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Re-Considering the Affinity between Metric and Tonal Structures in Brahms' Op. 76 No. 8

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Abstract: The relation between metric and tonal structures is a controversial discussion in music theory. Brahms' music is well-known for both its metric and harmonic ambiguities. According to David Lewin and Richard Cohn, Brahms' *Capriccio*, Op. 76 No. 8, is characterized by a deep affinity between metric and tonal processes. Both theorists analyzed the first section of the piece and found different metrical states of 6/4, 3/2 and 12/8 that correspond to harmonic regions associated with tonic, subdominant and dominant. Starting from this coincidence, they develop mathematical arguments supporting a deep affinity between harmony and meter. We re-consider the study of this relation from a different perspective using independent mathematical models, namely Inner Metric Analysis and the Spiral Array, that describe the metric and tonal domains. Inner Metric Analysis investigates the metric structure expressed by the notes independently of the notated bar lines, based on the active pulses of the piece. When applied to the *Capriccio* the model detects the different metrical states of 6/4, 3/2 and 12/8. The Spiral Array Model consists of a three-dimensional realization of the *tonnetz* that embeds higher-level tonal structures in its interior. When applied to the *Capriccio* the model segments the piece into tonally stable sections that correspond to Lewin's and Cohn's observation. The comparison of the results of these models provides further evidence of what Lewin and Cohn have proposed about a close relation between harmony and meter in Brahms' Op. 76 No. 8.

Proposal: The relation between metric and tonal structures is a controversial discussion in music theory. Brahms' music is well-known for both its metric and harmonic ambiguities. His *Capriccio*, Op. 76 No. 8, is characterized by a deep affinity between metric and tonal processes, according to Lewin (1981) and Cohn (2001) who analyzed the first section of the piece. We re-consider the study of this relation from a different perspective using independent mathematical models that describe the metric and tonal domains. The results provide further evidence of what Lewin and Cohn have proposed about a close relation between harmony and meter in this piece.

The description of the different forms of relations between metric and pitch processes is a challenging topic in music theory. According to Caplin (1983) most important theorists of the 18th and 19th centuries recognized a significant relationship between tonic harmonic function and metrical accentuation, but have little consensus on the nature of this relationship. Lewin (1981) and Cohn (2001) find a concrete form of a close relationship in Brahms' *Capriccio*, Op. 76 No. 8. Brahms' compositions are characterized by complex metric processes implying different forms of hierarchies, displacements and ambiguities, as discussed for instance in Schoenberg (1976), Epstein (1987), Frisch (1990), and Volk (2004). Lewin determines that the *Capriccio* contains, in the first 15 bars, the following metrical states: 6/4, 3/2 and 12/8. Each metrical state is associated with different sections as shown on the left side of Figure 1. Bars 1-2 and 5-8 are assigned as 6/4 (red region), bars 3-4 as 3/2 (blue region) and bars 9-13 as 12/8 (green region). Furthermore, each region corresponds to a harmonic function: "tonic" (red), "subdominant" (blue) and "dominant" (green). Tonally, the example is largely divided into two halves: F (bars 1-8) and e (a dominant-substitute key in bars 9-15). Lewin assigned the last two bars as 12/8 but additionally states a *metric modulation* back to 6/4 within these bars indicated with the light green color. Starting from this coincidence, Lewin develops mathematical arguments supporting a deep affinity between harmony and meter. Cohn extends Lewin's findings and characterizes the different metrical states by superimposed levels of pulses or motion that have conflicting periods.

This paper discusses the relation between meter and harmony in the piece from a different perspective. We apply the mathematical model of *Inner Metric Analysis* ((Fleischer, Mazzola & Noll 2000), (Nestke & Noll 2001), (Mazzola 2002), (Fleischer 2002)) and the mathematical model for tonal spaces of the *Spiral Array* (Chew, 2000) to the *Capriccio*. The comparison of the results offers a new perspective on Lewin's (1981) and Cohn's (2001) findings about a deep affinity between meter and harmony in this piece.

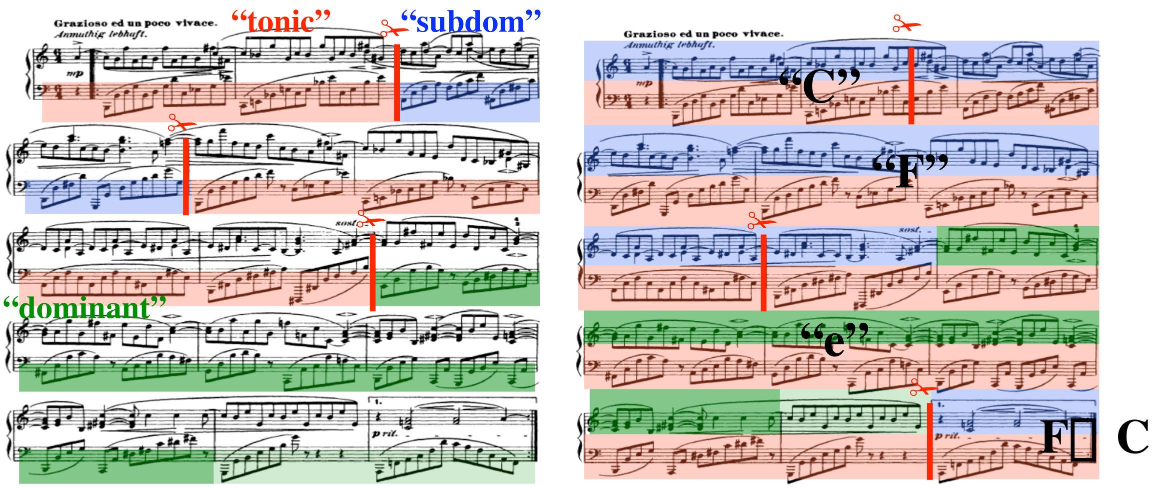

Figure 1. Lewin's Analysis (left) and results of Inner Metric Analysis and Spiral Array Tonal Analysis (right): red corresponds to 6/4, blue to 3/2 and green to 12/8, and vertical lines with scissor icons mark boundaries between harmonically distinct sections. The light green parts refer to modulations.

Inner Metric Analysis is based on the idea of studying the meter of a work by considering all active pulses in a piece, not unlike Cohn's analysis of the *Capriccio*. These different levels of motion, pulses or layers, have been used in different music theoretic approaches for the description of meter, such as in (Yeston 1976), (Lerdahl and Jackendoff 1983) and extensively in (Krebs 1999). Inner Metric Analysis investigates the *inner metric structure* of the notes *inside* the bars which is opposed to the normative state associated with the bar lines called *outer metric structure*. The model assigns *metric weights* to the notes that are generated from the superposition of the active pulses in the piece. A correspondence between the outer and inner metric structures is considered as Metric Coherence (Fleischer 2002). The application of the model to Brahms' Four symphonies in (Fleischer 2003) and (Volk 2004) has shown that Brahms' music is often characterized by a lack of Metric Coherence providing an explicit description of the discrepancies and ambiguities stated, for example, in (Frisch 1990) and (Epstein 1987).

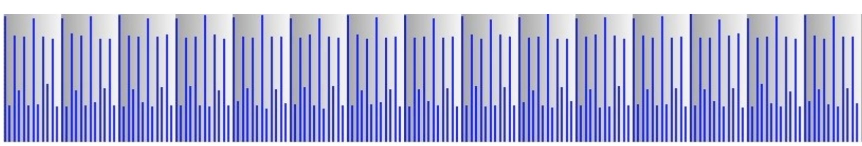

Figure 2. Metric analysis of the left hand of the Capriccio (time signature 6/4) of bars 1-15

The results of Inner Metric Analysis on the Capriccio reveal different metrical states in the left and right hand parts. Figure 2 displays an example from the analysis of the left hand. It shows the visualization of the metric weights (as vertical lines) that are assigned to all notes. The higher the line, the higher the corresponding weight. The x-axis represents the time axis, the background marks the notated bar lines. The metric weight is highest at the 1st and 4th quarter notes of the bars, the 2nd, 3rd, 5th and 6th quarter notes' weights form a second layer. The lowest layer consists of the weights of the weak eighth notes in between. Hence, the metric hierarchy associated with the 6/4 bar lines is reflected within the inner metric structure of the left hand. The inner metric structure of the right hand is characterized by groupings according to 3/2 in bars 1-8 (blue region in Figure 1 right) and 12/8 in bars 9-13 (green region). Bar 14 contains a metric modulation (light green region) to bar 15 that exhibits again 3/2.

Tonal Analysis using the Spiral Array. The analysis of Brahms' tonally ambiguous *Capriccio* using Chew's Spiral Array model provides some evidence for the affinity between tonal and metric structures in the piece. One recent application of the Spiral Array is the determining of sections with distinct pitch collections (see, for example, Chew 2004). The Spiral Array model represents pitches on a spiral such that spatially close pitch representations form higher-level tonal structures such as triads and keys, represented by spirals embedded in the interior of the structure. The pitch class spiral (shown in Figure 3) is a three-dimensional realization of the *tonnetz*. Unlike the *tonnetz*, the Spiral Array summarizes collections of pitches as points in its interior, called *centers of effect* (*c.e.'s*). The c.e. has been shown to be an effective surrogate for the tonal context of a musical selection (Chew & Chen, 2003). When comparing pitch collections from two consecutive segments of music as shown in Figure 3, the distance between their c.e.'s quantifies the tonal difference and likelihood of a boundary between the two musical selections. These tonal distances provide an appropriate means of determining boundaries between tonally distinct sections.

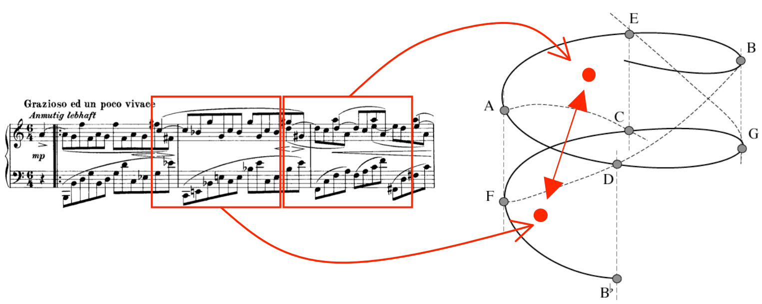

Figure 3. Distance between centers of effects (summary points) inside the Spiral Array provide tonal distance between consecutive segments of music.

Figure 1 (score on right) documents the statistically significant boundaries, marked by solid divider lines with scissor icons, discovered by the Spiral Array model when the c.e.'s are generated by 12 eighth notes' worth of music (as shown in Figure 3). Consider the three boundaries resulting from this Spiral Array analysis. The *Capriccio* is written in the key of C, yet never tonicizes in the key throughout the entire first section of the piece. The first boundary divides the initial nebulously C major region from the equally non-committal F (IV of C) region. Crossing the second boundary leads to an E minor (vii of F, also the relative minor of G) region and the final boundary leads back to the C region via F.

Comparisons. We now compare the metric and tonal analyses with each other and with Lewin's results. Considering that the sections for the tonal analysis often include the preparatory bar prior to a new section, our tonal and metric analyses appear to agree in the second and third boundaries. The first tonal boundary according to the Spiral Array has no correspondence in the Inner Metric Analysis segmentation, but has a parallel in Lewin's analysis.

Inner Metric Analysis is based on equidistant notes' attacks and does not consider pitch information. Lewin's and Cohn's analyses of the Capriccio on the other hand is explicitly based on pitch information. Surprisingly the right hand exhibits a 3/2 metric state within bars 1-8 in the Inner Metric Analysis results, which include the section of bars 3-4 labeled as 3/2 for the left hand by Lewin. Furthermore the right hand is grouped as 12/8 in bars 9-13 in accordance with Lewin's findings for the left hand. Hence metric states of the left hand assigned on the basis of pitch information correspond with metric states of the right hand assigned on the basis of time information.

Lewin segments the piece into the "antecedent" section, bars 1-8 governed by tonicized F harmonies, and the "consequent" section, comprising of bars 9-15 governed by tonicized e harmonies. Inner metric analysis splits the example into the first and second half, agreeing with Lewin's main sections. The tonal analysis using the Spiral Array gives the division between Lewin's "tonic" and "subdominant" regions in the antecedent section, and "tonic" and "dominant" regions between the antecedent and consequent sections. Bars 14-15 contain a metric modulation according to Lewin. The metric model also shows a modulation from 12/8 back to 3/2 in the right hand, and the Spiral Array analysis shows a boundary from e minor to F, leading back to the tonic, C. We have shown similarities in the results of corresponding sections of the mathematical models for metric and tonal domains with Lewin's and Cohn's findings, thus providing further evidence for the affinity between tonal and metric structures in the Brahms' Op.76 No.8.

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