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Crescendo/Diminuendo Asymmetries in Beethoven's Piano Sonatas

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A study of 32 piano sonatas by Beethoven reveals a significant asymmetry between increasing and decreasing dynamics. Specifically: (1) crescendos are more frequent than diminuendos, (2) crescendos tend to last longer than diminuendos, (3) large changes of dynamics tend to involve reductions in loudness, and (4) crescendos will more commonly follow low dynamic levels than will diminuendos follow high dynamic levels. These results support a "ramp archetype" of musical dynamics in which the music tends to build in a gradual way, but tends to subside relatively quickly. The results parallel a previous study showing an identical textural asymmetry in the evolution of polyphonic sonorities.

IN a study of voice entries and exits in multivoiced music, Huron (1990) demonstrated a significant asymmetry between increasing and decreasing textural densities. Specifically, it was found that voice entries tend to be incremental (one at a time) whereas voice retirements tend to be multiple (several at a time). Moreover, this same pattern was evident in the evolution of the density of textural sonorities. This pattern of textural change can be schematically represented as in Figure 1. In Huron (1990), it was found that this "ramp" paradigm was less characteristic of homophonic music than of polyphonic music—at least as measured by the introduction and retirement of parts or by the density of successive sonorities. However, it is possible that a similar pattern of textural change may be present in homophonic music via some other musical parameter. One of the characteristic differences between baroque and classical/romantic music is the latter's emphasis on dynamic shading. This suggests that an appropriate way to test for the presence of the "ramp archetype" in homophonic music is to examine the domain of dynamic level.

In the realm of musical dynamics, the ramp pattern suggests the following hypothesis.

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markings. For example, a passage may gradually increase in pitch height—suggesting a crescendo that may not otherwise be explicitly identified in the score. Nakamura (1982, 1987) has found that a general rise in pitch tends to enhance the impression of a crescendo.

Notwithstanding these difficulties, we may be confident that notated dynamic markings hold some degree of perceptual validity and, indeed, may be preferable to physical measures of sound-pressure level (Balzano, 1987). In particular, where dynamic markings are notated with great frequency and density, we may be more assured that the written markings correlate to a large degree with the perceptual experience of the music.

Beethoven's 32 sonatas for solo piano provide a prime example of a musical repertoire copiously annotated with dynamic markings. The Kalmus edition contains 11,508 dynamic markings in the 102 movements with a mean density of notated dynamics of 0.49 per bar. That is, on average, Beethoven notates a dynamic marking every two bars. This high notational density makes Beethoven's music especially suitable for a study of dynamic changes.

Some of Beethoven's markings have a questionable value in terms of the present study. The repertoire contains some 3514 "sforzando" markings—markings that may be considered localized accents. In most cases it is best to consider sforzando markings as superimposed on a base-line dynamic level. But sforzando markings themselves may have subtle effects on the overall level. For example, a persistent series of sforzandos may imply or be interpreted as a crescendo that is not otherwise explicitly notated. It is thus difficult to resolve whether sforzando markings ought to be excised or retained in the data analysis. In the analyses given below, where successions of dynamic levels are examined, two sets of results will be given according to whether sforzandos are eliminated or retained. In general, the results turn out to be similar.

Crescendo/Diminuendo Measures: Method 1

Indications of dynamic level can be arranged as on the following scale from loud to soft:

fff ff f mf mp p pp ppp

The ramp hypothesis predicts an association between the magnitude of a change of dynamics and the direction of that change. Successive dynamic markings that are neighbors in the above list may be deemed *gradual* changes of dynamics. By contrast, *abrupt* changes of dynamics might be defined as "jumps" of two or more values along this scale, such as the change from forte (*f*) to pianissimo (*pp*). Tables 1A and 1B give contin-

TABLE 1
Dynamic Changes

A. Sforzando-Sensitive

Change	Crescendo	Diminuendo
Gradual	153	184
Abrupt	291	547

B. Sforzando-Insensitive

Change	Crescendo	Diminuendo
Gradual	218	205
Abrupt	479	751

gency tables relating abrupt and gradual dynamic changes to the crescendo and diminuendo conditions. Table 1A presents data where sforzando markings are deemed to disrupt transitions in dynamic level. Thus the sequence “piano” followed by “sforzando” followed by “forte” is not equivalent to the sequence “piano” followed by “forte.” Table 1B presents data where sforzando markings are deemed to have no effect on the base-line dynamic level. In this latter case, all sforzando markings are ignored in the data analysis; hence the sequence “piano” followed by “sforzando” followed by “forte” is equivalent to “piano” followed by “forte.” Table 1A is thus a proper subset of Table 1B.

Both analyses show the predicted association between the direction and magnitude of change and are highly consistent with the ramp hypothesis (Table 1A: chi-square = 11.65; $df = 1$; $p = .000642$; $\phi = +0.100$; Table 1B: chi-square = 20.47; $df = 1$; $p = .000006$; $\phi = +0.111$). Moreover, the results show that there is little difference between the more stringent measurement conditions of Table 1A and the less stringent conditions of Table 1B. In both cases, a small but highly significant asymmetry exists between the manner in which the dynamic level builds and the manner in which it subsides.

The values mezzo-forte (*mf*) and mezzo-piano (*mp*) are comparatively rare in Beethoven. Hence, it is moot whether the marking “piano” (*p*) followed by “forte” (*f*) ought to be regarded as a “large” change of dynamic level. In Tables 1A and 1B, the markings $p \rightarrow f$ and $f \rightarrow p$ were deemed to be abrupt changes of level. A reanalysis of the data was carried out in which these transitions were deleted. The ensuing sforzando-sensitive results were found to be insignificant (chi-square = 1.87; $df = 1$; $p = .170999$; $\phi = +0.053$)—although the data remain skewed according to the predicted association. The sforzando-insensitive results remained highly signi-

ficant (chi-square = 17.42; $df = 1$; $p = .00003$; $\phi = +0.142$). This latter result implies that the ramp hypothesis is supported whether or not the difference between “piano” and “forte” is considered to be “large.” However, the results are most consistent with the view that forte-piano changes constitute a “large” change of dynamic level.

Crescendo/Diminuendo Measures: Method 2

A consequence of the ramp hypothesis is that small changes of dynamics ought to tend to increase rather than diminish the loudness. There are several ways of measuring small or gradual changes of dynamics. The most obvious way to change dynamics gradually is to specify overtly a “crescendo” or a “diminuendo.” Such dynamic changes may be indicated in the score by writing the terms “crescendo,” “cresc.,” “cres.,” “diminuendo,” “dim.,” “dimin.,” “decrescendo,” “decres.,” etc., as well as other terms such as “morendo.” Our hypothesis predicts that where these markings extend for a significant duration, the number of crescendos should exceed the number of diminuendos. In the Beethoven sonatas, 1263 crescendo markings are to be found, while only 360 diminuendos are indicated. The number of crescendos is approximately 3.5 times the number of diminuendos. This ratio differs significantly from an expected ratio of roughly equivalent numbers at better than the 0.001 level of confidence and supports the ramp hypothesis.

Aside from the ratios of crescendos to diminuendos, we must also be satisfied that the durations of the crescendos extend for a significant period of time—rather than merely being short-lived. For written dynamic terms, the effective length is occasionally indicated through the addition of dotted lines, (e.g., “dim - in - u - en - do” or “cresc. - - - - -”). The total number of diminuendo markings carrying dotted-line extensions is 50, while the number of crescendo markings carrying dotted-line extensions is 222—more than a fourfold difference. For convenience in tabulation we can define a “long” crescendo or diminuendo as one whose dotted-line extension extends over four or more bars (i.e., crosses three barlines). If we compare the number of long diminuendos (11) with the number of long crescendos (121) we see a tenfold predominance of long-term crescendos over long-term diminuendos.¹ Hence we can claim that crescendos are more frequent than diminuendos and that crescendos generally extend over a greater length of time than diminuendos. These results again support the ramp hypothesis.

1. A perhaps arbitrary and inconspicuous but revealing indication of the greater length of crescendos is the proportion of abbreviated terms: only 2.5% of diminuendos/decrescendos are spelled out fully, whereas 3.1% of crescendos are spelled out fully.

Crescendo/Diminuendo Measures: Method 3

An alternative method for indicating crescendos or diminuendos is through horizontal V-shaped or “hairpin” graphical markings. The ramp hypothesis predicts that where these markings extend for a significant duration, the number of crescendos should exceed the number of diminuendos. Without considering the length of these graphic devices, the number of graphic-diminuendos in fact exceeds the number of graphic-crescendos in Beethoven’s piano sonatas. This represents a reverse trend to that expected. However, this apparent anomaly can be resolved by examining the durations of these markings.

For the graphic hairpin symbols, the physical length of the printed symbol provides a convenient indication of its operative length. Table 2 provides a breakdown of hairpin crescendo/diminuendo markings by length criteria. A graphic hairpin symbol was deemed to be “long” if it crossed over one or more barlines.

Table 2 reveals a striking contrast. Although there are more hairpin diminuendos than hairpin crescendos, there is a strong association between length and the direction of change: diminuendos are significantly shorter in length (chi-square = 81.17; $df = 1$; $p = .000000$; $\phi = +0.248728$). Nearly 90% of hairpin diminuendos are less than a bar in length and so cannot truly be said to be “gradual.” If we compare only longer crescendo and diminuendo hairpin markings, the proportion of crescendos is more than double the number of diminuendos.

In short, Beethoven generally uses written terms such as crescendo or decrescendo as the preferred means of indicating those changes of dynamics that extend over several bars. Hairpin crescendo and diminuendo markings are reserved for shorter, more local, changes of dynamics. The typical hairpin dynamic marking has an effect over a duration of less than a bar. When hairpin markings extending across one or more barlines are considered, hairpin crescendos are significantly more prevalent than hairpin diminuendos. Once again these results are consistent with the ramp hypothesis.

TABLE 2
Lengths of Graphic Crescendos and Diminuendos

Length	Crescendo	Diminuendo
Long ^a	168	78
Short	392	674

^aOne or more barlines crossed by the graphic symbol.

Crescendo/Diminuendo Measures: Method 4

A further test of the ramp hypothesis can be pursued by examining the contextual relationship between markings of static level and immediately ensuing crescendo or diminuendo markings. In this case, crescendos and diminuendos may be indicated either through a written musical term or via the notation of a hairpin graphic symbol. The null hypothesis would posit that a crescendo would be as likely to follow *p* or *pp* as would a diminuendo to follow *f* or *ff*. However, Tables 3A and 3B refute this. If the dynamic level is high, the probability of an ensuing diminuendo is only between 8 and 11%.² However, if the dynamic level is low, the probability of the subsequent marking indicating a crescendo is over 40%. Once again this result is consistent with the ramp hypothesis.

Conclusions

A number of conclusions can be made concerning changes of dynamics in Beethoven's 32 piano sonatas. The musical term crescendo is significantly more common than the terms indicating diminuendo. When these

TABLE 3
Context-Determined Crescendos and Diminuendos

A. Sforzando-Sensitive

Crescendo Condition	Count	Diminuendo Condition	Count
PP - <	213/656	FF - >	33/651 ^a
P - <	861/2027	F - >	67/1082
	1074/2683		100/1733

^aInterpret as: 33 of 651 fortissimo markings are followed by the indication of a diminuendo.

B. Sforzando-Insensitive

Crescendo Condition	Count	Diminuendo Condition	Count
PP - <	222/656	FF - >	61/651
P - <	935/2027	F - >	133/1082
	1157/2683		194/1733

2. The precise figure depends on sforzando-sensitive or sforzando-insensitive contexts.

terms are accompanied by dotted-line extensions indicating the duration of the dynamic change, crescendos are significantly longer than diminuendos. Similarly, graphically indicated “hairpin” crescendos are significantly longer than corresponding diminuendos. Furthermore, large (abrupt) changes in dynamics are more prone to be reductions of loudness than increases of loudness. In addition, crescendos will more commonly follow low dynamic levels than will diminuendos follow high dynamic levels.

Together, the above results strongly affirm the existence of a ramp archetype in the musical dynamics of Beethoven’s piano sonatas. In general, it can be said that the music tends to build in a gradual way, but tends to subside relatively quickly. This result parallels Huron (1990), where a similar ramp archetype was found in the introduction and retirement of voices in polyphonic music. In a subsequent paper, we will develop a psychophysical theory as to why such an asymmetry might be favored in the organization of music.³

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3. The author extends his thanks to Dr. Mark Haggard of the British Institute of Hearing Research (Nottingham, U.K.) and to Dr. Robert Pascall of the University of Nottingham School of Music for offering valuable comments on an earlier draft of this paper. This research was supported in part through funds provided by the Social Sciences and Humanities Research Council of Canada, the Canadian Centennial Scholarship Fund (U.K.), and the U.K. Committee of Vice-Chancellors and Principals.