Joshua Ballance

The Path to the New Note
Interval Content in the Music of Anton Webern

Introduction

The analysis of intervals is a well-established topic in the analysis of the music of Anton Webern. It is a preoccupation that has been applied in various ways to music across his corpus: from Herbert Eimert's (1959) summary of interval proportions in Op. 28/i to Robert Hanson's (1983) analysis of various 'freely atonal' works.[1] Indeed, Webern is often fêted for his delicate control of the aggregate intervallic content of his music, and authors often refer to particular intervals (especially the semitone) as typical: Kathryn Bailey, for example, suggests that 'a focus on the minor second is particularly Webernesque' (Bailey 1991, 18); Richard Chrisman that 'semitones are generally characteristic of Webern's style' (Chrisman 1979, 83). Such broad comments about a composer's general style are ripe for computational investigation, as there is no other realistic way to explore a composer's intervallic tendencies empirically (manually counting intervals on that scale would be such a Herculean task as to be essentially impossible). A computational corpus study is therefore the approach adopted in this paper. The corpus comprises Webern's 31 works with opus numbers, which have been encoded in XML for analysis with music21.

The primary research question adopted in this paper is a simple extension of the idea posited above: across the corpus of his works, did Webern prioritise certain intervals over others? This initial question provides the jumping-off point for a number of related concerns regarding basic distributions: did Webern's intervallic preferences change across the corpus? To what extent did he deploy intervals unequally in individual movements? Did this change across the corpus? Having explored these initial distributional concerns, an understanding of Webern's intervallic practice can be supplemented by considering several other phenomena. The first draws directly on this research and concerns the relationship between the intervallic content of the dodecaphonic rows and the resulting music: how strictly does the former predict the latter? (This is not conceptually dissimilar to Lewin 1968 although it expands the scope significantly.) Recent work applying quantitative methods to dodecaphonic music has tended to focus on the statistical properties of the rows themselves, particularly in the context of the total set of all possible rows (e.g. Bisciglia 2017; Von Hippel and Huron 2020). Without a meaningful corpus of related music, little more can be achieved (programming a computer to create a corpus of all possible rows is relatively easy). The contribution of this paper, by contrast, is its ability to link the rows with the resulting music.

The next topic under discussion in this paper is that of harmonic coherence or integration. The relationship between the two 'domains' of harmony—linear and vertical—is another topic that has received significant attention in the analysis of Webern's music, and that of the Second Viennese School more broadly. Boulez, for example, suggests that Webern achieved 'the abolition of the contradiction that formerly existed between the horizontal and vertical phenomena of tonal music' (Boulez 1968, 383). Again, however, this discussion suffers from a lack of empirical investigation, particularly on any multi-movement scale. Analytical investigation instead tends to be confined to particular movements or even singular phenomena (e.g. Chrisman 1979; Whittall 1987). This paper will instead apply a comprehensive empirical approach to consider the degree of similarity between the interval content of the two harmonic dimensions.

Finally, this paper will expand on the concept of 'frozen' intervals, an idea that was casually introduced by Lewin (1968) and more formally explored by Brown (2020). It concerns the degree to which particular

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[1] *Pace* Forte (1998, x), I will use the term 'freely atonal' to refer to those works which are atonal, but not dodecaphonic (i.e. Opp. 3–15).

interval classes[2] are deployed as only a subset of the possible intervals (Brown, for example, is interested in the presentation of ic1 in Op. 24/iii as 'almost exclusively' 11 or 13 semitones). (Bailey (1983) has also explored this kind of 'freezing' with regard to pitch material in Op. 21, where she observes that throughout the exposition Webern freezes pitch classes at particular pitch levels, creating a symmetrical disposition of pitches around A4.) The questions here are similar to those above: where does Webern freeze intervals? Is there any regular change over time? Are some intervals more regularly frozen than others?

Methods

Much of the approach in this paper draws on my previous work in this area, so in general I will offer only a brief summary of the methods used for this research (for more detailed discussion of this approach in practice, see Ballance 2020b; for the comprehensive editorial policy adopted in encoding, see 2020a). As mentioned above, the corpus consists of Webern's 31 works with opus numbers. Movements of multi-movement works are considered individually, as they tend to be fairly harmonically self-dependent, giving an overall corpus of 107 movements. Each movement has been encoded using Sibelius software and then exported to XML for analysis with music21 (Cuthbert and Ariza 2010).

This paper uses two related types of data. The first is the distribution of intervals in the vertical harmonic dimension, measured by duration; the second is the distribution of intervals in the linear harmonic dimension, measured by frequency. The measurement of vertical intervals follows the 'n-gram' principle of segmentation (Conklin 2002). This has becoming something of a default strategy in computational music analysis, whereby the successive verticalities of a given passage are treated to a full expansion (termed 'chordify' in music21), which 'duplicates overlapping note events at every unique onset time' (Sears et al. 2017, 333). Example 1 & Example 2 show this process in action. Having chordified all the parts in each movement, the interval content and duration of each verticality is then recorded. Interval content is measured as the interval between each note in the verticality and the bass note of the verticality; duration is calculated in seconds, according to the tempo markings in the score. For example, the eighth verticality in Example 2 (marked) contains two intervals, respectively 11 semitones and 25 semitones, and a duration of $\frac{1}{6}$ of a second. Measuring intervals from the bass note is certainly not the only possible method. Jonathan Harvey (1982), for example, has argued forcefully that post-tonal harmony should often be heard from the middle rather than the bass, an argument that Jonathan Dunsby & Arnold Whittall take up (1988, 123–130). Indeed, Harvey cites Webern as his inspiration in this, quoting from a 1940 letter from the composer to the poet Hildegard Jone: 'There is not a single centre of gravity in this piece [Op. 29]. The harmonic construction (resultant of the individual voices) is such that everything remains in a floating state.' (Webern, Humplik, and Jone 1967, 40). Whether this statement is capable of supporting quite the authoritative weight that Harvey hangs on it is questionable. In a letter from the previous year, Webern had made a similar point, suggesting, in relation to the song that would become Op. 29/ii that "however freely it seems to float around—possibly music has never before known anything so *loose*—it is the product of a *regular procedure more strict*, possibly, than anything that has formed the basis of a musical conception before" (Webern, Humplik, and Jone 1967, 37). Whilst the similarity of language surely link the two, this hardly seems a comment about the specific construction of individual verticalities—as Harvey would have us believe. Rather, Webern seems to be deploying the word 'float' as a vague aesthetic description in contrast to the rigorous compositional procedures he employed. Perhaps even more significantly, a year later in 1941, Webern wrote in a letter to Willi Reich that his music, whilst using dodecaphony, 'doesn't on that account ignore the rules of order provided by the nature of sound *namely the relationship of the overtones to the fundamental*. Anyway it's impossible to ignore them, if there is still to be meaningful expression in sound! But nobody, really, is going to assert that we don't want that!' (Webern

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[2] Henceforth, ic or ics.

1963, 61 (emphasis added)). Whilst this is hardly a comprehensive refutation of Harvey's thesis, this does at least question the extent to which we should abandon bass-oriented interval analysis. In any case, Webern's opinions need hardly proscribe our analytical approaches, particularly as expressed throughout his letters, which Kathryn Bailey & Barbara Schingnitz describe as 'chaotic and repetitious' (Puffett and Schingnitz 2020, 24, see 24–26 for a fuller account of the volatile confusion that often characterises Webern's letter writing). Evidently there is value in assessing Webern's harmonic practice 'from the middle', yet I suggest that for a comprehensive approach, replicable across the entire corpus, it makes more sense to hear intervals from the bass. This is, after all, the traditional approach through which we tend to consider harmony.[3]

Example 1: Op. 9/i, bb.1–3.

Example 2: Op. 9/i, bb. 1–3, chordified.

Another possible approach would be to use Forte's interval vector (Forte 1973, 13–18). Whilst this is certainly a powerful tool, for this analysis, focussed as it is on the musical surface, it is simply too reductive. Whilst on a deep structural level ic analysis is helpful—and indeed will be deployed in this paper—to start from this position eschews an enormous amount of detail about the nature of the intervallic presentation that it is simply insufficient for dealing with the concerns of this research.

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[3] I use 'traditional' rather than Webern's 'natural' with reason. Whilst that latter may be accurate, his suggestion that this adds value to the music commits the same logical fallacy that Julian Anderson identifies in a raft of pre-spectral composers: given the inherently constructed nature of music, some sort of derivation from natural procedures does not produce or guarantee any degree of musical quality (Anderson 2000, 10).

Turning to linear analysis, this is a similarly thorny issue. As soon as linear analysis moves beyond monophonic lines, the analyst has to decide which notes are connected and so which intervals are to be counted. In polyphonic music with clearly defined contrapuntal lines this is relatively easy: in Op. 16, for example, the parts are segmented enough to be easily identifiable. In other contexts, however, this is much less clear. Consider, for example, the two horns at the start of Op. 21/i (Example 3). Should we understand there to be a relevant linear interval from G2–A3 in b.3? How about following the A? Should it be linked to the C3 or the A♭3 in b.4? In this case, the disposition of parts, 'aeration' with a crotchet rest, and slur seems to make it clear that we should link the G–A♭ and A–C, but not every extract has such a clear resolution. Only to add to the confusion, how about the row structure in a work of linear topography such as this? Again, this example has a fortuitous resolution: the row structure tracks the contrapuntal structure suggested above, but indeed raises further questions. The first statement of the row follows the second horn part to the end of b.4 and then moves to the E5 in b.6. Should this interval be counted? The approach adopted in this paper is largely to ignore the row structure. The emphasis of this paper is on the surface of the music, those intervals that can be (fairly) easily identified and plausibly heard (and which may therefore have some aggregate—if individually unperceived—effect). The rows, by contrast, form a *background* structure. Without getting into an extensive, and probably unresolvable discussion of Webern's ideological understanding of the row, he was clear that the row is 'not a "theme"' but achieved a sort of background unity, 'even if one's unaware of it' (Webern 1963, 55). This focus on the reasonably perceptible is also what underpins my analytical strategy for linear intervals. To expand the scope of the analysis comprehensively, I have produced a contrapuntal reduction of each work that creates a series of monophonic lines representing the contrapuntal parts in the piece (e.g. Example 4 &Example 5). The exact procedure is described comprehensively elsewhere (Ballance 2020a), but in essence it restricts contrapuntal lines to a single instrument, prioritises minimising interval size when a choice is to be made, and does not record an interval if the rest between notes is larger than a bar in length. The only other point to note is that duration of pitches has no bearing on the data-collection, the analysis merely counts frequencies of intervals. This is because there is no reliably replicable effect in the significance of an interval if it lies between, say, a minim and a crotchet, vs a minim and a semibreve, the latter is not necessarily twice as important (of course, other parameters like duration, timbre, texture could lend greater significance to the interval, but equally could not, and these are near-impossible to predict in a replicable, computational manner (for some early speculative work on salience conditions in post-tonal music, see Lerdahl 1989, 73–74).

Meiner Tochter Christina

Symphonie

I

Anton Webern, Op. 21

Ruhig schreitend (♩ = ca 50)

Clarinet in B♭

Bass Clarinet in B♭

Horn in F I

Horn in F II

Harp

Violin I

Violin II

Viola

Violoncello

Example 3: Symphonie, Op. 21/i, bb. 1–7.

Example 4: Op. 5/i, bb. 1–3.

Example 5: Op. 5/i, bb. 1–3, contrapuntal reduction.

Results

Overall Tendencies

The following summary will outline some of the key results from the data analysis in this paper. Comments about their implications for our understanding of Webern's music, and answers to the research questions, will follow in the Discussion.

Example 6 presents the overall distribution of intervals in Webern's practice. Intervals greater than an octave have been reduced to compound intervals. The results of each movement have been converted to individual percentages to control for movement duration, and then a mean average has been taken. Amalgamating Webern's total corpus in this way, it must be acknowledged, an intensely reductive act, and so forms only the initiating point for this paper. Nonetheless, this is exactly what authors imply when they remark that certain intervals are particularly 'Webernesque'. For each interval, the vertical proportion is shown on the left and the linear on the right. Correlations[4] have also been calculated with chronological corpus position as given in the Moldenhauers' biography (Moldenhauer and Moldenhauer 1978, 700–705).[5] These are listed in each bar, and are also represented in the colours of the bar (orange indicates positive correlation; blue, negative correlation; increasing intensity a stronger correlation). Calculating anomalous values indicates which intervals, if any, have a proportion which is unusually high or low.[6] The only such anomaly is the linear semitone (20.6%). For context, if all intervals were deployed equally, each would represent 8.3%. The same result is found if the linear and vertical results are combined and averaged: the semitone is the only anomaly, with 15.7%. Meanwhile, perhaps the most important single metric for assessing individual movements is the range of values (the difference between the proportions of the most common and least common intervals in a movement), which indicates the spread, and thus how evenly different intervals are deployed. Example 7 presents the range of intervals in each movement, organised chronologically. The correlation of range with corpus position is 0.10.
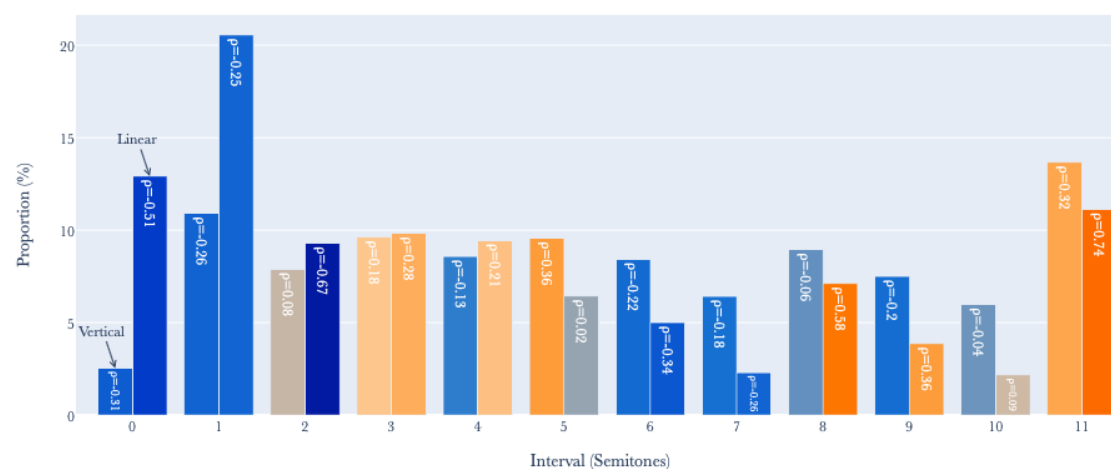

Example 6: Overall interval proportions & correlation (ρ) with corpus position.

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[4] Correlations are represented by ρ and are Spearman correlations, given to two decimal places.

[5] For ease, a full list can be accessed at https://github.com/joshua-ballance/Pitch-Class-Distribution.

[6] Anomalous values are calculated according to Tukey's rule, and therefore are defined as any value lying outside $1.5 \times IQR$ below the first or above the third quartile.
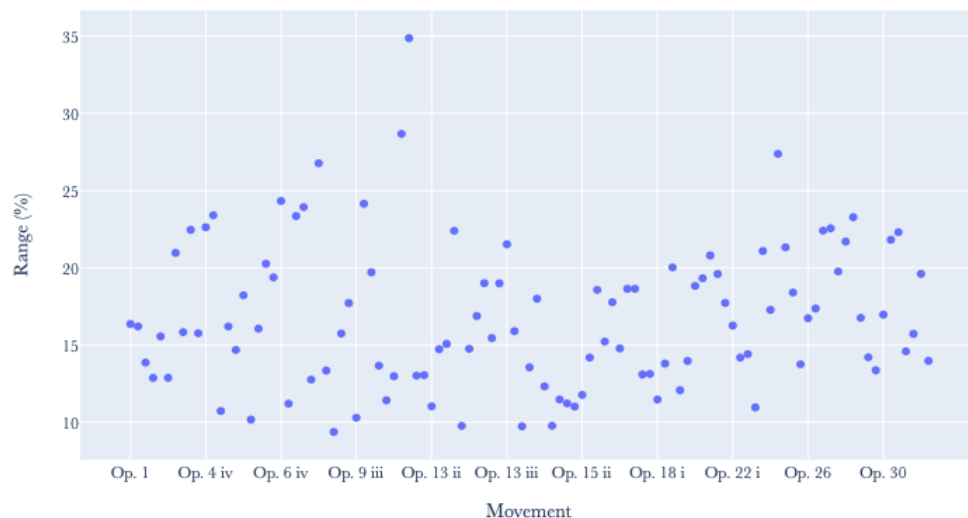
Example 7: Ranges of interval proportions.

Row Relationships

Having outlined the wider situation, we can turn to the second half of the corpus, the dodecaphonic works (Op. 17 onwards). The question here is to what extent the intervallic content of the row predicts the intervallic content of the movement. This is considered in terms of ics, as intra-row intervals can be deployed as any related ic. The prime form of the rows have been adopted from Bailey's summary (1991, 13–29), and include the interval 'round the back' (i.e. from the final note to the first note). Ic0 was removed from the analysis as it obviously does not occur in any of the rows. To investigate this, I ran an OLS Linear Regression Analysis for each ic, with the ic's frequency in a row as the independent variable, and the ic's proportion of a movement's total interval content as the dependent variable (note the slight difference here between the row's ic *frequency* (i.e. an integer in the range (0,12) and the movement's ic *proportion* (i.e. a percentage)). Linear and vertical relationships were analysed separately. The results of the analysis are presented in Table 1.[7]

Ic	Linear p>[t]	Linear coefficient	Vertical p>[t]	Vertical coefficient
1	0.000	5.201	0.000	7.216
2	0.001	8.341	0.000	8.158
3	0.000	5.304	0.000	6.223
4	0.000	4.893	0.000	7.641
5	0.000	10.730	0.000	5.635
6	0.000	5.172	0.000	3.199

Table 1: OLS Regression Analysis for row & movement ic content, separated by ic value.

This analysis has some value in indicating how Webern deployed different intervals in his dodecaphonic work, but the primary question here is more abstract and merely concerns whether the prominence of an

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[7] A brief guide to reading this table: the p>[t] columns indicate the results of a two-sided t-test. The value here is the probability that the result is greater than chance. I adopt the conventional significance level (α) of 0.05. Therefore, if the value in this column is less than 0.05, it can be deemed a statistically significant result. If this is the case, then we can turn to the coefficient column. This indicates the percentage change in the dependent variable for an increase of 1 in the independent variable. So, considering the results for linear ic1: p=0.000 and so p<α; the coefficient is 5.201, so for every additional ic1 in a movement's row, it's proportion of the ics in the movement increases by slightly over 5%.

ic in a row predicts its prominence in a movement. As such, the precise ic value is irrelevant. What is more, we gain statistical power by amalgamating the results from six variables to one. I therefore ran a further Regression Analysis, this time with the independent variable as an ic's frequency in a row and the dependent variable as an ic's proportion of a movement's total interval content. The results of this analysis are given in Table 2.

Dimension	p>[t]	Coefficient
Linear	0.000	5.392
Vertical	0.000	7.160

Table 2: OLS Regression Analysis for general row & movement ic content.

Harmonic Integration

Returning to the entire corpus, the third topic of discussion is harmonic integration. Given the empirical nature of this paper, this is interpreted here quite simply as the degree of similarity between the vertical and linear domains of harmony across the corpus, therefore putting aside any broader philosophical or structural concerns. Example 8 shows the correlation between linear and vertical interval proportions in each movement, ordered chronologically. Moving one level higher, the correlation between corpus position and each movement's correlation linear/vertical correlation is 0.30.
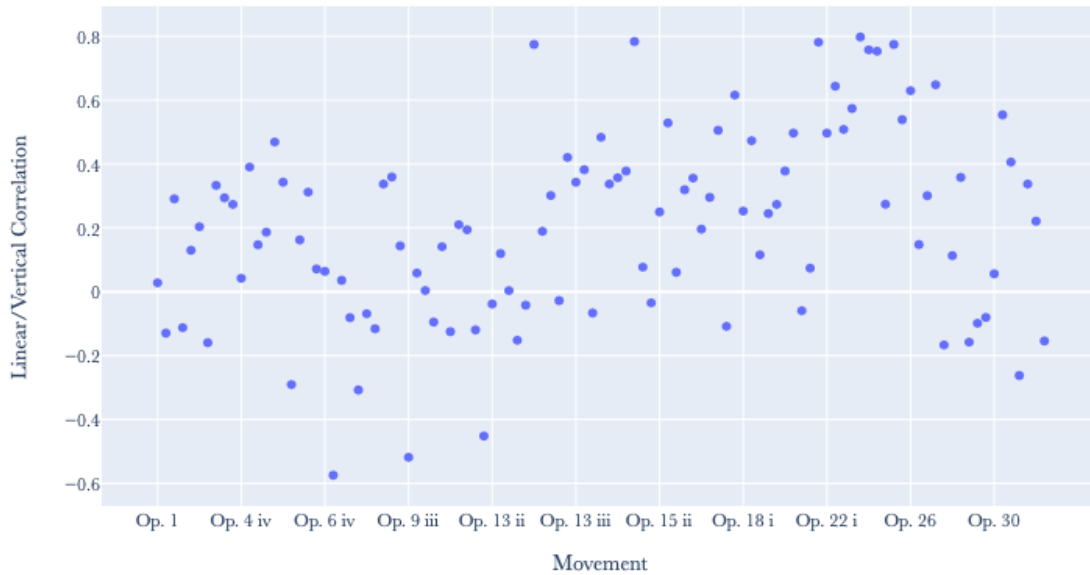
*Example 8: Linear/Vertical Interval Proportion Correlations.*

Frozen Intervals

The final topic of enquiry in this paper is that of frozen intervals. As discussed above, frozen intervals refer to the deployment of an ic in only a limited subset of all its possible intervals. The extent of this limitation requires careful definition. Indeed, in a dogmatic sense considering all possibilities, most music displays frozen intervals: intuition would suggest that linear intervals in particular tend to lie within one or two octaves, when, even allowing for the ranges of most instruments, they could exceed this and be distributed evenly across 3–4 octaves (for a discussion of the impact of musical memory on this phenomenon, see Snyder 2016, 172–73). Rather, we might expect extreme decay between successive octaves, perhaps

approximating a Zipf function.[8] Nonetheless, to my knowledge, there has been no work exploring frozen intervals in any other context (tonal or post-tonal). As such, we lack a broader context with which to theorise what might be deemed typical or unusual behaviour. This paper is restricted to considering Webern's music: developing and introducing an alternative reference corpus for comparison could certainly yield interesting results, but is far beyond the scope of this research. As such, consideration of frozen intervals here will remain relativistic, assessing which intervals are *more* frozen than is typical in Webern's own practice. Whether his practice is itself unusual remains unanswered.

To measure the degree of freezing of an ic in a movement is akin to measuring concentration or competition. As a result, to quantify the freezing of an ic, we can borrow a measure of market concentration from economics, the Herfindahl-Hirschman Index (HHI).[9] This gives a value in the range $(\frac{1}{n}, 1)$ where n is the number of participants: $\frac{1}{n}$ represents perfect competition (i.e. each participant has an equal market-share); 1 represents a monopoly. Interpreting this in the context of 'competition' between intervals of an ic is quite simple: low values indicate a relatively even dispersion across the possible intervals; high values suggest that only a few of the possible number of intervals account for most of the usage of an ic.

Considering the presentation of each ic in each movement is obviously beyond the scope of this paper, although a few specific examples will be considered in the Discussion. At this stage, it is beneficial instead to present some summarising data. In this vein, Example 8 shows the mean average value for each ic across the corpus, and Example 9 shows the mean average value for all ics in each movement. With regard to change over time, the correlation between a movement's average value and corpus position is 0.23 for vertical ics and -0.56 for linear ics.
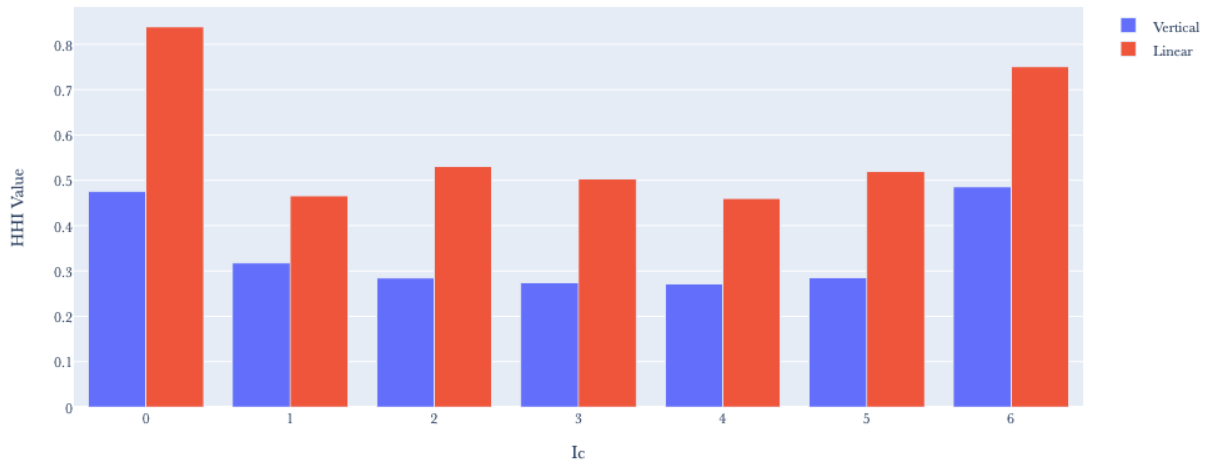
Example 9: Mean average HHI values for each ic.

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[8] A Zipf function is a power law probability distribution which states there is an inverse relationship between rank and frequency distribution (for his introduction of the phenomenon with regard to linguistics, see Zipf 1949, 19–55). It has also been identified in musical contexts (e.g. Rohrmeier and Cross 2008, 5–6).
[9] This is defined as the sum of the squares of each participant's market share, or in this case, the sum of the squares of each interval's percentage of its ic family.
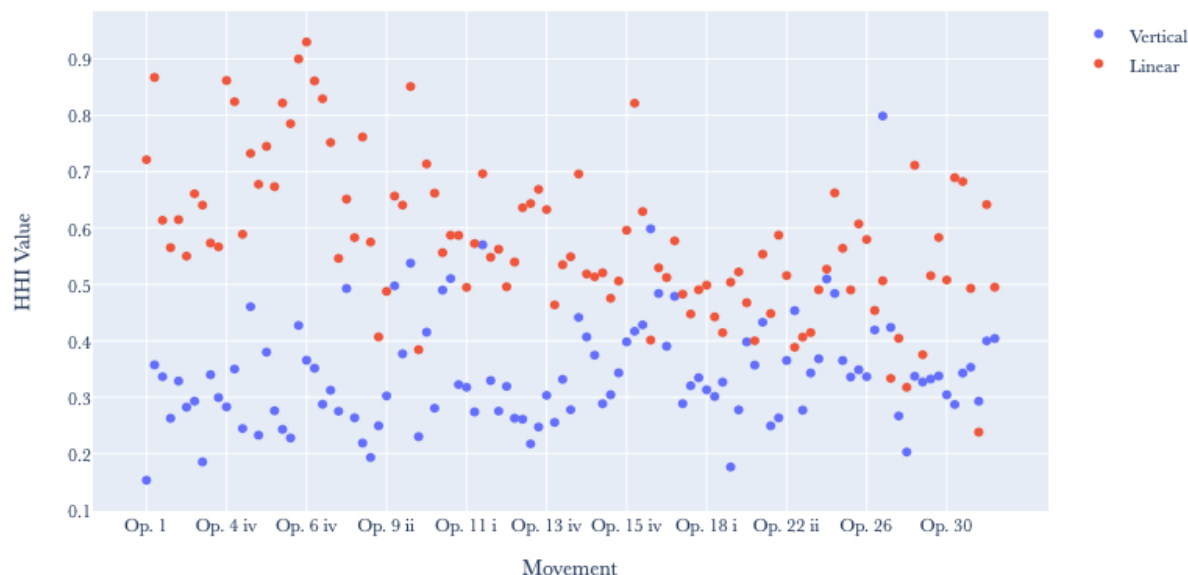
*Example 10: Mean average HHI values for each movement.*

Discussion & Conclusions

The results presented above suggest a wide variety of insights into Webern's practice, across a range of different areas. Opening with the most general observations, we can consider to what extent the minor second does indeed characterise his practice, as was suggested above. The results presented in Example 6 certainly go some way to confirming this: as was mentioned, the linear semitone is the only anomalous value, indicating unusual prominence across the corpus. It is notable, however, that both the linear and vertical major seventh are more frequent than the vertical semitone, as indeed is a linear unison/octave. Bailey's interest is primarily on the linear, and so it is perhaps unsurprising that her general observation refers most accurately to this dimension. Whilst direct precedents for this line of research are limited, there are some forbears in the literature. Herbert Eimert (1959) carried out a statistical survey (manually, presumably) of Op. 28/i, in which he found that Webern displayed a preference—again in the linear domain—for major sevenths and minor ninths. We will return to Eimert below when we discuss the implications of the dodecaphonic technique; for now, we can simply observe that his finding generally holds up across the corpus as a whole.

Another forerunner of this paper is an early corpus study by Roland Jackson (1970) comparing some works from the late Romantic and early atonal period to some later and dodecaphonic atonal music. As is often the case with older corpus studies, Jackson's work suffers from a tiny sample size, nine movements in total, some of which are merely represented by fragments. Nonetheless, it stands as an interesting premonition of what would later be feasible. To consider vertical content, for example, Jackson deploys the same 'full expansion' technique that is now standard practice (though he does not call it this). Regarding Webern's music, the earlier period is represented by the first 80 bars from Op. 5 (this peculiar selection comprises the first two movements in full, and approximately two thirds of the third movement); the later music by Op. 28 (seemingly in its entirety). As for his findings, these can be difficult to apply to the present paper as his representation in the essay tends to include only partial data and 'edited highlights' of his results. The one result that is somewhat comparable with this research is his suggestion that in the early period 'the minor second was slighted (and was almost totally absent in Webern's piece)' (Jackson 1970, 138). Unlike in this paper, to measure intervals Jackson uses interval vectors, and so by 'the minor second' he means ic1. Nonetheless, this is a surprising comment given the typical view of Webern's practice, as expressed above, as saturated with ic1, a finding confirmed by this research. Direct

comparison is unhelpful given the methodological differences between Jackson's research and this paper. Nonetheless, as interesting context, turning to the vertical results in this paper for Op. 5/i–iii we find that the semitone comprises, respectively, 13%, 11%, and 11% of interval durations, and the major seventh 12%, 7% and 11%. In most cases this is above what we might expect (recall that an even distribution would assign an interval 8%).

Whilst it is not possible to extrapolate much further from Jackson's research, his interest in observing trends does point to the next topic in this paper. The correlation figures in Example 6 show a wide variety of changes. Though most correlations are below ±0.5, and indeed a majority lower than ±0.3, there are a few intervals with strong correlations, displaying significant change over time: linear unison/octave (-0.51); linear tone (-0.67); linear minor 6th (0.58); and linear major 7th (0.74). The first two of these intervals might intuitively be associated more readily with tonal harmony, and so their decline is unsurprising. Indeed, a linear unison/octave interval becomes almost impossible in a dodecaphonic context (linear topography could theoretically allow it, but it would obviously be undesirable). The rise of the linear major 7th can perhaps be understood in a similar vein, though in reverse, as a relatively dissonant interval, and therefore one that is more attractive in an atonal context. As for the linear minor 6th, an explanation for this increase is not obvious, beyond changing personal taste. With regard to the other scholars, Boulez provides a comparison between Webern's different periods. He suggests that whilst Opp. 5 & 6 are 'composed of conjunct intervals or, if they are disjunct, intervals disposed in a register sufficiently narrowed so that the ear is able to perceive the continuity at once' (Boulez 1968, 379), in Op. 21 'the disjunct intervals are positioned so as to avoid even fortuitous establishment of any tonal rapport' (Boulez 1968, 384). In sum, Boulez seems to be suggesting that Webern's intervallic preferences grew wider over time. This, of course, is something we can assess quantitatively using the data in this paper. To do so, we can assume that Boulez means that Webern increasingly tends to prefer presenting an interval class as a wider interval, rather than wider intervals on their own terms (i.e. Boulez is suggesting that later in the corpus Webern is more likely to present ic1 as a minor ninth than a semitone, rather than prefer, say, a minor sixth to a major third). As such, we can assess what proportion of intervals fall into each octave in each movement, and then calculate the correlation of that proportion with corpus position. The results are given in Example 11. Strikingly, the linear and the vertical are almost mirror-images of each other. Whilst vertical ics are increasingly concentrated as smaller intervals across the corpus, for linear ics the reverse is true. One suspects from Boulez's phrasing (for example, the reference to 'the continuity') that he is talking primarily about linear intervals, and so is correct. Nonetheless, that Webern clearly tended towards increasingly closely-voiced verticalities over his corpus is also an interesting finding.
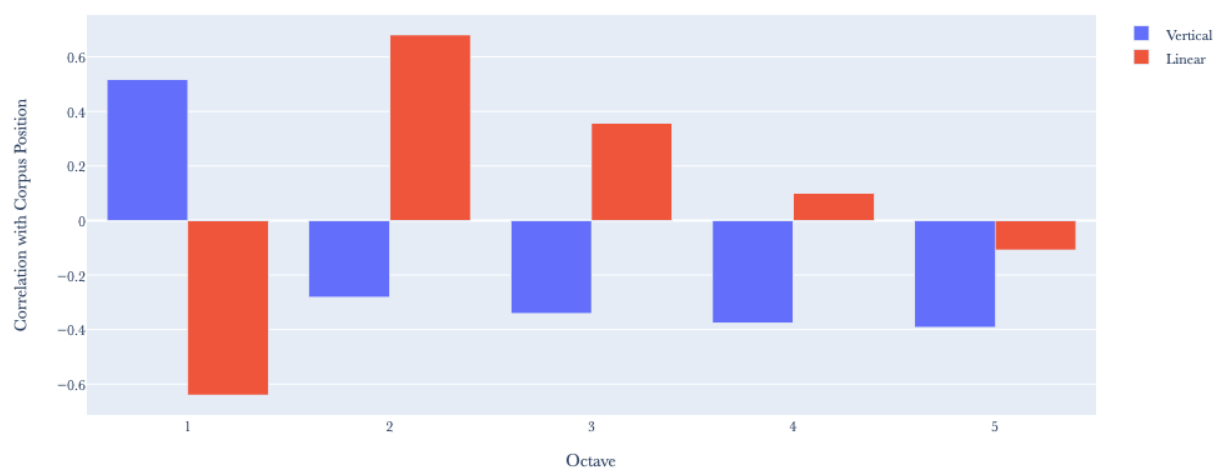
Example 11: Correlations between proportion of intervals in each octave and corpus position.

The other helpful metric in considering overall tendencies are the ranges of interval distributions. Example 7 makes it very clear that in this regard there is no overall pattern across the corpus. The bulk of the movements have a range between 10% and 25%, and the tiny correlation value makes it clear that there was no diachronic change in this regard. Op. 10/iii stands out as particularly unusual with a range of 35%, perhaps unsurprising given the idiosyncratic repetitive textures of the movement. Indeed, 70% of linear intervals in this movement are unison/octave (Ballance 2020b found that it had a peculiar pc distribution as well).

Turning to the dodecaphonic music, the finding in Table 2 that an increased frequency of an ic in a row predicts an increased frequency in a movement is notable, if unsurprising. Most fascinating, however, is that the effect is greater in the vertical domain than the linear. Scholars have often suggested that Webern was far more interested in the linear than the vertical. Bailey, for example, suggests that 'it is difficult to determine … whether the vertical effect of the coincidence of parts was a matter of much concern' (Bailey 1991, 334). Intuitively, we might expect that through the deployment of dodecaphonic rows would have a more profound linear effect than a vertical one, and yet that is not the case. Considering the manner of construction leads us to topography (see Bailey 1991, 30–93): reasonably we might expect a different effect between works constructed from different topographical techniques, and in particular, we might expect the row to have a greater vertical effect in block topography, and a greater linear effect in linear topography. The results for these subsets of the corpus, shown in Table 3, are therefore rather surprising: the reverse is true. An increase in ic frequency has a greater vertical effect if the topography is linear, and a greater linear effect if the topography is block. Admittedly these differences are small, approximately 1%, but that too is surprising: the effect of the manner of construction on the resulting music is *tiny*. Given that in particular in a linear topography work the dodecaphonic technique has no effect on the vertical coincidence of parts, and yet there is a strong relationship, this must surely be down to Webern— consciously or subconsciously. In the light of this research it seems difficult to support Bailey's contention that Webern was unconcerned with the vertical effect: the evidence is such that there is an unambiguous connection between row content and musical content, even when the row is irrelevant to the mechanical construction of the music.

Topography	Linear p>[t]	Linear Coefficient	Vertical p>[t]	Vertical Coefficient
Block	0.000	5.64	0.000	6.60
Linear	0.000	4.83	0.000	7.66
Combined	0.000	6.75	0.000	6.68

Table 3: OLS Regression Analysis for different topographies.

Clearly the implication of this finding concerns Webern's interest in harmonic integration; in particular, it suggests that he sought to achieve this (consciously or subconsciously) irrespective of the method of construction. This tallies with the general picture in the literature, which is of Webern following Schoenberg in an obsession with *Zusammenhang* or coherence (Gerhard 1951, 27–28; Webern 1963, 60–61). Example 8 allows us to explore this rather more comprehensively, and the results are rather interesting. The general weighting is towards positive correlations, and therefore alignment between linear and vertical interval proportions. A majority of movements (79/107) have positive correlations and the mean correlation is 0.20, a fairly weak positive correlation that suggests some degree of integration but with plenty of variety. That the correlation between movement correlations and corpus position is 0.30 suggests general increase in integration over time. Nonetheless, there is no marked change with the onset of dodecaphony, and several of the later works have negative correlations indicating relative disjuncture between harmonic dimensions. Similarly, there are no movements with an anomalously high correlation:

clearly Webern's practice varied significantly. Other correlations with possible variables include -0.19 with the number of parts in the ensemble, and 0.10 with movement duration, neither a particularly strong indicator of any meaningful relationship.

Finally, we can consider frozen intervals. Looking first at the overall trends in Example 9, perhaps the most obvious observation is that both vertical and linear present something of a U-shape. This is largely meaningless, as ic0 and ic6 have only one possible interval per octave, so are inherently more concentrated in a smaller number of intervals. Other than that, ics1–5 display remarkably similar HHI values. More notable are the higher linear values for both every ic and every movement in Example 10. This is perhaps to be expected: larger intervals are more logistically feasible in a vertical context than a linear one (particularly when measured from the bass of a verticality), and so allow more easily for a greater variety of available intervals. As for chronological change, the linear correlation suggests that over time Webern felt more able to deploy a wider variety of intervals for each interval class, an observation which is consistent with the above finding that he used intervals from a greater set of octaves later in the corpus. In sum: as time went on, he moved from using a relatively constricted set of comparatively small linear intervals in each movement to a more varied selection that also encompassed larger-octave intervals.

Returning to Brown, she cites various authors who identify Webern as focussing on representing ic1 as either a major seventh or a minor ninth (Brown 2014, 45–46). As this is apparently a commonly held position in the literature, it is worth digging into, as is her focus on Op. 24/iii. Starting with this movement, compared to the rest of the corpus it has the 26th highest linear HHI value and the 11th highest vertical value. This is certainly on the more concentrated end, but it is not remarkable in this regard. More exceptional are the anomalous movements: Op. 6/iv (linear HHI value 0.93), Op. 27/ii (vertical HHI value 0.80), Op. 16/ii (vertical HHI value 0.60), and Op. 11/iii (vertical HHI value 0.57). Op. 27/ii perhaps presents a particularly clear example: ics 2, 3, 4, 5, and 6 are all frozen at one interval level (respectively, minor seventh, minor third, major tenth, perfect fourth, tritone). This is perhaps partially explained by the use of canon to organise the music (for an exposition of the canonic structure, see Bailey 1991, 111–12), but it remains a remarkable situation. Brown's analysis of her chosen movement therefore provides a demonstration of exactly the sort of possible pitfall that a corpus study can avoid. Without any context from other works, it is impossible to know whether this movement is unusual or typical in its behaviour; with this context, we have a better sense. Of course, Brown is particularly interested in the treatment of the set-class 3-3 (0,1,4) which is prominent in the movement, and so the choice of example can be understood from that perspective.[10] As for ic1, Example 9 shows that it is unexceptional in the context of the total corpus.

This paper presents a wide variety of observations regarding Webern's style. Obviously, several of them could be bolstered by further analysis, both on a local and macro scale. In particular, the development of a representative reference corpus would provide a fascinating contextual framework to which to compare Webern's music. Nonetheless, this paper makes the case clearly that developments in intervallic content are an important and characteristic part of Webern's practice. In several areas, this paper also clearly outlines the need for corpus studies: investigating commonly held assumptions sometimes reveals that scholars' intuitions were correct (Boulez's assertions, for example, about widening intervals), but at other times the empirical reality does not match the assumptions. That there is a clear link between row content and the resulting music is notable, and yet the discussion of topography makes it clear that this relationship *did not require the row*. This poses serious questions about the assumption of Webern as focussed on the linear, and on the importance of the row in the mechanical construction of the music. If the same

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[10] Though it is beyond the scope of this study, it would theoretically be feasible to assess from a corpus perspective the degree of freezing in the presentation of particular set-classes, which would contextualise Brown's paper further.

effect could be achieved in both domains of harmony, even when only one is controlled by the row content, surely we must conclude that the row was less *mechanically* omnipotent than we might otherwise think. The narrative of the row as something that came as a gradual, almost inevitable aesthetic development seems apt (for Webern's telling of this history, see Webern 1963, 39–40). As for integration, the comments here are clearly partial, there is much more to be explored in this area, but they make an interesting suggestion that Webern's oft-expressed desire for integration was less effective in practice, and crucially that neither the onset of dodecaphonicism, nor his broader personal development as a composer, had any major effect in this regard. Finally, frozen intervals are the area that would be most augmented by more detailed case-study analysis. Brown has set out a stimulating example with her analysis of Op. 24/iii, but this paper hints that there may be more to find in other movements, which can be identified through this sort of corpus study.

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