

Tempo, Duration, and Flexibility: Techniques in the Analysis of Performance

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While ethnomusicologists and music critics have traditionally studied the differences between various performances of the same musical work, musicologists and theorists have studied what remains the same (namely the score). Musicology, therefore, has tended to focus on the more "work" oriented Western genres, and has avoided, until recently, the more "event" oriented musics including jazz and even opera. While opera has recently enjoyed wider study by professional musicologists, its advocates have tended, of course, to study it *as* musicologists, that is, with the claim that Rossini too has fixed authentic texts. Only after a critical edition is produced can "analysis" of this fixed text begin. As musicologists we tend to discuss the score as if it were the musical work, and to ignore Roman Ingarden's distinction between performances (which are events), scores (which are objects) and musical works (which enjoy a different kind of existence separate from both).¹ Further, a performance is an example of a musical work while a score is either a crude translated sample (a transcription of a single performance in all of its particularity) or a summary (a unique and personal attempt by the summarizer to establish certain essential qualities for an idealized performance) of the musical work. At best, a score is only a spatial representation of *some* of the elements of the temporal phenomenon we call music.

The problem, of course, is that it is easier to study what is both fixed and tangible, and the qualities which distinguish performances of musical works are often neither. In music where the pitches vary between performances, there are at least tangible differences we can study. In a previous study which investigated the performance history of the jazz composition 'Round

Midnight,² I demonstrated that performances altered not only the audience's perception of the musical work, but that even the legal definition of the musical work (the copyright) changed to reflect the changing performance traditions of the tune. While the musical work and the score may be culturally more important in the canonic repertoire of musicology, our reluctance to study performance has been more practical than phenomenological; as musicians we relish the differences, but as academics, the fear of "subjectivity" and the desire to move our discipline away from journalistic criticism, has kept us focused on the ever-present score.

However, while the differences between performances of given pieces in the canonic Western repertoire might seem to be entirely intangible, it is in fact possible to identify and analyze some of these differences. In this study, I examine the aspects of performance which are most conveniently quantifiable, namely tempo, tempo modulation, duration, proportion and the quality I call flexibility. That is not to say that one can or should only study the performance differences which one can quantify. My aim here is merely to demonstrate that even in a performance tradition where relative similitude is highly valued and pitches are (mostly) essential and invariable, differences between performances can still be studied with meaningful results.

Tempo is an especially important variable to study. In addition to being easily quantifiable, tempo has a long history of being considered the key interpretive element for all performers and especially for conductors. Wagner wrote, "what decides whether a conductor is performing a work correctly is his choice of tempo: if the choice is right we know at once whether he has understood the work."³ Beethoven too, considered tempo to be the most important aspect of a performance.⁴ Anton Schindler claimed, "When a work by Beethoven had been performed, his first question was always, 'How were the tempi?' Every other consideration seemed to be of secondary importance to him."⁵

Not only have tempo and tempo modulation long been at the center of the debate about what constitutes "good" or "correct" performance, but the theoretical debate about the role of the performer and the practical debate about tempo also have a long parallel history. There is a historical connection between the various theories of fidelity or authenticity and the practice of strict tempo. Conductors from Mendelssohn to Toscanini and Norrington have argued that fast and steady tempos "let the music speak for itself" without "interference" from the performer, while Wagner, Furtwängler, and Walter all argued that the conductor "breathed life" into a musical work principally through the practice of slightly modulating the

tempo. Tempo and tempo modulation remain central issues today in the continuing battle over whether the performer should be a creative partner with the composer or merely a re-creative executant.⁶

There is a further difficulty with studying performance and a further advantage of studying tempo. While the human ear and brain can only listen to one performance at a time (and then use descriptive language to attempt to remember and define the differences) tempo measurements result in a series of numbers. While the use of quantifiable data is no substitute for detailed listening, the computer is less likely to run out of memory than a human critic. A computer can store the initial tempo, the duration, or tempo fluctuations for a virtually infinite number of recordings and then display them before our eyes all at once. These different types of data can be sorted, examined and viewed in a variety of ways and it is the description of a variety of techniques with which to analyze this data which constitutes the bulk of this study.

Further, I hope that the data which follows illuminates not only the history of twentieth-century performance practice, but the degree to which musical works are dependent upon performance. While we like to think we can easily look beyond the "interpretation" and see the "musical work" directly, one of the first lessons of studying historic recordings is that every generation believes it is transforming scores into sound in the most "natural" and "authentic" way. Like speech, realizing a score is a highly conditioned activity. The systematic investigation of performance, while not quite reception history or aesthetics, informs them both.⁷ Understanding just what the differences are in objective terms is a first step in evaluating why certain performers and periods are considered "golden."

This study is primarily a demonstration of the analytical techniques which are crucial to the history of recorded interpretation and it is organized by the type of data. I begin with the most basic data, duration and basic tempo, and then move to more and more detailed data on proportions, and tempo fluctuation within movements, phrases and bars. Methods for acquiring the data and the techniques for its analysis are discussed in each section.

HISTORICAL TRENDS IN TEMPO

Do we play the same pieces faster or slower in this century? While few have examined the hard information regarding tempo change, all possible claims have been made. Both A. B. Marx, in the nineteenth century and Theodor Adorno, in our own, thought that the tempi of their own day were faster than they used to be.⁸ Similarly, Richard Taruskin cites a small sample of

data to suggest that the Bach Fifth Brandenburg Concerto is speeding up.⁹ Other studies suggest tempi are slowing down.¹⁰ It has even been suggested that the discrepancy between Beethoven's metronome markings and modern performance practice demonstrates how much tempos have slowed down.¹¹ (Others argue, on the same evidence, that Beethoven's metronome marks must be wrong.)¹² Finally, Nicholas Temperley's ingenious study of the timings made by Sir George Smart between 1819 and 1843 (mostly at the Philharmonic Society in London) concludes that durations (and therefore tempi) are neither consistently faster or slower than they used to be.¹³

With a long history of musical performance now captured on records, tapes, and CDs, and a computer which can remember all of the durations or tempos, we can now determine the exact facts of the matter, at least for the last 80 or so years. My aim is merely to establish if there has been any *historical* change in tempo. Determining the "correct" tempo, if such a thing exists, would be an aesthetic judgment, not a historical one. Even if we could prove that tempos were faster in Beethoven's day, that would not make them "correct." One could argue that they were historically accurate, but that would hardly constitute aesthetic correctness (assuming such a thing exists). Indeed, our attitudes to historical performance practices are decidedly contradictory. While we feel free to ignore the recorded evidence (Stravinsky conducting Stravinsky, for example) arguing that composers don't always know best, we still cling to a general ideology of fidelity (arguing that composers always know best). We will always argue about whether or not Stravinsky's tempo is good, but can settle the question of whether or not it is relatively faster or slower than most performances today.

Comparing the tempos and durations for recorded performances of a variety of works indicates that Temperley's conclusions are probably true for the most heavily recorded repertoire. Some individual works may be speeding up or slowing down, but the repertoire as a whole is getting neither faster nor slower. Fig. 1 shows the durations of first movement expositions for three works plotted against the year of the performance. The line is an extrapolated mean or linear regression; i.e., the computer assumes there *is* a trend and makes its best attempt to determine what it might be. 100% accuracy ($R\text{-sq} = 100\%$) would be reached if all of the points were on the line.¹⁴

Overall, these graphs demonstrate that there is *no* overall trend to faster or slower tempos. Individually, they indicate all three possible trends. The Beethoven seems to be speeding up (taking less time to play), while the Tchaikovsky is slowing down, and the Mozart hasn't (statistically) changed

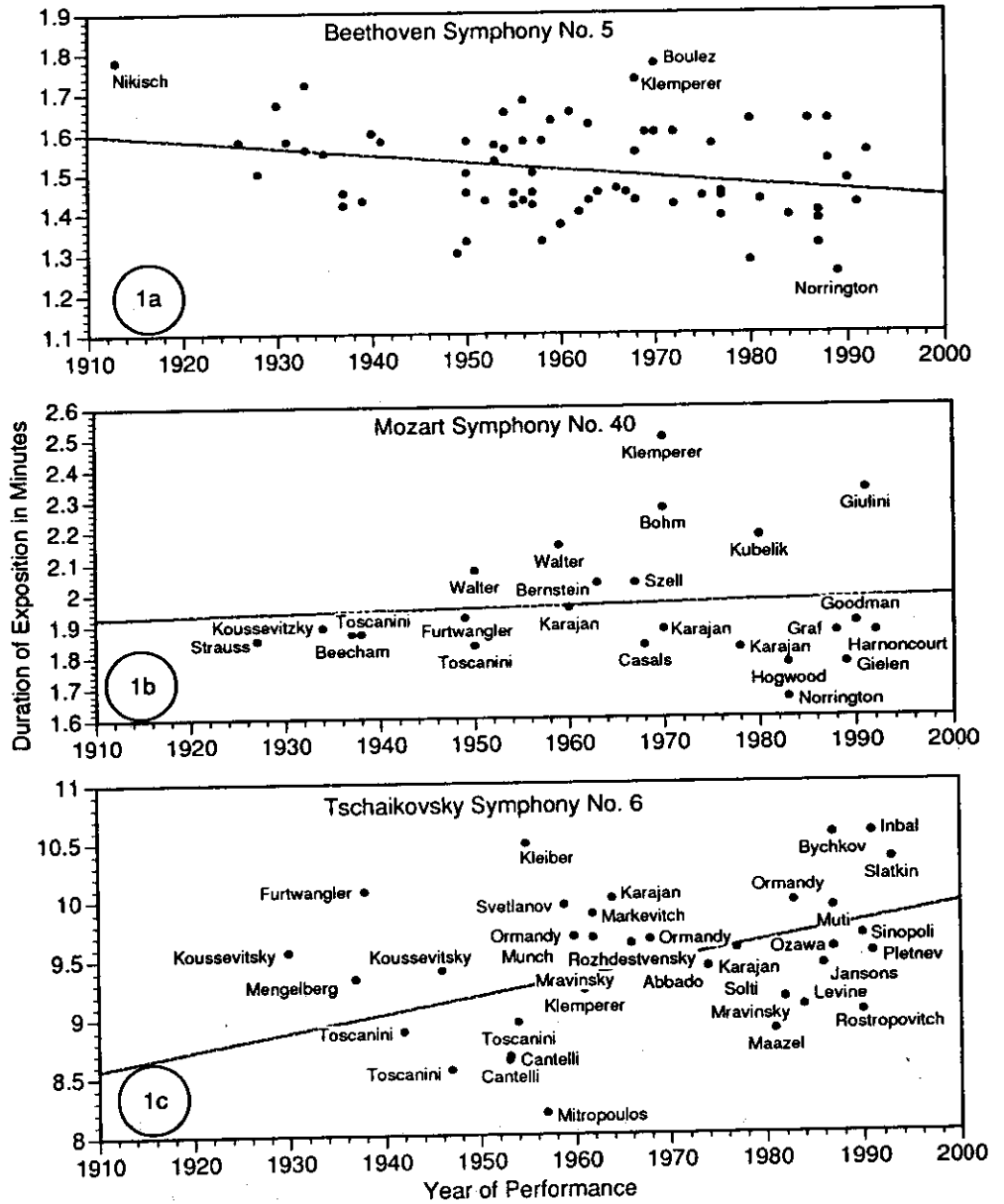


Figure 1. Durations of First Movement Expositions

at all. Not surprisingly, the entire repertoire cannot be said to be moving in one direction or the other.

While fig. 1 uses data only from first movement expositions, fig. 2 confirms that the results are the same for other movements; some works may be getting longer or shorter, but there is no general trend. Slow movements (like the beginning of the second movement of the Beethoven Symphony No. 5 shown here) are no more likely to slow down or speed up than first movements. While the entire first movement of the Mahler Symphony No. 4 appears to be almost 30 seconds shorter than it used to be, the consistency in the range of performance durations remains more impressive than the very slight decrease in average duration.¹⁵ Only in the Brahms Piano Concerto No. 2 is there a convincing trend toward greater length in recent performances ($p = 0.003$).

One might argue that if tempos in early recorded performances were artificially rushed due to technological limitations, the entire recorded repertoire (and especially works like the Beethoven Symphony No. 5 which have the longest recorded history) would display a tendency to slower tempos and longer durations with technological improvements and longer formats (LPs and CDs as opposed to 78s). They do not. The first recording of the opening movement of Mahler Symphony No. 4 (fig. 2b) by Hidemaro Konoye (1930) is still one of the longest ever recorded.¹⁶ Changes in technology have been crucial to the way we hear and perform music, but longer formats do not in general appear to have stimulated slower tempos.¹⁷

Looking for historical trends in a single piece is only the first of many areas open to investigation with this data. Even given such limited information (some of which is even available on the back of CD packages), we could begin to investigate the claims that conductors perform differently in the studio and on stage,¹⁸ or that they slow down as they get older.¹⁹ An investigation into the collaboration between soloist and conductor might also fruitfully make use of this data. For example, the Brahms example (fig. 2c) demonstrates that Claudio Arrau took similar tempos with both Bernard Haitink (1993) and Carlo Maria Giulini (1988).²⁰ Artur Schnabel and Emil Gilels, however, seem more willing to adopt the tempos preferred by the accompanying conductor. Both give later performances which are 7 to 8 minutes slower than their earlier ones. That the tempos in Gilels' first recording (1958) were chosen by Fritz Reiner seems possible since Reiner's recording with Van Cliburn three years later, also with the Chicago Symphony Orchestra, (1961) takes similar tempos.²¹ Reasons for tempo choices, however, are difficult to investigate.

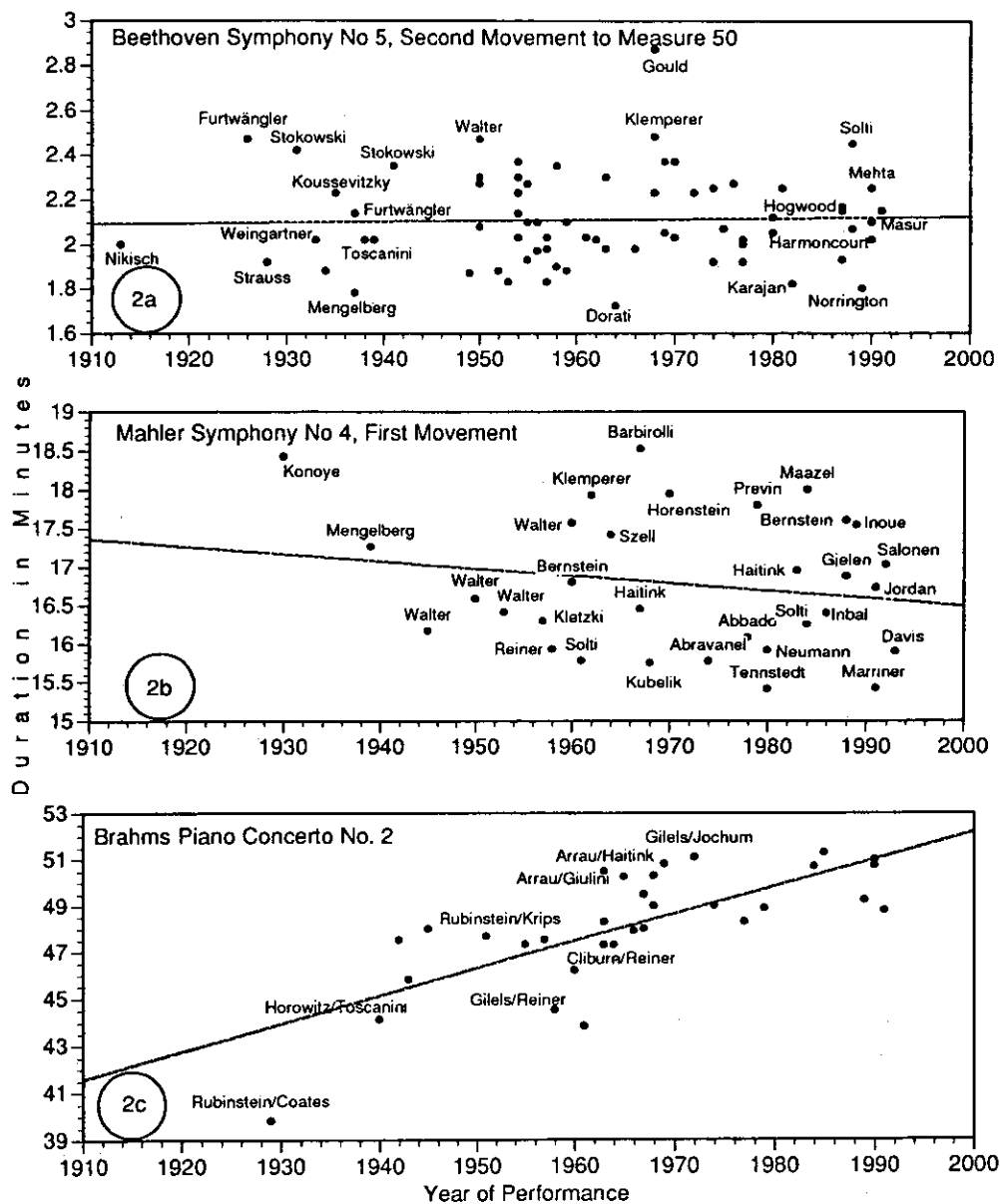


Figure 2. Additional Durations

Like studies into compositional style, the analysis of performance styles has to account for the complex interaction of a number of factors. Rubinstein and Gilels might be adapting to different charismatic conductors, but they might also be adapting to the changing performance styles of different decades or simply getting slower as they get older. Any investigation of one factor needs to consider all three. Ultimately any history of interpretation will want to consider all of these questions together in an effort to understand how individual, geographic, historical, and institutional performance styles change.²²

TEMPO AND DURATION

Logic and experience both suggest that duration and tempo are inversely related (and certainly a slower tempo *generally* results in a longer performance), but the relationship between tempo and duration is more complex than it seems.²³ Fig. 3 charts the history of the average *initial* tempos for two of the same selections.²⁴

All performance contains some degree of tempo fluctuation, but we still expect a generally faster performance to finish sooner. (How long can anyone hold the opening fermatas of Beethoven's Fifth?) While the first movement of the Mahler Symphony No. 4 does not contain specific metronome suggestions, it does contain numerous performance directions which ask for tempo changes and there is certainly a performance tradition which allows for a great deal of tempo flexibility. While we would expect a slower *haupttempo* (first called for in measure 4) to yield a longer movement, we are, therefore, not too surprised that fig. 2b (the duration of all performances) and fig. 3b (the *haupttempo* for all performances) are not exact mirror images. In general the performances by Klemperer, Barbirolli and Inoue which employ slower main tempos (and therefore appear near the bottom of fig. 3b) result in longer performances (which occur at the top of fig. 2b). The exact relationship between the conductors, however, is not so clear. Inoue's initial *haupttempo* is as slow as Klemperer's or Barbirolli's, but under his direction the movement is shorter than those under a number of conductors with faster opening tempos (like Maazel and Bernstein). Similarly, Konoye's opening tempo is quite average (fig. 3b) but his performance ends up as one of the longest (fig. 2b). And although all four of Bruno Walter's (progressively slower) tempos are slower than average (fig. 3b), three of his four performances are also shorter than average (fig. 2b). Finally, while the average duration of the movement seems to be shrinking (fig. 2b) this does not translate into an increasing average tempo! The average initial *haupttempo* for this movement has

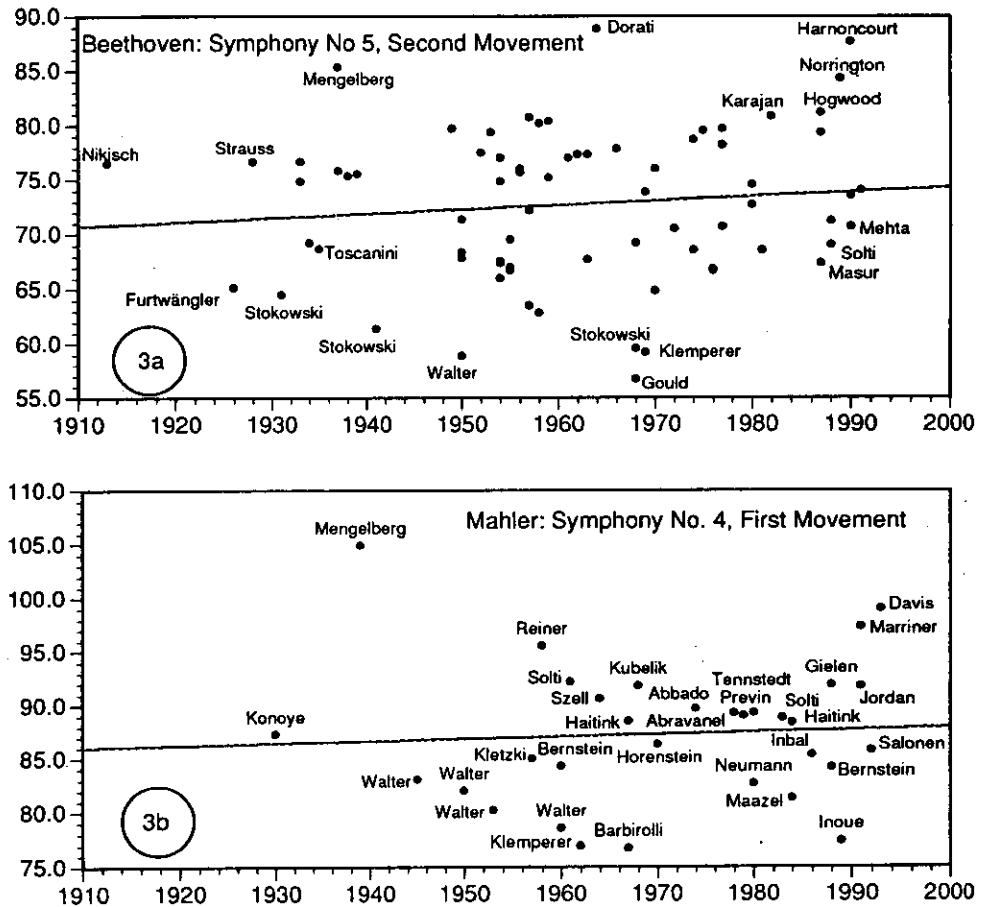


Figure 3. Average Initial Tempos

barely changed since Konoye's first performance ($p = 0.33$). At least with Mahler, we cannot assume that a longer duration means a slower basic tempo. While Mengelberg takes slightly longer than most, he also uses the fastest *haupttempo*. He is obviously slowing down somewhere.

In the Beethoven (fig. 3a), there should be less cause for monumental shifts of tempo within the movement. In the first 50 bars of the second movement of the Beethoven Fifth Symphony there are no tempo directions at all besides the initial *Andante con moto* (with eighth-note = 92). (Note that no one, even the most historically minded conductor, has ever

observed this metronome mark in a recorded performance.) Therefore, we might expect a greater correlation between the initial tempo (the average tempo of the first six bars for these purposes) and the duration of the first 50 measures of music.²⁵ Again this is *generally* true. The edges of each diagram indicate what we expect; Mengelberg's and Dorati's shorter performances (bottom of fig. 2a) are the result of faster tempos (top of fig. 3a). Similarly, Walter, Klemperer and Glenn Gould (at the piano) produce long performances with slow tempos. Gould and Furtwängler, however, produce performances which are significantly longer than others with the same initial tempo.

A look at two groups of modern conductors further demonstrates that internal tempo fluctuations must be accounted for when making durational comparisons. Kurt Masur, Zubin Mehta and Georg Solti all take slower initial tempos than Nicholas Harnoncourt, Roger Norrington and Christopher Hogwood (fig. 3a). While Masur takes the slowest initial tempo, he finishes the 50-bar passage well ahead of Mehta and Solti and only just behind Harnoncourt who begins with the fastest tempo. Given the initial tempo, the expected duration can be calculated for each performance. We would expect Masur to finish .54 minutes (or 32 seconds) after Harnoncourt.

Conductor	Year	Tempo	Expected Duration ²⁶	Actual Duration
Harnoncourt	1990	88	1.70	2.02
Norrington	1989	84	1.79	1.80
Hogwood	1987	81	1.85	2.15
Mehta	1990	71	2.11	2.25
Solti	1988	69	2.17	2.45
Masur	1987	67	2.24	2.17

We would expect that all of the actual durations would be longer than the expected ones, as with no tempo marks or changes the only anticipated tempo fluctuation would be a slight ritardando at the end of a phrase.²⁷ Harnoncourt, Hogwood, Mehta and Solti fit this model. While Masur finishes well ahead of time, only Norrington ends with the metronome. This, however, does not yet prove that Norrington's performance is metronomic. It merely demonstrates that his relaxation of the music is mirrored by an equal amount of compression. In other words, it is possible that he adds an accelerando to compensate for each ritardando. In any case, duration is clearly not simply the inverse of tempo; internal fluctuation is a crucial factor.

DURATION AND PROPORTION

One of the most consistent complaints of critics (and by extension a justification for performance research) is that performances can alter (usually only for the worse) the structural proportions of the work. Paul Banks, for example, concludes that the *Adagietto* from Mahler's Fifth Symphony has been slowed down to the point where "the nature of this movement has been greatly distorted; as a result the overall structure of the Symphony has been altered."²⁸ Joachim Braun argues that the correct proportions of a work are determined by the metronome markings and that changing the tempos, changes the "ideal" proportions of the work.²⁹ Similarly, most discussions of the hermeneutic and ontological implications of tempo focus on changes in proportion as the key factor.

While I fully support the proposition that performance choices have ontological consequences (both in the small sense that tempo choice can effect proportion and in the larger sense that what is heard affects how the work exists), it is duration, not tempo, which is the factor most closely related to proportion.³⁰ As I have demonstrated with figs. 1-3, tempo and duration are not always directly aligned. While it is logical to predict a change in durational proportions from changes in tempo, the measured durations often tell a different story.

The average tempo for a movement in multiple sections, like the first movement of the Tchaikovsky Symphony No. 6, is meaningless. However, it seems logical that the average tempo for each section of the piece might provide some evidence of changing proportions. Fig. 4 shows the average initial tempo for each of the four main sections: the *Adagio* introduction, the main *Allegro*, the *Andante* second theme and the *Allegro Vivo* beginning of the development.³¹ Here the trend has been to make the fastest section faster and the slowest sections slower.

While there has been a slight decrease in the "main tempo" (*Allegro non troppo*) it hardly explains the increase in the duration seen in fig. 1c. The increase in duration appears to come not from any general decrease in the main tempo, but from the steady decrease in the tempos of the slower sections. Despite the trends, it is difficult to find any single conductor who fits the exact pattern. Klemperer conducts the faster sections more slowly than average, but is just above average for the slower sections; Solti is faster than average for everything but the *allegro vivo*.

Fig. 5 represents in columns the total duration of the movement in minutes (the y axis) with the absolute duration of individual sections appearing in different patterns (keyed at the side). The percentage of the

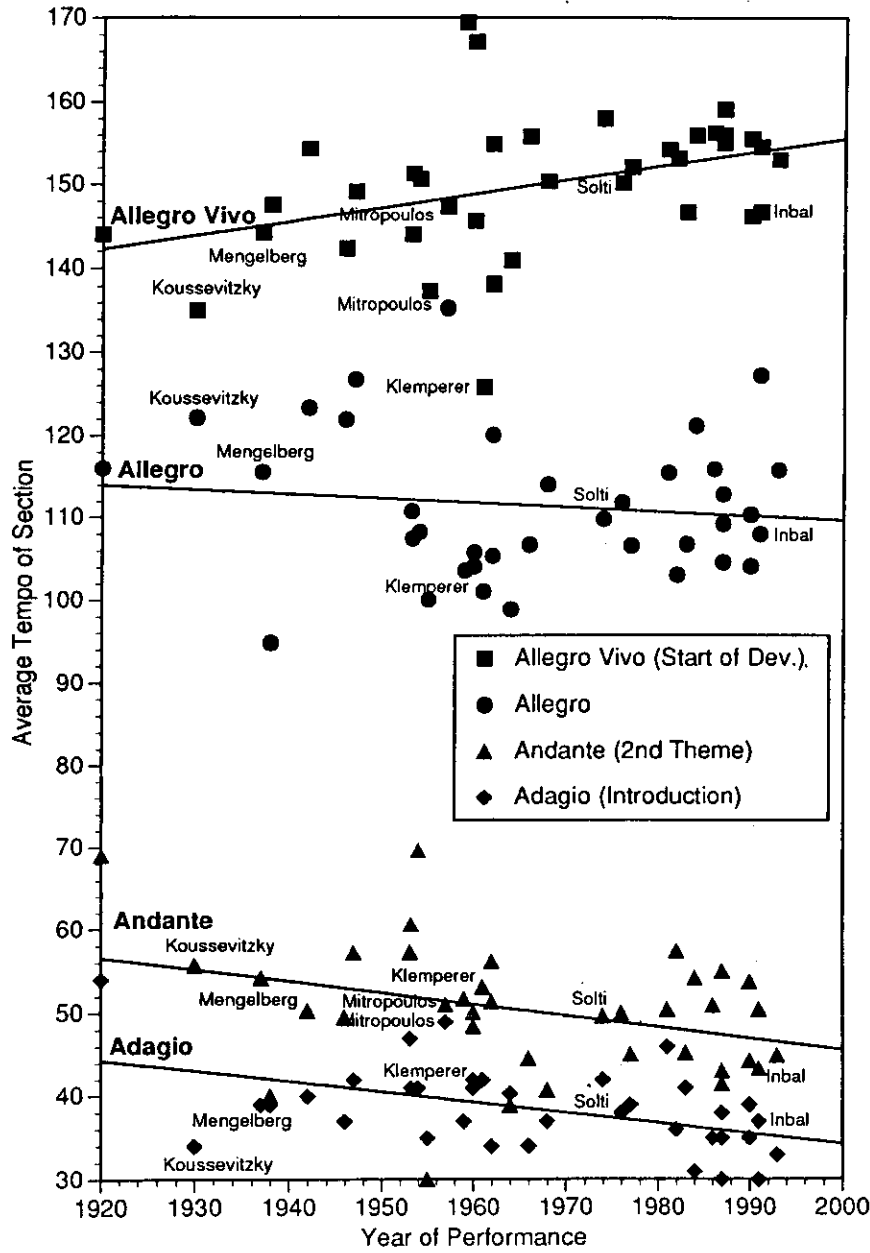


Figure 4. Tschaikovsky Symphony No. 6, First Movement: Average Tempos for Sections

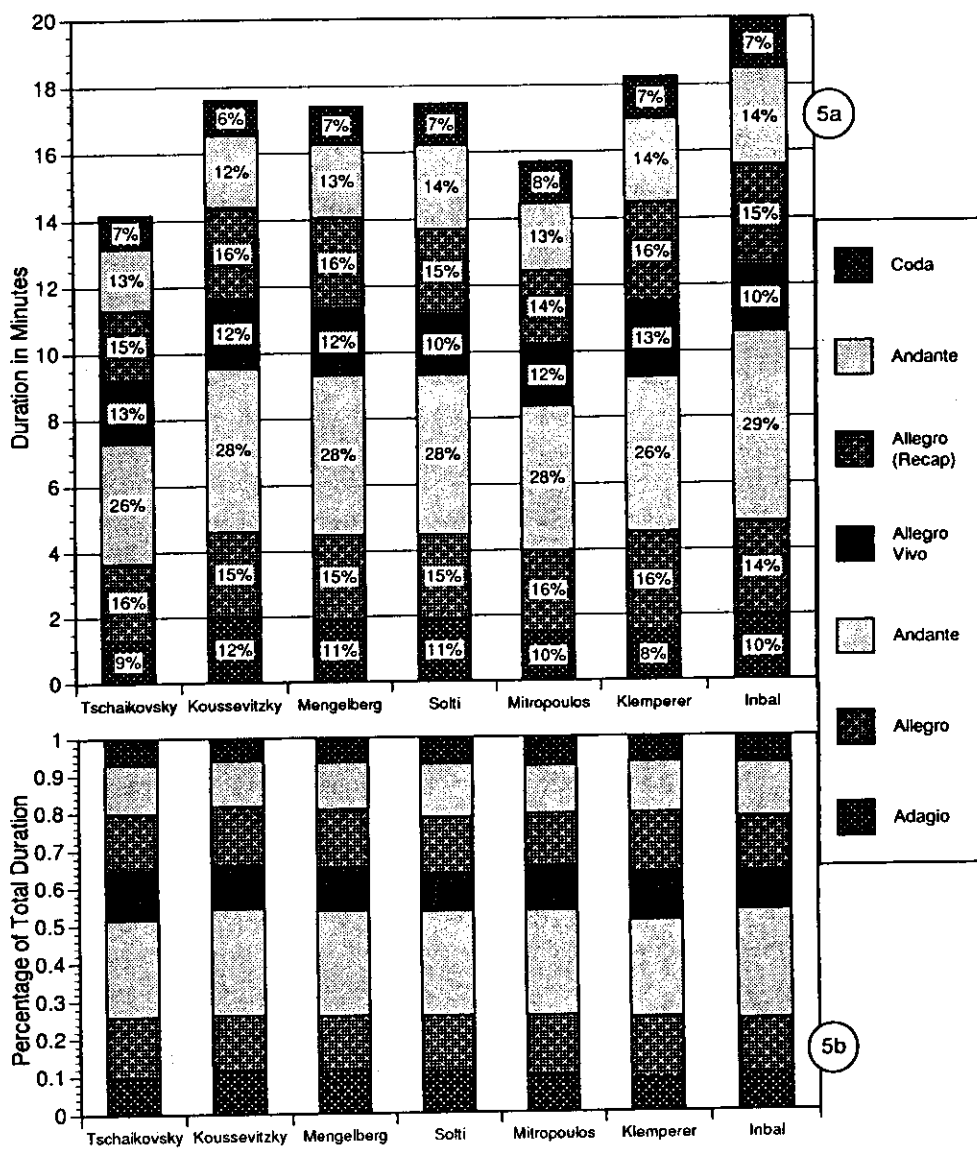


Figure 5. Tschaikovsky Symphony No. 6, First Movement: Sectional Durations

total duration is inscribed within each section. The bottom (fig. 5b) shows the percentage graphically so that any change in proportion would result in a different size box for that section.³² The figure shows the work of six conductors, who on the evidence of figs. 1c and 4 seem to employ radically different tempos. Despite the variety of tempos, all of the conductors ultimately produce performances of similar proportions. Mitropoulos produces the shortest performance on record, but his tempos for the *andante* and the *allegro vivo* sections are below average (fig. 4). Similarly Inbal produces the longest performance without taking the slowest tempos. More importantly, these different tempos do not produce radically different durational proportions. Klemperer employs one of the fastest opening *adagio* tempos and uses generally slow *allegro* tempos. Consequently his *adagio* and *andante* sections take up a slightly smaller proportion of the movement, 8% and 26% respectively against Koussevitzky's 12% and 28%. Klemperer's *adagio* takes only 1.55 minutes (only the Mitropoulos is shorter at 1.52 minutes) but since Klemperer's performance of the entire movement is longer, the *adagio* takes up a smaller proportion (8%) than Mitropoulos' (10%). While Klemperer's overall duration is unexceptional, his faster *andante* and slower *allegro* increase the durational proportion of the allegros and diminish the *adagio* and *andante* sections. Still, this does not result in a large shift in structural proportion (26% for the first *andante* is only slightly less than the average 28%).

Assuming for the moment that the metronome marks in the first edition are authentic,³³ it is possible to gain a crude idea of Tchaikovsky's intended durational proportions.³⁴ Ironically it is Klemperer, with his very long performance and complete disregard for metronome marks, who most closely matches these calculated proportions. As with Beethoven's, Tchaikovsky's metronome marks seem too fast for modern taste (fig. 4). This is especially so in the slow sections where the modern tendency is to perform much more slowly than the metronome mark. We would expect, therefore, that actual performances would slightly lengthen the *andante* (second theme) and *adagio* (introduction and coda) sections. Furthermore, the slow sections contain many ritardandi. As my calculated durations make only limited allowance for this³⁵ we are even more likely to expect all performances to spend a much greater percentage of their time in these sections. This is not the case. The surprise is that despite their wide differences in tempo and total duration, the real performances correspond very closely to the proportions implied by the metronome marks. While Tchaikovsky's absolute durations are short (fig. 5a) the proportions are indistinguishable from any of the performed versions (fig. 5b). Given that

few conductors use anything like Tschaikovsky's metronome markings in the slow sections it is even more surprising that my imagined and metronomic slow sections look unexceptional. In no case is a real performance more than 3% away from Tschaikovsky's implied durations.

The first conclusion must be that duration and proportion should be measured directly and not inferred from tempo. While the slowing of a section does increase the proportional duration of the section, it also lengthens the entire movement, which makes the proportional change smaller than the tempo change. Both Banks and Braun argue that it is this "proportional" change, which alters the musical work. Banks' claim that "the overall structure of the [Mahler] Symphony [No. 5] has been altered" looks somewhat different if we look at the change as a percentage of the total. Yes, the average length of the *adagietto* has gone from about eight minutes to just over ten, but the proportional change to the weight of the movement has been minimal. Early performances by Walter, Barbirolli and Kubelik give 13% or 14% of the total duration to their short *adagietti*, but recent performances, which are generally longer in *all* movements, still give the *adagietto* only 14–16% of the total duration.³⁶ While tempo changes can and do alter the proportional durations of musical works, these proportional changes cannot be assumed; measuring tempo to discuss proportion and vice-versa are flawed techniques.

The consistency of the proportions in fig. 5 still seems a puzzle. A partial explanation is that the average tempos, given in fig. 4, are measured from the beginning of the section. In both of Tschaikovsky's *allegro* sections the tendency in the first half of the century is to begin below tempo and gradually to get faster. In the slow sections, recent conductors are likely to opt for a slower tempo, but then less likely to decrease the tempo any further. Mitropoulos uses the fastest tempo to begin the *allegro* but still manages to make it 16% of his total duration (the highest). He also does little to honor Tschaikovsky's requests in measure 67 and 73 for tempo increases. (See fig. 12a) In the *andante* passages, Mitropoulos tends to push ahead, despite his average tempos, which keep these sections from growing in proportional value. Solti and Mengelberg use similar initial tempos and end up with virtually identical sectional durations, but their two performances could hardly be more different. Ultimately we need more detail (see below) as it is the tempo fluctuations on a bar by bar or even beat by beat level which tell the story.

To ensure that fig. 5 is not biased due to the shortness of its sections, fig. 6 demonstrates the same findings for two entire symphonic works. Eighteen representative performances are shown in chronological order of works.

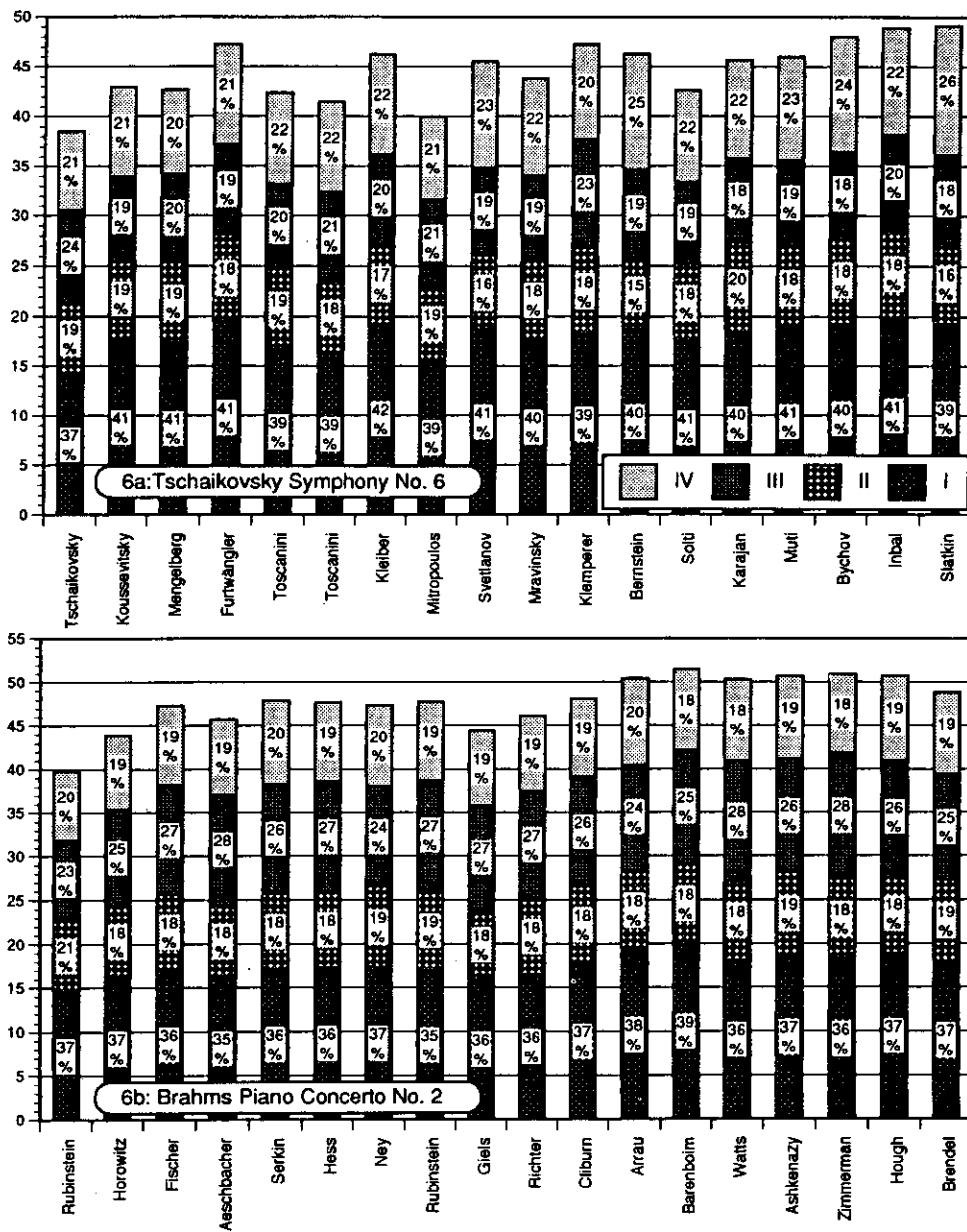


Figure 6. Movement Durations in Minutes (and as percent of total duration)

Actual duration in minutes is given for each movement with the percent of the total duration written for each movement. Tschaikovsky is again represented by durations calculated from his metronome marks. Both works take longer now than they used to, but in neither case has this substantially altered the proportions of the work. In the Brahms, Ashkenazy and Brendel add more than five minutes to Horowitz's time without changing the proportions of the work. The first complete recording (by Artur Schnabel and Albert Coates in 1929) is ten minutes shorter than most modern performances and includes some remarkable tempo fluctuations. Still, the proportions of the second and third movements vary only 2% from Brendel's.

In the Tschaikovsky (fig. 6a) is it possible to locate a few more significant proportional changes. Again over five minutes has been added to the total duration since the first recording, but here it does appear that the last movement is getting more than its fair share. While Koussevitzky takes 9.03 minutes (just over a minute more than the calculated 7.92) the finale still only takes up 21% of the total time. Slatkin, however, has increased the weight of the finale by increasing it in length to almost 13 minutes and preceding it with a fast *allegro molto vivace*. Is that enough to distort the work? While Bernstein and Slatkin do add length to the finale, it must be emphasized that even for the longest performances with the longest finales, the proportions are generally in line with shorter performances. Semyon Bychkov's finale (11.58 minutes) is almost as long as Bernstein's (11.63 minutes), but he manages to avoid Bernstein's proportional inflation of the finale by slowing down the second and third movements.

In addition to demonstrating that proportional duration should be measured directly and not assumed from tempo, these figures indicate that there is some sort of large scale compensation taking place. It may be that conductors deserve credit for controlling proportional duration. In addition, extreme tempos in either direction, slower tempos in slow sections and faster tempos in fast sections, seem to work as a curb on tempo fluctuations. *Adagio* movements which begin more quickly soon slow down (during *ritardandi*) and the slower performances catch up. In other words, even large changes in tempo often do not result in large changes to the proportions of the work. If the canonic composers did care about proportion, their intentions appear to be in pretty good hands.

TEMPO TOLERANCE

Even if a change in tempo doesn't alter the proportions, it does alter the way the music is perceived and can, therefore, still affect musical identity.

In fact, a change in the basic tempo is probably more noticeable than any resulting change in proportion.³⁷ There has been plenty of prescriptive musicological advice and rhetoric about metronome marks and returning to authentic tempos to “restore” musical works. Theorists have also discussed the absolute relationship of tempo to the musical work.³⁸ However, an examination of the evidence demonstrates that musical cultures typically have some degree of “tempo tolerance” and that it is possible, given the above data, to be descriptive about the amount of fluctuation allowed for each musical work in each culture and period.

The question of how much the tempo must be altered before the musical work is damaged, is cultural and aesthetic, and not theoretical or phenomenological; the answer depends on the composer, the piece and the audience, all of which are linked by cultural traditions. Tradition can mandate that certain qualities (like tempo, instrumentation, key or pitch accuracy) are essential and must be retained to ensure identity of the work or it may only require a certain range of values. (Even within Western music, jazz, opera, folk, pop, lieder and symphonic music cultures define the essential qualities of a musical work quite differently.) In other words, if an audience refuses to recognize a work unless it is played within a certain tempo range, or considers a performance outside this range a bad one, then that range becomes an essential quality of the musical work. If, however, the same work is identified or judged equally good at any tempo, then tempo is entirely arbitrary (i.e., it becomes an accidental rather than an essential quality).³⁹ It is ultimately audiences who determine whether a performance at a new tempo is still a performance of the work.⁴⁰ Tempo tolerance is something to be measured rather than prescribed.

We should assume that like all performance traditions, tempo tolerance changes. Performers are always experimenting with boundaries and some innovations are accepted while others are not. Those innovations that are reproduced become part of the tradition. For example, while Wagner's introduction of greater extremes of tempo was at first reviled,⁴¹ his style of conducting (like Liszt's similar style of solo performance) spawned an entire generation of performers who had greater freedom with tempo than those before. For Berlioz, however, tempo was an essential quality of the musical work. Each work had a single correct tempo, given by the composer:⁴² any other tempo “amounts, however unwittingly, to a serious distortion of the music.”⁴³ It was Wagner's innovation (and its later elevation to tradition) which changed tempo, within a certain range, into an accidental or interpretive quality.⁴⁴

In this century, tempo tolerance can be measured. Returning to fig. 3, note that the range of tempos remains fairly stable throughout the recording history of each work. (Remember that it is harder to generalize about the early years when there are fewer performances. It appears, from fig. 3b that the Mengelberg performance is unusual in its choice of tempo. Still, we cannot be certain if unrecorded performances before 1940 used tempi more like Konoye's or Mengelberg's.) Durations too, in figs. 1 and 2, seem to have a stable range. In all cases except the Brahms, the *range* of values is greater than any shift in the average tempo. For the Beethoven, fig. 3a, nearly all of the performances fall between 60 and 85 beats per minute for a tempo tolerance of roughly 30%. For the Mahler, fig. 3b, all of the performances except for Mengelberg's fall between 75 and 100 beats/minute for a tolerance of 25%. (Including Mengelberg raises the tolerance to 29%; excluding Reiner and Marriner lowers it to 19%.) The durational tolerances in figs. 1 and 2 similarly all fall between 20 and 30%. Only the Brahms (fig. 2c) has a smaller tolerance, where most performances fall within 8% of the mean. These figures suggest that tradition in this century will tolerate up to a 30% variation in tempo (i.e., that the slowest performances can be up to 30% slower than the fastest ones for all movements).⁴⁵ While the range varies with the work (and presumably the audience) the general range of values appears fairly consistent both in the performance history of a given work and across the entire repertoire. Slow movements seem to be able to tolerate more variation (see fig. 5)⁴⁶ but 30% seems a rather consistent *maximum* across the repertoire and across the century. Not everyone, of course, is willing to accept that it is audiences and not composers or critics who decide the phenomenological and aesthetic limits of interpretation. Braun, for example, argues that the aesthetic determination of a limit rests with the scholar: "We may suggest that in performances where the slowing down of Beethoven's tempo is as much as 20% or more, . . . a major distortion of Beethoven's idea takes place."⁴⁷ He summarizes the "experiments" of K. E. Behne and concludes that "the tolerated range of the 'right tempo' can be regarded as about $\pm 17\%$."⁴⁸ If Behne's laboratory subjects decided performances were "wrong" when they exceeded this limit, they were simply agreeing with accepted practice.⁴⁹ What was tested was a cultural limit and not a psychological one. (An audience for instrumental jazz, for example, would put fewer limits, if any, on the performer's choice of a tempo.) It is the actual practice of musicians and the response of audiences which determines when "a major distortion of Beethoven's ideas takes place." The "tempo tolerance" of a work is decided not by

experiment, nor by aesthetic or phenomenological judgment; it is decided by what has been tolerated during its performance history.

MEASURING TEMPO FLUCTUATION AND TEMPO MAPS

In addition to keeping track of the average tempo or duration for a large number of performances, a computer can also be used to measure the internal variations in tempo from measure to measure and even from beat to beat. I experimented with a variety of methods for making these measurements while working at Stanford University's Center for Computer Research in Music and Acoustics (CCRMA).⁵⁰ For this research, I found that it was accurate enough to tap along with each performance at the computer keyboard. The computer records the time between each tap, converts it into a tempo and then records it in a text file.⁵¹ The tempo measurements for each beat are then uploaded into a graphics/spreadsheet package from which all of the included graphs were created.⁵² There is, however, always some human error in the measurements.⁵³ When converted to a tempo measurement the accuracy was no greater than + or -3 beats per minute when measuring tempos in the 100 beats per minute range; i.e., 3% or 0.06 seconds per measurement. While this is not the most accurate way to make the measurements, the error is not cumulative and the large changes in tempo on a multi-bar or phrase level are reflected accurately.⁵⁴

I call the resulting graphs "tempo maps" and they allow us to look at several performances at once. The horizontal or X axis represents the measure and the vertical or Y axis, displays the tempo. Each line represents a single performance, and the scale on each map is the same so that comparisons between figures are valid. Fig. 7 uses only the average tempo per bar for every beat.

Tempo maps allow us to see at least two things we assume we can hear: that different performances by the same conductor do share stylistic similarities and that different conductors do things differently. Fig. 7 demonstrates that tempo maps offer a way to capture a tangible and fixed component of interpretive style.

Despite the "wiggle" from the human error in the measurements, the basic shapes for different performances by the same conductor are remarkably similar even with decades between performances and different orchestras.⁵⁵ The differences between the maps for different conductors are equally pronounced; the Berlin Philharmonic looks and sounds different under Karajan than it does under Walter (1950).

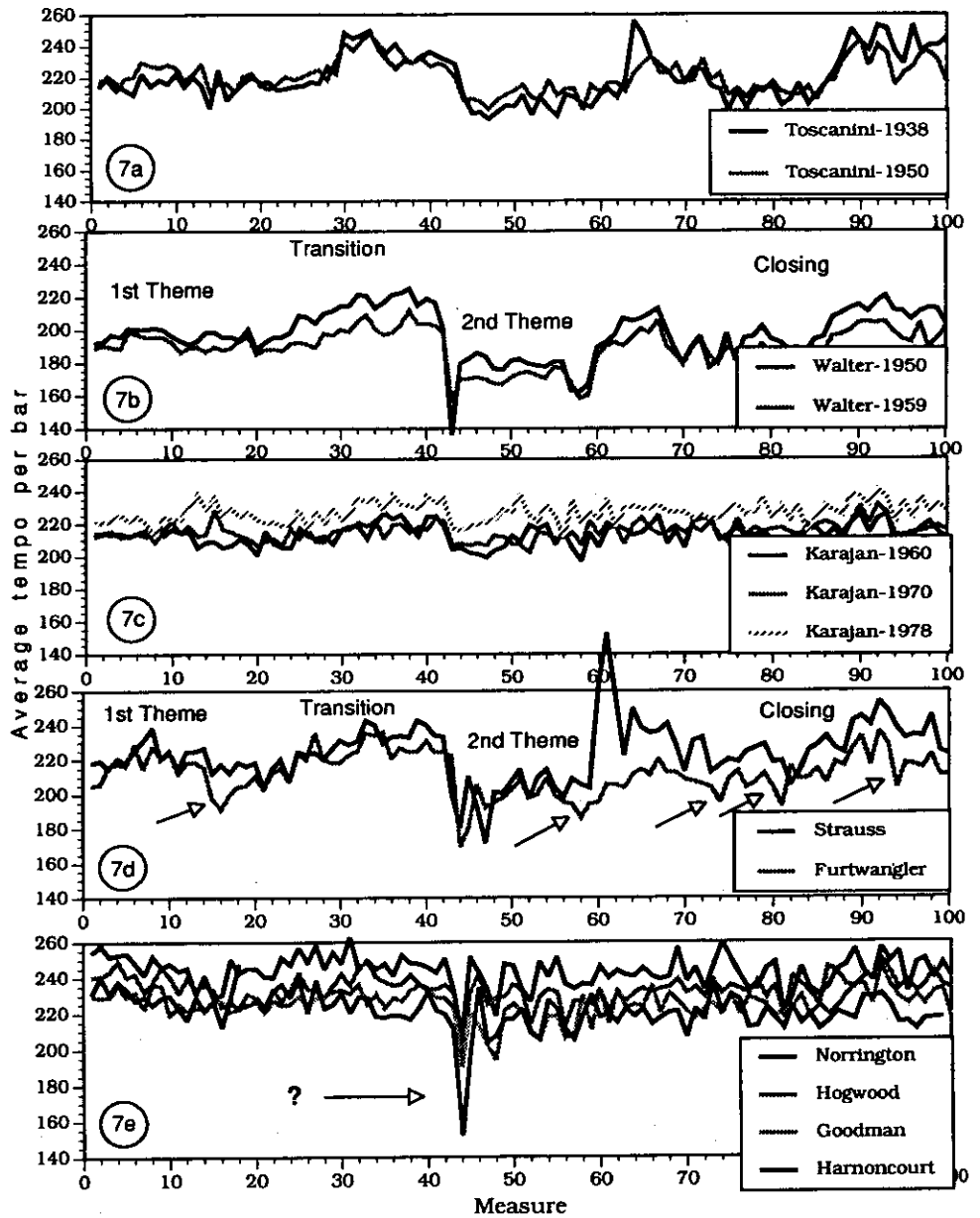


Figure 7. Mozart Symphony No. 40: Tempo Maps of First Movement Exposition

In some cases, the visual picture matches the one generated by critics. Walter's map (fig. 7b) seems to display some of the traits which are often attributed to him: slow tempos, very slow lyrical themes and the gradual and gentle play of tempo to indicate phrasing. The tempo map provides a somewhat objective correlate to the subjective description of Walter's performances as somewhat smoother, warmer and more graceful than either Toscanini's or Karajan's.⁵⁶ There also seems to be some truth to the generalization that while Toscanini was always rushing to a climax, Furtwängler often lingered over a phrase here and there; visually this turns into the difference between Toscanini's hills (fig. 7a) and Furtwängler's valleys (fig. 7d, see arrows). Similarly, critical opinion that performances from the original instrument conductors (fig. 7e) are fast and relatively flat seems justified; one might expect the same from a conductorless ensemble. (However, I cannot explain why all of these conductors add a Walter-sized fermata on the whole rest in measure 43 (fig. 7e arrow) and then resume steady tempo.)

These maps, however, also demonstrate some of the errors of critical and historical opinion. Toscanini's performances (fig. 7a) are full of tempo fluctuations and hardly exemplify the rigorous consistency of tempo which was attributed to him and hailed as the hallmark of modern conducting. It is rather Karajan's three performances (fig. 7c) which display the "evenness" of modern conducting. Further, Toscanini like all of the pre-Karajan conductors, speeds up the closing material, while the modern conductors religiously avoid this convention. These observations suggest that it is perhaps Karajan and not Toscanini who is the real father of modern conducting.

TEMPO AND EXPOSITION STRUCTURE

Fig. 7 also demonstrates that virtually every pre-Karajan conductor used tempo to delineate structure. Toscanini, Walter, Strauss and Furtwängler (figs. 7a, 7b & 7d) all mark the different parts of this exposition with changes in tempo.⁵⁷ Examining the average tempo for each section brings this trend into greater relief.

Fig. 8 presents only the average tempo for each section and demonstrates how the tradition has changed.⁵⁸ Fig. 8a demonstrates the old tradition of a slower tempo for the second theme and a faster tempo for the transition and closing sections. (Koussevitzky is the slight exception; his second theme still *seems* slower coming after his very fast transition, but it is actually faster than his initial tempo.) The later performances by Walter, Szell and Böhm (fig. 8b) speed up less during the transition but still slow down somewhat

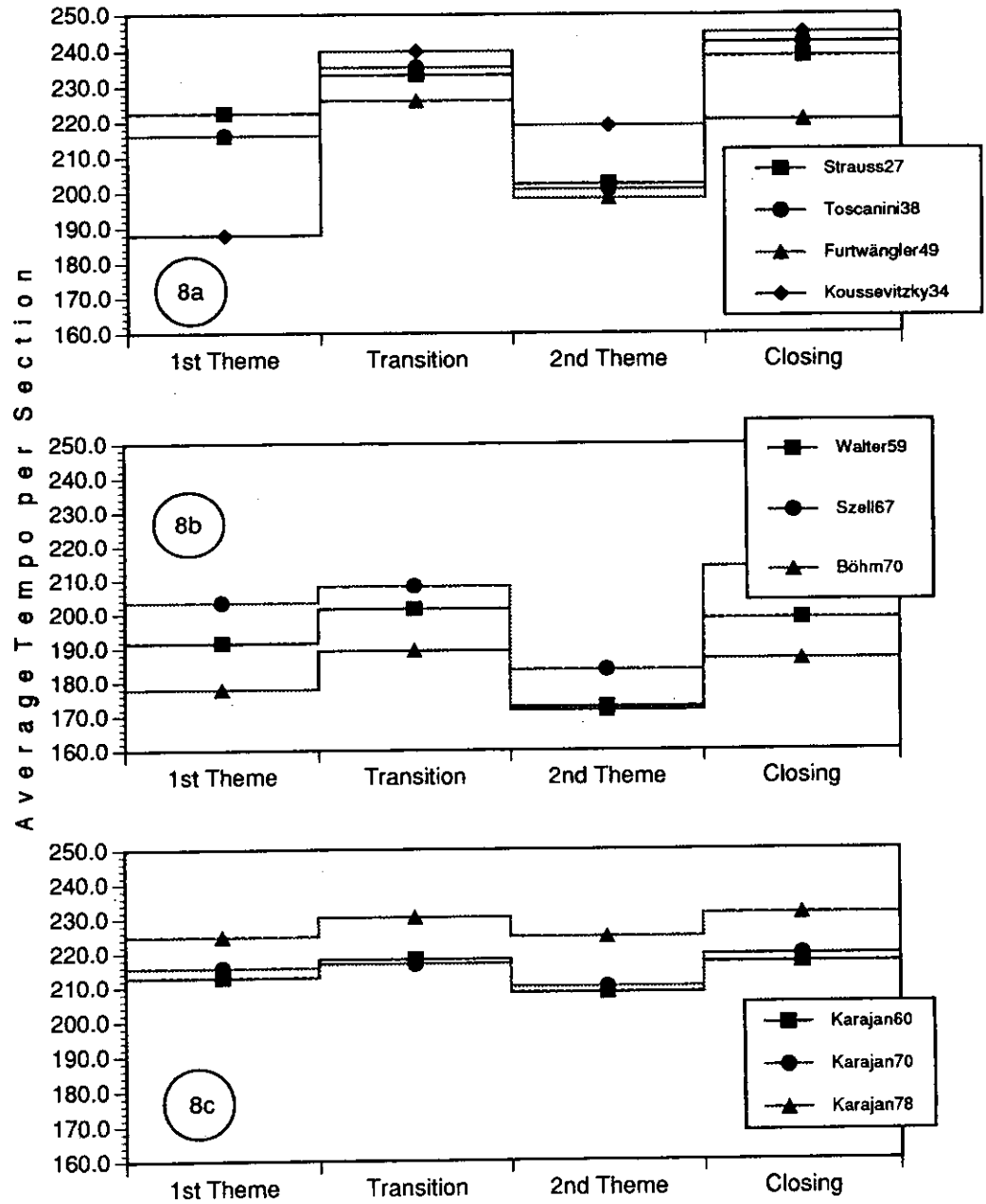


Figure 8. Mozart Symphony No. 40: Average Tempo by Section

for the second theme. Again it is Karajan's performance (fig. 8c) which almost manages to eliminate this tradition.

Interpretive ideology doesn't always govern practice. They may have been from different camps in the rhetoric of interpretation, but Walter and Furtwängler, "the romantics," and Toscanini and Strauss, "the literalists," all preserve the tradition of slowing down for the second theme. And despite Strauss' claims to objectivity, his performance contains a huge tempo increase to create a climax at measure 65. Similarly, tempo modulation occurs in none of the original instrument recordings (fig. 7e), despite the evidence which suggests it was a performance practice in Mozart's day. Türk, Czerny, and Hümmel all specified that a performer could and should hold back the tempo at the more lyrical moments like second subjects. All, of course, stressed that these changes of tempo should be "imperceptible."⁵⁹ Walter pauses just before he begins the second subject and this perhaps diminishes the noticeability of the tempo change he has engineered. Could this be a surviving oral tradition?

Norrington and Hogwood, like Toscanini and Strauss before them, believe the answer is no and largely blame Wagner. Toscanini loudly denounced these tempo changes as part of a Wagnerian tradition of over-interpretation, and indeed, Wagner did champion the idea that the tempo should change when the character of the music changes. To Wagner that was the principal role of the conductor.⁶⁰ He also stressed that these changes should be "imperceptible" (*unmerklich*).⁶¹ The English music critic Henry Smart, however, wrote that Wagner usually took the second subject a full third slower than the tempo of the main allegro.⁶² If Smart's mathematics are correct (which seems impossible), Wagner's tempo shifts would be significantly greater than any of these conductors.⁶³

FLEXIBILITY

Recent recordings get progressively flatter over time, both within and between sections. (See figs. 7 and 8.) The first movement of Beethoven's Symphony No. 5 produces a similar pattern to that found in the Mozart: the early recordings are more likely to include tempo modulation and more likely to use that tempo modulation to structure the piece.⁶⁴ However, the two possible sorts of tempo flexibility: dramatic section shifts (large-scale flexibility) and tempo variation within a single section (small-scale flexibility) are not correlated in any obvious way. We can explore this further by reorganizing the data.

The exposition of the first movement of the Beethoven Symphony no. 5 appears to be getting shorter (fig. 1a). Graphing the average tempo for each

section against the year of the performance gives three new graphs (figs. 9a, 9b & 9c).⁶⁵ The average tempo for the first and final sections has not changed during the recorded history of the work. For the second theme, however, the tradition of slowing down has been on the decline since Nikisch's recording (fig. 9b). This increase in tempo has not only caused some of the decrease in duration, but it also indicates a loss of large-scale flexibility; it is no longer fashionable to change tempo for this section.

We can also gain a rough measure of the flexibility (both large and small-scale) by directly comparing tempo to duration. Fig. 9d plots the duration of the exposition in minutes for each performance against the initial tempo for that same performance. The results provide some measure of the overall flexibility of the performance. The "metronome line" indicates what the duration would be if the orchestra stuck to the tempo unflinchingly, like a marching band; it is the simple mathematical relationship between tempo and duration.⁶⁶ The average flexibility line is a linear regression. As expected, most performances take longer than the metronome to complete the section; between fermatas and ritardandi there is in general more relaxation than acceleration. Performances above the "metronome line" represent more relaxation (slowing down and stopping), those below more compression (speeding up). Given the fermatas in the beginning, it is surprising that anyone manages to end up with greater compression than relaxation and the Beethoven graph looks somewhat like we expect; slowing is more common than rushing. In some works the opposite is true, however. In the exposition of the opening movement of the Mozart Symphony No. 40, the tradition of speeding up the closing (see fig. 8) causes the average flexibility line appears below the metronome line.

Performances which are near each other on this graph sound similar and most conductors' performances cluster together. (This again suggests that the graph presents an objective correlate of a heard phenomenon.) Stokowski's and Szell's three performances are in close proximity. The bottom part of the graph finds most of the conductors who claim a modernist interpretive ideology (including Tjeknavorian who claims to be the only one to take Beethoven's metronome markings). The isolated performances around the outside (clockwise: Boulez, Klemperer, Nikisch, Weingartner, Furtwängler, Strauss, Tjeknavorian, Norrington, Hogwood and Mengelberg) sound extreme by most standards and those in the middle more average. While Toscanini, Karajan and Reiner bunch together near the average flexibility line, Furtwängler's five performances are literally all over the map. As distance and direction from the line indicate sameness, Solti also offers three quite different readings. While this is a useful rough

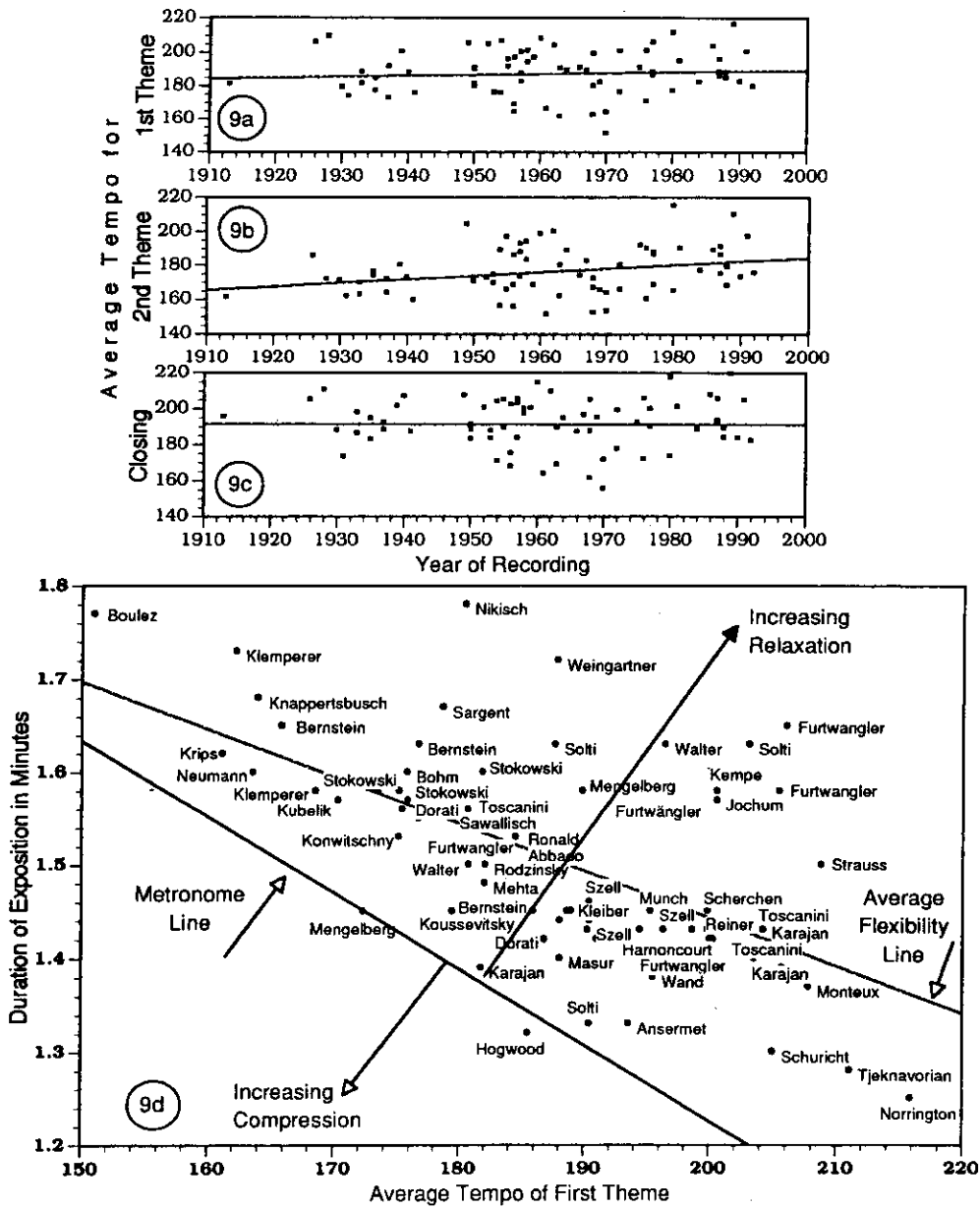


Figure 9. Beethoven Symphony No. 5, First Movement: Tempo and Flexibility Graphs

guide to flexibility, this graph must be coupled with additional information to be most fruitful. The Mengelberg performance which appears on the "metronome line," for example, is hardly metronomic. Rather, it balances the relaxation with compression.

FLEXIBILITY & INDIVIDUAL TEMPO MAPS: A CASE STUDY OF TSCHAIKOVSKY, SYMPHONY NO. 6, FIRST MOVEMENT

Unlike the Mozart and Beethoven examples, which have no instructions for tempo changes in their expositions, Tschaikovsky clearly marks the formal divisions of the first movement of his sixth symphony with changes of tempo. After a slow introduction, the exposition begins *Allegro non troppo*. This exposition has an unusual form in that the second subject which is marked *Andante* occurs twice separated by material (marked *Moderato mosso*) which does not return.⁶⁷ The development begins with a marked *Allegro vivo*. Despite Tschaikovsky's repeated directions to accelerate during the initial *allegro* (measures 67 and 73; see fig. 11b), however, many of the modernists try to hold the tempo flat during this section.

In fig. 10a, which is based upon the average tempo of each bar, the solid line represents the metronome markings of the first edition. Again note the greater diversity of approach among early recordings (fig. 10a) when compared to later ones (fig. 10b) and especially the variety in the *Moderato mosso* section.

We can do our most detailed investigation of the differences between performances by looking at individual tempo maps for not only the average tempo per bar, but the actual tempo from beat to beat.⁶⁸ While these data remain a bit overwhelming in their complexity, and only one performance can really be shown at a time, the variation in the width of the line gives another indication of how flexible the performance is: the amount of "wobble" for each conductor seems to vary as a function of small-scale flexibility (see figs. 11c & d).⁶⁹

Figs. 11a and b display performances by Muti and Svetlanov: an Italian and a Russian. Both are typical of their nationalities and of the modern era; both favor extreme tempo variation between sections and little variation within sections. (The sections are more easy to identify here than in any of the four maps which follow.) Both avoid Tschaikovsky's own directions to increase the speed during the opening *allegro*. Despite their reputation, most Russian performances are flat and uninflected. Muti's second rendering of the second subject (arrow) follows the common pattern of being noticeably more impassioned than the first. Svetlanov is unusual in that

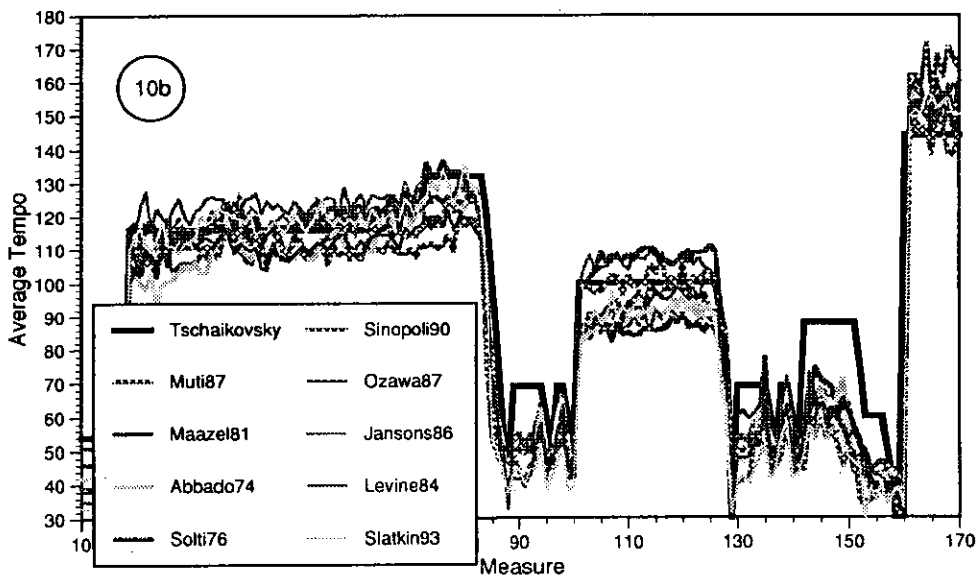
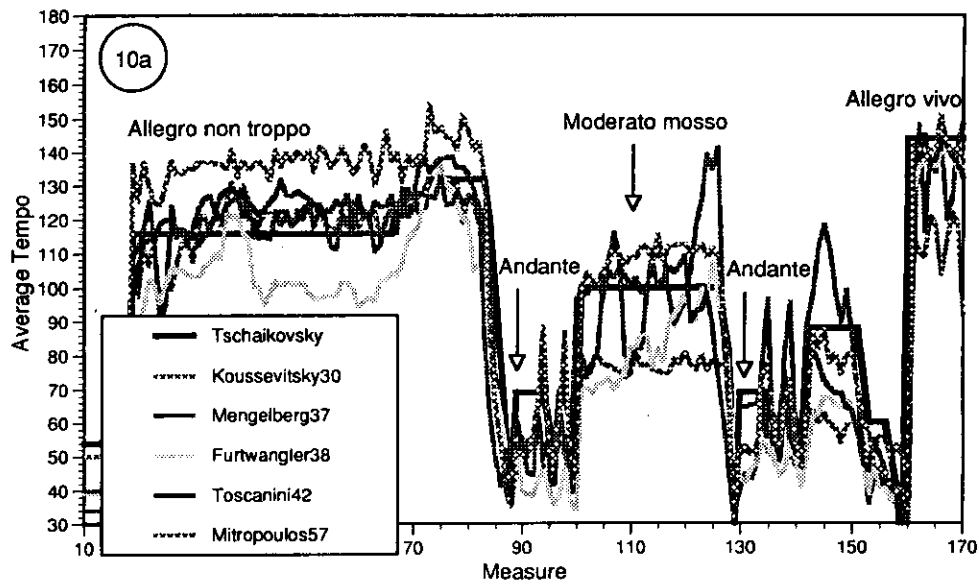


Figure 10. Tschaikovsky Symphony No. 6, First Movement Exposition: Tempo Maps of Average Tempo per Bar

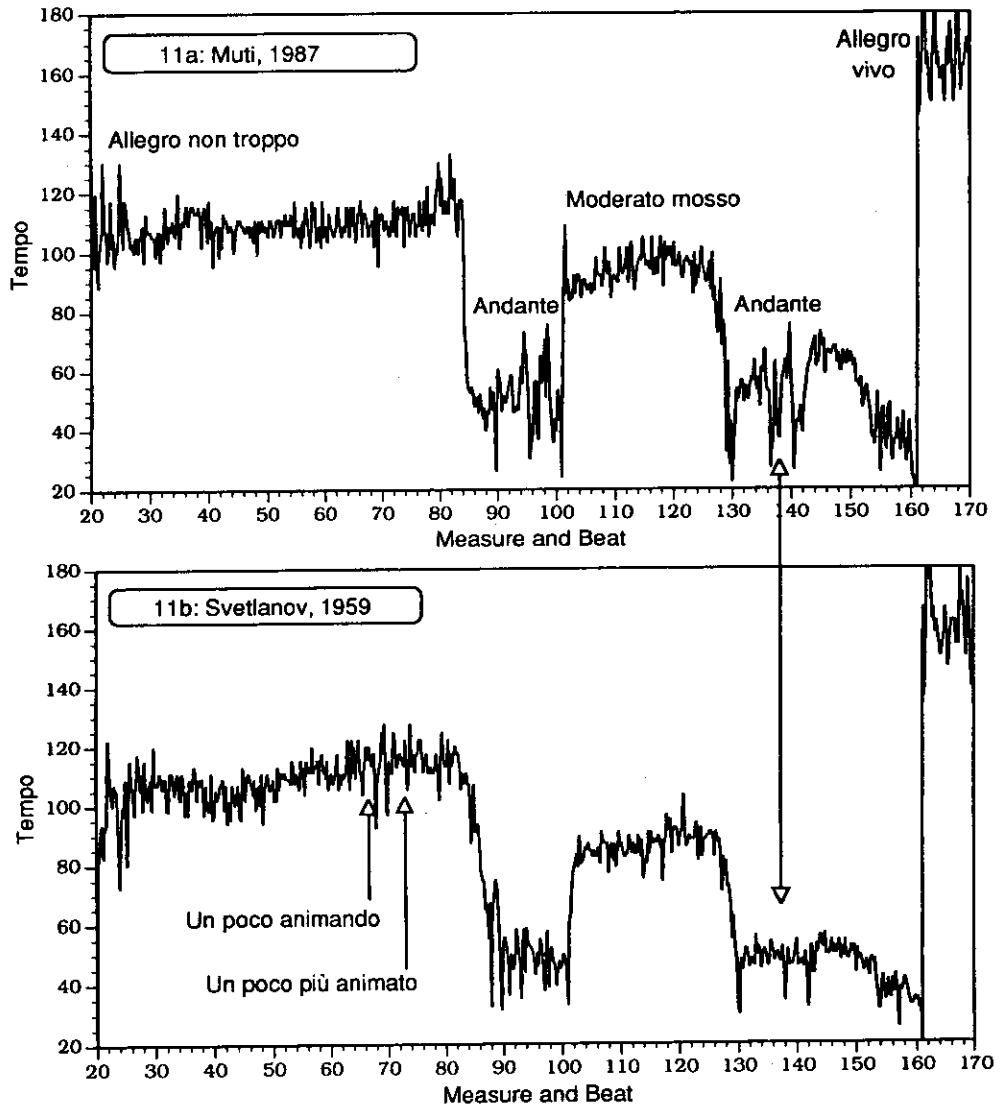


Figure 11. Tschaikovsky Symphony No. 6, First Movement: Tempo Maps with Tempo per Beat

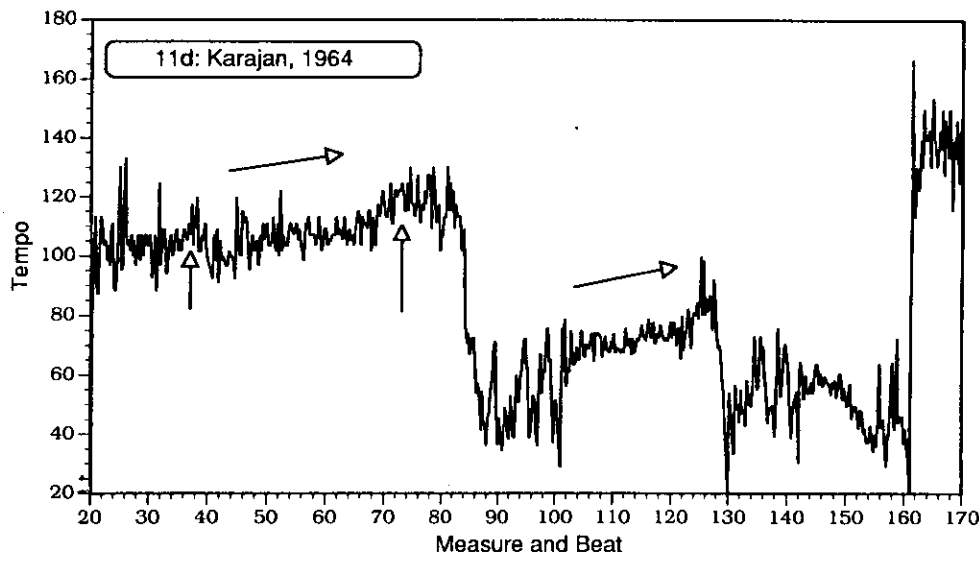
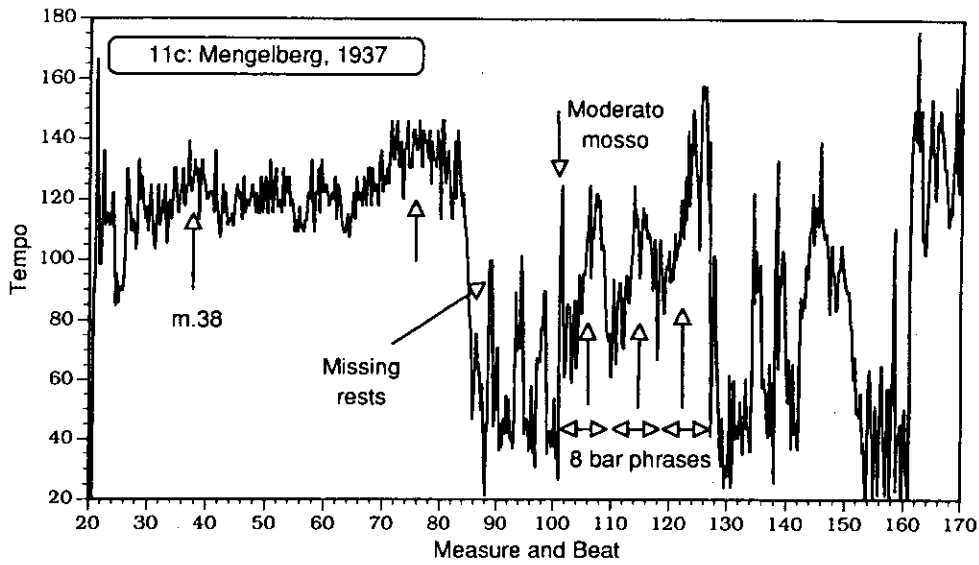


Figure 11. *continued*

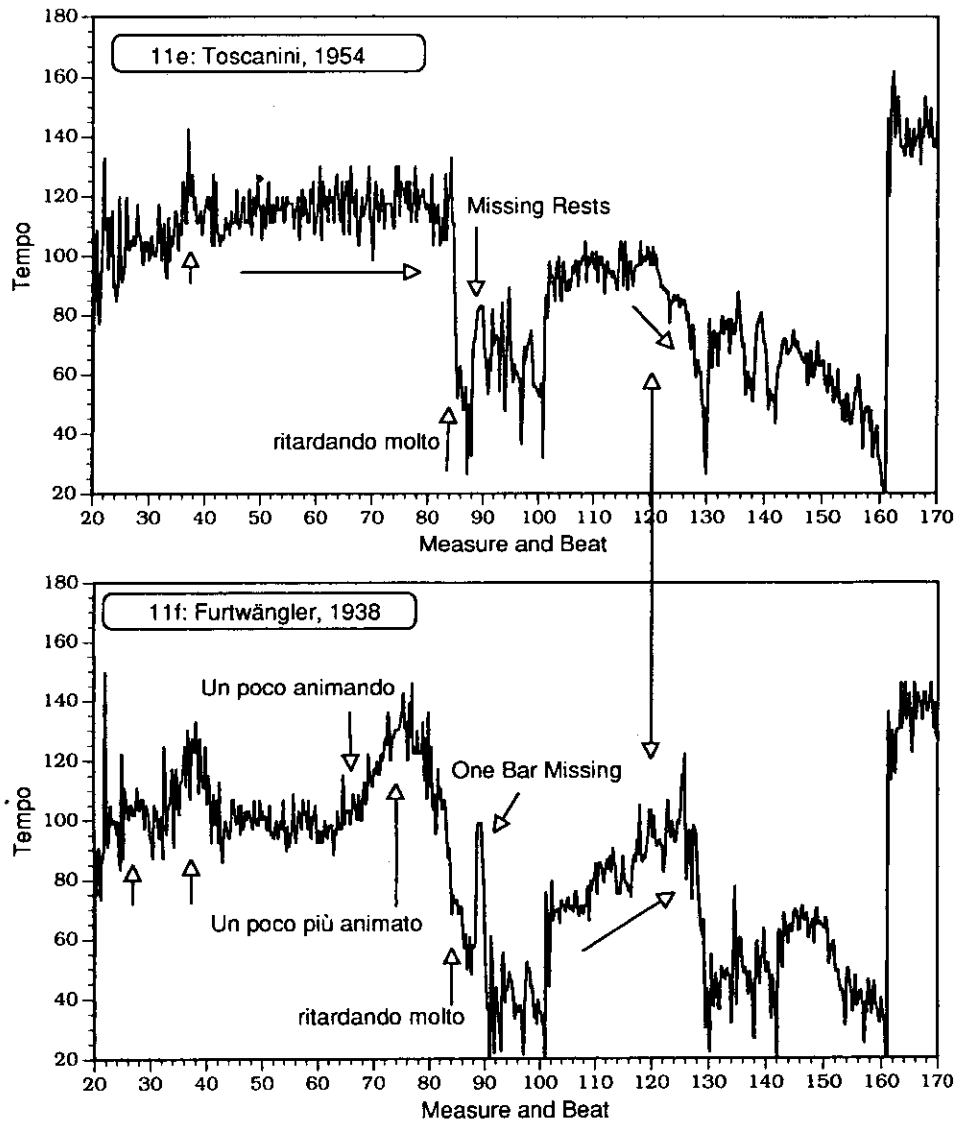


Figure 11. *continued*

his second rendering of the second subject is very even, ignoring Tschai-kovsky's own detailed and specific directions to accelerate and slow down.

Mengelberg's performance (fig. 11c) is unique and this figure displays his flexible and gradual approach to tempo modulation. Mengelberg's map is the widest in both the large scale (he has both the fastest and the slowest section-tempos) and in the "wobble" of the line (the flexibility from beat to beat.) He exhibits flexibility on all levels; section, phrase and beat. The most prominent tempo modulations, though, are the large shifts within the phrase. It is this tempo phrasing (the gradual sloping up and down of tempo) which most characterizes his performance. In the *Moderato mosso* section, for example, we can see how Mengelberg shapes each 8-bar phrase with an increase and then a decrease of tempo.

In addition to flexibility, in which Mengelberg's performance is extreme even by his own standards, we can also see many of the specific interpretive traditions which are typical of all conductors of his generation. First, there is a tendency not to settle into the *allegro* until after the climax at measure 38. In all of the early recorded performances this climax is accompanied by an acceleration and deceleration. (Note its absence in the Muti and Svetlanov performances.) Mengelberg also follows (or sets?) the tradition of not including Tschai-kovsky's fermata in measure 88 and all of the rests in measure 89 before the beginning of the second subject ("missing rests" arrow).

Karajan's Tschai-kovsky, it turns out, is less "modern" (i.e., flat) than his Mozart and Beethoven. While some conductors conduct all composers the same way, Karajan's style changes considerably when he changes repertoire. His Tschai-kovsky performance is flatter than Mengelberg's; nevertheless it preserves some of the inflections of the older performances. We see some (slight) tempo change at the climaxes in measure 38 and in measure 73 (where Tschai-kovsky specifically calls for an *accelerando*). While the evidence suggests that Karajan rather than Toscanini initiated the modern conducting style of steady tempos, this performance retains greater flexibility. The changes between sections are less steep and Karajan's second subject reflects more of Tschai-kovsky's impassioned directions than either Muti or Svetlanov. Both his *allegro* and his *moderato mosso* retain the slope of earlier performances as well.

Figs. 11e & f present the 1954 recording by Toscanini; and Furtwängler's only Tschai-kovsky recording, a 1938 performance with the Berlin Philharmonic. First note how similar the two performances are; they are both products of their conductors' nineteenth-century roots, but neither performance involves the wider tempo phrasing of Mengelberg or Koussevitzky.

Both conductors begin the movement slowly and mark the climax in measure 38 with tempo changes; Furtwängler does this in a more pronounced manner. For both, the *allegro* seems to begin in earnest in measure 42 where Tschaikovsky has marked the violins *saltando*. Both of the performances also ignore the fermata in measure 88, just before the second subject. Toscanini is kind enough to at least count most of the rests, if rapidly, but Furtwängler, far from lingering over this moment as he is so often accused, connects the high F# in the violas to the high F# in the violins and in doing so eliminates an entire measure. (See arrow)⁷⁰

The differences, however, are equally impressive. While both recordings include a slight increase in tempo to the high F# in measure 38 and then a ritard, the Toscanini recording is relatively even after this point. It is Furtwängler who obeys Tschaikovsky's repeated instructions to increase the speed and build the climax. At the end of the *allegro* it is Furtwängler who, like Mravinsky, begins the *ritardando* early while Toscanini waits until it has been prescribed in the score (arrow).

In the *moderato mosso* section (beginning in bar 101 just after the second subject), Furtwängler shapes the entire section into one larger phrase (unlike Mengelberg, who makes each 8 bar phrase into a huge tempo increase and then decrease). Toscanini holds it fairly steady until measure 121, when he begins a huge ritard 6 measures before it is called for in the score. Furtwängler at this point is continuing to build to the woodwind fortissimos in measure 123.

Thus while Toscanini claimed that he was peeling away layers of romantic tradition, especially in regard to Tschaikovsky, he follows most of the same traditional tempo fluctuations as Mengelberg, Koussevitzky and Furtwängler. The changes he does introduce often completely ignore the score. (He ignores the *animato* marks and begins the ritard, marked in measure 127, in measure 121.)

If we magnify the picture (the same data but on a smaller scale map) and focus just on the first statement of the second subject (measures 90–100 shown in example 1), we can see once again that repeat performances by the same conductor, even years later with different orchestras, yield similar results not only in general approach but down to the details of single notes and phrases.

Virtually everybody performs this section slower than the quarter = 69 marking it carries. While Koussevitzky can't get through measure 94 without a huge ritard (fig. 12a) Karajan manages to wait until Tschaikovsky asks for it in measure 95 (fig. 12b). The performances by the older generation again appear to be more angular and have more tempo modulations. In

Andante $\text{♩} = 69$ con sord. (*teneramente, molto cantabile, con espansione*)

89 *p* 90 91 92

93 *f* 94 95 *mf* 96 *f* *mf*

97 *f* 98 99 *mf* 100 *f* *mf*

incalzando *ritenuto* *come prima* *ritenuto*

Example 1. Tchaikovsky Symphony No. 6, First Movement, Second Subject

each case the conductor's last recordings (shown in black) tend to make the *ritardandi* bigger. (Fig. 12c)

This is even true for Toscanini (fig. 12e). (In fact, Toscanini adds the same dip at the end of measure 93 as Ormandy's last performance.) Compared to Toscanini, Furtwängler looks positively literal; his recording hardly looks out of place next to Jansons' and Inbal's typically steady modern recordings. (Fig. 12f)

The similarities extend beyond separate performances by the same individual to schools. All of the Russians (fig. 12i), including the recent Pletnev and Bychkov recordings, looks very much the same. The modern tradition (fig. 12h) appears to honor Tchaikovsky's *incalzando* followed by *ritenuto*. Magnitude, of course, is the issue. Large tempo modulations, even when indicated by the composer (perhaps especially in this case where the composer is so often accused of having an overly romantic compositional style as well) are still considered unfashionable. The modern tradition has retained the general outline of performances by Mitropoulos, Mengelberg and Erich Kleiber (fig. 12g) while reducing the magnitude of those changes. The modern tradition for this work, therefore, rejects both the Koussevitzky and Toscanini variants and opts for one descended via Karajan from Mengelberg and Erich Kleiber; we might think of this as the central German tradition.

CONCLUSIONS

The conclusions about methodology and the nature of the data are quite straightforward. The most general points include:

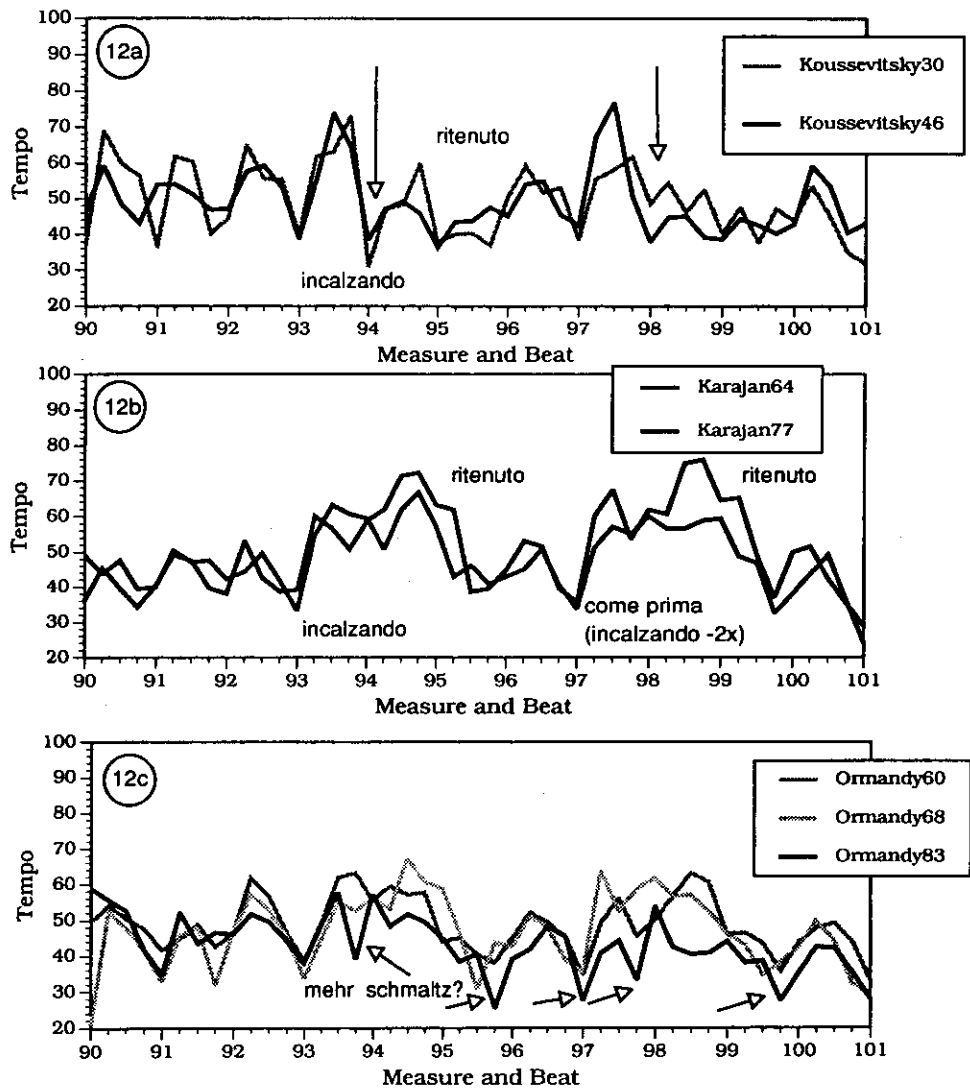


Figure 12. Tchaikovsky Symphony No. 6, First Movement:
Tempo Maps of Second Subject

1. While detailed listening to individual performances is crucial, historical investigations of performance traditions must use data sets as large as possible.
2. Tempo and duration are only generally inversely related so duration and durational proportions should be measured directly.

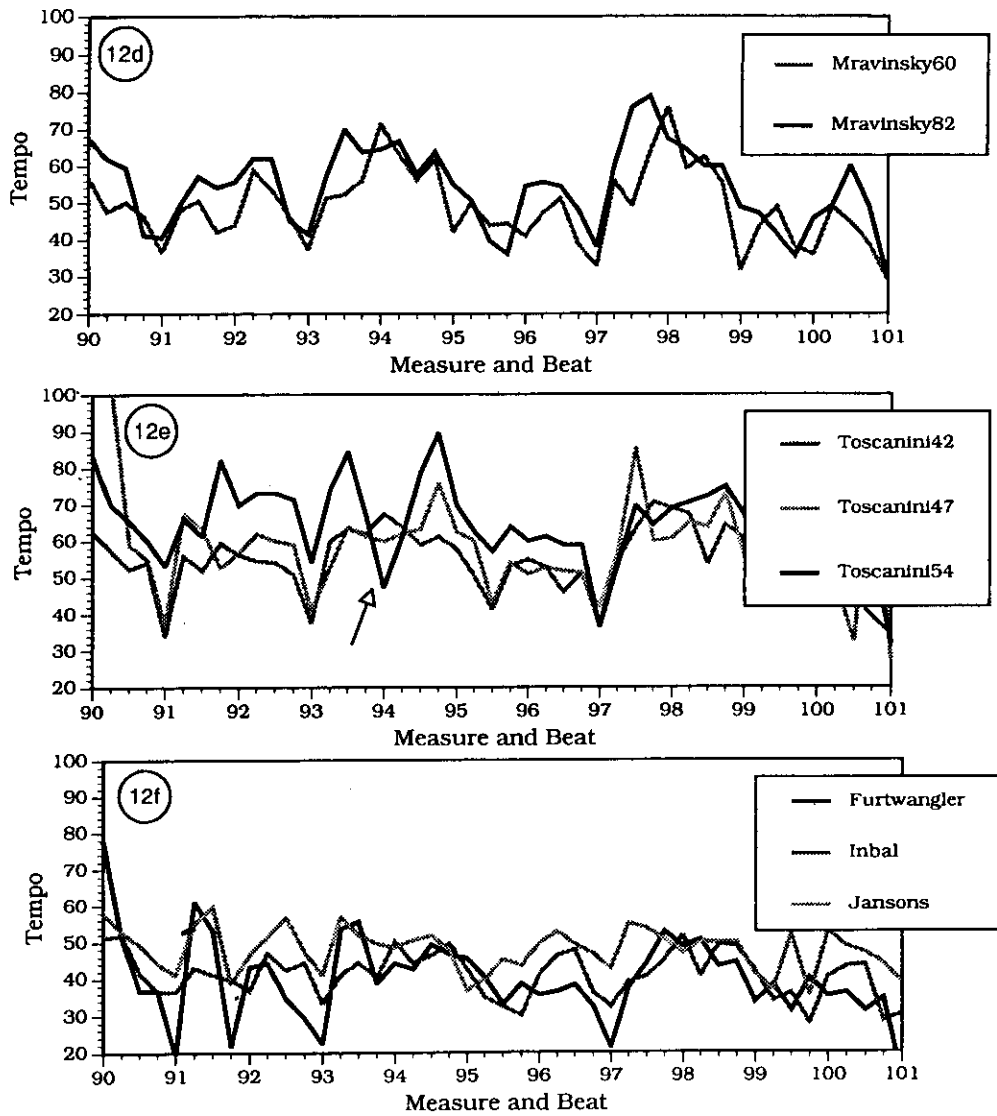


Figure 12. *continued*

3. Tempo data should be measured in the most accurate way possible and on the smallest level. While there is human error in the method related here, it is not cumulative, and accuracy of averages increases with the number of data points.

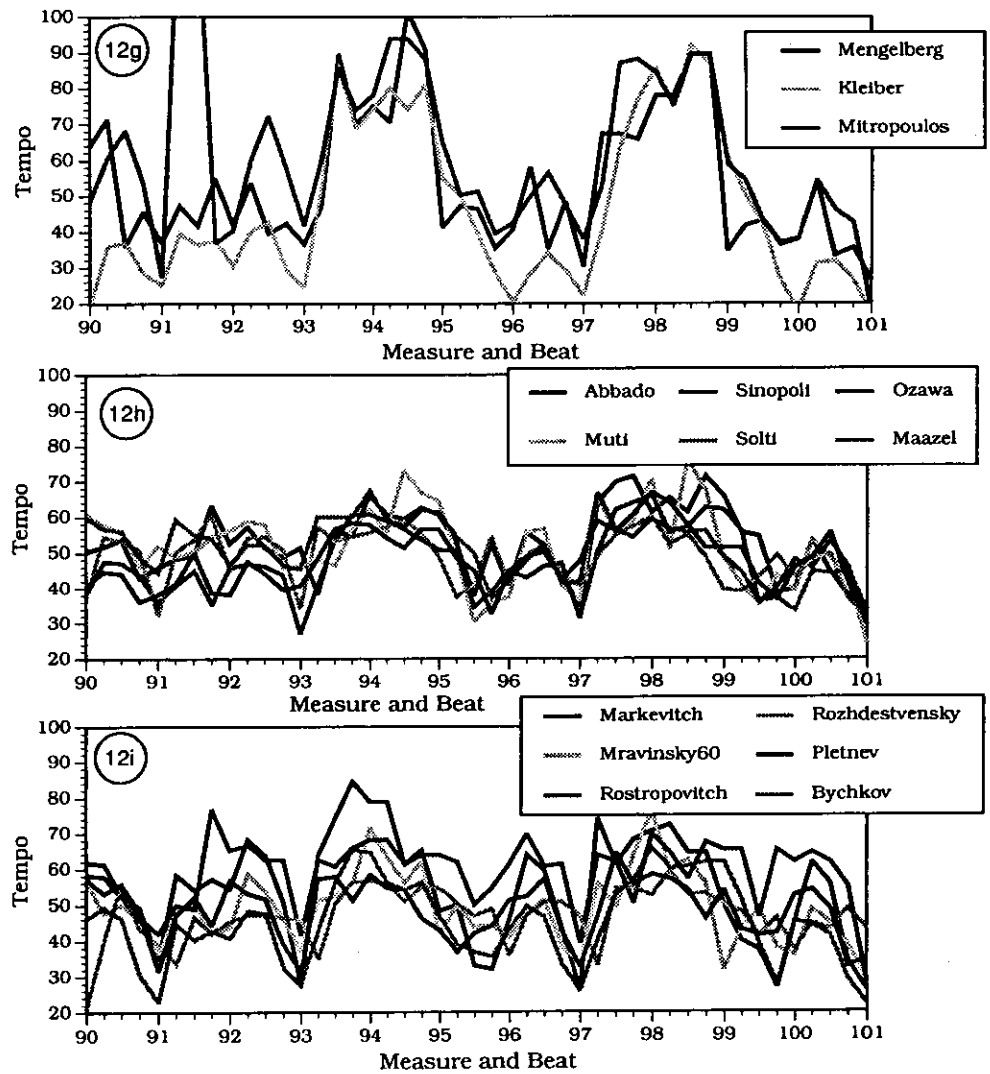


Figure 12. *continued*

4. There are two, perhaps three, unrelated levels of flexibility: sectional, phrase, and bar. Sectional or large-scale flexibility alters the tempo of an extended passage like a second subject. Small-scale flexibility involves smaller adjustments that take place either on the phrase or the bar level.

5. These levels of flexibility can and do change independently; a reduction in the use of small-scale flexibility may or may not be accompanied by a change in the use of large-scale flexibility.

6. Tempo tolerance (the amount of fluctuation in the average tempo tolerated in a musical culture or period) should be measured and not prescribed.

Beyond this, however, the conclusions become historical and cultural.⁷¹

1. Musical works neither automatically speed up nor slow down as they become more familiar. Some individual works demonstrate performance trends, but these must be individually tested with large data sets.

2. Even the most "improvisatory" conductors seem to retain a single conception and execution of the piece despite the effects of age, geography and personnel. Therefore, it should be possible to discover the characteristics of a conductor's style which are independent of any single work.⁷²

3. Conductors from the first half of this century preserve a greater interpretive independence while conductors from the second half of the century sound more alike. While a number of factors including new (or not so new) ideologies about role of the performer, have contributed to this, so has the rise of international jet travel and recordings.⁷³

4. Conductors from the first half of this century use more tempo fluctuation in more diverse ways than conductors from the second half of the century. While it is clear that tempo rubato was a common nineteenth-century performance practice,⁷⁴ it is difficult to know how much of even mid-nineteenth-century practice remains in the recordings of Nikisch, Toscanini and Mengelberg.⁷⁵ It is clear, however, that flexibility on all levels has been decreasing since mid-century.

5. In late romantic works with (usually marked) sections of contrasting material (Tschaikovsky and Mahler, for example), modern performances are often flat within each section but sometimes *increase* the dramatic shifts between sections (compare fig. 11a with fig. 11c). Muti's and Svetlanov's Tschaikovsky sections are internally flat, but the sections are clearly differentiated from each other (figs. 11a & b). Early recordings tend to contain large numbers of smaller tempo fluctuations. With acceleration at the beginning and slowing and the end of each new phrase or section (figs. 11c & f); the edges of sections are de-emphasized or blurred. The flexibility and flux of these "barely perceptible" internal tempo changes turn, in modern performances, into larger, "structural" tempo shifts between sections.⁷⁶ Perhaps large-scale sectional tempo change in these pieces is intended to compensate for a loss of small-scale internal rubato?⁷⁷

6. Interpretive ideology often appears to influence performance, but not always in the predicted manner. Conductors from the same generation tend to share traits as period style appears stronger than ideology. (Despite Toscanini's and Furtwängler's opposing rhetoric, their recordings, and those of virtually all of the early conductors, are especially rich in phrase flexibility.)

7. Finally it must be emphasized that individual works often manifest shifts in performance practices; these shifts are crucial to the way the work is heard, received and interpreted. We must continue to break down the conceptual barriers which compartmentalize discussions into those about works and those about performance. We cannot have one without the other.

Similarly, future performance studies should look on the one hand at period, geographical, institutional, generic, instrumental and individual artistic styles, and on the other, at specific traditions in the performance histories of individual musical works. As with the more familiar musicological investigation of compositional style, we need to understand the stylistic conventions to understand what makes the individual unique and vice-versa. In turn, this history of interpretation forms a rich intersection between the traditional studies of musical scores and the ever-increasing interest in the cultural context of music production.

NOTES

An early version of this paper was read at the 11. *Internationaler Kongreß der Gesellschaft für Musikforschung: Musik als Text* in Freiburg, Germany October, 1993. My thanks to Karol Berger, Nicholas Cook, Hermann Danuser, Laurence Dreyfus, Thomas Grey, Herbert Lindenberger, Bruno Repp and Richard Taruskin for their comments on the many drafts of this paper, to Philip Prescott for his help with the statistics, and to John Spitzer for editorial suggestions.

1. Ingarden classifies them as "intentional objects." Roman Ingarden, *The Work of Music and the Problem of Its Identity* trans. by Adam Czerniawski, ed. Jean G. Harrell (Berkeley and Los Angeles: University of California Press, 1986), 9–23, 34–40.
2. José A. Bowen, "The History of Remembered Innovation: Tradition and Its Role in the Relationship Between Musical Works and Their Performances." *Journal of Musicology*, 11 (1993), 139–173.
3. Richard Wagner, "On Conducting" in *Richard Wagner Prose Works*. trans. William Ashton Ellis, 2nd ed. 8 vols. (London: Kegan Paul, Trench, Trüber & Co. Ltd., 1895) 4, 314.
4. Beethoven's interest in tempo and metronome markings is well documented. In the *Wiener Vaterlandische Blätter* of October 13, 1813, he said "I look upon the invention of the metronome as a welcome means of assuring the performance of my compositions

everywhere in the tempo conceived by me, which to my regret have so often been misunderstood." A detailed discussion can be found in William S. Newman, *Beethoven on Beethoven: Playing his Piano Music his Way*. (New York: W. W. Norton & Co., 1988), 84ff.

5. Anton Schindler, *Beethoven as I Knew Him*, 2 vols. in 1, trans. Constance S. Jolly, annot. Donald W. MacArdle from the 3rd ed. of 1860. (Chapel Hill: The University of North Carolina Press, 1966), 423 fn.
6. For a more detailed account of the historical relationship between theory and practice see: José A. Bowen, "Mendelssohn, Berlioz and Wagner as Conductors: The Origins of 'Fidelity to the Composer'," *Performance Practice Review*, 6 (1993), 77-88. For discussion of the twentieth-century battles see Richard Taruskin, *Text and Act: Essays on Music and Performance* (Oxford: Oxford University Press, 1995).
7. The implications of these ideas for musicology and for performers are discussed respectively in two articles: José A. Bowen, "Finding the Music in Musicology: Studying Music as Performance" in Nicholas Cook and Mark Everist, eds., *Rethinking Music*, (Oxford: Oxford University Press, in press) and José A. Bowen "Performance Practice versus Performance Analysis: Why Should Performers Study Performance?" *Performance Practice Review*, 9 (1996), 16-35.
8. Adolf Bernhard Marx, *Anleitung zum Vortrag Beethovenscher Klavierwerke* (Berlin, 1863), 105, or 3rd ed. (Berlin: Behncke, 1898), 62; Theodor W. Adorno, "Neue Tempi," (1928) in *Moments musicaux: Neu-gedruckte Aufsätze 1928-1962* (Frankfurt: Suhrkamp Verlag: 1964), 74-83.
9. Richard Taruskin, "The Pastness of the Present and the Presence of the Past," in Nicholas Kenyon ed., *Authenticity and Early Music: A Symposium*, (Oxford: Oxford University Press, 1988), 187; rpt. in *Text and Act: Essays on Music and Performance* (Oxford: Oxford University Press), 134.
10. Gilbert Kaplan, "A Dirge? No. It's a Love Song" *New York Times* (Sunday, July 19, 1992); Robert Philip, *Early Recordings and Musical Style: Changing Tastes in Instrumental Performance 1900-1950*. (Cambridge: Cambridge University Press, 1992), 35-36.
11. Joachim Braun's study of the Beethoven Fourth Symphony uses metronome markings to argue that modern performances are from 5% (in the fast movements) to 23% (in the slow movements) slower than Beethoven intended. Joachim Braun, "Beethoven's Fourth Symphony: Comparative Analysis of Recorded Performances," *Israel Studies in Musicology* 1 (1978), 54-71.
12. For further discussion of Beethoven's metronome marks and the surrounding debate see Sandra P. Rosenblum, *Performance Practices in Classic Piano Music*, (Bloomington: Indiana University Press, 1989) and William S. Newman, *Beethoven on Beethoven: Playing his Piano Music his Way*. (New York: W. W. Norton & Co., 1988).
13. Nicholas Temperley, "Tempo and Repeats in the Early Nineteenth Century," *Music & Letters* 67 (1966), 323.
14. While the data points are accurate, these linear regressions represent only one way of analyzing them. These regression lines are useful, and indicate, in most cases, real trends, but three notes of caution must be sounded: (1) The lines vary in their mathematical reliability. (2) The lines assume the data is fully independent, but this is false. As with all historical data, the past can influence the future, but not vice-versa. (3) The lines are not predictive; the future is culturally, not mathematically, bound.
 - (1) While only one possible linear regression line exists for each set of data, not every line is equally reliable. As there is always an equation which gives a "best possible fit" given the data, it is possible to draw a line even when there is absolutely no trend. "R-squared" is a measure of how good the fit is so a bigger number represents a better

fit; it explains what percent of the variation is explained by the change in time. "P" is a measure of the chance that the null hypothesis is the likely one; when p is smaller than 0.05 the trend is said to be significant. For fig. 1a, R-sq = 8.5% and p = 0.013; there is a "significant" downward trend, but only 8.5% of the data is "explained" by the variation in year. For fig. 1b p = 0.747 so a straight line would be just as accurate a description of the trend. For fig. 1c, R-sq = 26.4% and p = 0.001, so the trend is highly significant.

(2) This line is most reliable in the years where there are the most data points. In fig. 1a the computer concludes (as we might) that Nikisch's performance was longer than the average performance in 1913 since it is the longest performance on record. That is both logical and mathematical, but the computer is not "looking" for historical change; it assumes that each performance carries equal weight, when in fact the early performances carry more. (Early performances can influence the tempo of later ones, but not vice-versa.) *It is impossible without further recordings to tell if Nikisch's performance was average or exceptional for its day.*

(3) The linear regression lines do not indicate likely future performances. As with most economic data, the predictive power of statistics is greatly limited since the future data will be created by human decisions. The point of these graphs is NOT predictive. Future performances, like past performance, will be governed by taste.

15. While p = .33 indicates that the trend is not significant, we can see that except for Previn, Inoue and Maazel, none of the conductors who favor the very longest performances (Bernstein, Horenstein, Walter, Szell, Klemperer, Barbirolli and Konoye) are still alive.
16. Barbirolli's live 16 January, 1967, recording with Heather Harper and the BBC Symphony Orchestra in Prague is perhaps two or three seconds longer (Suisa, CD, 1992: INCD 7291).
17. That said, J. B. Steane cites compelling evidence to suggest that many very early recordings by singers were faster in the studio than they were on the stage: J. B. Steane, *The Grand Tradition: Seventy Years of Singing on Record* (London: Duckworth, 1974), 10. I do not doubt that there are many more individual examples of this (it might even be the explanation for the lengthening of the Brahms Piano Concerto No. 2), but it is not a universal trend in symphonic music.
18. Is a studio recording really closer to an "ideal" reading because of the lack of external variables such as audience and hall size? The German music critic Martin Elste has advocated "Discology" as a separate branch of musicology partly due to the difference between recorded music and live music. While this difference exists, I would not want to obscure the fact that it is the very relationship between performance and music which has changed since the advent of recording technology. In addition to the worldwide dissemination of exact replicas of specific performances, studio recordings have changed our view of music. Musicians who grew up with only live music are, for example, more likely to view performance as an opportunity for something new to come into the world, rather than as an obligation to recreate what has happened in the studio.
19. While it is easy to discover examples of this "trend" it is equally easy to discover examples to the contrary. Karajan's three performances of the Mozart Symphony No. 40 (fig. 1b) get progressively shorter, not longer, for example. Large and systematic studies are needed to establish what and for whom trends exist.
20. Claudio Arrau, Carlo Maria Giulini (EMI, 1963, CD reissue CDM 7 69178 2, 1988); Claudio Arrau, Bernard Haitink (Philips, 1969, CD reissue 438 320-2, 1993).
21. Emil Gilels, Fritz Reiner (RCA, 1958, CD reissue 60536-2, 1991); Van Cliburn, Fritz Reiner (RCA, 1961, CD reissue 7942-2-RG, 1988).

22. I discuss the methodology for dealing with these problems at length in "Finding the Music in Musicology: Studying Music as Performance" (cited above, fn. 7).
23. All of the examples shown here deal with sections or movements without repeats in order to eliminate discrepancies between duration and tempo which might occur due to the performance of a different number of bars. In the Beethoven example in fig. 1, the Toscanini (1933), Furtwängler (1930), Mengelberg (1940), Walter (1959), Stokowski (1969) and Szell (1977) versions without repeats were recorded. In the graphs which follow, the total durations of these movements have been adjusted by adding the time of another exposition so that all comparisons are for the same number of performed bars. Figs. 1 and 2 demonstrate the different durations for performances of exactly the same number of measures.
24. The initial tempo for the Beethoven is the calculated average of the average tempo in each of the first six bars of the movement. (The average tempo per bar is calculated from measurements of the placement of each beat as described below.) The initial tempo of the Mahler is the calculated average of the average tempos of bars 4–15 which Mahler labels *haupttempo*. In both cases this gives what would be expected to be the main tempo of the movement. A general average of all measures is meaningless, since it includes all of the changes for following sections and fermatas. It gives a number which is related to duration and therefore eliminates the point of comparison we wish to make. These calculations record higher numbers for the performances which feel faster.
25. See below for a discussion of how a computer was used to make these measurements.
26. Duration is given in minutes for the first 50 bars or 150 beats; i.e., 150 beats divided by tempo in beats/min.
27. In fact, this section is full of traditional tempo shifts. See my "Finding the Music in Musicology: Studying Music as Performance" (cited above fn. 7).
28. Paul Banks, "Aspects of Mahler's Fifth Symphony: Performance Practice and Interpretation," *Musical Times* (May 1989): 262.
29. Joachim Braun, "Beethoven's Fourth Symphony: Comparative Analysis of Recorded Performances," *Israel Studies in Musicology* (I, 1978): 60.
30. Of course, tempo also affects how we perceive structure, but we need not digress into music psychology to clarify that the assumption that a new tempo automatically affects the durational proportions of a work is incorrect.
31. Each performance is plotted four times with all four points being aligned vertically. The linear regression has been calculated separately for each series of data. The metronome marks on the score are given using the symbols for the corresponding section along the far left axis of the graph; these four symbols correspond only to those metronome marks and not to any actual performance.
32. Each section is given as a percentage of the whole which the computer represents as 1; the y axis, therefore, is labeled as proportions of that whole.
33. While the authenticity of the tempo markings in the printed editions is unresolved, they were at least influenced by Tchaikovsky's conducting of the premiere in 1893.
34. For some sections this is relatively easy. The opening *adagio* contains 72 beats which are marked at 54 beats/minute for a calculated duration of 1.33 minutes. The *allegro non troppo* consists of 270 beats marked at 116 beats/min for 2.33 minutes. The difficulty here is that *un poco animando* is marked at measure 67, and *un poco più animato* (with a mark of 132) at measure 73, and a *ritardando molto* at 84. I calculated the duration for each section assuming 124 beats/minute following the *un poco animato*, and 85 beats/min following the *ritardando*, for a total of 2.31 minutes. The rest of the durations were calculated similarly with an extra four beats being added for the fermatas in measures 160 and 305. Fermatas (both here and in fig. 6) were calculated

as twice their notated duration. None of this implies that I believe composers care about such things.

35. Allowing some time for ritardandi in the calculated durations would raise these proportions a bit, but that would only make it more puzzling why all of the real conductors with their slower tempos, do not give this section significantly more time. It appears that conductors using slower tempos are less likely to slow down for ritardandi.
36. A complete case study of the Mahler Symphony No. 4 is forthcoming in José A. Bowen, "Mahler, Authenticity & Authority."
37. Given that tempo may or may not affect proportion, the importance of tempo and proportion to the identity of the musical work should be considered separately. Tempo is often justified as an important part of the work because of the resultant change in scale and duration. (This is Banks' argument, for example: Banks, 262.) Here I would like to consider the importance of tempo as an independent variable, regardless of its effects on proportion.
38. Nelson Goodman, for example, finds that metronome marks are binding, but that, in general, tempo is an "auxiliary direction." Any performance at any tempo "however wretched," therefore, is still a performance of the musical work. Nelson Goodman, *Languages of Art*, 2nd ed., (Indianapolis: Hackett Publishing Co., 1976), 185.
39. Phenomenology and aesthetics are both involved here. The essential question is which tempos are tolerated and, therefore, reproduced. A tempo may be too extreme either because the work is unrecognizable (to a particular audience) or because it is judged unpleasant. In either case, tempo tolerance is a social and audience-specific construction.
40. For a detailed discussion of this theoretical framework, see José A. Bowen, "The History of Remembered Innovation."
41. Henry Smart, "Review" *Sunday Times* [London] June 17, 1855. While Wagner complained about the overly fast tempos of his day, the balance of the evidence suggests that Wagner's own conducting exhibited new extremes of both fast and slow tempos. See José A. Bowen, *The Conductor and the Score: A History of the Relationship Between Interpreter and Text in the Generation of Mendelssohn, Berlioz and Wagner*, 3 vols. (Ph.D. diss., Stanford University, 1994).
42. Hector Berlioz, *Grand traité d'instrumentation et d'orchestration modernes contenant: le tableau exact de l'étendue, un aperçu du mécanisme et l'étude du timbre et du caractère expressif des divers instruments, accompagné d'un grand nombre d'exemples en partition, tirés des oeuvres des plus grands maîtres, et de quelques ouvrages inédits de l'auteur.* (Paris: Schonenberger, 1844); *Instrumentationslehre*, ed. Richard Strauss (Leipzig: G. Heinz, 1905); trans. Theodore Front (New York: Kalmus, 1948), 246. Berlioz, therefore, encouraged composers to leave metronome marks.
43. Hector Berlioz, *Memoirs*, trans. David Cairns (New York: W. W. Norton, 1975), 276. Of course even Berlioz must have allowed for some range of tempo.
44. Another of Wagner's innovations was also the change of the tempo within the movement: i.e., what in the next section I call flexibility.
45. Matthew Dirst has come to similar conclusions in his study "Tradition and Authenticity in a Bach Chorale Prelude," *American Organist*. Vol. 25, 3 (1991), 59.
46. A conclusion shared by Braun, op. cit., 55.
47. Braun, op. cit., 58.
48. K. E. Behne, *Der Einfluß des Tempos auf die Beurteilung von Musik*, (Cologne, 1972), 121. Braun's fn. 6 also includes references to N. Garbuzov, *Zonnaja priroda tempa i ritma*, (Moscow, 1950), 9, and A. Wellek, *Musikpsychologie und Musikästhetik*, (Frankfurt, 1963), 246.
49. Plus or minus 17 is approximately the same as my 30% variation from the highest value.

50. The initial aim was to create a program which could identify the conductor of a recording by analyzing and comparing tempo fluctuations and could then conduct a virtual orchestra in the style of any conductor. (My great thanks to Daniel Oppenheim and his program *D-mix* for making all of this possible.) A huge data-base of tempo fluctuations was needed. While it is possible to input music (in any number of forms) and get the computer to identify all of the events (notes), it is very difficult (for a computer) to determine the pulse and hence the tempo. Humans rather easily create a rhythmic hierarchy out of enormous variation in volume, accent and duration, but this mechanism which allows us to tap our feet remains something of a mystery. While an algorithm will eventually be developed, it is some years away. Another method of data entry was required.
51. This program for Macintosh was created for me in 1992 by James Davis, then a graduate student in Stanford's Computer Science Department. While the Macintosh clock is initially limited to an accuracy of 1/60th of a second, this can be increased to 24 decimal places—far more accuracy than is needed.
52. DeltaGraph Professional 3.5 (for Macintosh) was used but Excel would do many of the same functions. Neither of them can handle the entire data set of all performances of all works (a grid of 10,000 measures by 10,000 performances is needed), but DeltaGraph can handle a data set for a single piece (10,000 measures by 100 of performances). Excel cannot. Only SAS/GRAPH is capable of handling the largest data sets. More information is available in José Bowen, "A Computer-Aided Study of Conducting" in *Computing in Musicology*, ed. Eleanor Selfridge-Field and Walter Hewlett (1994).
53. The computer measured the time between events to many more decimal places than the human ear can detect. Compared to the inaccuracy of the human hand and mind, the minor delay from the keyboard (at least six decimal places beyond the necessary two) was completely immaterial.
54. Independent research has confirmed these levels of accuracy using similar methods and control tests. See Nicholas Cook, "The Conductor and the Theorist: Furtwängler, Schenker and the first movement of Beethoven's Ninth Symphony," in ed., John Rink, *The Practice of Performance: Studies in Musical Interpretation* (Cambridge: Cambridge University Press, 1995), 114. More accurate measurements can be made when studying piano music. Piano rolls leave a physical trace (see Hermann Gottschewski's dissertation, *Interpretation als Kunstwerk*, Freiburger Beiträge zur Musikwissenschaft, hrsg. Hermann Danuser, Bd. 4 (Laaber: Laaber Verlag, 1996) and there are a number of ways to extract timing data from disclavier pianos or MIDI files (see Bruno Repp "On Determining the Basic Tempo of an Expressive Music Performance" *Psychology of Music* 22 (1994), 157–167 and Peter Desain and Henkjan Honing, "POCO: an Environment for Analyzing, Modifying, and Generating Expression in Music" in *Music, Mind and Machine, Studies in Computer Music, Music Cognition and Artificial Intelligence* (Amsterdam: Thesis Publishers, 1992). Further information about POCO can be obtained from poco@psych.kun.nl.).
- Using frequency analysis to extract tempo data is accurate but extremely time-consuming for piano music. It is virtually impossible for any stretch of ordinary orchestral music. While it would provide slightly more accurate data, it is a measured accuracy beyond what most of us actually hear, and virtually all of the gain is wiped out when the times between beats are averaged to give an average tempo per bar (the measurement used in most of the graphs which follow).
- Finally, while most of the small "wiggle" in the lines (see fig. 7) comes from the human error, we might equally note that human listeners do not perceive any "wiggle" in these performances.
55. In Bruno Walter's case, the two recordings are from 1950 in Berlin with the Berlin Philharmonic Orchestra (Japan: King Record Co., CD: KICC 2073, 1990) and in 1959

- in Hollywood with the Columbia Symphony Orchestra (CBS Records CD: MB2K 45676, 1989).
56. The goal of performance analysis is not to reduce interpretation to numbers (anymore than it is the goal of compositional analysis to reduce compositions to diagrams) but rather (like compositional analysis) to develop empirical methods which will aid our investigation and provide insight into the differences between performances.
 57. Toscanini even uses tempo fluctuation to shape the phrases in the closing section.
 58. For these graphs a long stretch of average tempos per bar were averaged: 1–15 for the first section, 28–40 for the transition, 45–57 for the second section and 88–99 for the closing. Bars between the sections which might have additional fluctuations (like the caesura added by Walter in measure 44) were eliminated. Again each line (or symbol) refers to a single performance.
 59. Daniel Gottlob Türk, *Klavierschule, oder Anweisung zum Klavierspielen für Lehrer und Lernende*. (Leipzig and Halle: Schwickert; Hemmerde und Schwetschke, 1789), 372; Carl Czerny, *Über den richtigen Vortrag der sämtlichen Beethoven'schen Klavierwerke*. Chapters 2 and 3 of *Die Kunst des Vortrags*. Facsimile ed. Paul Badura-Skoda, (Vienna: Universal, 1963), 87; Johann Nepomuk Hummel, *Ausführliche theoretisch-praktische Anweisung zum Pianoforte Spiel vom ersten Elementar-Unterrichte an bis zur vollkommensten Ausbildung*, (Vienna: Tobias Haslinger, 1828), 417–418. See José A. Bowen, "Rubato and the Second Subject: a Performance History" (forthcoming).
 60. Richard Wagner, *Über das Dirigieren* (Leipzig: Breitkopf und Härtel, 1869) in Julius Kapp, ed., *Gesammelte Schriften*. (Leipzig: Hesse & Becker Verlag, 1914) vol. 9, 153–229.
 61. Wagner, op. cit., 181. Like Czerny, Wagner prescribes it only for selected locations.
 62. He [Wagner] reduces the speed of an allegro—say in an overture or the first movement—fully one third on the entrance of its cantabile phrases." Henry Smart, *Sunday Times* (London), June 17, 1855.
 63. That, at least, would corroborate Toscanini's and Hanslick's view of Wagner's conducting and Weingartner's view of von Bülow's conducting as too much of a good thing. See Eduard Hanslick, *Hanslick's Music Criticism*, trans. and ed. Henry Pleasants (New York: Dover Publications, 1988), 106; Felix Weingartner, *Über das Dirigieren* (1895) trans. Ernest Newman as "On Conducting" in *Weingartner on Music and Conducting: Three Essays by Felix Weingartner* (New York: Dover Publications, 1969), 16–23.
 64. Tempo maps for this movement can be found in José A. Bowen "Can a Symphony Change? Establishing Methodology for the Historical Study of Performance Styles" in (*Bericht des Internationalen Kongress der Gesellschaft für Musikforschung: Musik als Text*, (Freiburg: Bärenreiter, in press).
 65. The average tempos for each section are calculated from all of the beats in measures 25–55 (first theme), 59–80 (second theme), and 101–122 (closing). Figs. 9a and 9c do not show statistically significant trends while fig. 9b does.
 66. The number of beats divided by the beats per minute (i.e., the tempo) give the duration: Duration (in minutes) \times Tempo (beats/minute) = Beats.
 67. Note that the tradition of "imperceptibly" slowing the second theme has become not only quite perceptible, but codified in the score: Tschaikovsky marks the second theme of his sixth symphony *andante*. This is an example of how performance and composition are intertwined: it was surely the same idea that a lyrical or "feminine" second theme should contrast with the main "masculine" theme that led conductors to slow down Mozart's second themes, and Tschaikovsky to compose a slower theme here.
 68. Of course, there is no tempo between beats, but the duration between two beats can be turned into a tempo measurement.
 69. The previous tempo maps have only plotted average tempo per bar which is clearly a more accurate measure; error in a single measurement is often canceled out by another. The individual measurements are less accurate and surely most of the "wiggle" in each

line is due to the error of the measurement. (Other studies have eliminated the error wiggle by averaging or simply by using a cruder form of measurement.) Still, there do appear to be differences in the amount of wiggle. Large-scale flexibility can also be seen in the gross tempo changes between sections. The increased detail neither hinders nor improves our perception of these large-scale changes.

70. To be fair, it is possible that this was a later splice; since this is the only sound-document we have of Furtwängler's Tschaikovsky, we can't know for sure.
71. More detailed information about the cognitive nature of tempo fluctuations in music can be found in hundreds of journal articles and books about music psychology. (See Alf Gabrielsson's excellent overview and bibliography of music performance research in D. Deutsch ed. *The Psychology of Music* 2nd ed. forthcoming.) Musicological research into performance, however, is more focused on historical change and the cultural contribution to what performers do and why.
72. That, in fact, was the original aim of this research. See fn. 50.
73. Richard Taruskin argues that a desire for uniformity of metrical pulse and "true solidity" entered with twentieth century aesthetics. (Taruskin, "The Pastness of the Present," 110-112) See also Bowen "Mendelssohn, Berlioz and Wagner as Conductors: The Origins of 'Fidelity to the Composer'."
74. See Richard Hudson, *Stolen Time: The History of Tempo Rubato* (Oxford: Clarendon Press, 1994).
75. While we can never fully discover the magnitude of tempo shifts employed by Wagner from written sources, a study which combined the early recorded evidence with written evidence might prove interesting (comparing Weingartner's recording of Beethoven's Ninth to his detailed criticism of von Bülow's and Wagner's performances, for example).
76. This also corroborates Taruskin's observation that expressive gestures have become formal and structural devices in this century. Taruskin, "The Pastness of the Present," 161.
77. Note that this seems only to happen in large late-romantic works and not in Mozart, Beethoven, or any "early music." See José A. Bowen, "Mahler, Authority and Authenticity" (forthcoming).

ABSTRACT

Even a symphony, with its highly specific orchestral score, changes through performance, so the sound of music in performance, and not just the score, should be the "text" of musicology. This paper describes a series of new analytical techniques which make use of simple tempo and duration measurements and a computer data base. Hundreds of performances of symphonies by Mozart, Beethoven, Brahms, Mahler and Tschaikovsky were studied. Sections are presented on historical trends in tempo (claims that the repertoire are slowing down or speeding up are false), tempo and duration (they are not exactly inversely related), duration and proportion, tempo tolerance (which is culturally and not mathematically determined), tempo fluctuation, tempo maps, performance of exposition structure, and flexibility. Both historical and methodological conclusions are presented.