Bob Berg's solo on "Angles"

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Introduction

The present study attempts to reconstruct the creative processes underlying a specific jazz solo improvisation—Bob Berg's solo on "Angles"—using all available data from the musical surface as provided in the Weimar Jazz Database. To this end, we also try to integrate classical and computational analysis methods to gain a more complete picture than might be possible with either method alone. This includes general statistical descriptions, a look at tonal and intervallic choices as well as the metrical and rhythmical design. Central to our analysis will be an attempt to re-tell the 'story' of the solo with a special focus on playing ideas (midlevel units) and dramaturgic curves. We also take a closer look at the construction principles for lines, including a classification of line types, and in conclusion investigate the usage of interval and pitch patterns in order to arrive at a maximally complete picture of the creative devices and processes involved.

The object under study is a solo by Bob Berg (1951—2002), who was an eminent postbop tenor sax player of Miles Davis fame. He was born in Brooklyn, New York, and of Italian-Jewish origin. Unfortunately, only very little information is available about his life and personality. What is known is that he started playing saxophone at age 13 and studied at the Juilliard School, but never graduated. He became a professional musician already at the age of 18 and immersed himself in the New York loft jazz scene. He also dipped briefly into free jazz at the end of the 1960s. He was strongly influenced by John Coltrane and, in the 1970s, he initially shunned the then very popular fusion jazz, preferring more classical settings. From 1973 to 1976, he worked with Horace Silver, and was part of Cedar Walton's band from 1977 to 1981. His first record as a leader was *New Birth* from 1978, which featured Cedar Walton on keyboards and piano. In the 1980s, Bob Berg came to the attention

of Miles Davis, who included him in his famous electric band from 1984 to 1987, where he became known as an eminent fusion saxophonist. After he left Davis's Band, Bob Berg diversified his interests and played postbop, fusion, and other styles in various settings and groups. In an interview from 1996, he stated: "I feel pretty comfortable moving between different areas of music." Amongst others, he was a frequent collaborator with his band mate from the Miles Davis band, guitarist Mike Stern, and with another Davis alumnus, Chick Corea, on whose Stretch label he also released several albums. After his untimely death in a tragic car accident in 2002, Berg left a musical legacy of 12 records as a leader and 33 records as a sideman.

The piece "Angles" is a Bob Berg original from his 1993 record *Enter the Spirit*. The composition can be described as a typical postbop tune, with a chord progression that is halfway between tonality and modality, very much in the spirit of Wayne Shorter's compositions from the 1960s. The theme melody is angular, which might have been an inspiration for the title of the song. The form and chords of the theme are not maintained during the solos; instead, a simplified 48-bar scheme AAB of 16 bars each is used, with four chords lasting over four bars each (cf. Table 1). The tonality is not fully clear, but a tendency to A♭ major can be stated, since the A sections start with $A\flat^{maj7}$ and end with $E\flat^{7}$ and most of the chords more or less fit into A♭ major. Deviations can be found in the $D\flat^{7(\sharp 11)}$ in the A and B sections, which belong to G♭ major/minor, as well as in the altered $G^{7\sharp 9}$ and D^{7alt} chords at the ends of the B sections, which do not fit into A♭ major and have a rather unusual falling fourth relationship. The D^{7alt} leads back to the $A\flat^{maj7}$ with a tritone step, and hence these two chords might be interpreted as a semitone downward shifted variant of a $A\flat^{7}$–$E\flat^{7}$ connection, which would fit better tonally. Due to the unusual chord connections, the overall loose tonality and rather long chord lengths, the solo form is located somewhere between tonal and modal conceptions.

The tempo is rather high with 270 bpm and the rhythmic feel oscillates constantly between latin in the A sections and swing in the B sections. The accompaniment is very dense. In particular, pianist David Kikoski playing is rhythmically very accentuated, relentlessly pushing the energy, while often filling the phrase gaps in Berg's solo with rhythmical impulses. Drummer Dennis Chambers employs a modern, complex and busy drum style, while frequently reacting to Berg as well as driving him forward.

The solo comprises 799 tones in 38 phrases and 144 bars over three choruses. Most of the tones (85.4 %) are very short on an absolute scale (i. e., absolute duration class) which in this high tempo equals mostly the level of eighth notes (cf. Table 2). The syncopicity, i. e., the percentage of syncopated tones, is

Table 1: General characteristics of Bob Berg's solo on "Angles".

Composer	Bob Berg
Record	*Enter the Spirit* (1993)
Personnel	Bob Berg (ts), David Kiskoski (p),
	James Genus (b), Dennis Chambers (dr)
Tempo	270 bpm
Signature	$\frac{4}{4}$
Key	Mostly A♭ major
Form	A(16) A'(16) B(16)
	4-bar chord changes throughout
Chord Changes	A: $A\flat^{maj7}$ | Cm^{7} | $D\flat^{7}$ | $E\flat^{7}$ |
	B: Fm^{7} | $D\flat^{7\sharp11}$ | $G^{7\sharp9}$ | D^{7alt} |
Rhythm feels (theme)	A: Latin, B: Swing
Rhythm feels (solos)	A: Latin, B: Latin
Lengths	799 tones
	144 bars
	3 choruses
	8 phrases
Duration	127 s
Densities	6.3 tones/sec
	5.6 tones/bar
	21 tones/phrase
Metrical centroid	3+
Start of phrases	42 % (beat 3)
	13 % on 3+
	10 % on 1
	10 % on 2+
Syncopicity	9.2 %
Tessitura	*A*♭3 — *A*♭5
	(36 semitones / 3 octaves)

rather low (9.4 %) compared to the average value of about 30 % in the Weimar Jazz Database. This seems to be mostly due to Berg's highly precise timing, since, due to the metrical annotation with the FlexQ algorithm syncopicity values in the Weimar Jazz Database are partly driven by laid-back playing and rhythmical freedom. The listening experience corroborates this conjecture, as Berg's solo shows a very tight rhythmical performance.

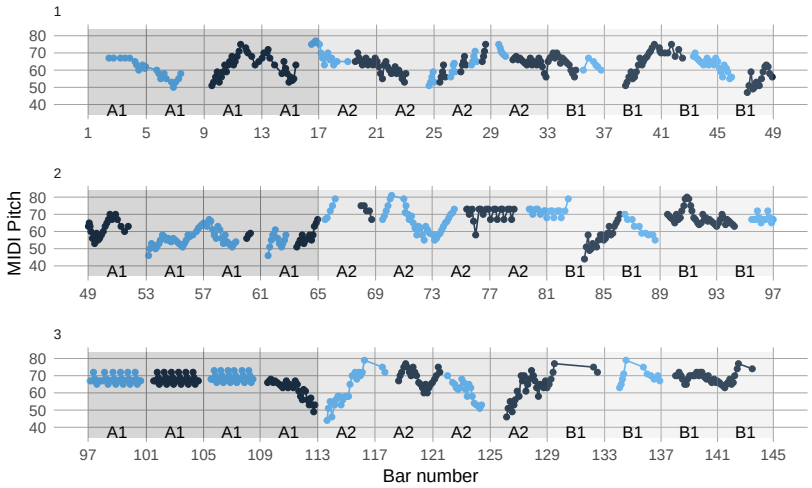

Figure 1: Piano roll representation of Bob Berg's solo. The single panels correspond to choruses. Phrases are colored alternatively; form parts are shaded with different gray tones.

The metrical placing of tones is uniformly distributed over all eighth note positions in the $\frac{4}{4}$ bar (Figure 2, middle panel). Interestingly, Berg has a strong preference for starting his phrases on and around the third beat of a bar (Figure 2, top panel; Table 1). As can be seen in Table 3, 22 of all 38 phrases start on beat 3, very often (ten times) also right after a chord change (see also Figure 1 for a visual overview of the interplay of phrase lengths, form sections, and four bar units). Another interesting fact is that Berg nearly always continues his phrases over the changes of contrasting form sections, i. e., A2 →B1 and B1 →A1, but not on the transition A1 →A2. The change of rhythm between the A and B sections under an ongoing phrase has a certain surprise effect and also contributes to the flow of the solo. The phrase endings are more diversely distributed but tend to fall on on-beats and also on the metrically strong first and third beats of a bar (Figure 2, lower panel).

With respect to accentuation in loudness, Berg shows a certain tendency to play (mostly in his fast lines) four eighth groups with descending loudness, starting from the strong first and third beat (Figure 3).

Table 2: Distribution of absolute and relative duration classes.

Duration Class	Absolute (%)	Relative (%)
very short	85.4	9.9
short	12.0	78.3
medium	1.9	9.4
long	0.6	1.6
very long	0.1	0.8

Table 3: Distribution of metrical and hypermetrical positions of phrase beginnings.

Bar phase	Beat position				Sum
	1	2	3	4	
0	1	1	10	0	12
1	4	2	4	1	11
2	1	2	6	1	10
3	2	1	2	0	5
Sum	8	6	22	2	38

Note. Bar phase = distance in bars from a chord change / four-bar block. Beat position = beat in the bar disregarding tatum position.

Tonal and interval choices

The overall pitch range is three octaves from A♭2 to A♭5, with a strong focus on the middle octave; 83 % of all tones are between A♭3 and E♭5 (Figure 4, top). Tonally, the pitch classes fit very well into A♭ major, even though G is the most common pitch class (accordingly, G4 is the most common tone), but this is due to some repeating patterns ('oscillations') in the third chorus, where G4 is the central tone. Looking at the pitch class distribution (Figure 4, bottom) the A♭ major seems to be rather dominant, with about 84 % of all tones coming from A♭ major. However, the solo makes a much more chromatic impression during listening. This can be explained by looking at the chordal diatonic pitch class distribution (Figure 5) and the chord-wise distribution of non-diatonic tones (Figure 6). There is a clear contrast between very inside, sometimes pentatonic playing on the one hand, and highly chromatic and even outside playing on the other hand. The latter mostly takes place in the second half of the B sections over the altered dominant seventh chords $G^{7\sharp 9}$

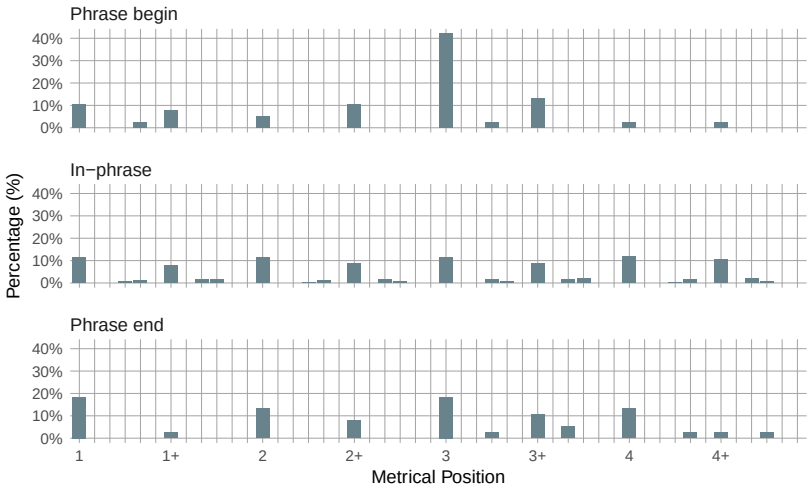

Figure 2: Metrical distribution in Bob Berg's solo differentiated for phrase position. Top: phrase beginnings ($N = 38$), middle: in-phrase tones ($N = 723$), bottom: phrase endings ($N = 38$).

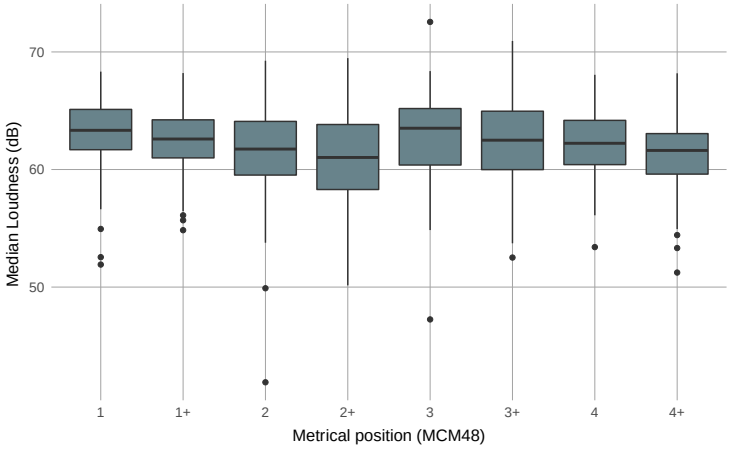

Figure 3: Loudness vs. metrical positions in Bob Berg's solo.

and D^{7alt}, but also once on the Cm^7 of the first A section in the second chorus and on the second $E\flat^7$ in the second A section of the first chorus, as well as the first A section of the last chorus. Interestingly, and this explains why the pitch class distribution fits so well in A♭ major: He often plays A♭ ionian on the $G^{7\sharp 9}$

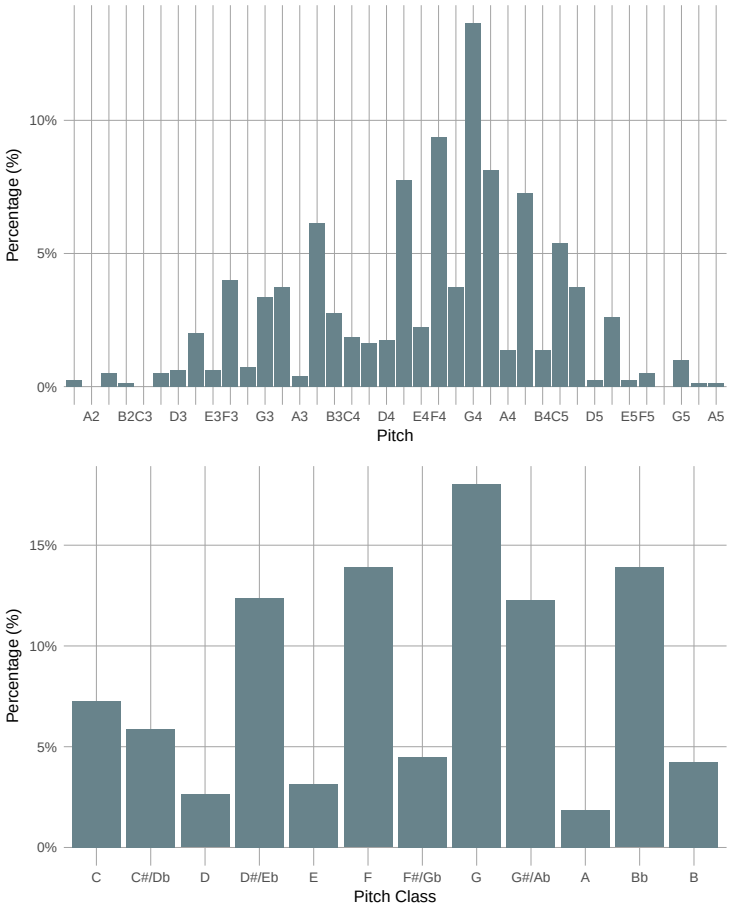

Figure 4: Pitch distribution (top) and pitch class distribution (bottom) in Bob Berg's solo.

and D^{7alt} at the end of the B section (e. g., in mm. 89–91 with a long $A\flat^{maj7}$ arpeggio). This is an interesting technique, since A♭ ionian fits well with the altered chords but also with the overall tonality. These are also the points of highest harmonic tension, so in some way this outside playing results mostly from ignoring these odd chords in the overall harmonic progression.

Another reason for the modern sound of the solo is Bob Berg's preference for upper structures. For example, he plays Cm over $A\flat^{maj7}$ (mm. 2–4, mm. 65–67), Gm^{7} over Cm (mm. 4–7), and $Fm^{7\flat5}$ over $D\flat^{7}$ (mm. 8–19, mm.25–28).

Table 4: Mean and median of chordal diatonic pitch classes mapped to third layers. See text for details.

Form section	Chord	Median	Mean
A1	$A\flat^{maj7}$	7.0	6.6
	Cm^{7}	5.0	6.9
	$D\flat^{7}$	5.0	6.7
	$E\flat^{7}$	7.0	6.2
A2	$A\flat^{maj7}$	7.0	7.1
	Cm^{7}	7.0	6.3
	$D\flat^{7}$	7.0	6.9
	$E\flat^{7}$	7.0	6.3
B1	Fm^{7}	5.0	6.3
	$D\flat^{7\sharp 11}$	9.0	8.5
	$G^{7\sharp 9}$	9.0	7.8
	D^{7alt}	9.0	8.9
All		7.0	7.02

This observation can be corroborated by mapping chordal diatonic pitch classes to third layers. This is done by mapping 1 and 3 to itself, and the mappings (7, ♯7, ♭7) → 7, (2, ♭9, ♯9) → 9, (4, ♯11) → 11, and (6, ♭13) → 13. Afterwards, mean and median values of the mapped chordal pitch class distribution are a measure for the amount of upper structures used. The results can be seen in Table 4, broken down by chords. The overall median is 7, i. e., the seventh, which is right in the center of a chord's expansion into thirds. The interval distribution is somewhat unusual, as can be seen in Figure 7. Compared to the overall interval distribution (lower panel), there are many more tone repetitions but also a flat plateau for small descending intervals. This however can be explained by the long oscillating figures in mm. 75–81 and mm. 95–108, in which similar figures are repeated very often. These oscillations are responsible for the unusual interval distribution, but are nevertheless very important for the solo as a whole.

Re-telling the story

The storytelling metaphor is an important aspect in jazz parlance and jazz research (Frieler, Pfleiderer, Abeßer, & Zaddach, 2016b) and might also be an active guiding principle for improvising jazz solos. Of course, there are

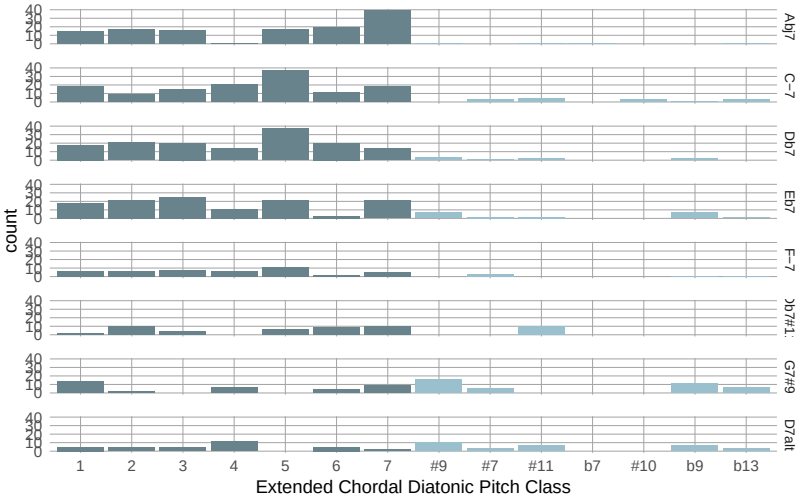

Figure 5: Tonal choices in Bob Berg's solo broken down for individual four-bar chords. Dark blue: diatonic pitch classes; light blue: non-diatonic pitch classes.

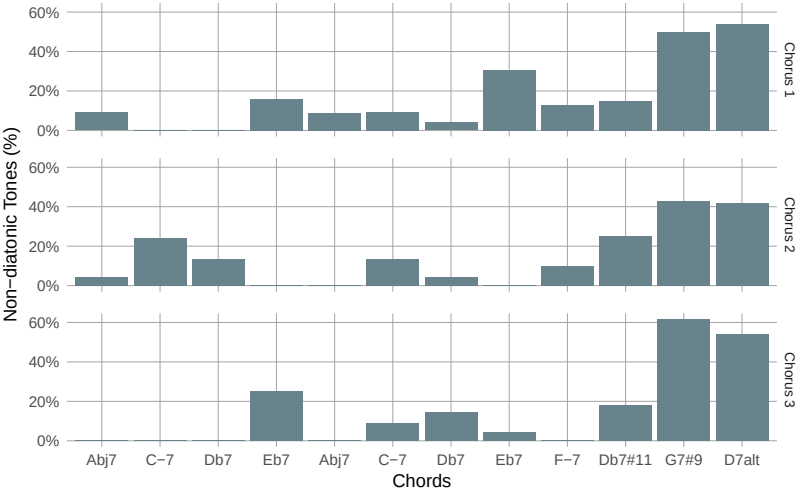

Figure 6: Outside playing in Bob Berg's solo for each chorus. Chords are listed as they appear in the AAB form.

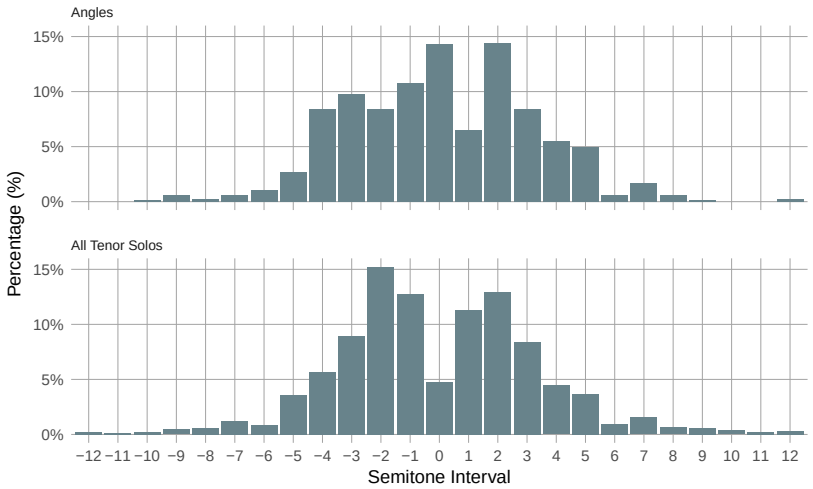

Figure 7: Semitone interval distribution in Bob Berg's solo (top) and in all other tenor sax solos in the Weimar Jazz Database (bottom).

no 'real' stories to be told in music due to the lack of denotative meanings. Nevertheless, a certain dramaturgy might be discernible, which might or might not follow narrative prototypes (e. g., the narrative arc).

In the following sections, we will first try a re-narration of the entire solo, based on midlevel units, and then have a look at global dramaturgic shapes.

Midlevel Analysis

Midlevel analysis is a qualitative annotation system for jazz solos which are inspired by playing ideas and called 'midlevel units' (MLU, cf. Frieler, Pfleiderer, Abeßer, & Zaddach, 2016a). There are nine main types of midlevel units (MLU) (*line*, *lick*, *melody*, *rhythm*, *expressive*, *theme*, *quote*, *void*, *fragment*) with 16 sub- and 38 sub-subcategories.

In Figure 8, a piano roll representation of the solo broken down into the main types of MLUs is depicted. The solo transcription in Figure 17 can be found annotated with full MLU types. Finally, in Table 6 a complete run-down of the sequence of MLUs in this solo is listed.

In this solo, 51 MLUs of only five main types are used: *line* (21), *lick* (11), *melody* (6), *rhythm* (6), *expressive* (6). 13 MLUs are glued together to form

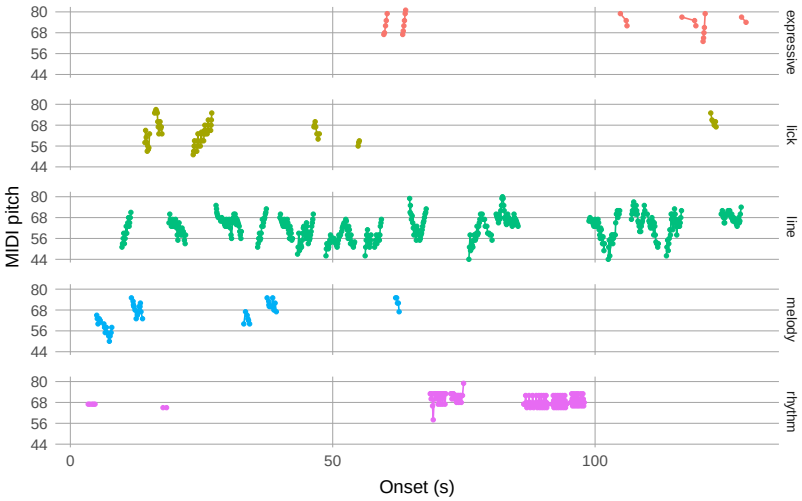

Figure 8: Piano roll of Bob Berg's solo differentiated according to midlevel units. From top to bottom: *expressive* (red), *lick* (olive), *line* (green), *melody* (blue), *rhythm* (purple).

phrases, and 13 MLUs are derived, mostly from the immediately preceding MLU. The mean duration of all MLUs is 2.0 s or 2.75 bars.

One striking aspect about the flow of ideas in this solo is the common combination *line→melody/expressive*, often directly glued to build a phrase. The *line* part is mostly of ascending type, whereas *melody/expressive* parts are mostly very short, just a few tones derived from major and minor triads and with descending contours. The first instance is in mm. 9–13, where a short sequence of four ascending $\text{Fm}^{7\flat5}$ arpeggios is followed right away by a simple melody from E♭ mixolydian. The next instance can be found in mm. 30–36, where a long, rather chromatic, wavy line ends in a simple C minor melody in mm. 35–36. Another instance is in mm. 38–42, where an ascending D♭ mixolydian ♯11 line ends in an E♭ mixolydian melody. Shortly after this, in mm. 47–51, a chromatic ascending line (mm. 47–48) is segued into a simple A♭ ionian line—right across the transition from the first to the second chorus and then into another short C minor melody. The next instance is to be found in mm. 63–67. Here, an ascending E♭ mixolydian line is ended by the first *expressive* MLU in the solo, which is constructed from the tones of an $\text{A}\flat^{\text{maj}7}$ chord and which resembles the melodies in m. 51 and mm. 2–4. It is directly followed by an *expression* variant, with a top tone a whole step up from G5 to A5, which suggests C dorian over the underly-

ing Cm^7. After this instance, which is a first peak moment in the solo, the series of longer oscillations starts. The next instance of the model is then to be found at the beginning of the third chorus (mm. 113–117), introduced here by a long-reaching, arpeggiated ascending line, ending in a C minor triad-based melody. An intensified variant can then be found a few bars later, in mm. 126–132, where the melody at the end is modified a bit to accommodate the Fm^7 chord. Again a few bars later, in mm. 134–136, a shortened and upwardly transposed echo follows, itself immediately succeeded by a *lick*, which resembles the melody in mm. 41–42. Finally, the very last phrase, in mm. 138–144, starts out with a faint echo of the oscillations from the second chorus, and then mutates into a short chromatic passage, segueing into a diatonic ascending arpeggio which ends in a short, two-tone *expressive* MLU. In a way, these very last seven bars contain the whole solo and its main ideas in a nutshell, functioning somewhat as a short conclusion.

The technique of ending a line with a short melodic part, often with longer tone durations, could be dubbed 'piggy tailing'. In many solos, the 'piggy tails' consist of only a few tones, normally one to three, which function as a short deceleration bringing a fast line to halt. One example for a more typical 'piggy tail' can be found in m. 124.

It interesting to look at ideas that occur only once in the solo. First, there is a Parker-sounding lick in m. 14–15 which is glued to a piggy tail melody. Indeed, the interval sequence $(-3, -4, -5, +3, -2, +1)$, starting on the third beat in m. 14, can be found three times in the Charlie Parker Omnibook.

Then, there is a very short *rhythm_single_irregular* in m. 18–19, which functions as an interruption of a longer line, even though the MLU right before it is labeled *lick*. Without this short intermission the whole complex would be just one long wavy line.

Generally, there is a shortage of short licks in this solo. Measures 24–28 present an ascending sequence of licks, which consists of $Fm^{7\flat5}$ arpeggios, nearly the same as the ones in mm. 9–11, but here extended higher and played in a specific 'choppy' rhythm, which transforms it into a sequence of licks. This is a good example of how the same sequence of pitches can be transformed into something distinctively different by only changing the rhythm—in this case by prolonging some inter-onset intervals. After he reaches the same endpoint (E♭5) as in m. 11, Berg continues with a very short and abridged version of m. 12, which sounds as a descending answer to the ascending arpeggios.

In m. 49, in the first bar of the second chorus, when the rhythm group shifts back from swing to latin, Berg plays his only embellishment figure in the entire solo, which vaguely recalls a pop jazz saxophone lick, but which is fully integrated in a much longer line of mixed character (cf. p. 14).

At the end of the first A section in the second chorus, in m. 60–62, there seems to be a short black-out in the flow of the solo. First, after finishing the long seven-bar line that started in m. 53, Berg continues with a very short lick, which is basically a transposed version of the 'piggy tail' of the line (m. 59). This sounds either as a bold confirmation of the preceding line, a false start of another line, or as a moment to gain time. After a bar-long pause, he embarks in mm. 61 and 62 on a short line, which is basically an $E\flat^{9}$ arpeggio over the $E\flat^{7}$ which does not sounds fully convincing, neither tonally nor in regard to phrasing. Next, as if 'upset' about this rather weak passage, he expresses that anger with a short diatonic up-swing (mm. 63 and 64) right into the first *expressive* MLU in the solo, which brings G5, the highest pitch so far, held for over one bar.

The last one-time element in this solo can be found in mm. 86–89, where Berg plays a mixed $E\flat/E\flat^{+}$ descending arpeggio with a constant eighth/dotted quarter rhythm pattern with tone repetitions (*line_i_dd*) over the $D\flat^{7\sharp 11}$. From that point on, all the remaining material is in one way or another related to some preceding material.

Dramaturgy

The dramaturgy of Berg's solo seems to be well-crafted, either intentionally or as emerging from group interaction. The general tension curve is doubly arched. This can be seen on one hand in the event densities across the course of the solo. In Figure 9, the number of tones of two-bar units shifted bar-wise along the time axis and plotted against the onset of the first tone of the bar unit is depicted, along with a polynomial trend. From the beginning on, the event density increases constantly over a long stretch and then dips down at the beginning of the second chorus to increase even more towards the end of the second chorus, where the highest densities are reached with the sequences of *oscillations*. The third chorus then sees a slow decay, but this does not mean that the intensity decreases, it is merely shifted to another dimension. This can be seen in Figure 10 where pitch and loudness curves of 20 note windows (with a hop-size of 10 tones) are plotted against the onsets of the windows. Both curves show an overall ascending trend—particularly the loudness curve—with some oscillations. One sees that the pitch heights rise quite rapidly in the first chorus but drop towards the beginning of the second chorus, to rise continually towards the end. In the third chorus, a certain saturation is reached, but in fact with strong oscillations, showing a stark contrast (at about 100 s). All in all, a clear peak in global intensity is reached with the sequence of oscillations.

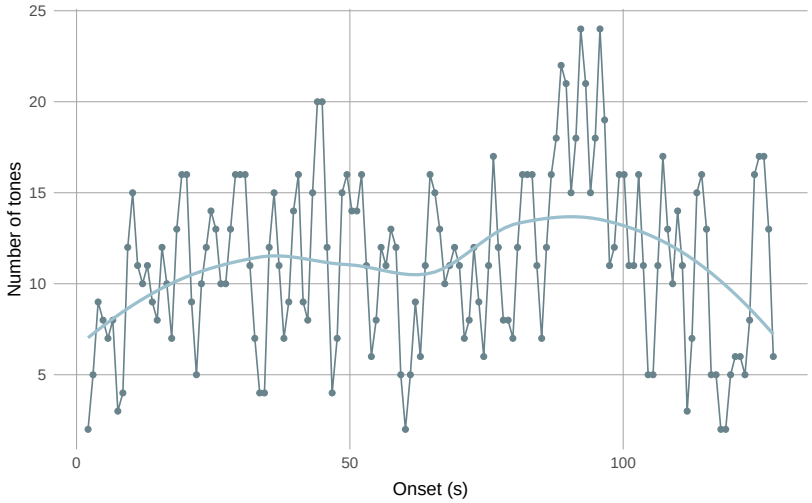

Figure 9: Event densities (number of tones) of Bob Berg's solo for windows of two bars shifted bar-wise along the solo.

This overall dramaturgy is also reflected in Figure 8. The *melody* and *lick* MLUs appear mostly in the first chorus whereas the second chorus is dominated by the sequence of *oscillation*s. The *expressive* MLUs appear for the first time at the beginning of the second chorus, and take over the role of the *melody* afterwards. This has an effect of intensification. The third chorus is then built from the double sequence of *line–expressive* and *line–line–expressive–expressive*, and resolves, finally, in the epitomic phrase *line–expressive* at the very end.

Line construction

The analysis of the MLU content of the solo shows that Berg utilizes different kind of lines in his solo: diatonic lines, arpeggios, chromatic lines, and mixtures thereof. To gain further insights, we manually classified the 21 *line* MLUs using this four-fold classification scheme and found four diatonic, three chromatic, six arpeggiated, and eight mixed lines. They indeed differ with respect to their interval content, as the distributions of frequencies of semitones, whole tones, and thirds show (Figure 11).

Using a similar system, we also classified line segments of seven intervals by moving this window by four elements. Segments always start at the beginning

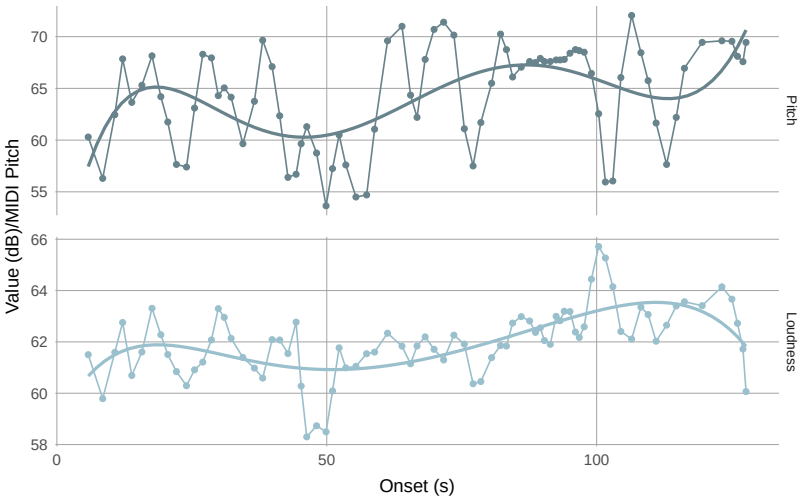

Figure 10: Smoothed pitch and loudness curves for Bob Berg's solo. Smoothing was done with windows of 20 tone events and a hop size of 10 tones. Trend line fitted with a polynomial of 6th degree.

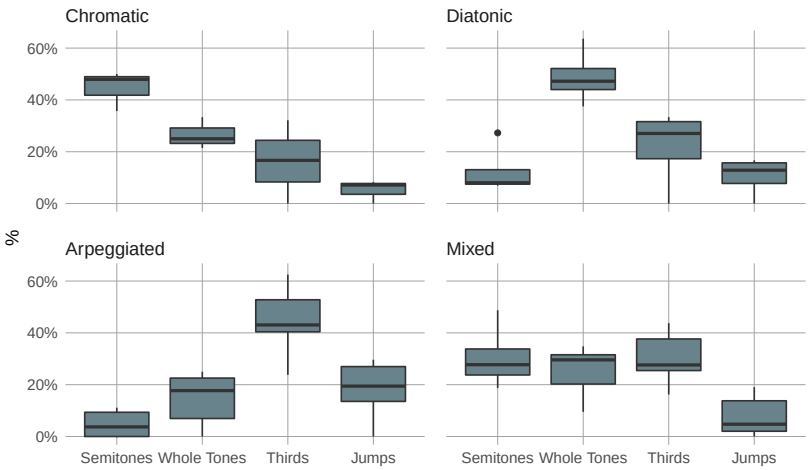

Figure 11: Interval content of the four line types found in Bob Berg's solo.

of *line* MLUs. A segment is classified as 'pentatonic' if thirds and whole tones account for more than two thirds of the intervals (i. e., five or more). It is

classified as ‘arpeggio’ if thirds and larger intervals account for more than two thirds of the intervals. It is classified as ‘diatonic’ or ’chromatic’, if semitones and whole tones account for more than two thirds of the intervals, and then depending on whether there are more semitones (‘chromatic’) or whole tones (‘diatonic’). Finally, segments are classified as ‘mixed’ if they do not fulfill any of these criteria or if the difference between the first and second most frequent class is less than 0.1. In Figure 12, the sequences of segment classes are plotted for each line in the solo. The first observation is a slight preference for mainly pentatonic lines (e. g., lines 1, 2, 4, 9, 18), although there is an equal share of pentatonic and mixed line segments (30.0 % each). The next common segment type is ‘chromatic’ (20.8 %), followed by arpeggios (13.3 %), and ‘diatonic’ 5.8 %. The length of lines ranges from 3 (line 8, 9, 11, 13) to 12 segments (line 7), with a median of 5.5. For the series of segment types, no obvious patterns can be identified, except that a segment type has a strong tendency to be repeated (about 50 %), which is partly due to the construction of our measure. Furthermore, chromatic segments tend to occur earlier in a line (mean normalized position = .45), whereas diatonic and pentatonic segments tend to occur later (mean normalized positions of .68 and .64). With respect to the entire solo, however, pentatonic segments tend to occur earlier, and arpeggios tend to appear later (e. g., in the third chorus, mm. 113ff. and mm. 126ff.). All in all, Berg shows a great variability in his approach to line construction.

Pattern usage

To investigate the usage of patterns in Berg’s solo, we used the partition function of the *melpat* module in the MeloSpyGUI with all seven Berg solos in the Weimar Jazz Database as a background corpus. Since the rhythms are rather uniformly based on eighth notes due to the abundance of lines, we only calculated interval and pitch patterns and no rhythmical patterns. For the interval domain, we extracted patterns with at least $N \geq 5$ intervals, which correspond to at least six tones. For the pitch domain, we demanded $N \geq 6$. For both cases, we extracted patterns that occur at least twice, but placed no restriction on the number of solos they should appear in.

We found 147 interval patterns meeting these conditions, with a coverage of 64.8 %, i. e., about two thirds of the tones in Berg’s solo are contained in an interval pattern of at least five intervals that occur at least twice somewhere in the seven Berg solos under consideration. This is the highest coverage of all Berg solos, which have a mean coverage of 56 %. But this is partly due to the extensive oscillations in the solo. However, when using all postbop tenor

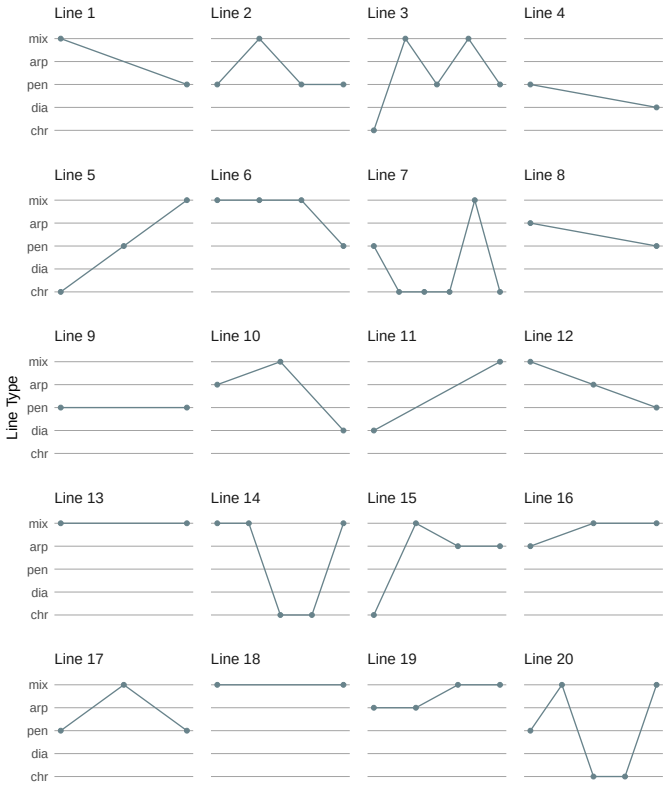

Figure 12: Classification of segments of seven intervals for *line* MLUs in Bob Berg's solo. Hop size is four intervals, i. e., points are separated by four notes each. chr = chromatic, dia = diatonic, pen = pentatonic, arp = arpeggio, mix = mixed.

solos, the coverage rises to 80.7 %, which is close to the mean coverage of 78.3 %.

We found 81 pitch patterns, with a coverage of 46.8 % (mean coverage across all Berg solos: 40.6 %). See Figure 13 for a display of interval and pitch patterns in Berg's solo. The longest patterns are produced by the oscillations and are not shown.

As expected, there are fewer pitch patterns than interval patterns (because a pitch pattern is automatically also an interval pattern, but not vice versa). The shorter patterns are more volatile, whereas the very long interval patterns are also pitch patterns, which shows that they are specifically rehearsed and then

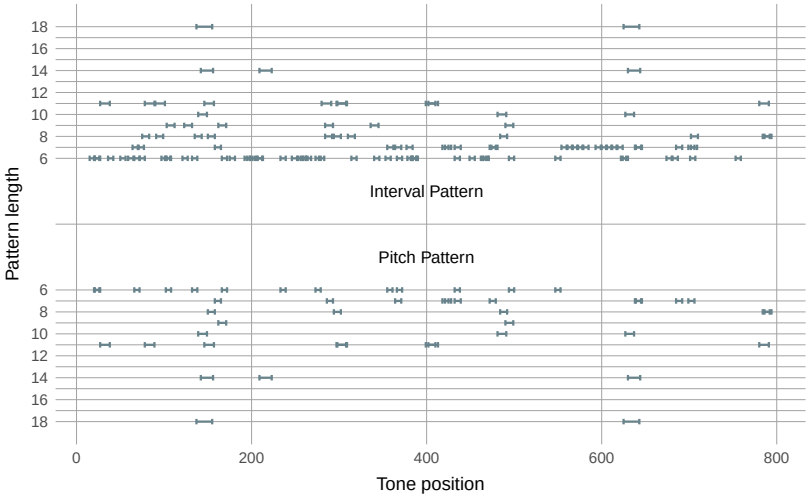

Figure 13: Interval (top) and pitch patterns (bottom) in Bob Berg's solo on "Angles" with an effective length of at least six occurring at least twice in the seven solos by Berg in the Weimar Jazz Database. Only patterns up to an effective length of $N = 18$ are shown, since the longest patterns are due to the oscillations.

reproduced. The shorter patterns are probably rehearsed in many different keys and thus can be used as building blocks, e. g., for line construction in many different harmonic situations. To illustrate the pattern usage by Bob Berg in this particular solo a little further, we produced a network of pattern similarities for the interval patterns. To this end, we calculated edit distances between patterns. The edit or Levenshtein distance (Levenshtein, 1965; Müllensiefen & Frieler, 2004) is defined as the minimum number of editions, deletions, and substitutions required to transform one sequence of symbols (here: intervals) into the other. For two completely different sequences of different length, the maximum number of operations is the length of the longer sequence. This can be used to convert the edit distance into similarity values between 0 and 1. The full matrix of similarities between all interval patterns was then converted into an adjacency matrix using a threshold of 0.5. This means that all similarities lower than .5 were set to 0 and all similarities above .5 were set to 1. These values were used to create a similarity network by feeding them into a graph representation algorithm from the `network` package for R (R Development Core Team, 2008). The result can be seen in Figure 14.

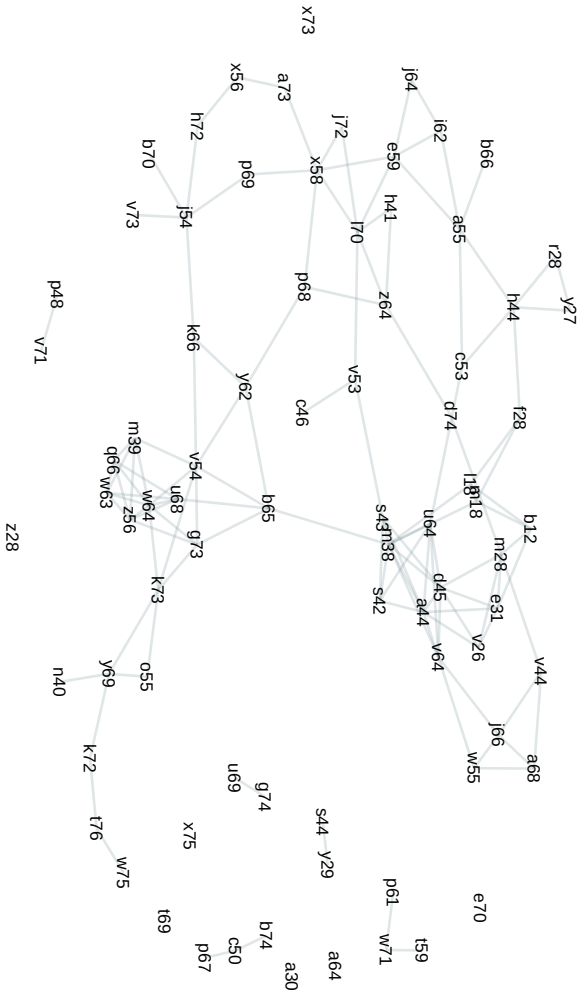

Figure 14: Network representation of all interval patterns in Bob Berg's solo. Edges are drawn according to pattern similarities, which were calculated using edit distance and range from 0 to 1, where a value of 1 means identity. Only connections with similarity greater than 0.5 shown. Node labels are arbitrary tags assigned by the partition algorithm.

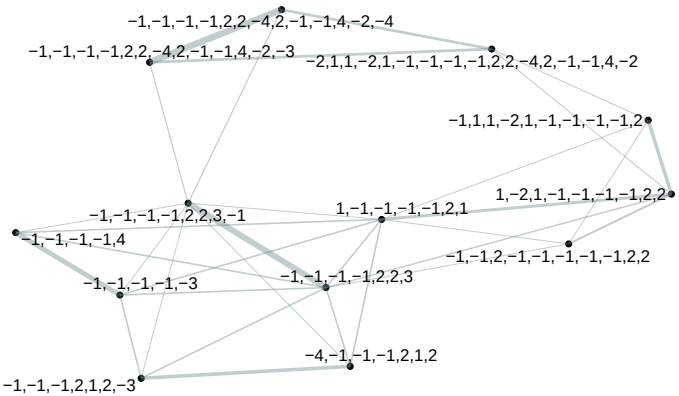

Figure 15: Close-up of the upper middle cluster of the full pattern network. Node labels are pattern values; edge widths are proportional to similarity.

One sees two clusters of strongly interconnected patterns and one rather loose cluster. There are also a few small cluster of only two or three highly similar patterns as well as several singletons. To highlight the cluster structures in more detail, we will have a closer look at the dense cluster in the upper middle of the network plot. It can be seen in Figure 15. A list of the patterns in this cluster can be found in Table 5 and are shown in Figure 16. The pattern b12 is the longest of all with 17 intervals (18 tones). It occurs twice in "Angles" (mm. 30 and 108) at the same metrical position and with identical pitches. It consists of a rather unpredictable sequence of mostly semi- and whole tones. Clearly, this pattern was pre-rehearsed. This is corroborated by the fact that the next two longest patterns, l18 and m18, are, except for their last tones, contained in pattern b12 as a suffix. On the other hand, pattern m28, apart from some slight rhythmical variation, is contained at the beginning of b12, as a prefix. However, it is counted as a separate pattern because it also occurs in another solo by Bob Berg (on "You and the Night and the Music" from the 1997 album *Another Standard*). The same holds true for pattern e31, which is fully contained in b12, but occurs five times in total in three different solos (there only as proper sub-patterns). All other patterns in this cluster are more or less variations of the material from the above mentioned patterns.

The main core of this pattern cluster is the interval pattern -1, -1, -1, -1, 2, 2 of four descending semitones and two ascending whole tones, mostly realized

Table 5: Upper middle interval pattern sub-network.

Tag	MM.	N	F_C	F_A	Value
b12	30, 108	17	2	2	-2, 1, 1, -2, 1, -1, -1, -1, -1, 2, 2, -4, 2, -1, -1, 4, -2
l18	31	13	2	1	-1, -1, -1, -1, 2, 2, -4, 2, -1, -1, 4, -2, -3
m18	43, 110	13	2	2	-1, -1, -1, -1, 2, 2, -4, 2, -1, -1, 4, -2, -4
m28	140	10	2	1	-1, 1, 1, -2, 1, -1, -1, -1, -1, 2
v26	54	10	4	1	-1, -1, 2, -1, -1, -1, -1, -1, 2, 2
e31	30, 92, 109	9	5	3	1, -2, 1, -1, -1, -1, -1, 2, 2
m38	55	8	2	1	-1, -1, -1, -1, 2, 2, 3, -1
a44	55, 92	7	3	2	-1, -1, -1, -1, 2, 2, 3
d45	140	7	2	1	1, -1, -1, -1, -1, 2, 1
s42	141	7	6	1	-1, -1, -1, 2, 1, 2, -3
s43	58	7	4	1	-4, -1, -1, -1, 2, 1, 2
u64	34	5	3	1	-1, -1, -1, -1, -3
v64	93	5	3	1	-1, -1, -1, -1, 4

Note. Tag = pattern name generated by the partition algorithm; MM. = measures in "Angles" where pattern can be found; F_C = frequency of pattern in the entire Bob Berg sub-corpus in the Weimar Jazz Database; F_A = frequency of pattern in the solo on "Angles".

in the middle octave starting from G4 and on a strong metrical position (first or third beat, only exception: v64). Only pattern u64 contains a slightly shorter version (last interval is a descending minor third —3). Notably, this core pattern does not occur as an independent pattern in the pattern partition, because it is always embedded in longer patterns. The most common continuation is a whole tone up (all patterns except s32 and v64), followed either by a descending major third or an ascending minor third.

Taken together, this pattern cluster alone shows clearly that Berg has a pre-rehearsed pattern vocabulary at his disposal, which is stable over time. It is mostly fixed in metrical and pitch position but can be varied by chaining different sub-patterns to longer patterns with contextual adjustments.

Creative Devices

In the foregoing sections, we provided a rich description of Berg's solo on "Angles" using many different perspectives. We would like to summarize here the most important creative devices that are employed by Berg.

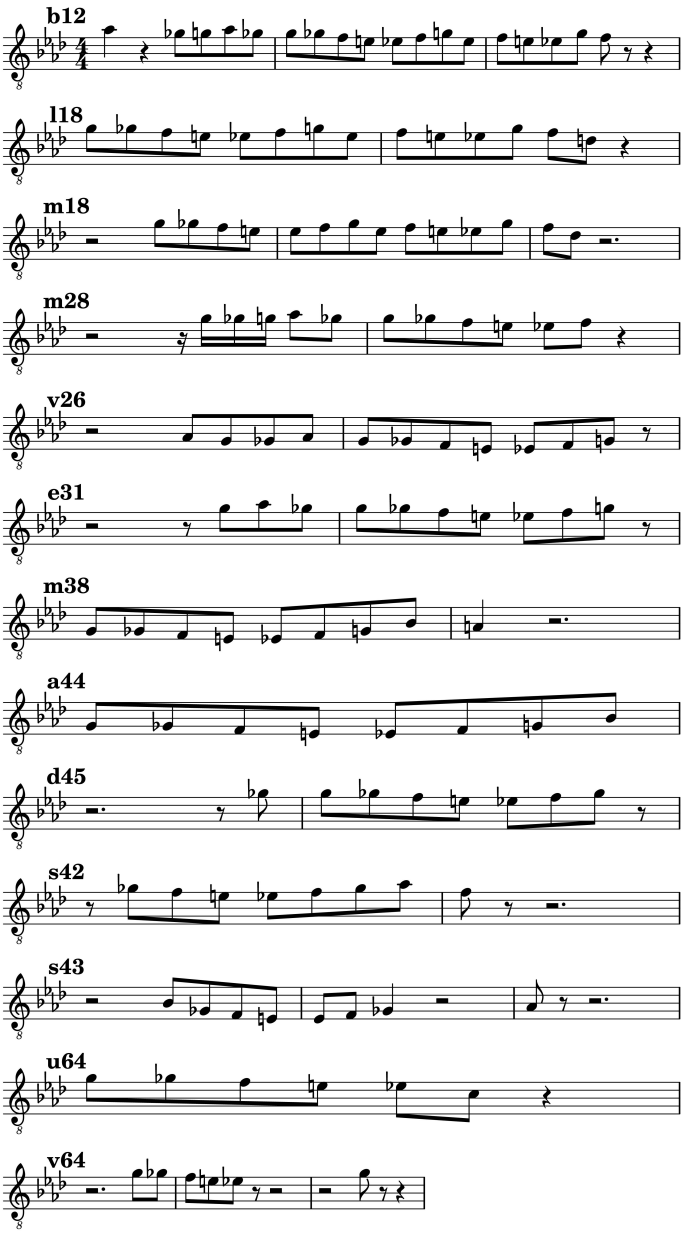

Figure 16: Interval pattern of the upper middle cluster of the full pattern network. All instances are the first instances in the solo on “Angles”.

First of all, the entire solo seems to follow a rather well-crafted dramaturgy. It shows a double arch shape with overall increasing energy. The dramaturgy seems to develop rather spontaneously and is partially driven by interactions with the band. One characteristic of this solo is the frequent changes of rhythm feel from latin to swing and back, which produce a tension and release pattern on the highest level. Berg nearly always continues his phrases seamlessly over these changes in rhythmic feel, which adds to the flow of his improvisation and the impression of mastery and virtuosity.

On the level of playing ideas, the solo is characterized by an abundance of lines with a conspicuous absence of licks. Rather, the frequently long lines of variable types are contrasted with either pentatonic or diatonic melodies which become more expressive during course of the solo. These melodic licks often occur at the end of a long line, and were dubbed 'piggy tails'. Such small extensions at the end of a longer line, or sometimes also at the beginning, can be frequently observed in jazz solos since bebop, but in this solo, these are rather long and melodious (or expressive). Their general function might be to give a certain form of closure to a line and/or coming to a stop after a fast-moving line. Sometimes, the effect is that the line feels like a mere upturn to its more melodious or expressive piggy tail.

As shown above, Berg constructs his lines very diversely, mixing pentatonic/diatonic sections with (wide) arpeggios and chromaticism. These lines appear to be composed from preconceived patterns that Berg has in his vocabulary. Some of these patterns can be found in solos on the same record but also in solos played years later.

The contrast between pentatonic/diatonic material and chromatic and outside material can be seen as a general feature of this solo. Though it is strictly rooted in A♭ major, the frequent chromaticism as well as the 'trick' of playing the main key over the outside harmonies D^{7alt} and $G^{7\sharp 9}$ at the end of each chorus, i. e., essentially ignoring these chords, create tonal tension and relaxation patterns which propel the solo forward. These parts are contrasted with melodies of ostensible simplicity as well as with expressive outbursts. The construction of lines with inside/outside elements as well as the inside vs. outside contrasts of larger parts can be seen as a kind of self-similarity and might result from deliberate artistic decisions. Berg works by contrasting the simple (e. g., pentatonic, melody) with the complex (e. g., chromaticism, elaborate asymmetric lines) on different levels. This might also be reflected in another important element not only of this solo but also of many other postbop players (e. g., Michael Brecker, Kenny Garrett, Chris Potter), namely the extensive oscillating figures. These normally have an intensifying effect, especially if played in ascending tonal sequences as in this solo. Compared to intricate

bebop lines, these oscillations are simple in construction and rather easy to perform, hence early bebop pioneers such as Parker and Gillespie might have shunned them as they were used by Rhythm & Blues 'honkers'. But the need for heightened expressivity in the postbop style, probably starting with Coltrane, (re-)introduced them into modern jazz improvisation, where they serve as energetic counterparts to more sophisticated line constructions.

Finally, Berg frequently uses motivic relationships and tonal sequences to create musical logic and coherence. The use of long and very long patterns (e. g., pattern b12 and m18) and parts thereof might also contribute to a sense of coherence. Apart from a few single ideas, much of the material in this solo is related in one way or another, sometimes subtly transformed and varied, sometime re-contextualized, sometimes re-used verbatim. In this regard, the very last phrase (mm. 139–144) is remarkable as it subsumes the entire solo in a nutshell and is hence also an epitome for Berg's coherent solo design.

Conclusion and outlook

This in-depth case study of a single solo attempts to retrace the underlying creative processes. As a case study, its power for generalizations is of course limited, but a large collection of similar in-depth case studies along with large-scale contextualization in a corpus might finally converge to form a stable and general model of jazz improvisation. We can state for now, however, that the results presented here are compatible with a three-level hierarchical model. The highest level is the overall dramaturgy of the solo, created in interaction with the band, which results in the decisions for certain playing ideas on the middle level, e. g., lines, melodies, expressive moments, oscillations etc., which are then—on the lowest level—realized by combining preconceived material on one hand and spontaneous out-of-the-moment inventions on the other. However, the last point has to actually been proven yet. The sub-corpus of Berg's solos in the Weimar Jazz Database is rather small. For the future, it would be highly desirable to gather a much larger collection to see whether certain elements, such as the melodic 'piggy tails' and the oscillation patterns, were indeed invented on-the-fly or whether pre- or postdecessors can be found in Berg's oeuvre.

Finally, the selection and pre-creation of the material, e. g., their tonal construction, seem to be highly specific for Berg's personal style but are nonetheless shaped by a general stylistic sensitivity.

Table 6: Run-down of MLUs in Bob Berg's solo on "Angles".

Measures	MLU	Scale	Comment
2–3	`rhythm-si`	G4	
4–5	`~melody`	C-aeol	
5–7	`~#melody`	C-aeol	Gm^{7} arpeggios.
9–10	`line-wavy-asc`	D♭-mixo	$Fm^{7\flat5}$ arpeggios upwards in zig-zag fashion.
11–13	`melody`	E♭-mixo	Melody reached after long ascending line ('piggy tail').
14–15	`~lick`	E♭-mixo	Strong cadential effect.
16–17	`lick`	E♭-mixo	Jump octave up.
18–19	`~rhythm-si`	F4	Short thinking pause.
19–23	`~line-wavy-desc`	E♭-mixo/C-aeol	Mostly diatonic.
24–25	`lick`	D♭-mixo	Sequence of licks as broken version of the $Fm^{7\flat5}$ arps. in m. 9–10.
25	`#+lick`	D♭-mixo	Three-beat pattern, metric shift.
26	`#+lick`	D♭-mixo	Last tone of lick is first tone of next.
26–27	`#+lick`	D♭-mixo	
27–28	`#+lick`	D♭-mixo	
28	`#+lick`	D♭-mixo	Last tone missing.
29	`#lick`	D♭-mixo	Answers last lick, dramatic pause.
30–34	`line-wavy-hor`	E♭-mixo	Largely chromatic line ('apparatus'). Interesting change to B section (swing feel) in middle of line, accompanied by a register change.
35–36	`~melody`	C-aeol	Line/melody with piggy tail. Stark contrast.

38–40	`line-wavy-asc`	D♭-mixo	Recalls the D♭^{7} arp. before.
41–42	`~melody`	A♭-ion	Line/melody with piggy tail.
43–46	`line-wavy-desc`	E♭-mixo	Outside.
47–50	`line-wavy-asc`	E♭-WT/A♭-ion	Change to second chorus mid-line.
51–52	`~melody`	C-minpent	Another piggy tail.
53–59	`line-wavy-hor`	chrom → G♭-majpent	Longest line.
60	`#lick`	D♭-mixo	More of a fragment, echoes small piggy tail of last line (cf. m. 29).
61–62	`line-wavy-hor`	E♭-mixo	Unusually short arpeggio line.
75–78	`rhythm-mr`	G♭-majpent	First oscillation. Heating things up a bit.
79–82	`#rhythm-mr`	E♭-mixo/ A♭-ion	Sequencing up first, but then down. Ends with a short piggy tail way up in the sky.
83–86	`line-wavy-asc`	A♭-ion/ D♭-mixo	Zig-zagging upwards.
86–88	`~line-i-dd`	D♭-mixo	Piggy tail after ascending line, between staircase and melody.
89–94	`line-wavy-hor`	A♭-ion	Outside. Mixture of diatonic arps., scales, and chromatic falls.
95–100	`rhythm-mr`	A♭-ion	Three-beat diatonic mordents are shortened to two beats, highest rhythmic energy.
101–104	`#rhythm-mr`	C-dor	Changes only A♭ to A, spicing things up.
105–108	`#rhythm-mr`	G-majpent	Moving a semitone up. Possibly the peak of the solo. Band fires up.

109–112	`line-wavy-desc`	E♭-mixo/ chrom	After a clear mark by the band, Berg is going back to lines, using the apparatus from m. 30.
113–116	`line-wavy-asc`	A♭-majpent	Far-reaching line from A♭2–A♭5.
116–117	`~expressive`	Cm	Again, a piggy tail after a long ascending line, again on a C minor triad.
118–121	`line-wavy-hor`	C-blues	A rather cheesy minor blues line.
122–124	`line-wavy-desc`	D♭-mixo	Continues preceding line after a short stop on C/D♭^{7}. Mistake?
126–129	`line-wavy-asc`	E♭-mixo	Up-swinging diatonic line with large intervals.
129–132	`~expressive`	F-aeol	Longest top tone in the solo. Again, line to expressive piggy tail, with another piggy tail.
134–135	`expressive`	D♭-mixo	Another top tone on #11, a WT higher. Upward sequence of expressive ideas.
135–137	`~##lick`	D♭-mixo#11	Piggy tail of the preceding `expressive`. Extended version of the previous piggy tail.
138–142	`#10line-wavy-hor`	F-minpent/ D-alt	Reminiscence of the last oscillation, but re-mixed into a wavy line.
142–144	`~expressive`	D-alt	Again, expressive piggy tail after a line. Segues into theme after this.

Note. mixo = mixolydian, min/majpent = minor/major pentatonic, aeol = aeolian, blues = blues scale, dor = dorian, WT = whole-tone scale, ion = ionian/major, arp = arpeggio, alt = altered scale, chrom = chromatic scale.

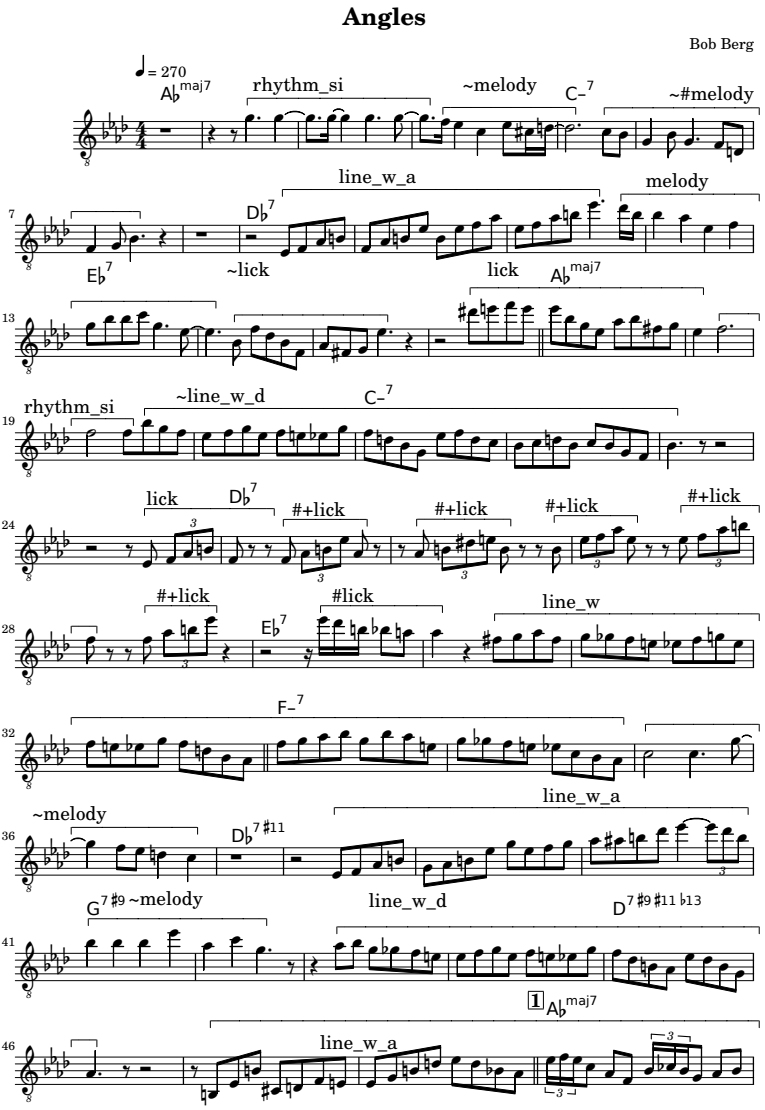

Figure 17: Bob Berg's solo on "Angles" with MLA annotations.

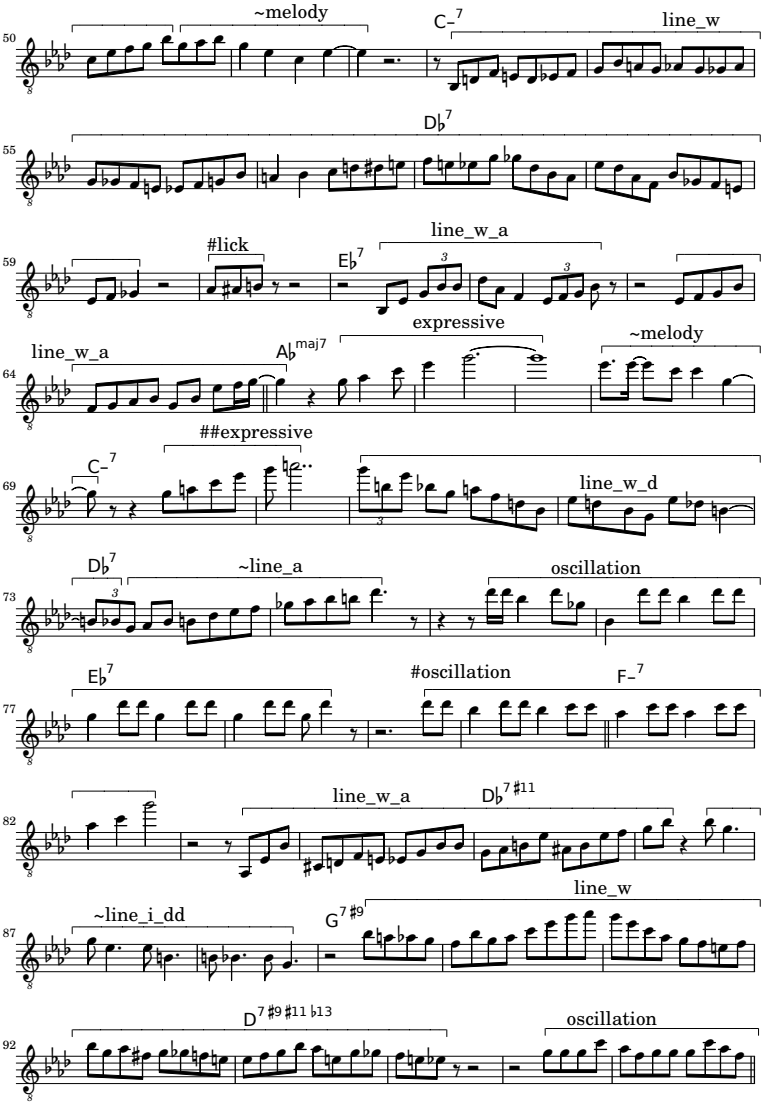

Figure 17: (Continued.)

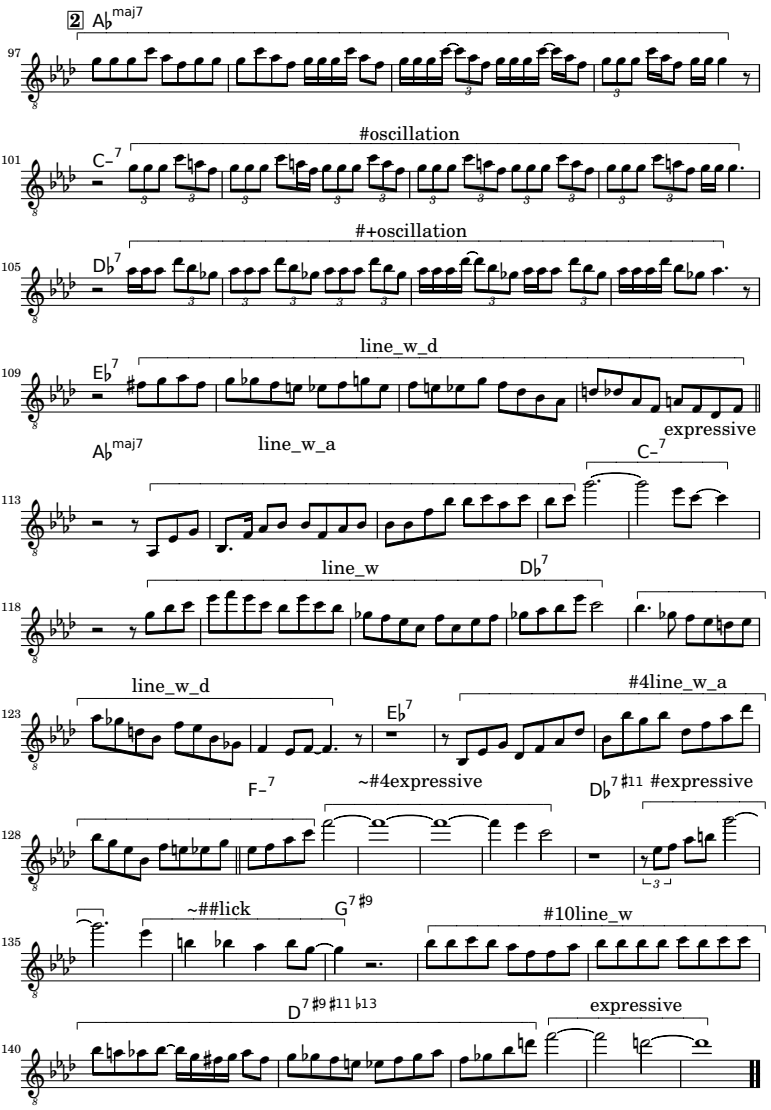

Figure 17: (Continued.)

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