Inside the Jazzomat

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# Inside the Jazzomat

## New Perspectives for Jazz Research

SCHOTT

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Weimar, June 2017

Martin Pfleiderer, Klaus Frieler, Jakob Abeßer,
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# Intro

# Introduction

Martin Pfleiderer

The Jazzomat Research Project is situated at the intersection between jazz research, music psychology and computational musicology. It aims at developing new perspectives for jazz analysis as well as for the psychology of improvisation and, last but not least, for computational music research and music information retrieval (MIR). Up to now, the ongoing research project's main contributions have been a database of 456 transcriptions of monophonic jazz improvisations (the Weimar Jazz Database) and a standalone software toolkit (MeloSpySuite/GUI) for the analysis of monophonic music; both of these, the database and software toolkit, are freely available and open to further additions and adjustments by users. Several studies and new approaches have been devised within the project both in the areas of jazz research and music psychology, e. g., the concept of midlevel units for analyzing jazz improvisations, resulting in a new model of improvisation, as well as in music information retrieval, e. g., approaches involving score-informed automated feature annotations of music recordings. The database and the software as well as the project's contributions to music information retrieval are introduced within the four chapters in the first part of this publication. The subsequent chapters within the second part of the book are devoted to nine analytical case studies using the Weimar Jazz Database and MeloSpyGUI. In this introductory chapter, the project's background both in jazz research, mainly jazz analysis, and in the computer-aided analysis of music is outlined. Then, a brief overview over the book's contents is given.

## Jazz research: studying the infinite art of improvisation

The Jazzomat Research Project ties in with a long tradition of jazz research which focuses on musicians and their performances, on creative processes

and their cultural contexts. By introducing computational methods for the analysis of recorded jazz improvisations the project aims at contributing to this multifaceted research tradition with new analytical methods, a comprehensive database and corresponding software tools.

Jazz is a musical performance practice which now spans over more than a century. The origins of jazz extend back to musical practices of African Americans living in New Orleans around 1900. In the 1920s, jazz increasingly gained recognition all over the United States and worldwide, culminating in the swing craze of the late 1930s and early 1940s. In these times, jazz was often viewed as a very popular musical practice for entertainment and dancing. However, since its beginnings, jazz has also striven for recognition as an art form. During the 1940s, 1950s, and 1960s, both jazz musicians and jazz critics strove for a cultural recognition of jazz. Modern jazz was increasingly appreciated in concerts and festivals as music one has to primarily listen to 'seriously', and jazz critics such as André Hodeir (1956) or Gunther Schuller (1958) started to write about the artistic value of jazz music. This critical writing involved an analytical approach to the music, relying strongly on recordings and transcriptions. In particular, Schuller (1958) intended to use methods of music analysis to prove that a jazz musician, in this case Sonny Rollins with his improvisation on "Blue Seven" (1956), is at a similar artistic level to European composers. Later, Schuller wrote two extensive historical studies of traditional jazz and swing (Schuller, 1968, 1989) featuring comprehensive analytical style portraits of leading musicians.

Since the late 1960s, the project of writing a history of jazz that is founded in analytical scrutiny was pursued by jazz critics and musicologists with analytical studies on jazz musicians such as Charlie Parker (Owens, 1974), Miles Davis (Kerschbaumer, 1978), Lester Young (Porter, 1985), or John Coltrane (Putschögl, 1993; Porter, 1998). Moreover, Thomas Owens (1995) adopted Schuller's approach of an analytical style history with regard to modern jazz styles (bebop, cool jazz, hardbop). His rather sketchy style portraits were complemented by many other studies, e. g., Bickl's study of several bebop musicians (Bickl, 2000). Ekkehard Jost (1975) presented an extensive study of the creative principles guiding free jazz or avant-garde jazz musicians of the 1960s by analyzing the music of, among others, Ornette Coleman, Cecil Taylor, and the late John Coltrane.

In general, the analysis of the creative principles that guide jazz improvisation relies strongly on recordings. However, it is questionable to study a recorded improvisation as a final musical work even if it results from a longer chain of rehearsals and preliminary recordings which could be conceived as draft versions (Tirro, 1974). On the contrary, the art of jazz could be termed an

"infinite art of improvisation", as the subtitle of Paul Berliner's seminal study states (Berliner, 1994), one that does not find its objective in an ultimate performance or recording of a piece. Ekkehard Jost argues for a methodology of jazz analysis that aims at describing the prevailing creative principles of an individual style of improvisation rather than certain musical artifacts:

> How relevant is an analysis of recorded improvisations made on a certain date and under certain circumstances (the group involved, the improviser's physical and mental disposition, the conditions imposed by the producer, etc.)? This will depend on the extent to which those improvisations can be taken, beyond the immediate musical facts, as indicative of the specific musicians' and groups' creative principles. (…) analysing and interpreting the features of a given improvisation demands that the analyst take (sic!) into account everything he has learned from other improvisations by the same musician. The significance of general pronouncements on the stylistic features of an improviser, from whom one has just a single solo at hand, is minimal, while the likelihood of drawing false conclusions is very great (Jost, 1975, p. 13f.).

This suggests a two-step methodology of jazz analysis: First, listen to the available recordings of a musician or a group. Then, choose the pieces that seems to be typical for the creative principles of the respective musician and analyze them in detail in order to pinpoint and depict those principles.

John Brownell (1994) emphasizes that jazz unfolds dynamically within a performance process which involves instantaneous improvisation as well as interaction between the musicians. Therefore, he differentiates between the analysis of those unfolding processes and an analysis of the results, such as commercial recordings. Focusing on improvisation as a process opens up an interdisciplinary field of investigation involving approaches and methodologies taken from ethnomusicology, sociology and music psychology. This involves interviews with musicians (Berliner, 1994; Monson, 1996; Norgaard, 2008; C. Müller, 2017), participatory observation in the recording studios and at club stages (Jackson, 2012), and introspection (Sudnow, 1999). Notably, many of these scientific approaches to jazz improvisation also involve an analytical study of recordings and their transcriptions. For instance, at least one third of Berliner's ethnographic study *Thinking in Jazz* (1994) is devoted to music examples transcribed from jazz recordings and to their analytical exploration.

Following the ideas put forth by André Hodeir and Gunther Schuller, Barry Kernfeld (Kernfeld, 2002b, 1995, p. 119-158) proposes different types of im-

provisation. In paraphrase improvisation, prevalent in jazz of the 1920s and 1930s, a musician refers closely to the original melody of a piece, ornamenting, varying or reworking it. By contrast, in so-called chorus phrase improvisation, jazz musicians improvise without much reference to a tune's theme, instead inventing new lines that fit the harmonies of the original composition. Often, this strategy relies on a vocabulary of formulas, patterns or 'licks' which are artfully woven into ever-changing melodic lines (formulaic improvisation). The usage of repeated patterns during improvisation has become one of the main issues in the study of jazz improvisation and is thoroughly discussed by Owens (1974, 1995), Smith (1991), Berliner (1994), and Finkelman (1997). In motivic improvisation, the musicians vary one or several motives, sometimes taken from the theme of a piece, but more often drawn from the ongoing stream of improvisational ideas, with strategies such as ornamentation, transposition, rhythmic displacement, expansion, compression etc. In particular, this type of improvisation flourished within modal jazz, avant-garde jazz and fusion music, since in those styles the musician is for the most part free from rapidly changing chords.

Besides these improvisation strategies identified by Kernfeld, there are several further dimensions and creative principles to be investigated in improvised jazz music. These are, first of all, the tonal and harmonic implications of improvised melodic lines as well as their relation to the original melody and the chords they are based on and, secondly, the rhythmic features of the improvised lines, including particular features such as cross rhythms or micro-rhythmic play that contribute to the overall 'feel', 'swing' or 'drive' of a solo (see e. g., Friberg & Sundström, 2002). While for a long time analytical jazz studies focused on the improvising soloists alone, Berliner (1994) and Monson (1996) presented transcriptions and analyses of a whole jazz group playing together. This, thirdly, opens up perspectives on the interactive processes between musicians. Robert Hodson (2007) and Benjamin Givan (2016) continued to systematically explore the interplay both between the soloist and rhythm section and within the rhythm section. Last but not least, the individual instrumental or vocal 'sound' characterizes the style of a jazz musician. All of these features contribute to the overall dramaturgy of a jazz improvisation, often described by metaphors such as "telling a story", "making a journey" or "doing a conversation" (see Berliner, 1994; Bjerstedt, 2014), its aesthetic coherence and complexity or simplicity, as well as to the stylistic conciseness and recognizability of a musician or style.

While there are countless studies on the leading jazz musicians of the 1940s and 1950s, approaches to postbop avant-garde and fusion music are still rather scarce. Besides Jost's seminal research on free jazz both in the United States and in Europe (Jost, 1975, 1987), e. g., Keith Waters (2011) examined the

recordings of Miles Davis' 1960s quintet, and Andrew Sugg compared improvisational strategies of saxophone players John Coltrane, Dave Liebman, and Jerry Bergonzi (Sugg, 2014).

Since the late 1960s, the growth of jazz studies was paralleled by a growing demand for jazz education and jazz theory, both in the United States and in Europe, and resulted in a consolidation or even canonization of jazz history for students' textbooks. However, since the 1990s, a critique of that canon and new approaches to jazz studies have been promoted by several researchers from various disciplines, namely by film scholar Krin Gabbard (1995a, 1995b, 1996) and literary scholar Robert O'Meally (2004; 2007). Both of them looked for relationships between jazz and American cultural history, e. g., by inquiring into the contribution made by jazz critics to the history of jazz, or the intersections between jazz music and other art forms such as literature, film, photography, and painting. This approach was labeled "new jazz studies" (cf. O'Meally et al., 2004) to set it apart from the 'old' jazz studies pursued by jazz critics and musicologists, who investigated jazz primarily as an art form and sometimes detached from its cultural meanings and the social conditions of production and reception. However, in 'new jazz studies', the music itself often tends to be faded out altogether and in this regard its approach often falls behind the efforts of jazz analysis to appreciate the sounding dimensions of jazz performances. Surprisingly, many studies in the anthologies edited by Gabbard and O'Meally are dedicated to the American jazz canon from 1940s bebop to 1960s avant-garde jazz, while minor figures as well as the somewhat confusing varieties of both jazz after 1980 and jazz outside the United States tend to be neglected.

To sum up, there are several approaches to studying jazz improvisation, all of which complement each other and in doing so, deepen and enrich the understanding, aesthetic pleasure and appreciation of the music as well as an interpretation of its meaning within its cultural and social context. The Jazzomat Research Project aims at contributing to these approaches with both a repository of several hundreds of high-quality transcriptions and computer-based methods. The transcriptions were manually annotated by jazz experts with the aid of computer software using a newly developed data format. Furthermore, a software toolkit was developed to meet the manifold requirements of an analytical approach to monophonic lines, e. g., the examination of pitches and their harmonic implications, duration, rhythm and micro-rhythm, as well as the usage of patterns. These achievements were possible thanks to the close collaboration of software engineers with both an interest in music research and an understanding of jazz on the one hand, and jazz researchers open to concepts and procedures from computational music anaylsis and music information retrieval on the other.

## Computational music analysis

The Jazzomat Research Project is rooted in a longer tradition of computational musicology and aims to contribute to that growing field of research—within and beyond jazz music. Computational musicology started within ethnomusicology where researchers often collected, annotated and examined large repositories of music recordings and manual transcriptions. Computers helped to handle these collections, e. g., by systematically managing the metadata and manual annotations (Bronson, 1949; Lomax, 1976) and enabling automated inquiries into those data. An important step towards computational music analysis was the introduction of machine-readable formats for sheet music. Besides widespread music formats such as MIDI (since 1982), several formats were developed for scientific purposes, e. g., the Essen Associative Code (EsAC), designed for building and analyzing the Essen Folk Song Collection, and the **kern-format. Since the 1990s, David Huron and others have encoded large amounts of sheet music in the **kern-format (Huron, 1999; Cook, 2004), including the Essen Folk Song Collection and many scores of classical European as well as non-Western music. Recently, Temperley and de Clerq designed a new format for their transcriptions of rock songs (Temperley & DeClercq, 2013; DeClercq & Temperley, 2011). According to Nicholas Cook, these new music databases

> present a significant opportunity for disciplinary renewal: [...] there is potential for musicology to be pursued as a more data-rich discipline than has generally been the case up to now, and this in turn entails a re-evaluation of the comparative method (Cook, 2004, p. 103).

Huron and collaborators developed a modular software toolkit, the Humdrum Toolkit, which enables a flexible analysis of various features encoded in **kern-format. Further modular analysis toolkits are the MIDI-Toolbox (Eerola & Toiviainen, 2004), which works within the MATLAB environment, and the music21 library for Python (Cuthbert & Ariza, 2010). All of these software tools have their merits and downsides of course; their helpfulness for jazz research appears to be rather limited. By contrast, the software toolkit MeloSpySuite/GUI for Windows and OS X was designed especially for the analysis of monophonic melodic lines and has several specific functionalities for jazz improvisations.

In general, computer-aided music analysis has many advantages. Computers are able to extract musical features quickly, accurately and automatically from large amounts of data, such as an improvisation encompassing hundreds or thousands of tone events, and repositories of thousands of folk songs or jazz

improvisations. The feature extraction results in representations (e. g., tables, graphs, statistical values) of the music in regard to various musical dimensions and creative principles, e. g., histograms of pitch class occurrence throughout a music piece or statistical values concerning its degree of syncopicity or chromaticity. As Cook puts it,

> [t]he value of objective representations of music, in short, lies principally in the possibility of comparing them and so identifying significant features, and of using computational techniques to carry out such comparisons speedily and accurately (Cook, 2004, p. 109).

Comparison is a central capacity of the human mind and an important operation in science. To compare two or more objects, one has to identify some common feature dimensions; if they had nothing in common, one would be comparing apples and oranges. Several objects can then be compared in regard to their similarities along these feature dimensions. The researcher's task is to choose suitable feature dimensions based on research objectives. The computer algorithms can then be used in order to extract the chosen features objectively and, in many cases, also more quickly and reliably. In any case, clear and explicit analytical terminology that can be unambiguously transformed into algorithms and data structures is a prerequisite of computer-aided analysis routines. At times, this can help clarify fuzzy 'traditional' terminology, which is a welcome side-effect.

Besides comparing pieces and identifying their significant features, computer-generated representations could also be used in a more explorative manner—as a kind of guidance leading the researcher to listen to particular features that had hitherto passed unnoticed. However, it is important to emphasize that these computational tools and facilities are not meant to (and are hardly able to) replace human researchers, but are for the most part designed for the purpose of enriching traditional methodologies. Since music analysis always involves individual processes of learning and understanding, a researcher has to listen closely to the music in the first place and then identify its typical and idiosyncratic features (cf. Cook, 2004, p. 107). However, this process of 'close listening' to certain pieces could be enhanced and stimulated by a kind of 'distant listening' enabled by algorithms and software tools. One main intention of the analytical case studies presented in the second part of this book is to demonstrate how the analysis of certain typical or particular examples can be fruitfully combined with computer-aided 'distant listening' to larger repertoires and how these latter routines could support and extend an understanding of the music.

## Inside the Jazzomat: an overview

This book is an interim report on the ongoing Jazzomat Research Project, focusing mainly on its contributions to jazz research and jazz analysis. In its first part, several basic assumptions and concepts of the project are introduced. In the following chapter the Weimar Jazz Database is introduced, including the transcription process, the assets and drawbacks of the data format as well as the criteria for data selection. Additionally, the contents of the Weimar Jazz Database (release version 2.0) and some of its features and peculiarities are outlined.

Then, the basics of computational melody analysis are discussed—which are at the core of the MeloSpySuite/GUI software. With the aid of this stand-alone software, various musical features of several musical dimensions can be extracted from the transcription data. The mathematical concepts of music representation, segmentation and annotation, feature extraction and pattern mining are introduced along with several examples. Included are short introductions into the approach to a metrical quantification of the data, the concept of midlevel annotation, descriptions of the most important of those features available in MeloSpySuite/GUI as well as the approach to pattern search with regular expressions.

In the subsequent chapter, a statistical approach to the characterization and analysis of musical style is depicted. By using a subset of the musical features extracted by MeloSpySuite/GUI as well as subsets of the Weimar Jazz Database, one can explore which musical features distinguish a certain subset of improvisations, e. g., all improvisations by a certain musician or in a certain jazz style, from the remaining improvisations of the database. The potentials of this powerful and promising statistical approach are exemplified in regard to several subsets and research issues.

While the Jazzomat Research Project focuses on symbolic data, i.e., transcriptions of recorded jazz improvisations, there are several additional aspects concerning an exploration of the audio recordings. Therefore, in the last chapter of the first part, several approaches to linking symbolic and audio data using state-of-the-art algorithms are introduced. At first, approaches based on a score-informed source separation between soloing and accompanying instruments are depicted. This approach leads to an automatic assessment of instrument tuning, tone intensity and tone-wise pitch contour tracking. Furthermore, approaches to an analysis of instrument timbre (as a central aspect within the personal sound of a jazz musician) and an approach to an automatic beat-wise transcription of walking bass lines with deep neural networks are introduced. Additionally, several findings that rely on these new approaches and the data of the Weimar Jazz Database are depicted.

The second part of the book encompasses nine analytical case studies which can also be read as examples of how to research on jazz improvisation either with statistical methods and computational analysis tools or with more conventional analytical methods—or with a combination of both approaches. By demonstrating some of these possibilities, the case studies aim at stimulating further analytical research with both the transcriptions included within the Weimar Jazz Database and the MeloSpySuite/GUI software. The main challenge is to meaningfully relate insights gained from closely listening to the music and from its close description with more abstract musical features and representations that can be generated automatically by the software. Each chapter focuses on certain issues exemplified by the analysis of one or more particular improvisations. In most cases, these analytical findings are contextualized within a larger stylistic context-—be it within the context of other improvisations by the same musicians or other musicians, or within a larger repertoire of recordings. The comprehensive aim of these analytical case studies is to open up new perspectives for analytical jazz research by combining the advantages of old-school jazz analysis with an analysis supplemented by computer-based methods and comparative approaches.

The first case study is dedicated to two improvisations on "Body and Soul"—one of the jazz standards most favored by jazz musicians. While Coleman Hawkins's recording of "Body and Soul" (1939) is widely appreciated as an important and influential milestone in the history of jazz improvisation, the focus is at first placed on the improvisation by a minor figure in jazz history, Don Byas, who recorded "Body and Soul" in 1944. Then, features of the improvisations by Byas and Hawkins are compared with each other and, in doing so, Gunther Schuller's characterization of an overall intensification process within Hawkins's solo (Schuller, 1989, p. 444) is re-examined by statistical means.

Trumpet player Miles Davis is said to have established a less formulaic and instead more melodic and motivic style of improvisation. In the case study on Davis's improvisation on "Airegin" (1954), presumably one of the first hardbop recordings, several features of Davis's 'mellow' style are characterized, especially in regard to both the usage of different categories of midlevel units and the overall dramaturgy of the improvisation. Additionally, Davis's solo is compared with both improvisations by several bebop trumpeters and other improvisations by Davis.

While Davis is a pivotal figure within the history of modern jazz and has been discussed in many books and articles, there are legions of jazz musicians who have been rather neglected by jazz analysis so far. Moreover, jazz styles such as West Coast jazz or postbop have only been tentatively explored by

jazz research up until today. In *West Coast lyricists* the styles of trumpeter Chet Baker and alto saxophonist Paul Desmond, which are often described as 'lyrical', are characterized and compared with those of other cool jazz and West Coast jazz musicians included in the Weimar Jazz Database. The case study aims both at exploring characteristics associated with Baker and Desmond as well as with West Coast jazz in general and at providing a foundation for further analytical research.

The remaining six case studies are dedicated to important musicians who are usually attributed to postbop style. Postbop musicians seem to be very influential for young jazz musicians and improvisation techniques developed by them are at the very core of more recent trends in jazz education (Kissenbeck, 2007). However, there is still a gap concerning an analytical, comprehensive characterization of improvisation strategies in postbop. The case studies aim at contributing to fill this gap. At first, two influential postbop trumpeters, Freddie Hubbard and Woody Shaw, are examined in regard to two aspects which seem to be characteristic for their personal style of improvisation: the usage of uncommon interval leaps within the fast lines played by both of them and the usage of recurring patterns, especially within Hubbard's solo on "Maiden Voyage" (1965) and Shaw's solo on "In a Capricornian Way" (1978).

Tenor saxophonist Michael Brecker is one of the most influential postbop musicians. His playing style could be characterized as a virtuosic exploration of several improvisation techniques, including temporarily playing 'outside' the chord changes or tonality. As is shown in the analytical case study of his improvisation on Thelonious Monk's "I Mean You" (1995), however, his inventive personal style is rooted in the jazz tradition and alludes to several more conventional strategies of improvisation. The relation between postbop playing and the jazz tradition is analyzed in an analytical case study of a solo played by tenor saxophonist Branford Marsalis in the trio recording "House from Edward" (1988). Again, the question of how different strategies of improvisation contribute to the overall dramaturgy of the piece is discussed.

While the case studies on Brecker and Marsalis are conceived as both a close analytical description of the particularities of a certain improvisation and a questioning and contextualizing of more conventional analytical tools based on jazz theory, the case study on tenor saxophonist Bob Berg's solo on "Angles" (1993) takes a slightly different approach. The dramaturgy of the solo is exhaustively explored in regard to many of the features that could be extracted by the MeloSpyGUI software, including midlevel units and pattern usage, and then contextualized within the repertoire of the whole Weimar Jazz Database. This statistical contextualization aims at answering one central