, they clarify this inversional relation by moving from pitch E6 down to A5, then from D5 up to A5, distinguishing the two differently directed dyads by different articulations.

Before this clarification, however, the clarinets and horns begin reiterating an {F<sharp>, C<sharp>} dyad. Seeking consistency with our hearing of m. 1, we may hear the C<sharp> generated by the structuring force of T_7 applied to F<sharp>. That note could be heard as a different transformation, T_4, of the D in m.1, which, like F<sharp>, is the lowest note of a perfect fifth. But the recurrence of the T_7 transformation also suggests that its inverse T_{-7} will again manifest. Indeed it does, at the entrance of the basses' thumping Bs, which are T_{-7} (F<sharp>). The piccolos' gestures that clarify transformation I also help us to hear the clarinets, horns, and string pitch classes analogously: The B is the inversion-around-F<sharp> of C<sharp>, a transformation labeled J on the example. We may accordingly conceive of all the ideas so far as two inversionally structured networks, the higher-pitched one produced from the lower-pitched one by the transformation T_3, shown labeling the cyan arrow connecting the circled notes that act as the networks' respective inversional centers. In this hearing, then, the B, as a fulfillment of expected processes, sounds closural. Accordingly, the ostinato settles on the resulting six-note chord for the longest unchanging time span yet.

In m. 15, as the first three ideas repeat unchanged, the structuring force of T_7 produces from the bass B an F<sharp> that proceeds to alternate thrice with C. This alternation can be understood as arising from the structuring force of I and also as emphasizing I's somewhat nonprogressive, stubborn quality: Since I is its own inverse, unlike T_7, its repeated application simply shuttles between two notes. The looping <F<sharp>, C>s here, then, recall the similarly looping <E, D>s of the first idea, which also result from repeating I. For thirty measures, the bass is unable to break out of the grip of this involution; tension mounts.

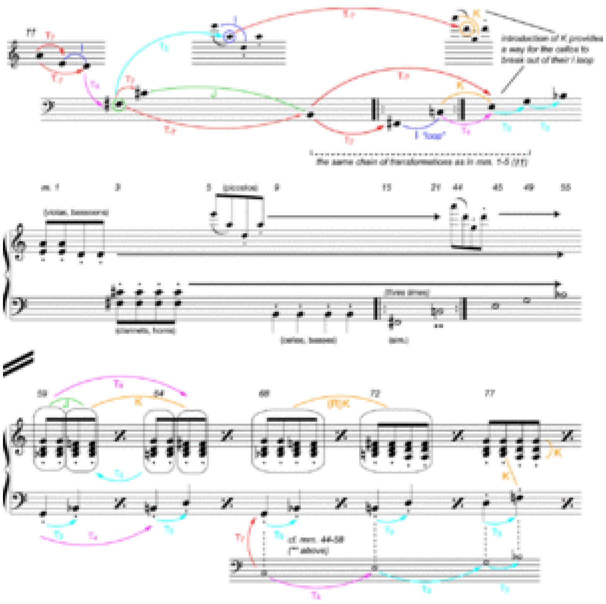
A way forward proffers itself at m. 44, when the piccolos change. Although unexpected (since none of the other ideas has changed yet), their new gesture seems consistent with the characteristic process of the music so far, for it is generated from their previous gesture by the same transformation, T_{-7} that generated D from A in m. 1. But more pregnantly, it also suggests the emergence of a new structural transformation, inversion-about-D, which is labeled K on the example. In the very next measure, K is deployed to break the I-loop impasse in the bass by changing the C to an E. This note sounds suitable because it is also a characteristic transformation $T–_7$ from the B that initiated the thumping idea, and it repeats, for the first time, the transformation T_4 that we understood to generate the first F<sharp>.[18]

The confluence of the actions of various structural forces at this moment may direct our attention to a larger-scale organizing process. Starting from their entrance on B, the cellos and basses have changed by T_7, then I, then T_4—exactly the series of transformations that generated the pitch-class series <A, E, D, F<sharp>> at the beginning of the piece. In this sense, the low strings are echoing and synthesizing the other ideas. Moreover, we might expect the repetition of the chain of transformations to continue, and indeed the next bass note after the E is T_3 of it, just as the piccolos' A is T_3 of the horns' F<sharp>. We might hear this large-scale repetition as achieving some closure.

Indeed, as another T_3 pushes the cellos up to B<flat>, the texture changes at m. 59 to the series of chord pairs. The pairs involve four distinct progressions. Analysts familiar with neo-Riemannian transformational theories, originally imagined by Lewin to model functions of triads in Hugo Riemann's dualist theory of harmony, may see an opportunity to apply them.[19] While these approaches have been highly developed[20] and are certainly applicable to some post-tonal triadic art music,[21] I do not avail myself of them here. Granted, three of the progressions could be read as neo-Riemannian Rs or Ls, but the fourth (involving a nontriadic chord) cannot, and there are other difficulties with such a reading. We have had little reason so far to hear triads as objects and R and L as transformations, and the positions of these chords vary, suggesting that the bass line itself has significance beyond mere membership in the chords, something that a purely triadic analysis could not address.[22]

The annotations on the lower grand staff of Example 3 indicate a hearing more in tune with the transformational account I have given of the ostinato. As concise as that was, it will seem even more plausible as it is shown to address questions about the larger-scale design of the piece, such as whether the alternating triads beginning at m. 59 are prepared by and continue the ideas of the opening ostinato. Most obviously, the chain of transformations just emphasized by the ostinato reappears, transformed by an established structural force and embellished. Specifically, the bass notes of the chord progression across mm. 59–77, <G-B<flat>, B-D, D-F>, can be heard as the result of applying the transposition T_7, which was active in the ostinato, to each of the pulsed bass notes in mm. 44–49 <C, E, G>, then elaborating each resulting note with its transformation by the recently prominent T_3. The staff added below mm. 68–77 clarifies the process.

More subtly, the chord progressions themselves manifest the structuring forces recently active in the ostinato, as indicated by the labeled arrows on the lower grand staff. The J transformation applied to the initial G minor chord (which combines the inversional center D with the most recent notes of the cello line) generates the following B<flat> major triad. K applied to B<flat> major produces a B minor triad, which is the T_4 transformation of G minor and which alternates in m. 64 with G major. The same transformation also dominates the following chords, as the <B minor, D major> progression of m. 72 is the retrograde-K of the <G minor, B<flat> major> progression of m. 68, and the F and A of the nontriadic chord in m. 77 are K-generated from notes of G major. The structuring force of K is further signified by the persistence of its inversional center, D, in every chord.



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Example 3 . Structuring forces in Adams's *The Chairman Dances*, mm. 1-91.

This account, then, portrays the ostinato as a large-scale preparation for the chords and attributes to the pitch materials in *The Chairman Dances* a future-striving, developmental character that suits its driving pulse.[23] Moreover, it renders the music post-tonal in the specific sense that it treats any apparently tonal objects, such as triads and fifths, as products of more fundamental transformative processes not dependent on Rameau's, Riemann's, or even Hindemith's harmonic concepts for their meaning. To emphasize this point, I have modeled this analysis explicitly on the case study that begins Lewin's first exposition of transformational analysis, which similarly identifies three inversions around D, F<sharp>, and A as structuring forces that generate and organize the diverse pitch structures in Webern's indubitably post-tonal Piece for String Quartet, Op. 5, No. 2.[24] The link I thereby assert between Adams' and Webern's compositions calls into question the view of minimalist music as a resurgence of "basic tonality."[25]

Form as a Manifestation of the Systematic Properties of Transformations

My brief analyses of passages by Kurtág and Adams suggest how the transformational concepts of isography and structuring forces provide a distinctive way to describe form and process in post-tonal music. These concepts take on greater significance, however, to the extent that the analyst considers the special properties of the transformations in a piece and how the transformations relate to each other as a system. It is not enough to simply draw arrows that can be labeled the same way. Only by understanding how those labels shape and define the field of possibilities can one appreciate why some transformations are used and not others and why certain events have special, crucial roles in the piece.

"Les champs," the third movement of Thomas Adès's *Lieux retrouvés*, Op. 26, for cello and piano (2009), offers an appropriately named opportunity to demonstrate how such systematic spadework can yield analytical fruit. Superficially the music seems elemental in the extreme. The cello sequences a simple four-note motive—a major and minor sixth, one ascending, the other descending, connected by a step. Every fourth repetition, it omits the last note of the motive, usually skipping an eighth-note beat, then restarts the sequence, creating a four-bar phrase. Within each phrase the sequence proceeds in a consistent direction, either by ascending perfect fourth or descending perfect fifth. Example 4(a) shows all phrases except the last, which acts as a coda by repeating the fifth phrase an octave higher.

In some of the phrases the motive appears subtly changed. For instance, m. 5 begins on an A, as did m. 1, but then moves up a minor sixth to F instead of up a major sixth to F<sharp>, and its last note is G instead of G<sharp>. We might conceive of this alternation informally as a change of mode from A major to A natural minor, or as a change from sol-la-ti-do in A major to ti-do-re-mi in F major, but those keys do not persist into subsequent measures.

A more exact description of the change is possible if we realize that the content of m. 5, {E, F, G, A} is an inversion of the content of m. 1, {E, F<sharp>, G<sharp>, A}, specifically the inversion that holds fixed the dyad {E, A}—the two short notes in the motive—which constitutes its only interval class 5. Example 4(a) highlights in green these tones that m. 1 and m. 5 hold in common. Accordingly, we may consider the family objects in the transformation system to be the 24 members of the T_nI set class (0135), which includes sol-la-ti-do and ti-do-re-mi in all 12 major scales.

Measures 2 and 6 are the same transformation, T_5, of their respective preceding measures. Therefore, they can be understood to manifest a transformation that has the same effect as the transformation changing m. 1 to m. 5: It holds fixed the two eighth notes, here D and A, which form the only instance of interval class 5. I call this transformation P. P does not have a fixed center like the inversions that structure *The Chairman Dances*—it is a “contextual” inversion whose center depends on which version of the motive it is transforming.[26] P can also be heard changing m. 3 to m. 7 (preserving eighth notes G and D) and m. 4 to m. 8 (although their second eighth notes are omitted). On Example 4(a), each of these measure-to-measure transformations is symbolized by an arrow connecting nodes that represent the contents of the motives in those measures.

Measure 17 corroborates this conception of the basic transformations in the piece as inversions that preserve rhythmically and harmonically distinctive dyads of the motive. As a pitch-class set, the motive here is the inversion of the contents of m. 1 that preserves the two *long* notes, {F<sharp>, G<sharp>}, which are the two members of the motive (forming interval class 2) that do *not* belong to the only interval class 5. Example 4(a) highlights in purple these tones that m. 1 and m. 17 hold in common. I call this transformation Q; it also changes the pitch classes of m. 2 to those of m. 18 (preserving the dotted quarter notes B and C<sharp>) and m. 3 to m. 19.

The distinctive aural “signatures” of contextual inversions P and Q, manifested by the particular interval classes and durations of the notes that they hold fixed, support hearing a simple binary form in “Les champs.” The first part introduces the motive and sequences it thrice by T_5, establishing that transformation as the basic action of the piece. From m. 4 to 5, however, T_5 does not appear, and instead we hear the P-transform of m. 1, signaled by the eighth-note tones they hold in common. There follows a much longer chain of T_5 transformations, cutting across the rhythmic and contour phrase boundaries in mm. 8–10, and persisting until m. 13 when the m. 1 motive suddenly reappears and begins to change again by repeated T_5s. In mm. 15–16, just when we would expect to hear a repetition of mm. 3–4, the cello plays notes that sound wrong, because they do not conform to the motive as it has been consistently presented thus far. Yet, in m. 17 the movement suddenly returns to the motive, now transformed by Q, as signaled by the long notes it holds in common with m. 13. It is then sequenced by T_5 until the final bar of the example.

This informal narrative implicitly raises some questions that a more detailed analysis should explain. Why are measures 9–12, which simply continue the T_5 sequence of the P-transform, necessary to the piece? What motivates the return of the motive at m. 13? And should we hear the Q transform in m.17 as sudden and disruptive or as motivated in some way? It is only by considering the systematic relations of T_5, P, and Q that these questions can not only be answered but also understood as interconnected.

The networks in Examples 4(a) through 4(d) support that consideration by manifesting some group-theoretical properties of P, Q, and T_5 that bear directly on audible aspects of form and process in “Les champs,” here organized into four observations:

1. From the arrows in Example 4(a) connecting the nodes representing mm. 1, 2, 5, and 6, it is evident that P commutes with T_5; that is, transforming the motive by P then T_5 yields the same result as transforming it by T_5 then P. The same is true of Q and T_5, and indeed of Q (or P) and all transpositions. Consequently, we may understand a hierarchical structure to the passage. Specifically, the entire chain of T_5 transformations in mm. 5–8 can be conceived as a single node in a higher-level network, a node that is the P transformation of a node containing the entire chain of T_5 transformations in mm. 1–4.[27] This abstract structure, diagrammed in Example 4(c), supports the grouping hierarchy that is articulated by rhythm and contour, treating mm. 1–4 and 5–8 as coherent units rather than as a mere reiteration of motives. Similarly, as shown in Example 4(d), we may understand m. 17 to initiate a T_5 network that is a whole unit: the Q transformation of mm. 1–3.

2. The top line of Example 4(b) shows that transforming a do-ti-la-sol form of the motive twice by T_5, that is, $T_5^2 = T_{10}$, will produce a form that shares two notes with the original. This formal fact directs us to the first prominent dyad repetition in the piece: The F<sharp> and E that are successive in m. 1 reappear in m. 3, associated by their long duration. Bracketed arrows over these measures in Example 4(a) point them out.[28]

3. Example 4(b) also shows that the Q transformation of any do-ti-la-sol instance of the motive is the T_1 (that is, T_5^5) transposition of the P-transformation of that instance. This formal fact helps us to realize something that we might not have otherwise noticed. Q(X) appears in m. 10 as the fifth in a chain of T_5 transformations of the P(X) phrase beginning in m. 5. Therefore, when it reappears in m. 17, it sounds like the resumption of a previous train of thought, rather than as disruptive. Thus we can understand that one purpose of mm. 9–12 is to extend the T_5 sequence of P(X) long enough to encounter the Q(X).

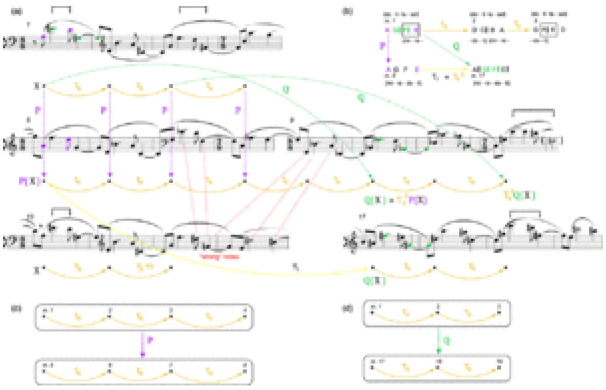
4. Together, observations (1) through (3) provide a basis for explaining how the extended T_5 sequence of P(X) in mm. 5–12 prepares for the return of the original motive in m. 13.

a. Consider first m. 10, when Q(X) appears as the result of the sequence from P(X) in m. 5 (observation 3). By definition, the two long notes of Q(X), Gb and A<flat>, are (enharmonically) the same as the long notes of X in m. 1. Now consider m. 12. It is two more steps along the T_5 sequence from m. 10, that is, T_5^2Q(X). Consistent with observation 2 above, it contains the two long notes of m. 10, F<sharp> and G<sharp>, which are also the long notes of m. 1—that is, the combined operation of Q followed by T_5^2 brings those notes into m. 12.

b. Now let us take an alternative perspective on the situation, starting with m. 3. It is two steps along the T_5^2 sequence from X, so (by observation 2) its long notes E and F<sharp> are the same as the central two high notes of m. 1. Now reconsider m. 12. As shown by the long Q arrow on Example 4(a), it is the Q transformation of m. 3. (Since, by observation 1, Q commutes with transposition, m. 12 can be regarded equivalently as Q T_5^2(X) or T_5^2Q(X).) Therefore its two long notes are the same as those in m. 3, E and F<sharp>—that is, the combined operation of T_5^2 followed by Q brings those notes into m. 12.

Combining both perspectives (a) and (b) allows us to see what is so special about m. 12: The motive there contains *three* of the four notes of m. 1, E, F<sharp>, and G<sharp>. No other transposition or inversion of m. 1 has so many notes in common with it, so m. 12 is the most suitable of all the T_5, P, and Q forms of the motive to set up the reprise of m. 1. (To heighten the connection, the cello omits the motive F<sharp> at the phrase boundary, but the piano provides it on the downbeat of m. 13 that launches the cello's statement of X.) Of course, we could have ferreted out this relation by examining set-theoretical characterizations of (0135) such as its common-tone T_n and T_nI vectors.[29] But that would not do justice to the process—the transformational pathways—that this particular piece uses to achieve the connection. P is perfectly coordinated with T_5 so that seven legs of the sequence starting from P(X) bring us as close as possible to X, touching along the way on Q(X) that will return as the incipit of the final phrase.

Thus sensitized to the structure of the transformations and their manifestation in the form of the piece, we can understand the special moment when things go awry. Since the material of m. 1 returns at m. 13, we would expect m. 15 to repeat m. 3. But the cello plays wrong notes D<sharp> and F instead of D and F<sharp>. The substitution of F might be understood to allude to the effect of the P transformation, which changed the F<sharp> of m. 1 to the F in m. 5. But the music is also preparing the reappearance of Q(X) in m. 17, by playing some of the prominent notes of mm. 7–9 in the same order. Red lines on Example 4(a) indicate them. This sort of investigation of the interaction and structure of transformations is especially important for post-tonal compositions, because it can uncover form-determinative processes that tonality, being absent, cannot create: processes of continuity, of articulation, of association, and of varied repetition.[30]



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Example 4 . A transformational account of Adès's "Les champs" from *Lieux retrouvés*, Op. 26.

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Now for any given piece there may be several plausible transformational systems, each with its own advantages and disadvantages. Indeed, a strong alternative exists for analyzing "Les champs." Julian Hook's theory of triadic transformations may be adapted to describe the prime and inverted forms of the motive and to represent the transformations I have called P and Q as members of an elegant group of transformations that have the same formal properties as those used in the neo-Riemannian analysis of triadic progressions.[31] This is a elegant solution, because all its transformations commute (whereas in my formulation P and Q do not) and because the group is simply transitive, implying that one can develop a precise sense of distance, which could help explain a piece that evokes the progressive scanning of a field in various directions. I have not adopted it, however, not only to spare the reader its details but also for a musical reason. It requires that we regard the measure-to-measure transformations to be different depending on whether they are operating on the prime or the inverted forms of the motive; for instance, mm. 1–4 and 13–16 would have to involve a different transformation than mm. 5–12 and 17ff. I see no purpose for such a distinction (the contour changes are not consistent with this segmentation) and prefer to regard them all as $T_{5.}$ This is simpler to hear, and it also helps us appreciate how Adès, in the postmodern spirit, has contrived to defamiliarize a tonal cliché—the descending circle of fifths, that is, repeated T_5s—and repurpose it as partner with the distinctive transformations P and Q in the creation of the musical form of “Les champs.” But Hook’s approach might permit comparing this piece to other post-tonal works to which it applies.[32]

Form as Manifestation of a Transformational Space

Just as we need to consider how the transformations in a given system combine, to take advantage of the full benefits of transformational theory so we should also conceive of the musical objects as constituents of a complete "space," or universe of possibilities, structured by the transformations. The first movement of Bright Sheng's *The Stream Flows*, for solo violin (1990), provides a clear example of the benefits of such a conception. Its opening section unfolds in four large segments, labeled with Roman numerals in Example 5(a). The beginning of each segment is marked by the appearance of a distinctive constellation of intervals, contour, and rhythm that evoke a popular folk melody from the Yunnan province of China. The allusion focuses attention on (anhemitonic) pentatonic collections, and that is rewarding, because the rest of each segment can also be heard to present intervallically and rhythmically distinctive motives, each using one of the twelve pentatonic scales. Instances of the motives are bracketed above the systems in the example, which distinguishes them by alphabetical label. The total pitch-class content of each motive is specified below the system by a single pitch-class name, which denotes the middle note in the do-re-mi whole-tone succession in its pentatonic collection. For example, D denotes the collection {C, D, E, G, A} of mm. 1–4. (Although this label may sometimes be heard as a "tonic," the following analysis does not refer to such pitch hierarchy.[33] Also, when more than one pentatonic scale could underlie a motive, the example indicates the alternatives in parentheses.)

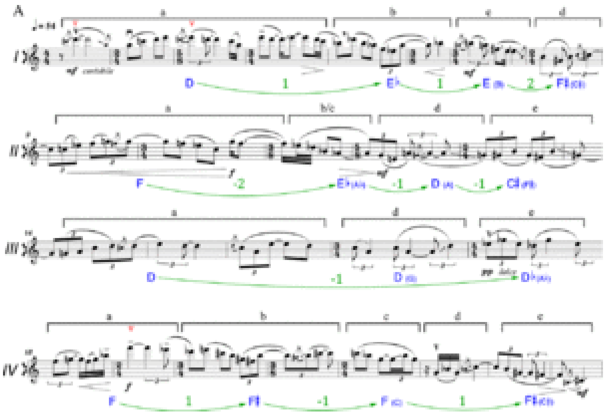
A middle section, mm. 26–51, intensifies the texture with faster, louder, higher, double-stop polyphony then eventually subsides to a low-register concluding section that recalls the opening of the piece. Still, during these developments, the shortest segments can be heard as either a single pentatonic collection or (in the polyphonic passages) as two pentatonic collections in different registers. Example 5(b), which summarizes the pitch content of the last two sections, identifies the collections by the same notational convention as does the previous example. Across the whole piece, as indicated by red Vs on the examples, a gradual diatonic ascent (from D5 to E6) of the pitch-climaxes in successive segments creates middle-ground continuity and direction.

Its fusion of strict pentatonicism with Western art-music techniques, which places this work stylistically among similar hybrids of Sheng's generation, also suggests a transformational approach that helps us to appreciate its distinctive individuality. [34] As in the analyses above, the approach begins by listening for recurring transformations, as revealed by their distinctive "signatures." The arrows on Examples 5(a) and (b) indicate the transformations that change each collection to its successor. Although there are several possibilities, as always, for present purposes let us consider a so-called "simply transitive" system in which the twelve transpositions are heard as the sole changes.[35] Consistent with the conception of the objects as members of the transpositional set-class

(02479), the arrows are labeled as transposition, in shorthand that uses an integer to denote the index of transposition; thus, 1 means T_1.

It is evident from the pentatonic collection's interval-class vector, [032140], that the various possible transformations sound different: Transposition by one class of interval will almost always hold a different number of notes invariant than transposition by another. Transposition by 5 or 7, for instance, keeps four pitch classes intact, while transposition by 4 or 8 holds only one invariant. Most of the transformations indicated on the Examples are by 1, –1 (=11), and 6, which produce results that have completely different content than their source. For instance the collection labeled D shares no pitch classes with its T_1-transpose E<flat>, as is plain at the start of the piece: The pentatonic measures 5–6 use entirely different notes than the pentatonic measures 1–4. Total change of content, then, is the signature of these transpositions. It is often signaled in this melody by the appearance of interval patterns that are not possible within a single pentatonic scale, for instance, the semitone from B<flat> to B in mm. 6–7, or the <E, D, C, B<flat>> whole-tone succession in mm. 4–5.

Having thus established which objects and transformations are pertinent and audible, an analyst may investigate how they create continuity and form. Happily, the most distinctive change of collection is also the most characteristic, in that most changes of collection are by T_1 or its inverse. T_6, with the same distinctive signature, also appears, but only in the B section—a contrast that helps distinguish the sections. The few other transformations that appear seem to be deployed strategically to create larger networks whose isography supports the medium-scale formal units initiated by the reappearances of the *Streams Flows* folk tune. Example 5(c) demonstrates this by representing the entire first section of the piece as a transformational network of six pentatonic collections. A distinctive series of transpositions, <1, 1, 2> takes us from the initial D to F<sharp>, then a <–1> takes us to F. This moment is important formally not only because motive a reappears then but because it initiates a network <–2, –1, –1> that is the retrograde of the network of the first large segment. Segments III and IV are similarly parallel, involving oscillations of 1 and –1, with the transition between them marked by the same transformation, 4, that spans each of the first two segments. Thus each side of the figure corresponds to one of the four large segments, and isography between the sides manifests the segments' formal relationships. Unlike in the Adès analysis above, there is not much further to say about how transformations create form, since the transpositions have such a simple structure.



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Example 5 . Pentatonic collections and their transformations in Bright Sheng's *The Stream Flows*, first movement.

However, we can recognize another aspect of form by considering another important and sometimes neglected feature of transformational theory: The objects form a coherent, closed "family" that informs our perception of them. As in human family systems, certain members may play special roles. For instance, each large segment that we heard in Section A (articulated both by motivic repetition and isography) ends the same way, on an object that may be heard as (collection) C<sharp>/ D<flat>. This explains why the pentatonic collections at the end of every large segment are ambiguous: so that they may be heard both as different, thus creating the isographic networks of Example 5(c), and as identical, thus creating and accessing a consistent cadential sound. Moreover, as in some family groups, some members may be more closely attached than others. We have already seen in Example 5(a) how the first large section may be heard as transformation among just six collections. The ambiguity of some of its motives permits collections G, A<flat>, A, B, and C to be intuited also. The contrasting B section brings three of these explicitly to the fore but leaves one collection, B<flat>, absent but implied, like a black sheep. This prepares for a satisfying conclusion. In the final A′ section, B<flat> appears at last, recreating the <1, 1> network of the more closely attached family members but with the relative outsiders A and B. Only by considering the entire space of collections can we appreciate how it is eventually traversed in its entirety by a few characteristic series of changes.

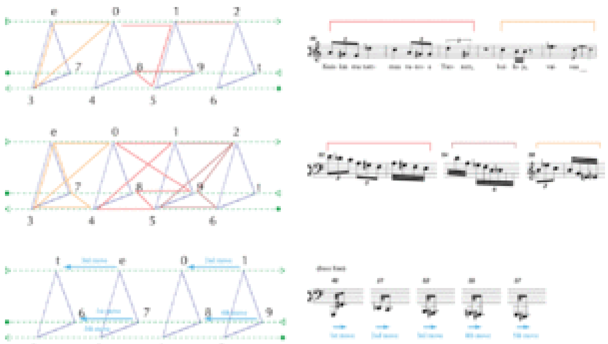
Assessment

These four analyses, which emphasize aspects of transformational theory that might not be recognized from textbook examples, inform an evaluation of how suitable such networks are for analyzing post-tonal music and serve as a corrective for some possible misapprehensions. The theory does not require the analyst to analyze all pieces as if they were constructed of a single idea, transformed in a few precisely defined ways; that would preclude applying the theory to music that is not so motivic or that involves multiple contrasting ideas.[36] To the contrary, the brief discussion of the Kurtág song in Example 2 shows how an analysis can involve different families of objects, each structured by the same family of transformations; the account of *The Chairman Dances* (Example 3) shows that the objects can be so elemental (e.g., pitch classes) that the transformation structuring can proceed flexibly and produce variety; and the analysis of *The Stream Flows* (Example 5) shows how the objects can be abstract enough to cover a wide variety of motives.

From the literature one might gather the impression that transformational theory concerns itself primarily with local continuities, that is, with the ways that one small object may change immediately to another. Yet all four analyses here consider larger-scale processes and how they articulate form. Example 2 showed how local relationships can function recursively to generate successions of diverse objects; this technique of contextual progression resembles serial composition but is easier to hear, since it typically involves very few transformations. In the movements by Adès and Sheng, the network isography of different event-successions articulated long segments, and the form of each piece involved a process, whether of systematic combinations of changes or of moving through an object space, that could be clearly described with transformational concepts. For *The Chairman Dances* and *The Stream Flows*, the theory provides a way to appreciate formal unity, by describing how contrasting sections are prepared by, and continue the developments of, preceding sections.

Thus these analyses demonstrate how transformational conceptions of post-tonality make it possible to understand and describe how diverse pieces control the flow of time, not as tonal music does, but still effectively.[37] I think it is no coincidence that the titles of compositions studied here evoke not static formal designs—like the titles of such classic works of 1950s' serialism as *Structures, Gruppen,* and *Partitions*—but intrinsically temporal processes: the rhythms of consciousness, the traversal of fields, dancing, and flowing water.

The theory may not appeal to those who valorize post-tonal music precisely because it seems to eschew proven, rational methods of composition or listening. Such an attitude may suit composers who, perhaps in the understandable wish to promote their distinctive voices, disclaim allegiance to systems that smack of the academy. But transformational theory is too flexible to be called a system, and it is better conceived as a listening strategy, not a compositional method, that facilitates discourse about important aspects of their works that cannot be addressed in other terms.



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Example 6 . A transformational space for the concluding section of Saariaho's "Sydän" from *Leinolaulut.*

Indeed, a listener of contemporary art music who is sensitized to the concepts of transformational theory can better appreciate how composers who are confronted by the limitless possibilities of the putatively lawless post-tonal universe constrain and focus their invention. For instance, the acclaimed orchestral work *in vain* by Georg Friedrich Haas (2000) achieves a striking effect by alternating two apparently contrasting textures, one presenting rapid, differently paced overlapping lines in equal temperament and the other a long progression of chords built of the natural overtones of changing fundamental pitches. Transformational theory suggests interpreting them as different manifestations of a single underlying idea—the lines' tempi are integer subdivisions of durations, and each overtone-chord's pitches are integer multiples of the fundamental[38]—and also hearing the progression of the chord fundamentals, moving down alternately by minor third and semitone, as a slow-motion isographic replay of the similarly regular changes in the rapid lines. A very different piece, Kaija Saariaho's traditionally textured song "Sydän" from her cycle *Leinolaulut* (2009) concludes (mm. 45–68) with a passage in which the note changes in the vocal melody and its accompaniment seem organized into a transformational space like those shown in Example 6 (the ends of the lines connect to each other as shown by the matching symbols, so each figure actually forms a torus). The pitches in the textural streams change rather freely but almost always by semitone or third, thus along the short pathways in the figure. Eventually a series of similar gestures touches on every node in the space. Analogous spaces may be conceived to regulate pitch processes in music by Adès and Carter.[39] Thus the notions of isography and transformational spaces, far from being quirks of early modernism, comport well with the concerns of many aesthetically diverse post-tonal composers and provide a helpful way to understand and appreciate their music's temporality.

Notes:

([1]) Milton Babbitt, "Some Aspects of Twelve-Tone Composition," *The Score and IMA Magazine* 12 (1958): 53–61; Allen Forte, *The Structure of Atonal Music* (New Haven, CT: Yale University Press, 1973); John Rahn, *Basic Atonal Theory* (New York: Longman, 1980); Robert D. Morris, *Composition with Pitch Classes* (New Haven, CT: Yale University Press, 1987).

([2]) Popular post-tonal textbooks include Joseph N. Straus, *Introduction to Post-Tonal Theory*, 3d ed. (Upper Saddle River, NJ: Pearson, 2004); Stefan Kostka, *Materials and Techniques of Post-Tonal Music*, 4th ed. (Upper Saddle River, NJ: Pearson, 2011); and Miguel Roig-Francoli, *Understanding Post-Tonal Music* (New York: McGraw Hill, 2007). Paul Hindemith expounded his harmonic theory in *The Craft of Musical Composition: Book 1—Theoretical Part*, trans. Arthur Mendel (London: Schott, 1942).

([3]) Lewin introduced the theory in "Transformational Techniques in Atonal and Other Music Theories," *Perspectives of New Music* 21.1–2 (1982–1983): 312–71 then developed it more fully in *Generalized Musical Intervals and Transformations* (New Haven, CT: Yale University Press, 1987), henceforth *GMIT*.

([4]) Michael Cherlin, "On Adapting Theoretical Models from the Work of David Lewin," *Indiana Theory Review* 14 (1993): 19–43; Ramon Satyendra, "An Informal Introduction to Some Formal Concepts from Lewin's Transformational Theory," *Journal of Music Theory* 48.1 (2004): 99–141; Steven Rings, *Tonality and Transformation* (New York: Oxford, 2011), 9–40.

([5]) Straus, *Introduction*, mixes intervallic and transformational interpretations in some analyses (70, 105, 128). Roig-Francoli writes of arrows manifesting pitch-class-set relations in *Understanding Post-Tonal Music*, 113. Some limitations of Lewin's concept of interval are discussed in Dmitri Tymoczko, "Generalizing Musical Intervals," *Journal of Music Theory* 53.2 (2009): 227–54.

([6]) Lewin, *GMIT*, 158.

([7]) Lewin's *Musical Form and Transformation: Four Analytic Essays* (New Haven, CT: Yale University Press, 1993), intended to demonstrate the scope of the theory, analyzes music by Dallapiccola, Stockhausen, Webern, and Debussy, and his other writings treat post-tonal pieces by Schoenberg, Babbitt, Bartók, and Carter. A complete list of other scholars' post-tonal transformational analyses cannot be presented here, but some sense of their variety, technical sophistication, and currency can be gleaned from Guy Capuzzo, "Lewin's Q Operations in Carter's *Scrivo in vento*," *Theory and Practice* 27 (2002): 85–98; Clifton Callender, "Continuous Transformations," *Music Theory Online* 10.3 (2004); and Thomas M. Fiore, Thomas Noll, and Ramon Satyendra, "Morphisms of Generalized Interval Systems and PR-Groups," *Journal of Mathematics and Music* 7.1 (2013): 3–27.

([8]) A thorough exegesis of Lewin's famous discussion of the "less-Cartesian" "transformational attitude" of "someone *inside* the music" (*GMIT*, 158–59) may be found in Henry Klumpenhouwer, "In Order to Stay Asleep as Observers: The Nature and Origins of Anti-Cartesianism in Lewin's *Generalized Musical Intervals and Transformations*," *Music Theory Spectrum* 28.2 (2006): 277–89.

([9]) Lewin, *GMIT*, 209–19, distinguishes different sorts of ordering in networks.

([10]) Daniel Harrison, "Three Short Essays on Neo-Riemannian Theory," in *Oxford Handbooks Online*. In its focus on change, transformational theory resembles category theory, a recent branch of mathematics that has also seen creative application to music, beginning with Guerino Mazzola, *Gruppen und Kategorien in der Musik: Entwurf einer mathematischen Musiktheorie* (Berlin: Heldermann, 1985). For a critical look at the status of "objects" in Lewin's theory, see John Rahn, "Approaching Musical Actions," *Perspectives of New Music* 45.2 (2007): 57–75.

(11) Lewin, *Musical Form and Transformation*, 32.

(12) John Roeder, “Constructing Transformational Signification: Gesture and Agency in Bartók’s Scherzo, Op. 14, No. 2, mm. 1–32,” *Music Theory Online* 15.1 (2009).

(13) Other important general theories of musical temporality include Christopher Hasty’s “Rhythm in Post-Tonal Music: Preliminary Questions of Duration and Motion,” *Journal of Music Theory* 25.2 (1981): 183–216, and “On the Problem of Succession and Continuity in Twentieth-Century Music,” *Music Theory Spectrum* 8 (1986): 58–74.

(14) The formal conditions spelled out in *GMIT*, 199–200, allow for less obvious sorts of isography, but most instances, as here, involve exact identity of transformations. A passage that Lewin cites as exemplary (from Schoenberg’s song “Als wir hinter dem bebluhmten Tore,” Op. 15, No. 11) begins with the pitch series <B<flat>3, D<flat>4, F4, D4>, which can be expressed as a network of pitch classes connected by the series of transpositions <T_3, T_4, T_9>. Later this collection of pitch classes itself is transformed by the same series of transpositions, appearing as {C<sharp>, E, F, G<sharp>}, which is T_3 of the original, then as {F,G<sharp>,A,C}, which is T_4 of the second version, and finally as {D,F,A,F<sharp>}, which is T_9 of the third version. Lewin, “Transformational Techniques,” 333–6.

(15) The application of this Schenkerian term to post-tonality is Straus’s, not Lewin’s. Straus also uses it to refer to a different technique, closer to one featured in Schenkerian analysis, where the notes of a motive recur, in order, as prominent events in longer segments. For instance, the incipits of the first four phrases of Webern’s Song, Op. 3, No. 1 recapitulate the first four notes of the first phrase. Straus, *Introduction*, 103–6; see also Roig-Francoli, *Understanding Post-Tonal Music*, 110.

(16) Another transformational view of songs in this cycle was developed by John Clough in “Diatonic Trichords in Two Pieces from Kurtág’s *Kafka-Fragmente*: A Neo-Riemannian Approach,” *Studia Musicologica Academiae Scientiarum Hungaricae* 43.3–4 (2002): 333–44.

(17) The conception of a transformation as a “structuring force” was introduced by Lewin in “Transformational Techniques,” 312.

(18) Although it is not germane to the present discussion, readers should note that there is an important technical objection that could be raised about the network in Example 3. It does not satisfy one of Lewin’s conditions for transformational graphs: “path consistency.” If we remove the contents of the nodes, the resulting graph seems to assert, for example, $K(x) = T_4(x)$ for any pitch class x, and that $KIT_7(x) = T_{-7}(x)$. Clearly those statements are not true in general. However, Julian Hook, in “Cross-Type Transformations and the Path Consistency Condition” *Music Theory Spectrum* 29.1 (2007): 1–40, makes the case that even non-path-consistent networks can model “meaningful musical relationships” (28). Moreover, he suggests, “in conjunction with the relaxation of the path consistency requirement, multiple arrows can sometimes offer a musically suggestive way

to model alternative interpretations simultaneously" (30 n 24). Indeed, it seems important to recognize that the bass E in Example 3 is simultaneously T_{-7}(B) and K(C) and T_4(C). In Hook's terms, the graphs involved in Example 3 are "realizable" but not "universally realizable."

([19]) Lewin, "Transformational Techniques," 329–33.

([20]) Edward Gollin and Alexander Rehding, eds. *The Oxford Handbook of Neo-Riemannian Music Theories* (New York: Oxford University Press, 2011); Richard Cohn, *Audacious Euphony: Chromatic Harmony and the Triad's Second Nature* (New York: Oxford University Press, 2012).

([21]) For instance, Straus, *Introduction*, 158–67, and John Roeder, "Transformational Aspects of Arvo Pärt's Tintinnabuli Music," *Journal of Music Theory* 55.1 (2011): 1–41.

([22]) In some of Adams' opera *Nixon in China*, from which this work is adapted, neo-Riemannian progressions can also be heard. Straus, *Introduction*, 161–5.

([23]) A very different narrative of *The Chairman Dances* as the progressive resolution of three "enigmas" is offered by Catherine Pellegrino in "Aspects of Closure in the Music of John Adams," *Perspectives of New Music* 40.1 (2002): 147–75.

([24]) Lewin, "Transformational Techniques," 312–16.

([25]) "By the mid-1960s, musical modernism had reached its furthest extremes of sonic mayhem and chance-produced spectacle. A decisive move back to basic tonality was to be expected," Alex Ross, "Critic's Notebook; Of Mystics, Minimalists and Musical Miasmas," *New York Times,* November 5, 1993.

([26]) Lewin, *Musical Form and Transformation*, 7; Jonathan Kochavi, "Some Structural Features of Contextually Defined Inversion Operators," *Journal of Music Theory* 42 (1998): 307–20; Joseph N. Straus, "Contextual-Inversion Spaces," *Journal of Music Theory* 51.1 (2011): 43–88. They are a feature of many of Lewin's analyses, not least because they enable product networks and hierarchy.

([27]) See Lewin, *GMIT*, 204–6, for an explanation of why the commutativity of T_5 and P allows us to rewrite the network in (a) as the network-of-networks in (b).

([28]) Example 4(b) also indicates another formal property that is important to the piece but is not especially clear in the cello part alone: Any T_5 succession of the do-ti-la-sol form of the motive creates a mi-re-do-ti form of the motive that spans the two forms. The latter is audible, for example, across mm. 1–2 as the pitch series <F<sharp>4, E4, …, D4, C<sharp>4>, and the piano part (not shown) often brings out this descending line. Of course, this property is a familiar feature of the diatonic scale, as it is structured into two major tetrachords, but complete scales are not particularly evident in this movement.

([29]) Rahn, *Basic Atonal Theory,* 97–123; Morris, *Composition with Pitch Classes*, 67–73.

([30]) Dora Hanninen, *A Theory of Music Analysis: On Segmentation and Associative Organization* (Rochester, NY: University of Rochester Press, 2012).

([31]) Here is a sketch of this alternative, following the models outlined on pages 111–113 of Julian Hook's "Uniform Triadic Transformations," *Journal of Music Theory* 46.1–2 (2002): 57–126. We represent any statement of the motive as a referential pitch class together with a sign indicating whether it is a prime or inverted form. Thus m. 1 could be represented as <A, +> and m. 5 as <A,–>. The transformation linking these two is <–, 0, 0>, which is the uniform triadic transformation (UTT) that Hook uses to represent the neo-Riemannian Parallel transformation. What I call Q would be represented as the UTT <–, 1, 11>. These two UTT belong to the simply transitive K(11, 0) Riemannian group of UTTs, which also include, instead of T_5, the *Schritt* transformations <+, 5, 7> and <+, 7, 5>. The former transforms m. 1 to m. 2, and the latter transforms m. 5 to m. 6. An application of UTT theory to indubitably post-tonal repertoire may be found in Julian Hook and Jack Douthett, "Uniform Triadic Transformations and the Twelve-Tone Music of Webern," *Perspectives of New Music* 46.1 (2008): 91–151.

([32]) Other extensive analytical applications of UTTs to the triadic post-tonal art-music repertoire include Roeder, "Transformational Aspects of Arvo Pärt's Tintinnabuli Music," and Scott Cook, "Moving Through Triadic Space: An Examination of Bryars's Seemingly Haphazard Chord Progressions," *Music Theory Online* 15.1 (2009).

([33]) A segmentation of the opening of *The Stream Flows*, less determinedly pentatonic but generally compatible with mine, may be found in Peter Chang, "Bright Sheng's Music: An Expression of Cross-Cultural Experience—Illustrated through the Motivic, Contrapuntal and Tonal Treatment of the Chinese Folk Song *The Stream Flows*," *Contemporary Music Review* 26.5–6 (2007): 619–33. By referring to traditional Chinese modes, Chang attributes tonics (different than my referential notes) to his segments; he does not consider transformations of any sort.

([34]) Nancy Yunhwa Rao, "Hearing Pentatonicism Through Serialism: Integrating Different Traditions in Contemporary Chinese Music," *Perspectives of New Music* 40.2 (2002): 190–232.

([35]) Lewin defines a simply transitive group in *GMIT*, 157.

([36]) Roeder, "Constructing Transformational Signification," 12.1.

([37]) Some of tonality's control of temporality can also be modeled transformationally, for example as shown in Rings, *Tonality and Transformation.*

([38]) Lewin, *GMIT*, 60–85; Andrew Mead, "On Tempo Relations," *Perspectives of New Music* 45.1 (2007): 64–108.

([39]) John Roeder, "A Transformational Space Structuring the Counterpoint in Adès's 'Auf dem Wasser zu singen,'" *Music Theory Online* 15.1 (2009), and "A Transformational Space

for Elliott Carter's Recent Complement-Union Music," in T. Klouche and T. Noll, eds., *Mathematics and Computation in Music* (Berlin: Springer, 2009), 303–10.

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