3 **Rhythm in language and music**

A recent series of empirical studies has focused on the relationship between the rhythm of language and musical rhythm. Specifically, the experiments focus on the linguistic concept of *stress-timing* vs. *syllable-timing* in language and the degree to which the rhythmic characteristics of spoken languages in the two categories are reflected in 19th century instrumental music.

### 3.1 Stress-timed vs. syllable-timed languages

Rhythm in spoken language is an effect involving the regularity of occurrence, or a measure of *isochrony*, of some type of speech item; the item can be a speech unit (such as a syllable) or a linguistic event (such as accent or stress). Languages may be categorized as *syllable-timed* (for example, French and Spanish) or *stress-timed* (for example, English and German).\(^1\)

In a *stress-timed* language, stressed syllables are perceived to occur regularly, resulting in an expansion or compression of individual syllables in order to accommodate the recurrence of the stresses. Example 3.1 adapts an example from Fox (2000) illustrating this concept. In each of the six examples, the vertical lines represent equal intervals of time; the length of individual syllables within each utterance is compressed or expanded

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\(^1\) This typology was initially put forward by Pike (1945: 34-35) and reiterated in Abercrombie (1965, 1967) and others. There is a third category of *mora-timed* languages, but the only language consistently assigned to this category is Japanese.
to maintain a perceptual isochrony between the stressed syllables immediately following
the vertical lines.

Example 3.1: Illustration of regularity of stresses: adapted from Fox (2000)

(a) | four | large | black | dogs |
(b) | seventy | terrible | menacing | elephants |
(c) | seventy | large | menacing | dogs |
(d) | four | terrible | black | elephants |
(e) | four | unfortunate | ceased | dogs |
(f) | seventy unsuccessful | old | administrator |

or

(f) | seventy unsuccessful old administrator |

In contrast, in a syllable-timed language such as French, individual syllables are
perceived to be of nearly equal duration and therefore occurring at regular time intervals.
In addition, since French does not have lexical word stress, there are not notable
fluctuations of pitch or amplitude to lend prominence to individual syllables. Thus,
according to MacCarthy (1975), “continuous French spoken fluently by native speakers
conveys the general auditory impression that syllables in each group … are being uttered
at a very regular rate.”

The linguistic classifications of syllable-timed and stress-timed are controversial ones.
Repeated attempts to empirically illustrate the classification of syllable-timed and stress-
timed languages have failed to quantifiably confirm strict adherence to the principle of
isochrony. However, many linguists agree that the principle of isochrony can underlie
the rhythm of a language even if it is not manifested phonetically in an experimentally

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3 Beckman (1992), Laver (1994).
demonstrable fashion.⁴ As Laver (1994) says, “the concept of an approximately isochronous rhythm in speech has been so tenacious in the history of phonology and phonetics that it seems unlikely that it is completely without foundation.”⁵ Laver, Lehiste (1977) and Couper-Kuhlen (1993) regard isochrony as primarily a perceptual phenomenon, describing it as a “subjective” rather than “objective” isochrony; the perception of isochrony on either the syllabic or the stress level is dependent upon the human cognitive tendency to impose rhythm upon things occurring with some semblance of regularity, such as a clock ticking, the sound of footsteps, or the motion of windshield wipers. Lehiste (1977) and Couper-Kuhlen (1993) point out that because differences in duration between stresses or syllables are well below the threshold of perception, we still perceive the unit to be recurring isochronously even though the principle cannot be proven quantitatively.

Some of the strongest evidence for the perceptual-based theory of linguistic isochrony comes from studies done on language acquisition and categorization in infants. Numerous perceptual studies demonstrate that infants are able to discriminate on the basis of rhythm between sentences in their native language and sentences from a language belonging to another rhythmic class.⁶ In addition, Nazzi, Bertoncini and Mehler (1998) demonstrated that French newborns are capable of discriminating between rhythm classes other than that of their own syllable-timed language. Infants in the study were capable of cross-category discrimination between English (stress-timed) and Japanese (mora-timed), but

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⁶ Ramus, Nespor and Mehler (1999), p. 266 offers a long list of studies on infant perception of speech rhythm.
not capable of within-category discrimination between two stress-timed languages, such as Dutch and English. This illustrates that the rhythm of speech plays an important role in the perception of language, as the French newborns were able to discriminate between languages with different rhythmic classifications but not able to discriminate between two languages with the same rhythmic classification.\(^7\)

Other recent research demonstrates that perceptual processes involved in discriminating language on the basis of rhythm are not limited to human beings. Similar categorical perception tasks have been documented in tamarin monkeys, and Toro and Trobalón (2005) have recently demonstrated that rats exhibit the same ability to discriminate between languages with different rhythmic structures, in this case Dutch and Japanese.\(^8\)

3.2 \textit{nPVI}

Despite the failure of experimental attempts to demonstrate quantifiable isochrony in stress-timed and syllable-timed languages, recent studies (most notably Grabe & Low 2002 and Ramus \textit{et al.} 1999) have demonstrated that there are quantitative rhythmic differences between stress- and syllable-timed languages.\(^9\) These studies have focused on the role of vowel duration in the two types of languages; they hypothesized that since vowels are primarily responsible for the length of a syllable, an increased variability in vowel length would result in greater variability in syllable length, whereas a language


\(^9\) Wenk (1987) is also a notable study, although it focuses on another distinction in linguistic rhythm, the concept of \textit{leader-timed} vs. \textit{trailer-timed} languages.
with little variation in vowel length would have little overall variation in syllable length.

Grabe and Low studied languages that fell under the traditional categories of stress- and syllable-timed languages and determined that the durational variability of vowels in a stress-timed language is in fact quantitatively greater than that of a syllable-timed language.

The model Grabe & Low developed to measure the amount of durational variability in a language is called the normalized Pairwise Variability Index, or nPVI, defined as:

\[
\text{nPVI} = 100 \times \frac{\sum_{k=1}^{m-1} \left| \frac{d_k - d_{k+1}}{d_k + d_{k+1}} \right|}{m-1}
\]

In this equation, \(m\) is the number of vocalic intervals\(^{10}\) in an utterance and \(d_k\) is the duration of the \(k\)th interval. The nPVI focuses on the average difference in duration between successive durations. It is a normalized measure: each difference in duration between successive events (represented by \(d_k - d_{k+1}\)) is divided by the mean duration of the two intervals ((\(d_k + d_{k+1}\)) / 2).

As stress-timed languages will have greater durational variability between successive vocalic intervals due to the compression and expansion of syllables, the average difference in duration will be higher; therefore, the expectation is that stress-timed languages will have a higher nPVI measurement than syllable-timed languages with

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\(^{10}\) “Vocalic intervals” simply refers to measured vowels; the span of time in between vowels is called an “intervocalic interval.”
lower variability. Ramus et al. (1999) also tested this hypothesis using a slightly different algorithm.

Grabe and Low (2002) studied eighteen languages traditionally classified as stress-timed, syllable-timed, mora-timed, mixed, or unclassified. Example 3.2 reproduces the results for the stress and syllable timed languages only, as those are the most relevant here.

**Example 3.2: nPVI values for stress-timed and syllable-timed languages (Grabe and Low, 2002)**

Overall, the nPVI values for the languages historically considered to be stress-timed exhibited a statistically significantly higher nPVI than those considered to be syllable-timed, demonstrating the higher variability in syllable duration in stress-timed languages. The results for Ramus et al. (1999) were similar. In addition, the results illustrate a

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11 Ramus et al. (1999)
continuum within the categories of stress-timed and syllable-timed languages. French and Spanish are on the low end of the nPVI range for syllable timed languages, while Singapore English and Tamil are on the high end; thus French and Spanish may be said to be more strongly syllable timed than Singapore English and Tamil.

3.3 Applying the nPVI to music: four studies

While the nPVI was originally intended to be a measure of the average variation of successive vocalic intervals in spoken language, Patel and Daniele adapted it for use in studying the relative durational contrast between successive rhythmic events in music in their article published in Cognition in 2003. In the Winter 2003 volume of Music Perception David Huron and Joy Ollen published a follow-up study, to which Patel and Daniele published a response in the same issue (Patel and Daniele 2003b). In 2004 Daniele and Patel published a study similar to Patel and Daniele (2003b) in the Proceedings of the 8th International Conference on Music Perception & Cognition. Each study takes a slightly different approach to the application of the nPVI to music; the following sections summarize the methodology and results from each previous study.

3.3.1 Patel and Daniele (2003)

The initial study by Patel and Daniele (2003) used the nPVI measure to study fragments from British and French instrumental music to determine if rhythmic differences in the spoken languages were reflected in the rhythm of music written by composers who spoke those languages.
The musical material for Patel and Daniele’s study was drawn from the Barlow and Morgenstern *A Dictionary of Musical Themes, 2nd Edition* (1983), and focused on 19th–20th century composers who were native speakers of British English and continental French. The themes studied were selected using very strict criteria including the elimination of all vocal music; the elimination of instrumental works whose titles suggested a vocal origin, as well as instrumental works belonging to genres with particular rhythmic patterns (such as waltzes, gigues, gavottes and marches); and the elimination of works for children and works intended to imitate or evoke another culture.

In addition, the themes had to have a minimum of twelve notes, no rests, no fermatas, and no grace notes, and there had to be a minimum of five eligible themes from that composer. These restrictions narrowed the number of themes eligible for the study to a total of 319 themes from six English and ten French composers, shown in Example 3.3.

**Example 3.3: Musical material studied in Patel and Daniele (2003)**

<table>
<thead>
<tr>
<th>English composers</th>
<th>No. of themes</th>
<th>French composers</th>
<th>No. of themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arnold Bax</td>
<td>9</td>
<td>Claude Debussy</td>
<td>48</td>
</tr>
<tr>
<td>Frederick Delius</td>
<td>20</td>
<td>Vincent D’Indy</td>
<td>12</td>
</tr>
<tr>
<td>Edward Elgar</td>
<td>41</td>
<td>Gabriel Fauré</td>
<td>25</td>
</tr>
<tr>
<td>Gustav Holst</td>
<td>18</td>
<td>Arthur Honegger</td>
<td>8</td>
</tr>
<tr>
<td>John Ireland</td>
<td>11</td>
<td>Jacques Ibert</td>
<td>12</td>
</tr>
<tr>
<td>Ralph Vaughan Williams</td>
<td>38</td>
<td>Darius Milhaud</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Francis Poulenc</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Maurice Ravel</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Albert Roussel</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Camille Saint-Saëns</td>
<td>36</td>
</tr>
<tr>
<td><strong>Total no. of themes:</strong></td>
<td><strong>137</strong></td>
<td><strong>182</strong></td>
<td></td>
</tr>
</tbody>
</table>

Patel and Daniele used Grabe and Low’s nPVI measure to study the relative durational contrast between successive rhythmic events in their carefully chosen fragments,

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12 Their criterion was that the composer had to be born in the 19th century and died in the 20th.
predicting that the rhythm of instrumental music by British composers would demonstrate a higher durational contrast than that of French composers similar to the higher durational contrast between successive vowels in spoken British English than in spoken French. As a comparison, they used linguistic nPVI values from Ramus (2002). Example 3.4 illustrates both the nPVI values from Ramus (2002) and the nPVI values for Patel and Daniele’s study.

**Example 3.4: Charts from Patel and Daniele 2003**

The results show a significant difference between the rhythm of the French and English themes, with the stress-timed English themes demonstrating the predicted higher durational contrast (Mann-Whitney $U$-test, $U = 10091$, $p < 0.01$). In terms of absolute value, the nPVI for the British English songs is closer to that of the French linguistic nPVI than to that for British English. However, it is not possible to compare the absolute values across the studies, as there are two different units being measured (duration of vowels vs. duration of rhythmic events), and there are two different calculation methods
being used. What is important to note is that the difference in nPVI reflected in the linguistic study holds up to a significant degree in the musical study.

3.3.2 Huron and Ollen (2003)

Huron and Ollen (2003) replicated Patel and Daniele’s study, dramatically expanding the sample size. Their results were consistent with those of Patel and Daniele, although the difference between the mean values for English and French (45.6 and 43.7, respectively) was smaller than that found by Patel and Daniele; nonetheless, the results were significant (Mann-Whitney $U$-test, $U = 414813; p = .027$), indicating the hypothesis holds up even with less stringent sampling criteria.

In addition to confirming Patel and Daniele’s original hypothesis about British English and French, Huron and Ollen (2003) calculated average nPVI values for music written by composers of other nationalities including American, Austrian, Czech, German, Hungarian, Italian, Polish, Russian, Scandinavian (including Danish, Swedish, and Norwegian), and Spanish. These results are reproduced in Example 3.5. They noted that results were comparable for related languages such as American English and British English, for Austrian and German, and for syllable-timed Romance languages such as French, Spanish, and Italian.

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13 Huron and Ollen calculated the nPVI values for every theme in the first (1948) edition of the Barlow and Morgenstern thematic dictionary, for a total of 7784 musical themes.
Example 3.5: Mean nPVI results from Huron and Ollen (2003)

<table>
<thead>
<tr>
<th>Nationality</th>
<th>Normalized Pairwise Variability Index (nPVI)</th>
<th>Standard Error</th>
<th>No. of Musical Themes</th>
</tr>
</thead>
<tbody>
<tr>
<td>American</td>
<td>46.3</td>
<td>1.12</td>
<td>415</td>
</tr>
<tr>
<td>Austrian</td>
<td>42.0</td>
<td>0.65</td>
<td>1194</td>
</tr>
<tr>
<td>Czech</td>
<td>47.1</td>
<td>1.56</td>
<td>232</td>
</tr>
<tr>
<td>English</td>
<td>45.6</td>
<td>0.90</td>
<td>737</td>
</tr>
<tr>
<td>French</td>
<td>43.7</td>
<td>0.73</td>
<td>1188</td>
</tr>
<tr>
<td>German</td>
<td>42.0</td>
<td>0.59</td>
<td>2006</td>
</tr>
<tr>
<td>Hungarian</td>
<td>45.4</td>
<td>1.62</td>
<td>244</td>
</tr>
<tr>
<td>Italian</td>
<td>42.7</td>
<td>1.06</td>
<td>529</td>
</tr>
<tr>
<td>Polish</td>
<td>45.1</td>
<td>1.74</td>
<td>254</td>
</tr>
<tr>
<td>Russian</td>
<td>39.8</td>
<td>0.82</td>
<td>736</td>
</tr>
<tr>
<td>Scandinavian*</td>
<td>45.9</td>
<td>1.79</td>
<td>141</td>
</tr>
<tr>
<td>Spanish</td>
<td>42.5</td>
<td>1.85</td>
<td>108</td>
</tr>
</tbody>
</table>

* Danish, Swedish, Norwegian (Finnish excluded)

3.3.3 Patel and Daniele (2003b) and Daniele and Patel (2004)

Patel and Daniele (2003b) investigated an apparent contradiction in Huron and Ollen’s data: German and Austrian are both stress-timed languages, so the hypothesis would predict a higher nPVI for the German and Austrian themes than the nPVI value for themes associated with syllable-timed languages. However, the results in Huron and Ollen (2003) show an nPVI for German and Austrian themes that is lower than those for syllable-timed Romance languages such as French, Italian, and Spanish (42.0 for both German and Austrian; 43.7, 42.7, and 42.5 for the Romance languages, respectively).

In an attempt to explain this result, Patel and Daniele (2003b) plot the average nPVI for twenty individual German and Austrian composers\(^{14}\) as a function of time based on birth year, expanding their original study from 19th–20th century composers to the time period from 1637–1895. The resulting graph, reproduced in Example 3.6, shows a significant direct relationship between a composer’s birth year and the average nPVI value.

\(^{14}\) For this study, Patel and Daniele used all German and Austrian composers from the Barlow and Morgenstern (1983) who had at least 15 usable themes based on selection criteria similar to that used in Patel and Daniele (2003a) – that is, a much more stringent selection criteria than that used by Huron and Ollen (2003).
Example 3.6: Patel and Daniele (2003): nPVI as a function of composer birth year

The trend line illustrates the best-fitting regression line (nPVI = [0.075 x birth year] – 95.742). The regression of birth year against nPVI is highly significant ($r^2 = .49$, $df = 18$, $p < .01$). As a hypothesis to explain these results, Patel and Daniele suggest the upward trend of the nPVI of German and Austrian composers was not because of any changes in spoken German from more a syllable-timed to a more stress-timed language and its resultant effect on music, but rather was due to the declining influence of Italian music on German composers over the period of time and the rise of nationalism as a musical movement. They claim that “[s]ince Italian music has a low nPVI, the stylistic influence of this music might outweigh any linguistic influence of the German language on the nPVI of German and Austrian music,” and conclude:

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… if one takes a low musical nPVI to be evidence of an Italian influence, then it appears that the influence of Italian music was particularly pronounced during the Baroque (1600-1750) and Classical (1750-1825) eras, with waning influence during the Romantic era (1825-1900).\footnote{Daniele and Patel (2004), p. 761.}

The Italian-influence hypothesis is problematic primarily because it is a \textit{post hoc} hypothesis; that is, Patel and Daniele developed this hypothesis to explain a phenomenon they found in the process of doing the study, rather than developing the hypothesis initially and running the study to determine the validity of the hypothesis. Also, since they developed the hypothesis from the data they used for the study, it is possible that this trend holds \textit{only} for the data they studied and will not hold up to a more robust study.

Daniele and Patel state in their conclusion that “… it is possible that the historical trend we have discovered in German/Austrian music reflects pan-European changes in musical style between 1600-1900.”\footnote{Daniele and Patel (2004), p. 761.} However, it is also possible that the lower musical nPVI for German and Austrian music in this time period is a result of other factors unique to German music and/or the stylistic periods encompassed.

\subsection{The current study}

The current study replicates previous studies in applying an nPVI-based measure to a database of music to determine the degree of influence the rhythmic patterns of language have on the music. However, while the previous studies focused on instrumental music exclusively, the current study consists of vocal music from the 19th century. The previous studies did not study vocal music because they assumed that the rhythmic patterns of
stress-timed and syllable-timed languages would be present. Wenk (1987) did investigate vocal music, but used a very small \( n \) of only two pieces to study differences between British English and French.\(^{19}\) As Wenk (1987) claimed,

A logical starting point for an investigation of linguistic influences on musical form is vocal music, for if such effects are not apparent there, one could hardly expect them to prevail in purely instrumental composition.\(^{20}\)

However, Patel and Daniele ran their study on instrumental music, stating “[i]f music is based on words, and words have different rhythmic properties in the languages under study, then it would be no surprise if musical rhythm reflected linguistic rhythm.”\(^{21}\)

In applying the nPVI measure to the current database of French and German vocal music, a number of considerations were necessary. The previous studies were inconsistent in their handling of rhythmic events that may have a significant impact on the nPVI results. Also, since the previous studies were using short thematic excerpts, it was not necessary for them to be concerned with issues such as phrasing. As the current study uses a much larger corpus of data, some important decisions and modifications to the nPVI calculation were necessary.

### 3.4.1 Rests

Rests indicate the absence of sound at a particular moment. It is important to note that in plainchant notation, there was no symbol for the rest save for a vertical line drawn

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\(^{19}\) Wenk (1987) used the *Messe in sol majeur* by Francis Poulenc (1937) and the *Mass in g minor* by Ralph Vaughan Williams (1922). Wenk compared readings of the text of the ‘Gloria’ from each mass by a native speaker of the language with the rhythmic characteristics of each setting to determine the relationship between characteristics of *leader*– vs. *trailer–timing* present in the language and the music.

\(^{20}\) Wenk (1987), 971.

\(^{21}\) Patel and Daniele (2003). Emphasis added.
through the staff at phrase endings; since the rhythm of the notated music was primarily based on the rhythm of speech, there was no need to indicate silence. Rests with durational specificity only became necessary with the rise of the rhythmic modes in the 13th century; Franco of Cologne referred to the rest as *vox amissa* (‘lost’ note, in contrast to *vox prolata*, ‘sung’ note), and developed a system of notation to indicate these lost notes.  

In monophonic music such as that being studied by Patel and Daniele and Huron and Ollen (as well as in the current study), rests can occur *intra*-phrase or *inter*-phrase; that is, a rest can occur within a phrase or in between two phrases. An *intra*-phrase rest is a rest, typically of a relatively short duration, that does not interrupt the continuity of a phrase and maintains the overall meter. An *inter*-phrase rest maintains the overall metrical organization but creates a perceptual separation between two distinct phrases.

When calculating the nPVI value for musical excerpts, it is necessary to determine what to do with both *intra*-phrase and *inter*-phrase rests. One possible solution is to limit the musical material studied to material that does not contain either type of rest, as was the approach in Patel and Daniele’s original nPVI study (2003) and in their followup to Huron and Ollen (Patel and Daniele 2003b). This exclusion severely limited the amount of material available for their study within their already limited scope of the Barlow and Morgenstern.

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Huron and Ollen (2003) did allow for *intra*-phrase rests; their solution was to add the duration of the rest to the duration of the preceding rhythmic event. This allowed them to use more themes from the Barlow and Morgenstern thematic dictionary, eliminating part of the restriction on musical material faced by Patel and Daniele in their study.

However, this approach assumes that the listener perceives a note preceding a rest as lasting through the duration of the rest. It is questionable whether the musical listener perceives a rhythmic event preceding a rest as extending through that rest or whether, as is more intuitive, the rest is an absence of rhythmic events and therefore should not contribute “duration” to the nPVI calculation.

In addition, the approach results in an artificial lengthening of duration for notes preceding a rest. Depending on the length of the rest and the overall nPVI value of the theme, this lengthening could have a non-trivial effect on the nPVI value of the theme. Example 3.7a shows a hypothetical short phrase of eight quarter notes, an *intra*-phrase measure rest, and then eight more quarter notes.\(^\text{23}\)

\(^{23}\) Obviously a full measure rest may be too large to consider an *intra*-phrase rest; this is for illustration purposes only.
Example 3.7: The effect of a rest on nPVI values

If the rest is eliminated, the nPVI for the entire phrase is 0.0 – that is, there is an absolute minimum amount of rhythmic variety between successive rhythmic events because each successive rhythmic event is the same as the one preceding and following. However, the rest is included as part of the duration of the previous quarter note (thereby lengthening that note’s duration to 5 beats), the nPVI of the phrase increases dramatically to 38.1.

This nPVI value implies that there is a significant amount of variety in successive rhythmic durations when in actuality there is no rhythmic change in the phrase; the only reason for the increase in nPVI is the addition of the rest to the previous rhythmic event.

For purposes of comparison, Example 3.7b shows an eight note phrase from a Bizet song used in the current study whose nPVI is the same as the hypothetical example if the rest is added to the previous duration; it is clear that the Bizet phrase has a much greater durational variability of actual rhythmic events than the hypothetical example, and that the addition of the rest to the previous duration has a significant effect on the nPVI value.

Daniele and Patel (2004) changed their selection criteria to include themes by German and Austrian composers in which
... there was at least one continuous sequence of 7 or more notes without a rest. For such themes, the nPVI was calculated for each continuous sequence of 7 or more notes and the mean of the resulting nPVI values was taken as the nPVI of the theme.\textsuperscript{24}

Thus while a theme containing rests was not immediately disqualified from study (as in their earlier studies), Daniele and Patel did not count rests as durations but rather as boundary markers, and only calculated sequences of seven or more rhythmic events whether or not that sequence constituted an entire phrase. This method results in continuous sequences of less than seven notes not being included in nPVI calculations, which potentially eliminates short phrases or short passages following \textit{intra}-phrase rests; it may also result in fragments from two different phrases being averaged together if themes contained more than one phrase not separated by a rest. The averaging of nPVI values for distinct phrases or separate sequences of durations also is problematic and will be discussed below.

\textit{3.4.1.1 The approach to rests in the current study}

After careful consideration of the strengths and weaknesses evident in the methodologies employed by the previous studies, the current study takes the following approach to rests:

1. \textit{Intra}-phrase rests are eliminated, and the rhythmic events before and after the rest(s) are considered to be adjacent rhythmic events for the purposes of nPVI calculations; and
2. \textit{Inter}-phrase rests are retained although not used in calculations, and the rhythmic events before and after the rest(s) are not considered to be adjacent rhythmic events for the purposes of nPVI calculations.

\textsuperscript{24} Daniele and Patel (2004), p. 760.
There are several benefits of this system. First, with this approach, phrases are not divided internally based on the existence of rests, as in Daniele and Patel (2004). As the current study focuses on vocal music, it is likely that there would be a higher number of *intra*-phrase rests than the instrumental phrases studied by Daniele and Patel due to both physical demands on the performer and perceptual demands on the listener. As Wenk (1987) describes, even spoken French tends to be broken into smaller sections when comprehension is a primary concern, so it would be reasonable to expect that a composer would set shorter sequences of rhythmic events:

Generally speaking, when they wish to make sure the message gets across, French speakers subdivide a given stretch of utterance into a greater number of rhythmic groups (that is, produce groups involving a smaller number of syllables), as it is presumably easier for listeners to decode relatively small chunks of speech than to store longer sequences of words in short-term memory (see Wingfield and Byrnes 1981:18) for later access and processing. It is likely (Cutting and Pisoni 1978:45) that longer rhythmic groups would simply be lost, thereby impeding comprehension. Surely, a composer’s commitment to making his text understandable despite the acoustic distortions imposed by melodic, harmonic, and contrapuntal effects could be assumed to cause him to favor smaller numbers of syllables per rhythmic group.25

Therefore, if the current study delineated phrases based solely on the placement of rests it would be likely to result in a large number of small phrases. According to the criteria established in Daniele and Patel (2004) many of these small phrases would not be eligible for study, as they did not calculate nPVI values for strings of less than seven rhythmic events.

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Discarding *intra*-phrase rests also makes it unnecessary to adopt Huron and Ollen’s method of adding the duration of a rest to the duration of the previous rhythmic event. As described above, this approach had two problems: first, the addition of the duration of a rest to the previous rhythmic event implied that the rhythmic event preceding a rest continued through the duration of a rest; and second, the resulting lengthened duration could have a non-trivial effect on the nPVI calculation due to the increase in durational variability.

3.4.2 *Grace notes*

The interpretation of grace notes is a topic of great debate in performance practice. No time period (and indeed no two composers) treated grace notes consistently, which makes them difficult to account for in a rhythmic study.

The previous studies were inconsistent in their treatment of grace notes. Patel and Daniele (2003) and (2003b) and Daniele and Patel (2004) explicitly excluded themes containing grace notes. This eliminated the issue of how to represent and/or calculate the duration of a grace note, but had the disadvantage of limiting repertory for study. Huron and Ollen (2003) represented grace notes as a 64th note and included the duration in their nPVI calculation; this eliminated the limitation of repertory but introduced a number of issues regarding calculation of the nPVI. For one, the solution did not subtract an equivalent amount of time from the note either preceding or following the grace note, so a measure containing a grace note would have a total duration of longer than that indicated by the overall meter. In addition, Huron and Ollen’s solution could lead to an
inaccurate representation of the nPVI due to the potentially large durational contrast between a 64th note and almost any other note value; themes containing grace notes might have their overall nPVI inflated by the inclusion of the duration of the 64th note.

3.4.2.1 The approach to grace notes in the current study

In the current study, songs containing grace notes were included, but the grace notes were eliminated from durational calculations. The rationale behind this was driven primarily by the overwhelming inconsistencies in composers’ use of grace notes; to accurately account for the intended performance of every grace note in every song by every composer in the study would have been virtually impossible. However, eliminating a song simply because it contained one or two grace notes seemed to be an arbitrary decision that would limit the repertory unnecessarily.

Despite not using the grace notes to calculate nPVI values, there are hypotheses involving grace notes that can be investigated. One hypothesis is the intuitive notion that a language more inclined to have greater variation between successive durations would be more likely to contain grace notes – that is, a stress-timed language such as German would be expected to have more grace notes because the stress-timing of the language allows for larger degrees of fluctuation (such as that between a short grace note and a longer duration) between successive stresses. To study this hypothesis, we can count the number of grace notes used in the songs in each language and compare that to the overall number of durational events in the database:
<table>
<thead>
<tr>
<th>Language</th>
<th># of grace notes</th>
<th># of total notes</th>
<th>% of grace notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>German</td>
<td>241</td>
<td>43190</td>
<td>.55%</td>
</tr>
<tr>
<td>French</td>
<td>531</td>
<td>35959</td>
<td>1.47%</td>
</tr>
</tbody>
</table>

This indicates a higher percentage of grace notes in the French songs than in the German songs. To determine whether the difference in percentage is significant, we can determine whether the percentage of grace notes in German songs falls within a normal distribution based on the data for the French songs. The result is an $\sigma = 4.51$, indicating that the German results fall more than four standard deviations from the normal distribution based on the French results. The confidence interval for $\sigma = 4.51$ is 99.9999%, indicating that there is a less than 0.0001% chance that a random sample of the German songs would produce the same percentage of grace notes per sample as the French songs.

This illustrates that the French songs included in the current study use a statistically significantly higher percentage of grace notes than the German songs, in contradiction to the hypothesis that German songs would contain more grace notes. This is not necessarily a robust result because of the single test case, but this would imply that there is a reason for the more frequent use of grace notes in French vocal music that would appear to have little to do with the rhythmic aspects of the language.

### 3.4.2.2 Representation issues for grace notes and gruppettos

In Humdrum, grace notes and gruppettos have specific methods of representation:

*Grace notes* (acciaccaturas) are visually rendered as miniature notes with a slash drawn through the stem. In the **kern representation these notes are treated as “durationless” notes and are designated by the lower-case letter “q”. Hence, the token “G#q” denotes a G#3 grace note with an
indeterminate duration.

Non-canonical *gruppettos* are miniature (non-cue) notes (typically appearing in groups) whose stems do not contain a slash, and whose notated durations cause the total notated duration for the measure to exceed the prevailing meter. These gruppetto notes are encoded as notes retaining their notated durations, but all such notes are also designated by the upper-case letter “Q”.

The nPVI tool designed by Huron automatically changed grace notes (originally indicated with a lowercase *q*) to a $64^{\text{th}}$ note duration, but did not make any accommodations for gruppettos, represented by the large $Q$. In fact, it appears that none of the themes in Huron and Ollen (2003) contained gruppettos, as the nPVI tool used by Huron and Ollen for that study was unable to process any rhythmic material that contained gruppettos.

To account for the wider rhythmic variety in this much larger study, two new Humdrum tools were written, *qswap* and *qkill* (see Appendix III, *Tools and Commands*). The *qswap* tool had two functions: first, it was a more robust and reliable way to change notated grace notes to a $64^{\text{th}}$ note duration as per Huron and Ollen’s method; and second, it accounted for gruppettos, which was something that Huron’s nPVI tool could not process. The *qkill* tool eliminated all grace notes and gruppettos entirely. Many nPVI calculations in this study were run twice – once on files that had been *qswap*-ped and once on files that had been *qkill*-ed – to determine what, if any, effect grace notes and gruppettos had on the overall nPVI results. The results of those studies are discussed below.

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3.4.3 Phrasing

By using the Barlow and Morgenstern thematic dictionary for their musical material, Patel and Daniele and Huron and Ollen were limited to its short thematic incipits, generally consisting of one or a very small number of phrases. The Barlow and Morgenstern does not make any attempt to delineate themes by phrasing; indeed, examples often are cut off mid-phrase. Neither Patel and Daniele or Huron and Ollen make any mention of trying to include only complete phrases in their study, as their selection criteria were focused elsewhere.

There is evidence that perceived isochrony is confined to relatively short speech fragments; that is, the duration of the perceived isochrony has a tendency to change from phrase to phrase and not remain constant over a longer utterance. In fact, the isochrony seems to conform to the principles of the intonational phrase or tone group as described in Chapter 2.27 Because the nPVI measure is normalized, two phrases can exhibit the exact same nPVI but use completely different units of isochrony; this accounts for varying rates of speech across speakers. As a result, while the primary use of the nPVI is to compare the degree of rhythmic variation of one phrase to that of another, it is of limited use to calculate the nPVI of multiple phrases across phrase boundaries, as each phrase will likely be using a different unit of isochrony and will as such skew the results of the nPVI. Thus it is more useful to calculate the nPVI value of individual phrases and compare them to each other than to calculate the overall nPVI value of multiple phrases, because the duration of the unit of isochrony is likely to change from phrase to phrase.

Most of the existing linguistic studies on nPVI values have used individual sentence-length utterances for their corpus. However, the studies have used different criteria to determine what constitutes a unit to which to apply the nPVI. In earlier work, Grabe and Low calculated nPVIs for individual intonation phrases; in Grabe and Low (2002), however, they calculated the nPVI value for entire sentences, some containing multiple intonation phrases, because of the difficulty of determining intonation phrase boundaries in languages with which they were unfamiliar. The approach in (2002) was also designed to eliminate as many subjective linguistic decisions as possible.

Similarly, there are differences in the way phrasing was considered – or, more appropriately, not considered – in the earlier musical studies. Since the corpus for the earlier studies was drawn from the Barlow and Morgenstern, which makes no phrase divisions nor any attempt to include full phrases, the studies by Patel and Daniele make no attempt to define phrase boundaries. Similarly, because Huron and Ollen included musical material that included rests, if the rests were inter-phrasal, they were including multiple phrases in their calculations. Therefore the lack of standardization in linguistic studies can also be seen in the musical studies using the nPVI measurement.

3.4.3.1 Phrasing in the current study

As discussed above and in Chapter 2, the duration of isochrony in spoken language is generally accepted to be at approximately the intonation phrase level – that is, an individual intonation phrase will exhibit a durational level of isochrony that may then

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28 Grabe and Low (2002) recorded one speaker per language reading the fable “The North Wind and the Sun,” a standard text used in phonetic research, and Ramus (1999, 2002) used a set of five sentences selected from a multi-language corpus, with four speakers for each language studied.
change in the next intonation phrase. If the nPVI of two individual phrases with different levels of isochrony were measured in combination with each other, the nPVI value would reflect the change in the level of isochrony and would not accurately reflect the nPVI of each individual phrase. Fox (2002) explicitly says that

… the approximate equality of syllable length is restricted to relatively short accentual phrases [and] considerable divergences are found between phrases; to measure the syllables across more than one accentual phrase will in many cases easily ‘disprove’ the hypothesis [of syllable-timing].

Fox also discusses the “resetting” of the unit of isochrony (a “foot”) for stress-timed languages, and claims that “the ‘ideal’ foot length appears to be reset for each phrase. Averaging the lengths of feet over sentences or longer utterances is therefore likely to produce meaningless results.”

Thus, when applying the nPVI to music, it follows that in order to accurately represent the durational variability of rhythmic events, the nPVI measure should be applied to the closest musical correlate to the intonation phrase level of speech, which, as discussed in Chapter 2, is the individual musical phrase. As a result, in this study the nPVI measure is applied to individual phrases and not to a musical sample as a whole, as the latter method will not provide an entirely accurate representation of the nPVI measure of individual phrases.

Example 3.8 illustrates this principle using two phrases of eight rhythmic events each, one phrase comprised entirely of eighth notes and the other phrase entirely of half notes. The level of isochrony in the first phrase is the eighth note and in the second phrase is the half note. Since there is the absolute minimum amount of durational variability (i.e.,

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none) in each of the two phrases when considered individually, the nPVI of each phrase would be zero. However, if the two phrases are combined to make one phrase and the nPVI value is calculated from the combination of the two, the nPVI would be 8.000, reflecting the durational variability present between the last eighth note of the original first phrase and the first half note of the original second phrase. Thus combining phrases whose level of isochrony is different results in an nPVI value that does not accurately reflect the durational variability present in each individual phrase.

Example 3.8: Effect of change of level of isochrony across phrases on the nPVI value

Therefore, for this study, the nPVI tool developed by Huron and Ollen (2003) was modified to calculate the nPVI value for individual phrases. The modified version of the nPVI tool was called pnPVI, for “phrase-nPVI” (see Appendix III: Tools and Commands).
Example 3.9 reproduces a sample output from the *pnPVI* tool, illustrating the results of running *pnPVI* on a file named “`chausson005.krn`.” The first column of the output indicates the song composer; the second column indicates the file name; the third column indicates the phrase number within the song; the fourth column indicates how many rhythmic events occur within that individual phrase, and the rightmost column provides the pnPVI (phrase-nPVI) value for that phrase.

**Example 3.9: Sample output from the *pnPVI* command.**

<table>
<thead>
<tr>
<th>Composer</th>
<th>File Name</th>
<th>Phrase</th>
<th>Events</th>
<th>pnPVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>001</td>
<td>10</td>
<td>65.5179</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>002</td>
<td>11</td>
<td>77.3333</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>003</td>
<td>10</td>
<td>41.0256</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>004</td>
<td>11</td>
<td>33.3333</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>005</td>
<td>10</td>
<td>67.4074</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>006</td>
<td>11</td>
<td>58.1128</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>007</td>
<td>10</td>
<td>35.5556</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>008</td>
<td>5</td>
<td>33.3333</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>009</td>
<td>7</td>
<td>55.5556</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>010</td>
<td>10</td>
<td>72.9932</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>011</td>
<td>11</td>
<td>34.6686</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>012</td>
<td>10</td>
<td>42.5365</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>013</td>
<td>11</td>
<td>45.3333</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>014</td>
<td>20</td>
<td>51.1736</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>015</td>
<td>20</td>
<td>85.5404</td>
</tr>
</tbody>
</table>

This example illustrates that the pnPVI value can range widely from phrase to phrase of a song, as demonstrated by the pnPVI of 72.99 for phrase ten followed by the pnPVI value of 34.66 for phrase eleven.

### 3.5 A comparison of methods of nPVI calculation

#### 3.5.1 *pnPVI* and Daniele and Patel (2004)

The method used for calculating the pnPVI for individual phrases is superficially similar to the system used in Daniele and Patel (2004) in which they calculated the nPVI for continuous sequences of seven or more rhythmic events; if an excerpt contained more

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31 This file is Chausson’s “Printemps triste,” Op. 8, No. 3.
than one continuous sequence of seven or more rhythmic events, they would average the
nPVI for each sequence to determine the average nPVI for the excerpt as a whole. They
then averaged together the nPVIs for each excerpt to arrive at the overall mean nPVI
values for each composer shown in Example 3.6.

The analogous process for the $p_nPVI$ tool would be to average the results for the
individual phrases to arrive at the pnPVI for the song as a whole. If the pnPVI values of
the individual phrases in the above Chausson example are averaged together, the result is
a pnPVI of 53.294.

However, Daniele and Patel’s method of averaging the nPVI values for each continuous
sequence of seven or more rhythmic events is not necessarily the best representation of
the overall pnPVI of the excerpt. Averaging the results assigns an equal weight to the
nPVI of shorter sequences as it does to that of longer sequences, which can skew the
results. Example 3.10 illustrates this with a hypothetical example that contains a sequence
of eight rhythmic events with a pnPVI of 0, a rest, and then a sequence of nineteen
rhythmic events with a pnPVI of 42.9630. If the two values are averaged, as in Daniele
and Patel (2004), the result is an nPVI of 21.4815; the process of averaging gives equal
weight to the two values. As the second sequence of events contains more rhythmic
events, however, it intuitively should be given more weight in the nPVI calculation.
Example 3.10: Effects of averaging on the pnPVI of multiple phrases.

In the current study, therefore, the pnPVI values for each phrase are weighted before averaging by multiplying the pnPVI value for the phrase by the number of rhythmic events in the phrase. In the example above the pnPVI of 0 is multiplied by 8 because there are eight rhythmic events in the phrase, while the pnPVI of 42.9630 is multiplied by 19; those two results are then added together for a total of 816.297, which is then divided by the total number of rhythmic events in the phrase (27) for a weighted overall pnPVI of 30.233. This weighted pnPVI more accurately reflects the amount of durational variability occurring in this short hypothetical example, because it gives the correct amount of weight to each of the phrases.

Referring back to the Chausson example given above in Example 3.9 as an illustration of the output of the pnPVI tool, the weighted pnPVI value for the entire song is calculated by multiplying the pnPVI value for each phrase by the number of rhythmic events in the phrase, summing the results, and dividing by the total number of rhythmic events in the song. This process is illustrated in Example 3.11.
Example 3.11: Finding the weighted average of chausson005.krn.

<table>
<thead>
<tr>
<th>Composer</th>
<th>File name</th>
<th>Phrase #</th>
<th># of events</th>
<th>pnPVI</th>
<th>pnPVI x # of events</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>1</td>
<td>10</td>
<td>65.5179</td>
<td>655.179</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>2</td>
<td>11</td>
<td>77.3333</td>
<td>850.6663</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>3</td>
<td>10</td>
<td>41.0256</td>
<td>410.256</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>4</td>
<td>11</td>
<td>33.3333</td>
<td>366.6663</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>5</td>
<td>10</td>
<td>67.4074</td>
<td>674.074</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>6</td>
<td>11</td>
<td>58.1128</td>
<td>639.2408</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>7</td>
<td>10</td>
<td>35.5556</td>
<td>355.556</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>8</td>
<td>5</td>
<td>33.3333</td>
<td>166.6665</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>9</td>
<td>7</td>
<td>55.5556</td>
<td>388.8892</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>10</td>
<td>10</td>
<td>72.9932</td>
<td>729.932</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>11</td>
<td>11</td>
<td>34.6686</td>
<td>381.3546</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>12</td>
<td>10</td>
<td>42.5365</td>
<td>425.365</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>13</td>
<td>11</td>
<td>45.3333</td>
<td>498.6663</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>14</td>
<td>20</td>
<td>51.1736</td>
<td>1023.472</td>
</tr>
<tr>
<td>CHAUSSON</td>
<td>chausson005.krn</td>
<td>15</td>
<td>20</td>
<td>85.5404</td>
<td>1710.808</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td></td>
<td><strong>167</strong></td>
<td></td>
<td><strong>9276.792</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Weighted pnPVI (9276.792/167):</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>55.5496</strong></td>
<td></td>
</tr>
</tbody>
</table>

Thus the average pnPVI of the song represented in the file chausson005.krn without weighting is 53.294 and the weighted average is slightly higher at 55.5496, reflecting that some longer phrases or phrases with more rhythmic events have higher pnPVI values. Overall, the weighted pnPVI average is a more accurate representation when measuring the amount of durational variability in multiple phrases.

3.5.2 pnPVI and Huron’s original nPVI tool

As described above, Huron’s original nPVI tool differed from Daniele and Patel’s (2004) method of calculation. Daniele and Patel used rests as cues for segmentation but did not include them in any calculations; in contrast, Huron’s system included rests in the calculation by adding the duration of a rest to the duration of the previous rhythmic event. Also, Huron’s tool did not segment on the basis of rests (as in Daniele and Patel 2004) or of phrasing (as in the current study). Running Huron’s original nPVI tool on the hypothetical example presented in Example 3.10 results in an nPVI of 42.8121
(compared to the unweighted pnPVI of 21.4815 or the weighted pnPVI of 30.233). The dramatic increase in Huron’s nPVI calculation results from the addition of the duration of the rest to the duration of the final quarter note in the previous measure. The inclusion of the rest creates an artificially large durational variability when the resultant long duration is compared to the rhythmic events that both precede and follow that duration.

When Huron’s original nPVI tool is applied to the entire Chausson song from Examples 3.9 and 3.11, the resulting overall nPVI is 74.5311. Since Huron’s original nPVI tool did not segment on any basis, there is no need to average or weight the results of the calculation. The result from Huron’s method is clearly different from the average nPVI of 53.294 calculated in a method similar to Daniele and Patel (2004) and the weighted average of the current study of 55.5496, and is most likely due to the problems illustrated in the above example.

### 3.6 Results

Example 3.12 summarizes results of the previous studies relevant to the current study as well as the results of two linguistics articles cited in those studies as a basis for comparison. Each of the four musical studies listed in the chart use a slightly different calculation method, as do the two linguistics articles listed. The variations in the methodology of measuring nPVI in the previous musical studies make it difficult if not impossible to directly compare results from one study to the next.
Example 3.12: Variation in nPVI measurements across studies

<table>
<thead>
<tr>
<th>Music</th>
<th>Language</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Patel and Daniele 2003</td>
<td>Huron and Ollen 2003$^{32}$</td>
<td>Patel and Daniele 2003b</td>
<td>Daniele and Patel 2004</td>
</tr>
<tr>
<td>French</td>
<td>41.0</td>
<td>43.7</td>
<td>n/a</td>
</tr>
<tr>
<td>German</td>
<td>n/a</td>
<td>42.0</td>
<td>37.27$^{33}$</td>
</tr>
</tbody>
</table>

The only musical study in which French and German were both studied using the same methodology was in Huron and Ollen (2003); in that study, the lower nPVI for German contradicted the expected results and prompted the post hoc hypothesis about the declining influence of Italian music in Patel and Daniele (2003b) and Daniele and Patel (2004).

Thus this present study is necessary and important in order to determine whether or not the linguistic characteristic of durational variability measured by the nPVI carries over into French and German music. In addition, as the four previous studies focused on a limited instrumental repertory from the Barlow and Morgenstern thematic dictionary for their studies, this study is the first attempt to apply the linguistic nPVI measure to a much larger corpus, as well as the first to apply it to vocal music.

3.6.1 Overall pnPVI results and the effect of grace notes

Section 3.4.2 above discussed grace notes and gruppettos and their potential effect on the overall nPVI of a phrase, and described two tools developed to account for these

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$^{32}$ Complete results of their study are shown in Example 3.5.

$^{33}$ These results are the average of the average nPVI given for each composer in the respective articles. The authors do not explicitly calculate the average overall nPVI for German composers in these studies, but as their studies involved no weighting of results, they most likely would have calculated the average German nPVI by simply averaging the results for the individual composers together as was done here.
problematic rhythmic events: *qswap*, designed to include both grace notes and gruppettos in the pnPVI calculations; and *qkill*, designed to eliminate both from consideration. Example 3.13 lists the overall weighted pnPVI averages by composer using both methods of calculation, and Example 3.14 illustrates this comparison graphically.

**Example 3.13: Weighted overall pnPVI averages by composer with and without grace notes.**

<table>
<thead>
<tr>
<th>Composer</th>
<th>Weighted mean pnPVI with grace notes</th>
<th>Weighted mean pnPVI without grace notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bizet</td>
<td>49.5</td>
<td>49.0</td>
</tr>
<tr>
<td>Chausson</td>
<td>51.9</td>
<td>51.9</td>
</tr>
<tr>
<td>David</td>
<td>52.8</td>
<td>50.4</td>
</tr>
<tr>
<td>Debussy</td>
<td>33.0</td>
<td>33.0</td>
</tr>
<tr>
<td>Duparc</td>
<td>56.3</td>
<td>56.3</td>
</tr>
<tr>
<td>Fauré</td>
<td>54.1</td>
<td>54.1</td>
</tr>
<tr>
<td>Gounod</td>
<td>46.3</td>
<td>46.0</td>
</tr>
<tr>
<td>Lalo</td>
<td>51.4</td>
<td>49.5</td>
</tr>
<tr>
<td>Massé</td>
<td>48.9</td>
<td>46.2</td>
</tr>
<tr>
<td>Massenet</td>
<td>48.2</td>
<td>45.3</td>
</tr>
<tr>
<td>Reber</td>
<td>55.2</td>
<td>53.7</td>
</tr>
<tr>
<td>Reyer</td>
<td>49.1</td>
<td>44.5</td>
</tr>
<tr>
<td>Saint-Saëns</td>
<td>51.3</td>
<td>51.1</td>
</tr>
<tr>
<td>Brahms</td>
<td>45.1</td>
<td>45.0</td>
</tr>
<tr>
<td>Franz</td>
<td>45.2</td>
<td>44.1</td>
</tr>
<tr>
<td>Schubert</td>
<td>46.5</td>
<td>46.5</td>
</tr>
<tr>
<td>Schumann</td>
<td>59.7</td>
<td>58.9</td>
</tr>
<tr>
<td>Strauss</td>
<td>55.7</td>
<td>55.3</td>
</tr>
<tr>
<td>Wolf</td>
<td>47.5</td>
<td>46.9</td>
</tr>
</tbody>
</table>

The table and graph illustrate that including grace notes and gruppettos in pnPVI calculations can indeed have an effect on the overall pnPVI average for each composer. The relatively short time value of grace notes and gruppettos creates an increase in the amount of durational variability occurring between sequential rhythmic events, and therefore leads to an increase in the average pnPVI of individual phrases, the weighted
average pnPVI of songs, and, as shown here, can have a dramatic effect on the overall average pnPVI of composers.

Example 3.14: Comparison of weighted overall average pnPVI values by composer, with and without grace notes.

As discussed in section 3.4.2, because of the increased durational variability that results from using grace notes and gruppettos, these ornaments would be expected to occur more frequently in stress-timed languages, such as German, whose rhythmic characteristics involve a higher degree of durational variability. However, as discussed earlier and made evident from the table and chart above, the French composers represented in the current study used a higher frequency of grace notes and gruppettos than did the German composers represented, and this increased use of ornamentation does have an effect on the overall pnPVI average.
Most notable for the French composers are the results for David, Lalo, Massé, Massenet, Reber, and Reyer, and for the Germans, Franz; each composer’s average pnPVI decreased when grace notes and gruppettos were excluded from the pnPVI calculations. Composers whose pnPVI average stayed the same (Chausson, Debussy, Duparc, and Fauré) used no grace notes or gruppettos in the pieces represented in the study.\textsuperscript{34} It is interesting to note that Noske (1970) describes Fauré and Duparc as the “first great masters” of French song and refers to the later composers, Chausson and Debussy, as quintessentially French.\textsuperscript{35}

Earlier it was proposed that the higher number of grace notes and gruppettos in the represented French songs is likely due to some other stylistic characteristic of or influence on French music and not a result of the influence of the rhythmic properties of the spoken language. In fact, in his \textit{Letter on French Music}, Rousseau decries the use of elaborations in French recitative as inappropriate to the language:

Add to this the frédons, the trills, and the portimenti which recur at every moment, and tell me what analogy there can be between speech and all this glum drapery, between declamation and this so-called recitative. … It is quite obvious that the best recitative that could suit the French Language must be almost entirely opposite to the one that is in use: that it must range within very small intervals, neither much raising nor lowering the voice, few sustained sounds, never outbursts, still fewer shouts, above all nothing which resembles singing, little inequality in the duration or value of the notes, nor in their degrees either.\textsuperscript{36}

\textsuperscript{34} As can be seen in the table, the results of the two different calculations for Brahms are very similar but do reflect a difference. Also, the results for Schubert do not appear to reflect a difference between the two calculations but in fact are anomalous to the rest of the results; when the grace notes and gruppettos are removed from calculation, Schubert’s pnPVI average actually increases very slightly (+ 0.02).
Interestingly, Rousseau blames the use of “spun-out sounds, trills and other ornaments of song” on the influence of Italian melody on French melody, and urges young French composers to “continue to despise Italian Music in public.”

As the use of grace notes and gruppettos in French music appears to have a non-linguistic origin, it is appropriate to use the pnPVI values in which the grace notes and gruppettos are not included in the pnPVI calculation for either language. This allows for a more accurate comparison of the aspects of French and German music that may rely on the rhythmic characteristics of the spoken languages by allowing us to compare both languages at their rhythmic baseline. Therefore the remainder of the pnPVI discussion will use results that do not include grace notes and gruppettos.

3.6.2 Overall pnPVI results by language

The overall weighted average pnPVI value for both French and German is shown in Example 3.15. The marker represents the weighted overall average pnPVI of the language, and the bars represent the range of the overall weighted pnPVI values by composer as listed in Example 3.13.

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Example 3.15: pnPVI distribution and average by language.

While the weighted overall average pnPVI is lower for French than for German (47.9 and 48.1, respectively), this is not a significant result when compared to either the average nPVI values calculated by Grabe and Low (2002) of 43.5 and 59.7 or the NPVI averages in Huron and Ollen (2003) of 43.7 for French and 42.0 for German.

This result indicates that the hypothesis regarding the rhythmic characteristics of stress-timed and syllable-timed languages and their effect on the rhythmic characteristics of vocal music does not hold for the current set of data. What is most significant about this result is that the hypothesis has failed in a sample of a genre of music where the relationship between language and music has traditionally been assumed to be a strong one.

While there may be no clear trend across languages, there are interesting results for individual composers that invite further study. For example, from the table in Example 3.13 and the chart in Example 3.14, it is obvious that the weighted average pnPVI value
for several composers is quite different than that of their linguistic peers. Debussy’s strikingly low pnPVI is one clear example for the French songs, as are the high pnPVI values of Schumann and Strauss for the German songs.

Example 3.16 shows the weighted average pnPVI value for songs by individual composers and also illustrates the distribution range of weighted average pnPVIs for songs for each individual composer.\(^\text{38}\) For example, the weighted average pnPVI value for Bizet songs ranges from a minimum of 21.6 to a maximum of 76.8, with a weighted average of 49.7.

**Example 3.16: Distribution and weighted average song pnPVI values by composer**

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\(^{38}\) These averages are slightly different than the averages in Example 3.13 as that value is the weighted average of weighted phrases, and these are the weighted averages of songs (calculated by weighting the weighted phrases). Thus the average here is calculated by weighting the pnPVI of each song, which itself was calculated by weighting the phrases.
Worthy of mention from this graph are the low weighted average pnPVI and low distribution range for the Debussy songs, as well as the narrow distribution range (but relatively high weighted average pnPVI) for Chausson and the relatively high weighted average pnPVI and distribution range for Duparc, Schumann and Strauss. However, with the exceptions of Debussy and possibly Schumann, there is no clear trend for the individual pnPVI values to be lower for French composers than for German composers, as was predicted by the hypothesis and the previous studies.

Therefore, the hypothesis that the syllable-timed French language would influence French composers to write music with a lower amount of durational variability than that exhibited by music influenced by the stress-timed German language has so far not held for a cross-language study, and, with the exceptions of Debussy and Schumann, has not held robustly for individual composers.

3.6.3 pnPVI as a function of time

As discussed in section 3.3.3 above, Patel and Daniele (2003b) studied an anomalous result in Huron and Ollen (2003) by plotting the average nPVI of twenty German and Austrian composers as a function of the year of the composers’ birth, using a time period of 1637-1895. Their results, shown in Example 3.6, showed a significant correlation between a composer’s birth year and an increase in the average nPVI value.

A similar graph of the weighted pnPVI value of both French and German songs in the current study provides some interesting results. Example 3.17 illustrates the weighted
pnPVI of each French song in the study plotted against the year of its composition, as opposed to the composers’ birthdate as in Patel and Daniele (2003b). The graph shows the weighted average for the French songs by the decade of composition; the plot for 1840 represents all songs composed between 1840-1849, the plot for 1850 represents all songs composed between 1850-1859, and so on up to 1900, which only represents songs written in the year 1900. The vertical bars represent the range in which the individual songs’ weighted pnPVI fell, and the marker and value represent the weighted overall average for songs composed in that decade.

Example 3.17: Average weighted pnPVI of French songs by decade of composition

![Graph showing average weighted pnPVI of French songs by decade of composition.]

The dotted trend line illustrates the best-fitting regression line (weighted pnPVI = [-2.4179 x date of composition] + 56.757). The regression of year of composition against average pnPVI is significant ($r^2 = .6817$, $df = 1$, $p = .02$). The chart clearly shows a
general trend of declination in pnPVI value over the course of the time period 1840-1900 for the French songs in this study.

Example 3.18 illustrates a similar graph for the German songs in the study. Again, the graph shows the weighted average for the German songs by the decade of composition, the vertical bars represent the range in which the individual songs’ weighted pnPVI fell, and the marker and value represent the weighted overall average for songs composed in that decade.

**Example 3.18: Average weighted pnPVI of German songs by decade of composition**

![Graph showing average weighted pnPVI of German songs by decade of composition](image)

The dotted trend line illustrates the best-fitting regression line (weighted pnPVI = [0.4929 x date of composition] + 45.107). There is a slight correlation between the decade of composition and an increase in the average weighted pnPVI value. However, unlike the results in Patel and Daniele (2003b), the regression of year of composition against average pnPVI is not significant ($r^2 = .0509$, $df = 1$, $p < .6$).
These results conflict with the clear and significant positive correlation between composer’s birth year and average nPVI as illustrated in Example 3.6. There are slight differences in the data used to create each chart that may help explain some of the differences. The most obvious difference is the source material; as discussed, Patel and Daniele (2003b) were using small incipits of instrumental music, whereas the current study is using much larger amounts of vocal music. Also, the graph in Example 3.6 is representing data from individual composers and plotting them as a function of that composer’s birthdate; each marker represents the nPVI average of only one composer, whereas the graph in Example 3.18 represents all songs composed in that decade by the six German composers represented in the current study.

One subtle difference is the difference in time period being studied. Patel and Daniele were investigating a trend in nPVI values from 1637–1895, while the current study is limited to the period between 1820–1900. The overall rising trend illustrated in Example 3.6 is a result of the full set of data for the longer time period; Example 3.19 uses the data from Patel and Daniele’s study but graphs only the data for composers whose birth year fell within the time period of 1820–1900.

The dotted trend line illustrates the best-fitting regression line \( \text{nPVI} = [-0.0219 \times \text{composer birth year}] + 83.853 \), and the regression of composer birth year against average nPVI is not significant \( (r^2 = .0064, df = 1, p = .85) \). Unlike Patel and Daniele’s chart from Example 3.6 illustrating a clear overall increase in nPVI from the time period of 1637–1895, this chart shows a slight trend of 
\textit{declination} when the data for the period of 1820–1900 is extrapolated and studied.

The results of the two graphs in Example 3.18 and Example 3.19 indicate that there was no significant trend in nPVI values for the time period from 1820–1900 in either instrumental music or vocal music written by German composers. The nPVI of vocal music demonstrated a slight increase overall, and the nPVI of instrumental music a slight decrease, but neither result is statistically significant.
Charting French song pnPVI and German song pnPVI together over time, as in Example 3.20, illustrates the trend in each language in relation to the other. While the overall weighted average pnPVI for the data in this study do not support the original hypothesis, it is interesting to note that for the decade of 1890, the last decade for which there is data for both languages, the pnPVI averages for the two languages (French, 39.4; German 50.0) do in fact support the original hypothesis in a statistically significant way. It is also interesting to note that the trendlines suggest a convergence of French and German nPVI values in the time period from 1860-1870, and the pnPVI averages for both the 1860s and the 1870s roughly indicate this convergence.
Example 3.20: Cross-language pnPVI plot over time

Example 3.21 shows the pnPVI trend of individual French composers based on the repertory encoded in the current study. This chart illustrates that the overall decline in the nPVI of French song demonstrated in Example 3.20 is not the result of data for one or two composers influencing the results. Only two French composers in the study, Massé and Chausson, had an overall trend of increase in pnPVI; the other ten French composers all exhibit a trend of declination in the pnPVI average of their works as the 19th century progressed.\footnote{Debussy’s trendline goes off the scale of the chart for readability purposes; the trendline ends in 1898 with a value of 28.6.} Some composers, such as Gounod and Saint-Saëns, exhibit a sharp overall decline in nPVI value throughout the 19th century; others like Fauré and Reyer show a less pronounced trend of declination. Thus the overall decline in nPVI of French songs is
not the result of the influence of any one individual composer on the data, but rather seems to be a general trend among French composers.

Example 3.22 illustrates the individual pnPVI trend for three of the six German composers included in the study. As with the French songs, the overall rise in the average pnPVI of German song through the 19th century appears not to be the result of influence of any individual composer, as each of the German composers exhibited an increase in pnPVI in their compositional activity.

\[\text{40 As most of the data for Schubert, Schumann, and Strauss came from song cycles, the years of composition for those three composers were not variable enough to provide an accurate trendline over time.}\]
Example 3.21: pnPVI trend by French composer
Example 3.22: pnPVI trend by German composer

3.7 Conclusions

The primary hypothesis was that French-influenced music would have a lower nPVI than German-influenced music, reflecting the influence of the rhythmic properties of the spoken language, specifically the greater degree of durational variability present in spoken German than in spoken French. The hypothesis has not held up in a simple comparison between two large groups of songs; the difference between the weighted average pnPVI for all French and German songs were not statistically significant, and with only a couple of exceptions there was no clear trend for the weighted overall average pnPVI of individual composers.

However, when pnPVI is plotted as a function of time, there is a clear declination trend for the average pnPVI value of French-influenced music and a slight rising trend for the
average pnPVI of German-influenced music throughout the 19th century; these trends are borne out by both the plot of the overall average pnPVI for each language and by the data for the individual composers. It is unlikely that these trends are the result of changes in the spoken language over that time period; therefore, there must have been stylistic changes in French and German song that caused the nPVI to rise or decline. In combination, the two trends result in the average nPVI values for each decade approaching and reaching statistical significance by the end of the century. Moreover, these final values match closely the linguistic nPVI results of Grabe and Low (2002).

As discussed in section 3.3.3, Patel and Daniele (2003b) posited a post hoc hypothesis for their results, claiming that the increase in nPVI for German composers was the result of the declining influence of Italian music on German composers. The results for German in the current study support Patel and Daniele’s findings that the nPVI value of German music tended to increase towards the end of the 19th century, even though their own data for the time period contradicts their findings. It is not possible to determine whether this increase in nPVI is due to the waning influence of Italian music, as is their assertion, but this study is an independent test of the overall trend they identified in their study, and is a verification of that overall trend. More study is necessary to determine if the Italian influence hypothesis is accurate.

It is notable that the declining trend in pnPVI values for French composers coincides with an increase in musical nationalism happening in France and a more concerted effort on the part of composers to reflect a French musical character. A century before, in his
*Letter on French Music,* Rousseau had decried the current state of composition in France as inappropriate to the language:

It is quite obvious that the best recitative that could suit the French Language must be almost entirely opposite to the one that is in use: that it must range within very small intervals, neither much raising nor lowering the voice, few sustained sounds, never outbursts, still fewer shouts, above all nothing which resembles singing, little inequality in the duration or value of the notes, nor in their degrees either.\(^{41}\)

It may be that composers listened to Rousseau’s pleas, but not until the end of the 19\(^{th}\) century, as these are all characteristics of French music that become *more* characteristic of French music as the century drew to a close, as we have seen with the sharp decrease in the average pnPVI value of French songs.

\(^{41}\) Rousseau, *op. cit.*, p. 166.