“Historically Informed” Corpus Studies

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Musicians can choose between various “historicist” or “presentist” ways of performing works from the past. Music scholars who study early music sometimes are forced to make similar choices. If one thinks of corpus studies in music as an objective form of counting the “elements of music,” the question of what constitutes an “element” can involve similar historicist/presentist dilemmas. The article examines three historically significant characteristics of European art music—three historicist features—that are not always recognized in presentist corpus studies. For an illustrative example, a comparison is made between how the cadenza doppia in a Bach toccata for organ might be represented in a corpus study as either a two-voice framework or a series of Roman numerals in the tradition of Allen McHose (1947). Because that type of cadence was a commonplace in Bach’s time and in Bach’s compositions, a corpus analysis should be able to detect its multiple occurrences as a core element of the music.

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The catchphrase “historically informed” can be incendiary in the world of Western classical music. To its proponents it means performing the music of the past on instruments of the past (“period” instruments) and in the styles of the past (“authentic” performance practice). To its opponents it connotes a deceptive marketing ploy that pretends to recover the irrecoverable sounds and manners of musicians who died before the dawn of recording (Taruskin, 1990). Over recent decades the disputes between proponents and opponents have settled into chilly détente, with many metropolitan centers now having successful resident ensembles from both camps. Yet even if one discounts some of the earlier disputes as overblown rhetoric or a vying for commercial advantage, there still remains a significant intellectual core to the arguments pro and con. Intractable dilemmas can arise from the interplay of past and present, memory and imagination.

Living musicians, for example, play music in the present, even if the scores they play were written in the past. From their location in the present these musicians must make specific choices about how to reanimate those silent texts. Some players may view current performance standards as the ideal and older practices as evolutionary dead ends. I will term this a “presentist” orientation. Other players may view various historical styles as worlds unto themselves, each a perfection in its own time and for its own purposes—a “historicist” orientation. The same dilemmas are often forced upon music scholars. In the course of their work they may need to make clear choices between historicist and presentist alternatives, even if the underlying issues are far from clear or easily resolvable. When such choices are made in corpus studies they can have real implications for the kind of results obtainable and for the types of evidence that might thus be presented for or against a particular theory of the musical mind.

In many ways corpus studies have been the subject of musicology, music theory, and ethnomusicology since the inception of those disciplines. Knud Jeppesen’s pioneering work in the 1920s on the style of Palestrina, for instance, was based on a meticulous examination of the entire corpus of Palestrina’s works (Jeppesen, 1922). The word “corpus” has graced the titles of several scholarly editions, as for example the series titled Corpus of Early Keyboard Music (Caldwell, 1963–) or the Corpus mensurabilis musicae (Ranzini, 1966–). My own dissertation and the ensuing book A Classic Turn of Phrase involved a large corpus study (Gjerdingen, 1984, 1988), and generations of music historians have worked with corpora of musical prints and manuscripts as part of their daily routine. What distinguishes “corpus studies” in the sense intended by this special issue of Music Perception is the formalization of inquiry such that it can be accomplished through machine computation, hence as a form of computational musicology, and further, that the results have import for the study of music cognition. If anything, the sharpening of concepts and categories into algorithmic form may require one to make even starker choices between presentism and historicism, though the choices may not always be recognized as such.
In terms framed by the musicologist Carl Dahlhaus, one scholar may view a musical phenomenon as “natural” while another views it as a “second nature” (Dahlhaus, 1968). A natural phenomenon may be stable over all times and places whereas something learned as a second nature may be limited to a specific era and social group.

A simple recipe for doing a corpus study of any type might read as follows:

1. Define the set of elements believed to occur within the corpus.
2. Calculate appropriate statistics on the time series of those elements.
3. From those statistics, deduce pertinent norms or rules for the corpus.

While stages 2 and 3 may be amenable to numerical methods and explicit algorithms, stage 1 may not. It is thus often at stage 1 that the researcher makes decisions that reveal a presentist or historicist bias.

Take, for example, how a Medieval narrator, author of the Latin tale of Vergil and Lucinius, conceptualized the domain of literacy as a tidy hierarchical system with a presentist bias (Johannes, ca. 1200).

Vergil, on account of his respect for and friendship with the king, took the boy [Lucinius] and taught him the elements of letters [i.e., the alphabet]. Then, gently and with enticements, as is the custom of teachers, he rapidly taught him how to construct syllables out of letters, and how to form sentences out of syllables, and then how to complete an oration out of sentences.

[At Virgilius, ob reverentiam et amicitiam regis puerum recipiens, primo quidem ei litterarum tradidit elementa ac deinde blandiendo leniendoque, ut moris est magistrorum syllabam ex litteris conficere et ex syllabis formare dictionem et ex dictionibus vero perficere orationem in angustia temporis perdocuit.]

The narrator was describing Hellenistic methods of education (Marrou, 1948) which, though of great authority in ancient times, have limited relevance to a modern understanding of literacy. Today we know that literacy depends heavily on a remembered lexicon of words and a learned phrasicon of multi-word constructions, all stored with culturally and historically contingent meanings attached (Langenberg, 2000). In the act of reading, many such domains of knowledge interact in complex ways. The relative ease with which readers can understand texts in which the internal letters of every word have been scrambled (Rawlinson, 1976) shows how little the art of literacy relies on a strict hierarchy of letters-to-syllables-to-words-to-sentences-to-orationes, however useful such a scheme may have been pedagogically. The Medieval narrator recognized a systematic notational hierarchy in the corpus of Latin texts, but took for granted all the situated, real-world knowledge needed to give meaning to those texts.

If one were to replace Vergil with perhaps the Abbé Vogler (1749–1814), one of the first music teachers to adopt Roman numerals as proxies for musical elements (Grave & Grave, 1988), the story of Lucinius might read as follows:

Vogler, on account of his innovations for teaching nonmusicians, took the boy [Lucinius] and taught him the elements of scales [i.e., the notes]. Then, gently and with enticements, as is the custom of teachers, he rapidly taught him how to construct intervals out of notes, and how to form chords out of intervals, and then how to complete a composition out of chords.

Vogler’s imagined outline would be as limiting as that of the Medieval narrator—the systematics of notation do not give an accurate picture of the cognitive structure of music literacy. Of course the advantage of such a presentist account is its broad applicability—the notational hierarchy would be much the same for Bach or Stravinsky. But this generality comes at the price of excluding any explicit role for knowledge specific to a given time and place. In the following discussion I hope to show not only that including historically contingent elements in stage 1 of a corpus analysis can improve the results but also, more generally, that three methodologically convenient assumptions adopted in many computer-assisted corpus studies of past styles are insufficiently sensitive to historically significant characteristics of European art music. These assumptions are: (1) a single auditory stream, (2) event contiguity, and (3) unlimited scope for statistics.

THE ASSUMPTION OF A SINGLE AUDITORY STREAM

Modern corpus studies originated in studies of language (Firth, 1957; Sinclair, 1992; Quirk, 1960;), and the working hypotheses of those studies continue to influence corpus studies in music. If one thinks of language comprehension as involving a type of auditory scene analysis (Bregman, 1990), one sees that studies of verbal corpora have made the quite reasonable and often methodologically necessary simplification that language constitutes a single auditory stream, one represented either as transcribed speech or as written text to be heard internally by a reader. A corpus of transcribed conversations or
literary dialogues requires that speakers “wait their turn,” and transcribers will customarily edit out or regularize instances where speakers overlap or cut into another speaker’s utterance. In musical parlance one might say that while corpora of speech allow for antiphony, they do not welcome polyphony.

The story of Vergil and Lucinius dates from the time of the first preserved examples of European art-music. The churches and monasteries of Medieval Europe daily performed incantations selected from a large repertory of melodies mythologized as originating with Pope Gregory (c. 570), hence the term Gregorian chant (Hiley, 1993). Its notation was frequently described in Latin as a series of “points” (puncta), after the black dots or small squares used to mark the musical notes. For the most sacred ceremonies, skilled singers would embellish the chant with one or more additional auditory streams. This was sometimes described as setting “a point against a point” (puncta contra punctum [Petrus, ca. 1300s]), and it is from the latter two words of this Latin phrase that we get our word **counterpoint**. The European art-music tradition from its inception thus assumed at least two auditory streams. In particular, two streams typically formed a dynamic scaffold to which still other streams could be added. One voice of the scaffold was the “holder” (tenor) of the chant while the other formed the “second song” (discant), hence functioning as what music historians term a “discant-tenor framework” (Cyrus, 2000).

This underlying presumption of a guiding two-stream structure remained central to music education and composition in the Renaissance (Schubert, 2002) and continued without interruption into the 17th and 18th centuries. Italian composers, for example, were still called **contrapuntisti** in the days of Bach and Handel (Pitoni, ca. 1713), and the music centers of Bologna, Rome, and Naples all required apprentice musicians to become fluent in the extemporized creation of two-voice counterpoint (Sanguinetti, 2012). Further north, the Langloz manuscript (Renwick, 2001) shows how fugal partimenti were used to aid training in extemporized counterpoint within Bach’s circle. The historically important duet of the discant-tenor framework or the bass-melody framework might be likened to a pas-de-deux in classical ballet. One could try to reduce the dancers’ interactions to a single numerical “stream,” computing perhaps the time series of a distance-vector. But would knowing that the male dancer is 0.76 meters from the female dancer really tell us anything of significance about the art of dance? It seems more likely that one would need to know what **both** dancers were doing and how they interacted in terms of the established categories of ballet in order to model a human understanding of a pas-de-deux. By the same token, trying to “iron out” the inherent two-ness of a two-voice framework risks ignoring a fundamental feature of this musical art of coordinated human actions.

**THE ASSUMPTION OF EVENT CONTIGUITY**

Some of the obvious statistics to compute on any corpus would be the distribution of event frequencies and the transitional probabilities between events. In studies of language, Zipf’s law (Zipf, 1935) emerged from the ranking of word frequencies, and important concepts in information theory were first exemplified by the transitional probabilities of letters of the English alphabet (Shannon, 1951). Whereas studies of corpora of English texts can confidently assume the significance of contiguous strings of characters, or of the explicit cues (white space) that demarcate direct successions of words, the question of what to count is considerably more complex in music.

Take, for instance, the opening measures of J. S. Bach’s G-major Suite for Cello (BWV 1007; see Figure 1).

It is a true statement that the opening G2 is followed immediately by D3 and then by B3. But as the prelude continues a listener begins to recognize that those three pitches are less the contiguous elements in a melody and more the subsequently discontiguous events in a three-voice chorale (i.e., three auditory streams; Cambourpoulos, 2008; Davis, 2001). In this latter sense the B3 of measure 1 “goes to” the C4 of measure 2, even though those tones are separated by (depending on how one counts) three to seven intervening tones. Perceptually relevant events in a musical corpus may thus occur in multiple streams where perceived contiguities—and hence computable transitions—occur at multiple time spans.

Implied polyphony is a known trait of Bach’s works for solo cello or violin. Yet even when separate instruments...
are available to perform each auditory stream, discontiguous events remain important. Take, for example, the opening bars of Haydn’s string quartet Op. 20, no. 5 (Hob. III:35; see Figure 2), where the composer lays out a stock 18th-century “opening gambit” (Gjerdingen, 2007, Chapter 6).

The stock melody, aurally highlighted by long tones on the downbeats of each measure, ascends the first three steps of the F-minor scale (1-2-3, as marked on Figure 2); the default bass for this opening gambit would sound scale degrees 1-7-1, which is exactly what Haydn presented. In Haydn’s world, such moves were as common as the chord progressions (the “changes”) of a Gershwin song might be to a jazz musician today. Note, however, that while the melodic transition 1-2 does involve contiguous tones (F4-G4), the 2-3 transition does not. Haydn’s art depended for its effect on his listeners’ ability to hear discontiguous events as focal points in the syntax of his theme.

In his Studies on the Origin of Harmonic Tonality, Carl Dahlhaus (1968/1988) singled out a clearly perceptible metrical hierarchy as one of the contributing factors in the transition from the looser tonal organization of the 16th century to the more modern tonal organization of the 18th. In the sacred works of Palestrina, for example, many if not most of the important relationships between tones involve contiguous pitches. With Vivaldi, by contrast, an understanding of many of his long sequences depends on a listener being able to relate discontiguous pitches that occur at corresponding moments within successive metrical units. If this recognition of discontiguous but fundamentally important events is central to a listener’s experience of Vivaldi, Bach, Haydn, and practically every composer who came later, then it is a questionable methodological shortcut to limit the computation of event frequencies and transition probabilities to directly adjacent tones.

**THE ASSUMPTION OF UNLIMITED SCOPE FOR STATISTICS**

Allen McHose, longtime professor at the Eastman School of Music and a major influence on American music theory, was among the first to employ statistical methods in the analysis of harmony (McHose, 1947). He tabulated frequencies and transitional probabilities for musical events, using Roman-numeral representations as proxies for those events. His practice of choosing an inventory of chords to represent the elements of a musical corpus was in line with views widely held in early 20th-century psychology. Edward B. Titchener, for example, stated in his Outline of Psychology (1902, p. 85) that, “Since the first task of the psychologist is to analyse consciousness into its elements, he is obliged to count up the total number of sensation qualities.” McHose’s inventory of chordal types served as a plausible realization of Titchener’s call to establish the “total number of sensation qualities.” Psychology, of course, went on to largely reject Titchener’s approach. The Gestalt psychologists in particular noted that a perceived whole (Gestalt) was often more important than the details of its parts.

One problem with taking chordal types as independent actors in the world of music—that is, reifying these “sensation qualities”—is that musical relationships can be highly dependent on context. The great pianist (and musical conservative) Claudio Arrau once complained that Shostakovich “has not written one good note of piano music. No. Let me correct that. He has written one good note, but not two” (Kahn, 1972, p. 52). Though his assessment would be disputed by Shostakovich’s many admirers, Arrau did understand that musical elements out of context have little intrinsic meaning. McHose allowed his statistics unlimited scope, assuming that local contexts had no strong influence on the meaning of, for example, a “IV” chord. What if, however, statistics constrained by local scope better reflected actual usage?

Take, for example, the question of whether a native speaker of English should use the definite or indefinite article preceding the word “stroke.” A global analysis of the immense corpora of English currently available for study might reveal no strong preference for either article. But if the statistics are limited in scope to particular topics, the results are quite different. When the context

![Figure 2. Joseph Haydn, String Quartet in F Minor (Op. 20, no. 5; Hob. III:35), mm. 1–3.](image-url)
is personal health, native speakers almost always use “a,” as in “She had a stroke” (Danielsson, 2003). To say “She had the stroke” would mark the speaker as an outsider of some sort. Yet if the context is time, native speakers invariably say “He arrived at the stroke of midnight.” Most native speakers could not even imagine saying “He arrived at a stroke of midnight.”

Particular linguistic constructions (form-meaning combinations of words; Goldberg, 1995) can have a strong effect on the probabilities of particular verbal collocations. In the words of Stefanowitsch and Gries (2003), experts in computational corpus analysis:

Traditionally, the lexicon and the grammar of a language are viewed as qualitatively completely different phenomena, with the lexicon consisting of specific lexical items, and the grammar consisting of abstract syntactic rules. Various expression types that fall somewhere in between lexicon and grammar (i.e. various types of fully or partially fixed multi-word expressions) have been recognized but largely ignored (or at least relegated to the periphery) by mainstream syntactic theories (notably, the various manifestations of Chomskyan generative grammar). The predominance of this view may be part of the reason why corpus linguists, until recently, have largely refrained from detailed investigations of many grammatical phenomena. The main focus of interest was on collocations, i.e. (purely linear) co-occurrence preferences and restrictions pertaining to specific lexical items. If syntax was studied systematically at all, it was studied in terms of colligations, i.e. linear co-occurrence preferences and restrictions holding between specific lexical items and the word-class of the items that precede or follow them.

These authors pioneered the “collostructional analysis” of verbal corpora, where instead of allowing global scope, statistical calculations are designed to uncover the internal regularities of particular constructions.

If, in McHose style, one asked, “To which chord does a IV chord progress in ‘common-practice’ music?” there would be an array of answers of varying probabilities representing an unknown number of different musical contexts and constructions. If, by contrast, one said, “To which chord does a IV chord progress in a ‘Prinner’?” the answer would be “I⁰”, with a probability near 1.0.” “Prinner” (Gjerdingen, 2007, Chapter 3) is the name given to a common riposte in opening passages of innumerable 18th-century works. The opening of the Aria movement from a violin sonata by Jean-Marie Leclair (see Figure 3) shows an initial Romanesca schema followed, as is the norm, by a Prinner riposte. In this context, IV not progressing to I⁰ would be potentially ungrammatical, regardless of the global statistics.

It may be worth noting that recognition of the Prinner, as one of the core patterns of 18th-century musical syntax, emerged only after an extensive corpus analysis of the repertory, an analysis that focussed on the coordinated behaviors of voices.

Bach bring all his forces together to present what most listeners will remember as the theme of this work (see Figure 4):

In terms of late 17th- and early 18th-century musical practice, measure 32 (after the downbeat chord) presents a formulaic two-voice canon (Gjerdingen, 2007, Chapter 16). The lower voice (the “Follower” or comes) is characterized by note-to-note contiguity, while the upper voice (the “Leader” or dux) is diminished and thus serves as a model for the comes only through discontiguous pitches occurring at regular time intervals. The subsequent measure then presents a standard type of five-count cadence (here five eighth-notes) that closes on the first beat of measure 34. This cadence, a widely acknowledged norm of Baroque practice, was known by Italian masters as the “double cadence” (cadenza doppia [Fenaroli, 1775, p. 8]). It was one of three basic cadences taught to every apprentice musician at the conservatories in Naples (see Figure 5), and as late as the mid-1780s Mozart taught it to his student Thomas Attwood (Gjerdingen, 2007, p. 103).

In Example 5, the numbers below the brackets indicate the “count” of each cadence. Note that the five-count cadenza doppia has one voice moving twice from the leading-tone to the keynote, which may partly explain the meaning of “double” in the cadence’s name. In Victorian times the double cadence was sometimes termed a “consonant fourth” cadence (Smith, 1989) to justify the seeming preparation of a dissonant fourth (in Figure 5, the second C5 in the soprano voice of the cadenza doppia, viewed in relation to the bass G3) by a “consonant” fourth (the first C5). Such verbal hair-splitting is indicative of how this common tonal construction—a partially fixed multi-note expression, to paraphrase Stefanowitsch and Gries (2003)—was refractory to analysis by rule. The two-voice framework in the upper voices of the cadenza doppia strictly observes all the rules of Bach-era counterpoint, but its placement over a pedalpoint G introduces secondary effects (the emergent “fourths” between G3 and C5) that the rules could not cover.

To the casual listener, Bach repeats the music of measures 32–34 in measures 34–36. A glance at the score (see Figure 6), however, reveals that the melody of measures 32–34 has become the bass of measures 34–36 and vice versa.

The latter measures are, with some slight alterations, inversions of the earlier measures. The two underlying schemata, however, remain easily recognizable. In the case of the cadenza doppia, Bach preserves a two-voice

![FIGURE 4. J. S. Bach, Toccata (BWV 564), mm. 32–34, showing the brief canon in m. 32 and the five-count cadenza doppia in mm. 33–34.](image-url)

![FIGURE 5. The simple (a), compound (b), and double (c) cadences widely taught in Bach’s day.](image-url)
framework even under inversion (see Figure 7). One voice descends stepwise from F to C, sounding scale degrees 4–3–2–1 (in the Renaissance, this was usually the tenor part). The other voice, B–C–C–B–C, sounds scale degrees 7–1–1–7–1 (the older discant part). The temporally and tonally specific collocation of these two voices was a norm that Bach scrupulously observed, though a fuller description of his practice would require a discussion of the other two voices, a look at how considerations of sonority could affect the two-voice framework, and a conspectus of exemplars of the cadenza doppia in other meters and tempos.

In measure 37, Bach modulates to the key of G major and presents the two-voice framework of the cadenza doppia on the upper manual of the organ, replacing the implied pedal point on scale degree 5 heard in measure 33 with a series of root-position basses (see Figure 8a). And in measure 60 he presents, in the key of E minor, a fourth variant of the cadenza doppia (see Figure 8b). Bach places the beginning of the old discant part in the bass before completing it in the soprano voice. This is his most free setting of the cadenza doppia in the entire toccata and immediately precedes the return of the two-measure module (the “theme”) first heard in measures 32–34.

If the cadenza doppia represents a satisfactory stage 3 result of corpus analysis—“satisfactory” in the sense of matching a known norm or ground truth of the musical style—then how should its elements be represented at stage 1? In other words, what element(s) should be passed to stage 2 calculations so that at stage 3 one could arrive at the cadenza doppia?

In the tradition of McHose, some corpus analyses have chosen Roman numerals (with or without figured-bass superscripts) as stage 1 elements. Roman-numeral analysis has the methodological advantage of producing a single string of symbols—the assumption of a single auditory stream. But as Table 1 below demonstrates, a disadvantage is that the four variants of the same cadenza doppia produce four very different strings of Roman numerals. For a machine classifier to recognize that these symbols all represent the same musical category would likely require a custom-designed parser of considerable sophistication, and it would not be easy to prevent such a parser from treating the instances at
measures 37 and 60 as two cadences (not the intended meaning of “double cadence”). The methodological difficulties are augmented by the loss of information about voices. As mentioned, Bach’s music takes as a point of departure the coordinated actions of individual vocal or instrumental parts, even in works for solo cello or violin. The integrity of those parts cannot be reliably reconstructed from a string of Roman numerals. Moreover, the complexities and the extent of subjective interpretation contained in these composite symbols (e.g., “V 5/4/2”) can lead to cases where even the momentary musical context cannot be determined without reference to the score.

The table’s rightmost column lists the frequency of these four strings of Roman numerals in the one-movement corpus of Bach’s toccata. None of the strings occurs more than five times.

By contrast, Table 2 shows the same four variants represented as a two-voice framework. The numbers in the columns indicate scale degrees (in terms of the local key), and the measure numbers of first instances correspond with those of Table 1 for ease of comparison.
I believe that one can make at least three direct observations from Table 2: (1) the variants that appear initially in measures 33, 35, and 37 are so similar, differing by only a few notes out of the eighteen total, that they ought to form a single category with 11 instantiations; (2) the first eleven of the twelve cadenze doppie in Bach’s toccata, and might weakly associate them with the twelfth instance (m. 60). The idea of a general category—“cadenza doppia”—that comes in two subtypes—one where “voice 1” begins on 4 and one where it begins on 2—was a fact of 18th-century practice, something implicit in a set of brief musical rules published in 1775 by the Neapolitan maestro Fedele Fenaroli (1775, p. 6). Shortly before specifying the details of the cadenza doppia, Fenaroli noted, as an “axiom” (assiome musicale), that when the bass moves from scale degree 5 to 1, one can give a 7th to the first chord (hence in three voices replacing the 2 with 4); “this seventh [= 4 of voice 1 in Table 2] cannot rise but must resolve by falling to the 3rd degree of the key” (“La settima minore si dà alla quinta del tono, che torna alla prima; la quale settima non può salire, ma risolvere calando alla terza del primo tono”).

If one were to posit the historically informed melody and bass patterns of the cadenza doppia as stage 1 elements, and were to do the same for the components of the canon-like schema first seen in measure 32, a pattern I have previously named a Fenaroli in honor of the maestro mentioned above (Gjerdingen, 2007, Chapter 16), then a likely stage 2 processing of this single movement would result in, among other things, a statistical validation of there being at least two significant collocations of voice pairs (the two schemata). Subsequent stage 3 processing would likely reveal the transitional probability of the succession “Fenaroli ⇒ cadenza doppia.” That simple collocation of schemata accounts for approximately 40 percent of the toccata (not counting the opening flourishes). Failure to recognize this pairing would truly be “missing the forest for the trees.” In linguistic terms, the focus shifts from lexemes to phrasemes, as it has in construction-based or usage-based grammars (Goldberg, 1995). Just as it could be exceedingly hard to deduce the meaning of the common idiom “kick the bucket” (= die) from an analysis of its three constituent words in an arbitrarily large corpus, so a purely bottom-up analysis of a musical corpus might struggle to identify larger patterns that have special meanings and functions within a musical culture.

With stage 2 results grounded in the types of choices at hand in Bach’s world, stage 3 deductions of norms can have direct musicological and psychological relevance. On the musicological side one could compare a large corpus of Bach’s works with similar works by, for instance, Vivaldi. The young Bach had studied Vivaldi assiduously at the very time of composing his Toccata. In the words of a noted Bach scholar, “Indeed, it was Vivaldi who exercised what was probably the most lasting and distinctive influence on Bach from about 1712–13, when a wide range of the Italian repertory became available to the Weimar court orchestra. Bach drew from Vivaldi his clear melodic contours, the sharp outlines of his outer parts, his motoric and rhythmic conciseness, his unified motivic treatment and his clearly articulated modulation schemes” (Wolff, 2001). A comparative corpus analysis of Bach and Vivaldi could perhaps help to pinpoint which aspects of Vivaldi’s compositional method Bach absorbed and which he did not. On the psychological side, one sees evidence for the central role that memory must take in recognizing and differentiating the interplay of known compositional units in a game of combinations—what many scholars in Bach’s world named the ars combinatoria (Leibniz, 1666; Ratner, 1970). The two schemata just mentioned are, to be sure, historically contingent and unknown to many musicians today. They would be unlikely to occur in the works of Schoenberg or Steve Reich. But there can be little question that they ought to constitute elements in any historically informed analysis of this work by Bach. The same rationale would apply to the entire corpus of Bach’s work, and very likely to the much larger corpus of composers working during Bach’s lifetime. More than a century later, echoes of such an overlearned pattern can still be found in the works of Carl Czerny, a pupil of Beethoven. The colorful harmonization and bravura right-hand passegework shown in Figure 9 only partially conceal the traditional cues of the cadenza doppia. This ancient and quite predictable five-count cadence helps Czerny bring to a sure close the torrent of notes that make up the opening section of this advanced exercise in “finger dexterity.”

**Discussion**

As mentioned earlier, 18th-century apprentice musicians were given exercises to complete that required...
them to commit to memory the musical schemata of their day. Many of the instructional works known as partimenti, for instance, end with the cadenza doppia indicated by the bass (the other voices were added by the student in performance). For example, a partimento by Francesco Durante, one of Bach’s Italian contemporaries, modulates to the dominant key at the end of its first phrase and confirms the modulation with a cadenza doppia (see Figure 10), using in fact the same alternate bass for a cadenza doppia that Bach used in the analogous location shown earlier in Figure 6 (m. 37). The instructional intent of the partimento is clearly evident in its presentation of two schematic sequences, one ascending, one descending, prior to the cadenza doppia.

In Handel’s great coronation anthem “Zadok the Priest” (1727), it is a cadenza doppia that brings to a close the extended orchestral introduction and ushers in the thundering chorus, an intentionally grand moment captured in the recent film The Young Victoria (see Figure 11). The cadenza doppia was, of course, not something invented in Bach and Handel’s day. A recent article by Menke (2011) explores many instances of the cadenza doppia in the 16th and 17th centuries. This cadence was already a stock item in the
days of Palestrina, and it went on to become the most frequently used large cadence in 17th-century sacred music.

I mention this background to Bach’s usage because it speaks to the close connection of music theory with music history. When historical experts look at Bach’s compositional technique, they often note the retention of many 17th-century musical practices—hardly surprising since Bach was born and trained in the 17th century. Musicians of the past were part of complex, ongoing traditions, and the heavy use of the *cadenza doppia* by composers from the 16th through the early 19th centuries is an indicator of how useful compositional constructions could persist and survive significant changes in musical style.

Two current research programs in corpus analysis both take an historically informed approach to music in the Renaissance. One is the ELVIS project at McGill University and the other is the Digital Du Chemin project, which connect researchers in the U.S., Canada, and France. “ELVIS” is an acronym for “Electronic Locator of Vertical Interval Successions: The First Large Data-Driven Research Project on Musical Style.” The ELVIS project is not limited to music before 1600, but at least two of its researchers, Julie Cumming and Peter Schubert, are noted scholars of that era. “Digital Du Chemin” is part of a larger project, *The Chansons of Nicholas Du Chemin (1549–1568)*, hosted by the Centre d’Études Supérieures de la Renaissance in Tours, France. Lead researchers are the musicologist Richard Freedman (Haverford College) and Philippe Vendrix (CESR). In both cases, eminent music historians are collaborating with experts in data analysis and music information retrieval (MIR) to achieve impressive results. In the Du Chemin project, for instance, missing voice-parts have been reconstructed based on norms in the corpus, and in the ELVIS project one can view comparative statistics concerning the use of a particular type of cadence by different composers. In both cases an analysis of the collocations of voice-pairs plays an important role in the research. For the 18th-century repertory of Italian-influenced music, which includes almost every composer from Bach and Handel to Haydn and Mozart, the work at Northwestern University by James Symons (2012) shows considerable promise. By looking at something as simple as melodic patterns that occur frequently at regular temporal intervals in a repertory of two-voice solfeggii, and then by correlating those melodic patterns with associated bass patterns, he has been able not only to validate most of the schemata previously claimed as norms of the Italian style but also to identify new ones. When viewed together, these ongoing studies suggest a remarkable continuity in the practices of earlier musicians, practices that can be easily connected with the current practices of jazz musicians and others working in vernacular styles.

In conclusion, I would like to note that although historically informed corpus studies can be considerably more difficult to plan and execute, in large part because of the heterogeneous nature of a multitude of patterns, the results are potentially more grounded and useful. This type of heterogeneity has been a topic of interest in the “London School” of linguistics since the work of J. R. Firth in the 1950s. In his *Dictionary of Linguistics and Phonetics*, David Crystal (2003) writes that “Firthian” principles call for “an approach to linguistic analysis based on the view that language patterns cannot be accounted for in terms of a single system of analytic principles and categories (monosystemic linguistics), but that different systems may need to be set up at different places within a given level of description.” In the sample corpus analysis of Bach presented above, the fact that a pair of simple two-voice frameworks could account for about 40 percent of Bach’s *toccata* (not counting the opening flourishes) is reminiscent of some recent research in corpus studies of speech. Erman and Warren (2000) found that about 55 percent of a large corpus of English texts (both written texts and transcribed speech) was made up of “pre-fabs,” meaning learned multi-word units. This and similar research results are showing that the brain likely enables the fluent “on-line” production of speech through the recall of contextually appropriate pre-fabs. However complicated and profound we may find Bach’s musical art, there is little question that he could “speak” it in the sense of improvisation and fluent mental composition. If historically informed corpus analyses of music can show that musicians manage the rapid on-line production of music by drawing upon similar repertoires of pre-fabs, then such studies can provide further support for the idea of general cognitive abilities being at the foundation of specialized cognitive skills.

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