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1. Introduction

The study of Jazz has been a part of musicology for more than a century now. The influential people who developed the genre, the songs and tunes themselves which travelled a continent and then the world, the roots which stretch across oceans and bring together music traditions from disparate peoples and cultures, all of these belong to the domain of Jazz research. But one of the most signifying aspects of Jazz, improvisation, the spontaneous extemporizing on a song, where either a group or an individual depart from the ‘notes on the page’ and create something on the spot and in the flow, has been the cornerstone of the scientific investigation of Jazz since this work started.

Jazz music was to become one of the first, if not the very first, music genres which turned into “mass culture”. With the development of recording technology, Jazz records soon flooded the United States and this was to have a decided impact not only on the social aspects of music consumption, but also on the art itself and those who created and those who researched it. Certain recordings made by certain artists became widely disseminated and soon earned unofficial status as *the* version of a particular song, and all who come after then position themselves in relation to it by either referencing the foundation and then expanding on it, or by completely departing from it to follow a new path.

This was the effect on musicians, but the researchers also felt the impact of recordings. Where once one looked to the score for *the piece*, now one turned to the recording, the audio itself becoming the text of the Jazz repertoire. However, in order to analyze the music and especially the improvisation, in order to have something in one’s hand that could be manipulated and studied, transcriptions were made to capture what the soloist had spontaneously laid down. The transcriptions made use of classical western European music notation to try and represent what had happened in the moment, but already here the problem becomes clear; Music notation is simply too blunt of an instrument to capture all the details of Jazz (or any) music. The audio itself is where the art lies, so working with a written transcription will always necessarily leave essential details out. This is where the tools of the modern era offer a better alternative.

The Jazzomat project, hosted by the University of Music Franz Liszt Weimar, ran from 2012-2017 and developed a system of digital annotation which allows the researcher

to perform computer-assisted as well as statistical analyses of jazz solos. Among the advantages of these digital transcriptions are that 1) they can be much more detailed than traditional music notation, 2) the software can extract data and show trends which may not be easily or immediately apparent to the human ear, and 3) they allow statistical analysis of a large corpus in a way which traditional notation does not, allowing the researcher to recognize global trends within a particular style and base their conclusions on hard data rather than subjective impressions. The pillars of the project are the Weimar Jazz Database, a collection of transcriptions conforming to the Jazzomat standards, and the MeloSpyLib, a Python Library designed to extract data from the transcriptions.

In the original Jazzomat project there was a heavy emphasis on music from the Bebop era of Jazz. One aim of this thesis is to expand the corpus of traditional jazz solos in the Weimar Jazz Database (WJD), allowing for a more detailed look at the early stages of the development of Jazz. To this end, four representative trumpet players from this time period were chosen: Joe Oliver, Freddie Keppard, Louis Armstrong, and Bix Beiderbecke. Table 1 shows the trumpet players currently included in the WJD and an overview of their transcriptions in terms of style and number.

Table 1: Trumpet Players in the WJD

Artist	Style (number of solos)
Bix Beiderbecke	Traditional (5)
Buck Clayton	Swing (3)
Charlie Shavers	Traditional (1)
Chet Baker	Cool (8)
Clifford Brown	Hardbop (9)
Dizzy Gillespie	Bebop (6)
Don Ellis	Postbop (6)
Fats Navarro	Bebop (6)
Freddie Hubbard	Postbop (4), Hardbop (2)
Harry Edison	Swing (1)
Henry Allen	Traditional (1)
Kenny Dorham	Bebop (1), Hardbop (3), Postbop (3)
Kenny Wheeler	Postbop (2), Fusion (1)
Lee Morgan	Hardbop (3), Postbop (1)
Louis Armstrong	Traditional (8)
Miles Davis	Postbop (6), Hardbop (8), Fusion (4), Bebop (1)
Nat Adderley	Hardbop (2)
Roy Eldridge	Swing (6)
Woody Shaw	Postbop (8)
Wynton Marsalis	Postbop (7)

There are only 15 traditional-style trumpet solos in the WJD, which is reason enough to expand the corpus, and both Oliver and Keppard, two of the titans of early Jazz, are not included at all. This expansion will allow not only a more detailed look at traditional Jazz and how the genre as a whole first developed, but it will also allow more comparisons to what came after, adding context and illuminating previously uncertain or unexplored aspects of Jazz. The following table summarizes the solos which form the corpus under investigation for this thesis. The entries are organized by song title, performing group and date, then timestamps for the solo.

Table 2: Corpus of solos

Joe “King” Oliver	Freddie Keppard	Louis Armstrong	Bix Beiderbecke
<i>Aunt Hagar’s Blues</i> , King Oliver and his Dixie Syncopators 10.09.1928. 0:59-1:33	<i>High Fever</i> , Cookie’s Ginger-snaps 22.06.1926 0:24-0:39 and 2:59-3:20	<i>Chimes Blues</i> , King Oliver’s Creole Jazz Band 6.04.1923. 1:59-2:39	<i>Clementine</i> , Jean Goldkette and his Orchestra 15.09.1927. 1:58-2:21
<i>I’m Watching the Clock</i> , King Oliver and his Dixie Syncopators 10.09.1928. 1:39-2:17	<i>It Must Be the Blues</i> , Jasper Taylor and his State Street Boys January 1927. 0:35-1:02 and 1:54-2:28	<i>Cold in Hand Blues</i> , Bessie Smith 10.04.1925. 1:55-2:34	<i>From Monday On</i> , Paul Whiteman and his Orchestra 28.02.1928. 0:22-0:58
<i>New Orleans Shout</i> , unnamed group 30.12.1929. 0:10-0:47	<i>Salty Dog take 1</i> , Freddie Keppard’s Jazz Cardinals September 1926. 2:00-2:49	<i>Cornet Chop Suey</i> , Louis Armstrong’s Hot Five 26.02.1926 1:53-2:15	<i>Jazz Me Blues</i> , Bix Beiderbecke and his Gang 5.10.1927. 1:57-2:29
<i>Showboat Shuffle</i> , unnamed group 22.04.1927. 1:45-2:10	<i>Salty Dog take 2</i> , Freddie Keppard’s Jazz Cardinals September 1926. 1:58-2:43	<i>Gut Bucket Blues</i> , Louis Armstrong’s Hot Five 12.11.1925 1:56-2:17	<i>Since My Best Gal Turned Me Down</i> , Bix Beiderbecke and his Gang 25.10.1927. 1:25-1:44
<i>Snag It</i> , King Oliver’s Jazz Band 11.03.1926. 1:45-2:10	<i>Stock Yard Strut</i> , Freddie Keppard’s Jazz Cardinals September 1926. 2:14-2:35	<i>The King of the Zulus</i> , Louis Armstrong’s Hot Five 23.06.1926. 1:21-2:10	<i>Sorry</i> , Bix Beiderbecke and his Gang 25.10.1927. 1:15-1:34 and 1:52-2:11
<i>Speakeasy Blues</i> , King Oliver and his Dixie Syncopators 10.09.1928. 0:07-0:35		<i>Muskrat Ramble</i> , Louis Armstrong’s Hot Five 26.02.1926. 1:01-1:24	<i>Tiger Rag</i> , The Wolverine Orchestra 20.06.1924. 0:59-1:30 and 2:00-2:37
<i>Wa Wa Wa</i> , King Oliver’s Jazz Band 29.05.1926. 0:44-1:08		<i>Oriental Strut</i> , Louis Armstrong’s Hot Five 26.02.1926. 1:31-2:14	<i>Way Down Yonder In New Orleans</i> , Frankie Trumbauer and his Orchestra 12.05.1927. 1:39-2:29
		<i>Weatherbird</i> , Louis Armstrong and Earl Hines 5.12.1928. 1:40-2:38	
		<i>Yes! I’m in the Barrel</i> , Louis Armstrong’s Hot Five 12.11.1925. 0:05-0:30	

The research questions for this thesis are 1) How do these four traditional jazz trumpet players compare to each other; in what ways are they similar and in what ways are they distinct from one another? 2) Are there idiomatic features of each player's improvisational style and if yes, what are they? 3) Based on the commonalities between the players, what are some idiomatic features of traditional jazz trumpet improvisation?

To clarify and answer these questions, first a literature review was performed to collect statements and claims about the idiomatic style of each player. 7-9 solos for each player which are not yet in the WJD were then transcribed according to the Jazzomat method and analyzed using the MeloSpyLib. Using the results of the analysis, these statements could finally be verified or called into question. Additionally, certain trends in the statistical analysis allowed for new statements about the players' idiomatic styles as well as about traditional Jazz trumpet playing in general.

Chapter 2 will describe the Jazzomat method of transcription and annotation in detail as well as document the challenges of working with early Jazz recordings. Chapter 3 will then introduce the musicians and roughly sketch their biographies with a focus on their interconnections and possible mutual influences so that we can contextualize their comparative results. Chapter 4 will present the results of the Jazzomat and statistical analyses and let the data speak for itself, pointing out connections to the literature where they may be present. Then, chapter 5 will return to the literature and present the authors' claims in light of the new data from the analyses. Finally, Chapter 6 will summarize what was learned about the players, the style, and the genre as well as point out open questions and possible next steps towards a deeper understanding of Jazz.

2. Method

The following chapter provides an overview of the Jazzomat Method which was used to transcribe and analyze the solos. First, the structure of the Jazzomat is discussed, then the transcription process. Finally, particular difficulties with the transcription of and special considerations unique to early jazz are described and their implications for the project are illuminated.

2.1. The Jazzomat

The Jazzomat Research Project is hosted by the University of Music Franz Liszt Weimar and has as its goal “to investigate the creative processes underlying jazz solo improvisations with the help of statistical and computational methods. The overarching goal is to explore the cognitive and cultural foundations of jazz solo improvisation.”¹ Within this framework there were several sub-goals:

to describe and discriminate different jazz improvisation styles by various features, e.g., with regard to the relations of pitch to metre, tonality and the underlying chords;

to compare features of jazz improvisation with features in other styles and areas of music;

to explore the cognitive foundations of improvisation while testing theories about the cognition of creative processes, e.g., by determining recurring melodic and rhythmic patterns and their underlying melodic-rhythmic prototypes;

the dependence of improvisational material on external parameters like instrument, tempo, key and their interrelationship;

to evaluate and enhance pedagogical approaches towards jazz improvisation;

*to test and enhance statistical methods of music analysis, e.g., measures of complexity and coherence.*²

The two main foundations of the project are the Weimar Jazz Database (WJD) and the Python Library MeloSpyLib. The following subsections will give an overview of the WJD and the MeloSpyLib.

2.1.1. The Weimar Jazz Database

The Weimar Jazz Database is a collection of, currently, 456 transcriptions of jazz solos drawn from recordings spanning from 1925 to 2009.³ 78 musicians are represented in the database at this point. The solos are organized by musician, title of the piece, instrument, style, year, tempo, and number of notes. Table 1 provides an overview of the specific predefined metadata fields for the recordings in the database.

¹ Pfeleiderer, Martin, The Jazzomat Research Project, <<https://jazzomat.hfm-weimar.de/>>, last accessed: 10.11.2022.

² Ibid.

³ “Database Content”, in: *The Jazzomat Research Project*, <<https://jazzomat.hfm-weimar.de/dbformat/dbcontent.html>>, last accessed: 10.11.2022.

Table 3: Metadata Fields of Solos in the WJD

Style	Genre	Rhythm Feel	Tonality Type	Key	Tempo Class
Bebop	Blues	Ballad	Blues	Major	Slow (<60 bpm)
Cool	Great American Song-	Funk	Color	Minor	Medium Slow (60-
Free	book	Latin	Free	Ionian	100 bpm)
Fusion	Original	Swing	Functional	Dorian	Medium (100-140
Hard Bop	Riff	Two-Beat	Jazz-Blues	Phrygian	bpm)
Mix	Traditional		Modal	Lydian	Medium up (140-
Other	Worms			Mixolydian	180 bpm)
Post-bop				Aeolian	Up (>180 bpm)
Swing				Locrian	
Traditional					

For the purposes of this thesis it will be useful to go over how the Jazzomat Project defines certain metadata features including style, genre, rhythm feel, and tonality type. Given the timeframe of solos examined here, the relevant stylistic distinction is between Traditional and Swing. The Jazzomat understands Traditional Jazz as “all traditional jazz styles, mainly Dixieland/New Orleans, Ragtime and revivals thereof.”⁴ Hallmarks of traditional jazz in the New Orleans idiom include the standard instrumentation of a so-called “front line” made of trumpet, clarinet, and trombone, backed up by a rhythm section made of chordal instruments like banjos, guitars, or pianos, a bass instrument such as a string bass or tuba, plus percussion of some kind, be it various drum setups or even a washboard. The characteristic sound of traditional jazz is created by the collective improvisation of the front line and the “oom-pah” groove of the rhythm section. Ragtime’s characteristic sound is accomplished by a high degree of melodic syncopation and typically angular, arpeggiated lines. The Jazzomat cites the Wikipedia articles related to Dixieland/New Orleans, Ragtime, as well as Swing music. Here, Swing is understood as arranged music emphasizing the back beat, i.e. 2 and 4 in a bar of 4/4, departing from the two-beat feel of traditional jazz in favor of a 4/4 feel with a characteristic quarter-eighth-eighth rhythm pattern in the

⁴ “Database Glossary”, in: *The Jazzomat Research Project*, < <https://jazzomat.hfm-weimar.de/dbformat/glossary.html>>, last accessed: 12.11.2022.

drums, using riffs to create strong and repetitive danceable rhythms as well as other musical devices, mainly call-response interactions between sections of the ever-growing bands.⁵

Even the Jazzomat considers the category Genre to be a “rather rough qualifier, thought merely for a first quick orientation.”⁶ Most importantly these genre classifications provide criteria for determining the form and possible melody of a tune, which then informs the identification of improvised choruses. The genres of interest for the current investigation are Blues, Great American Songbook, and Traditional. Blues is described by the Jazzomat as “self-evident”, with the additional note that some earlier blues songs may overlap with the Traditional genre classification.⁷ Both 12- and 8-bar Blues forms are common in New Orleans style Jazz. The Jazzomat orients itself to the Great American Songbook based on Wikipedia: “The Great American Songbook is a term used to denote the canon of the most important and most influential American popular songs of the 20th century – principally from Broadway theatre, musical theatre, and Hollywood musical film. These enduring songs are from the 1920s through the 1950s, and include dozens of songs of enduring popularity.”⁸ Tunes in this category are likely to be in what is now understood as Standard 32-bar form, in verse-chorus form, or possibly march form. Finally, the Jazzomat defines the Traditional genre as “This category comprises traditional compositions/tunes such as gospels, spirituals, folk songs, ragtimes and the like, which are mostly used in traditional jazz forms.”⁹ As mentioned above, there may be some overlap between this and the Blues genres, but the presence of a unique melody and different structure as compared to the more standardized melody phrases in 12- and 8-bar blues help distinguish this genre.

Of the multiple grooves categorized by the Jazzomat, the ones relevant to this thesis are Swing and Two-Beat. The characteristic features of swing according to the Jazzomat are the quarter-eighth-eighth cymbal pattern, emphasis on beats 2 and 4 with the hi-hat, plus a walking bass and swung eighth notes.¹⁰ Two-Beat, on the other hand, is a groove with an “oom-pah” feel which, as the name suggests, makes the listener feel rhythms in

⁵ “Swing Music”, in: *Wikipedia*, <https://en.wikipedia.org/wiki/Swing_music>, last accessed: 12.11.2022.

⁶ “Database Glossary”, in: *The Jazzomat Research Project*, last accessed 14.11.2022.

⁷ “Database Glossary”, in: *The Jazzomat Research Project*, last accessed 14.11.2022.

⁸ “Database Glossary”, in: *The Jazzomat Research Project*, last accessed 14.11.2022.

⁹ “Database Glossary”, in: *The Jazzomat Research Project*, last accessed 14.11.2022.

¹⁰ “Database Glossary”, in: *The Jazzomat Research Project*, last accessed 14.11.2022.

groupings of two even though notation might display measures of 4/4.¹¹ In addition, besides the inclusion of such features as strong backbeat accents from chord instruments like guitar, banjo, or piano and root-fifth bass patterns, the Jazzomat understands two-beat grooves as lacking walking bass, a ‘ring-ding-a-ding’ cymbal, as well as ride cymbals and hi-hats.¹² This is one of the main determining characteristics which led the selection of solos for the corpus under investigation in this thesis; since the goal is to understand improvisation in a traditional New Orleans idiom, only two-beat grooves are considered.

One objection to the exclusion of the Latin rhythm feel might come from citing Jelly Roll Morton himself: “Now in one of my earliest tunes, *New Orleans Blues*, you can notice the Spanish tinge. In fact, if you can’t manage to put tinges of Spanish in your tunes, you will never be able to get the right seasoning, I call it, for jazz.”¹³ However, although latin-flavored music does rightfully belong under the umbrella of jazz, all solos considered for and examined in this thesis do not fall under the category of a Latin rhythm feel, not out of deliberate exclusion but simply because there were no examples of improvisation with a Latin feel on the albums from which the solos were drawn.

Tonality type is the least difficult category for this corpus of trumpet players in the traditional New Orleans idiom. Most of the pieces fall under the category of Functional, meaning they work within the harmonic traditions of European art music from the classical and romantic eras. The ‘jazzy’ aspect is simply the standard use of 4-note chords instead of triads. The Jazzomat further distinguishes a separate Blues category, whose hallmarks include “the use of dominant-seventh chords in a tonical fashion, the importance of subdominant relationships (as opposed to dominant relationships in functional harmony) and a strong codification of harmonic form (Twelve-bar blues progression).”¹⁴

The transcriptions are stored as melody data in SQLITE3 format. Table 2 shows the overview of tables contained in the WJD. These transcriptions are the raw material which is then analyzed with the MeloSpyLib to reach conclusions about a particular musician’s improvisation or the idioms of a particular style of jazz.

¹¹ “Database Glossary”, in: *The Jazzomat Research Project*, last accessed 14.11.2022.

¹² “Database Glossary”, in: *The Jazzomat Research Project*, last accessed 14.11.2022.

¹³ Jelly Roll Morton speaking in: Lomax, Alan, *Mister Jelly Roll*, New York, NY: Grosset & Dunlap 1950, p. 62.

¹⁴ “Database Glossary”, in: *The Jazzomat Research Project*, last accessed 16.11.2022.

Table 4: Overview of Tables in the WJD

Table Name	Description
beats	Table for beat annotation of WJD melodies, referenced by melody(melid)
composition_info	Infos regarding the underlying composition of a WJD solo, referenced by melody(melid)
db_info	Information regarding the distributed database file like version information, license, etc.
esac_info	EsAC infos for EsAC melodies, referenced by melody(melid)
melody	Main table for all melody events
melody_type	Indicated type of melody: WJD solos or EsAC (Folk songs using Essen Associative Code), referenced by melody(melid)
popsong_info	Pop song infos, referenced by melody(melid)
record_info	Infos regarding the specific audio recording a WJD solo was taken from, referenced by melody(melid)
sections	All sections (phrase, chorus, form, chords, etc), referenced by melody(melid)
solo_info	Solo infos for WJD solos, referenced by melody(melid)
track_info	Information specific to a track on a record (or CD)
transcription_info	Transcription infos for WJD solos, referenced by melody(melid)

2.1.2. The MeloSpyLib

The MeloSpyLib is a suite of functions “for encoding, analyzing, visualizing, and converting monophonic melody data.”¹⁵ The mathematics and programming behind the library is extensively documented in the article “Computational Melody Analysis” in *Inside the Jazzomat*.¹⁶ Suffice it to say that the modules of the MeloSpyLib work together to create a digital representation of monophonic melody data that can then be manipulated and analyzed. These modules are:

- 1) Basic Representation, which “entails all classes to represent melodies and metadata as well as transformations and abstraction related to them”,
- 2) Input/Output, which “entails classes for melody reading and writing”,
- 3) Feature Machine, which allows extraction of user-defined features,

¹⁵ “Basic Concepts and Representations“, in: *The Jazzomat Research Project*, < <https://jazzomat.hfm-weimar.de/melospy/melospy.html>>, last accessed: 10.11.2022.

¹⁶ Frieler, Klaus „Computational Melody Analysis” in: *Inside the Jazzomat. New Perspectives for Jazz Research*, Mainz: Schott Music GmbH & Co. KG 2017, pp. 41-84.

- 4) Pattern Retrieval, which entails classes for the extraction of patterns on arbitrary abstractions of melodies,
- 5) Similarity, which allows user-defined similarity computations, and
- 6) Visualization, which allows the visualization of the extracted features.¹⁷

They serve to create a machine-readable representation of the music where the basic representation is expanded upon and enriched with annotations from humans. The basic representation starts out from a core representation of a melodic event, defined as “triplets (onset, duration, value), where onset and duration are measured in seconds, and values can be any object, often simply a label”.¹⁸ This is then differentiated into specializations of pitch, meter, and when chaining these events together further information can already be derived, such as Inter-Onset-Interval and pitch intervals. From here, human-made annotations bring more information into the picture, ranging from local annotations on the character of an event (e.g. intensity and timbre) to contextual ones such as phrase segmentation.¹⁹ Further classes include chord objects and metrical frameworks.

The above set of data classes form the lower level of data which can be manipulated and analyzed by the MeloSpy software. Above this sit the Midlevel Units (MLUs), a set of classes which define the units of a solo which the player is most likely to consciously use. The idea is that musicians are not thinking ‘play this note this long, then this note this long, etc...’, they are instead working with larger chunks, either of material they make up on the spot or pre-practiced patterns which they can rattle off in the right context.²⁰ Examples of some MLUs in the Jazzomat are a *line*, defined as “a series of tones for the most part proceeding in small, step-sized intervals with high rhythmical uniformity and a salient trajectory in pitch space” and a *theme*, which is “material taken directly from the theme of the tune, possibly with variations”.²¹ When a solo is annotated with both of these levels, there is an extensive basis of data which the software can work on to extract features.

¹⁷ “Basic Concepts and Representations“, in: *The Jazzomat Research Project*, < <https://jazzomat.hfm-weimar.de/melospy/melospy.html>>, last accessed: 4.9..2023.

¹⁸ “Basic Concepts and Representations“, in: *The Jazzomat Research Project*, < <https://jazzomat.hfm-weimar.de/melospy/melospy.html>>, last accessed: 5.9..2023

¹⁹ Frieler, Klaus „Computational Melody Analysis” in: *Inside the Jazzomat. New Perspectives for Jazz Research*, Mainz: Schott Music GmbH & Co. KG 2017, pp. 46-47.

²⁰ Frieler, Klaus „Computational Melody Analysis” in: *Inside the Jazzomat. New Perspectives for Jazz Research*, Mainz: Schott Music GmbH & Co. KG 2017, p. 54.

²¹ Frieler, Klaus „Computational Melody Analysis” in: *Inside the Jazzomat. New Perspectives for Jazz Research*, Mainz: Schott Music GmbH & Co. KG 2017, pp. 56-57.

Feature extraction in the MeloSpy software works on ‘transformations’, or abstractions, of the basic representation plus annotations. For example, a transformation of the basic representation into a duration class takes the duration value from the triplet and sorts it into one of five duration classes.²² Similarly, a pitch transformation will take the ‘value’ part of the triplet, where the pitch label is stored, and use that to assign the note its MIDI pitch name. Some transformations require more than just the basic representation, for example chordal pitch class, which acts just like the pitch transformation but then uses the chord annotation to give the note a chord-relevant label, such as 3 for third. Through these transformations, features can be drawn from the basic representation and annotations.

Given the data and features which the software can then read, the fourth and fifth modules of the MeloSpyLib can then begin to search for patterns and similarities across a broader corpus of solos. This is the basis for tools like the Dig That Lick Pattern Similarity Search Engine, which works on a database of defined licks to show what licks may be circulating in a given corpus of transcribed solos.²³ Using this and other similarity searches, the researcher can trace musical ideas as they are passed on from musician to musician. It is also a useful tool for discovering how musicians construct their solos- whether they are really and truly freestyling or if they are using patterns and licks, cutting and pasting in different contexts to create different solos.

This thesis will work on the lower level of data and annotation, below the MLUs, and begin with the features which can be transformed from the basic representation and annotation.

2.2. Transcription

This section will outline the transcription process used to convert the audio signal into a format that the MeloSpyLib can process. The MeloSpyLib uses a machine-readable transcription of the audio signal to analyze the solo and extract data. These transcriptions were made using Sonic Visualizer and involve a multi-step, multi-layer workflow, at the end of which the transcription is enriched with enough metadata to allow analysis and

²² “Transformations“, in: *The Jazzomat Research Project*, < <https://jazzomat.hfm-weimar.de/melospy/melospy.html> >, last accessed: 5.9.2023

²³ “Documentation“, in: *Dig that Lick Pattern Similarity Search*, <https://dig-that-lick.hfm-weimar.de/similarity_search/documentation>, last accessed 5.9.2023.

comparisons of many different musical aspects. Certain Vamp Plugins also assisted in the creation of the transcriptions: *BeatRoot Beat Tracker*, *IBT- INESC Beat Tracker*, and *Tuning*.

2.2.1. Beat Annotation

After a section of the tune was chosen, it was exported as its own audio file so that the transcription would just be tied to the particular passage and not the entire tune. Following this, the waveform visualization was exchanged for a spectrogram visualization, which allowed for easier beat and note transcription. The first layer of annotation is the beat layer. As noted in *Inside the Jazzomat: New Perspectives for Jazz Research*, not only does a performance done by live musicians require flexibility in the produced ‘beat grid’ to account for micro-rhythmic variations (the slight push/pull between the rhythm instruments and the melody instruments), even the concept of beat as a discrete moment in time brings up deep philosophical questions about the nature of the beat and whose beat the transcription should represent.²⁴ It would exceed the scope of this thesis to attempt to answer the philosophical questions, so suffice it to say that the project decided to focus on the beat defined by the hi-hat ring-ding-a-ding pattern.²⁵ Since this pattern was absent in early jazz recordings, another anchor was chosen, namely the collective beat of the chordal instruments and the two-beat bass. This turned out to be a sword which cuts both ways; on the one hand, the accompaniment is generally very consistent with simply articulating the current chord on each beat (or in the bass’ case, every other beat) of the measure, a fact that makes hearing the beat felt by the ensemble fairly easy. On the other hand, the acoustic recording technology of the day created a very distinct foreground/background split, meaning that the accompaniment was often muffled and hard to hear behind the melodic instruments who were closer to the mic.

This difficulty aside, the manual tapping of the beat using either a midi keyboard or the computer keyboard proved to be frustratingly inaccurate because of lag times between the tap and the input into the program. Therefore, the beat tracking plugins *BeatRoot* and *IBT* were used to create the initial set of annotated beats. The objections from the Jazzomat against using beat tracking programs seem to be that they establish an inflexible grid based

²⁴ Pfleiderer, Martin: “Introduction” in: *Inside the Jazzomat. New Perspectives for Jazz Research*, Mainz: Schott Music GmbH & Co. KG 2017, pp. 24-25.

²⁵ Ibid, p. 25.

on the detected tempo at the beginning of the audio and that they cannot reliably follow the beat in most jazz recordings.²⁶ While the latter is most certainly true – there are guaranteed to be mismatches between the detected beats and the actual beats when using these plugins – the current version *BeatRoot* delivers generally satisfactory and also flexible results and on top of this, the positions of the detected beats can be edited afterwards to line up with the real beat in the recording. Thus, after generating the first set of beats, each excerpt was listened through multiple times at a slower tempo and the beat positions were carefully adjusted to match the recording well. *BeatRoot* was the preferred plugin because it was much more consistent in the quality of its beat detection, but there were cases where pieces with extreme tempos, either fast or slow, confused the algorithm into recognizing either half-note or eighth-note pulses as the beat. In these cases *IBT* was used because of the option for defining a tempo range to detect the beat at, allowing for the correct pulse level to be annotated. When adjusting the positions of the beats afterwards, the spectrogram representation was helpful; rhythmic events can be seen as vertical structures in the graph, thus giving visual support for the placement of a beat in a difficult to hear spot.

In some cases the beat layer produced by the *IBT* plugin caused errors in the Melo-Spy software. To fix this, a new beat layer which was unaffiliated with the plugin was created, then the beats were imported into this fresh layer and the old one was deleted.

2.2.2. Note Annotation

Once the beat layer was complete, the next step was to transcribe the notes layer. By default, the piano roll in Sonic Visualizer is set up in reference to A = 440 hz. However, both the recording speed and the playback speed of these early jazz recordings creates variations in the reference pitch. Therefore, before transcribing the notes the relative tuning of the recording was determined using the *Tuning* plugin. This produced a set of estimates for the local tuning during the whole excerpt, and the most prevalent was chosen as the unique tuning for the transcription. The implications for this with respect to pitch/melodic analysis are discussed in chapter 2.3. After adjusting the tuning of the piano roll, the notes were transcribed. Again, the spectrogram was useful here because the duration of the pitches was generally easily visible as horizontal structures, and sometimes even expressive effects such as vibrato, bends, and scoops showed up in the visualization.

²⁶ Ibid., p. 24.

While the challenges of the original Jazzomat, such as lightning-fast lines where the individual pitches were hard to make out, did not come up during these transcriptions (the early jazz players seem to be more focused on rhythm and effects), sometimes the lines of the trumpeters got covered by the band. However, there was never a case where the line disappeared completely. Most questions on what to notate came up when capturing effects like bends, slides, fall-offs, and rips. In the first three cases, the anchoring note was transcribed with an additional note in the text layer describing what the effect was. In cases where a bend or slide led from one note to the other, both the start and end notes were transcribed and the first note received a text annotation. When dealing with rips (fast low-high leaps with non-specific pitches in between), the starting and ending notes were transcribed and the very short initial note annotated with the text ‘rip’.

2.2.3. Text, Regions, Chords, Meter, and Form Parts

Following the notes layer, the transcription was enriched with further metadata to capture the nuances of jazz performance and provide context for the melodic and rhythmic analyses. In the text layer descriptions of special effects, e.g. vibrato, bends, or mute effects, were attached to their parent note. This is of particular importance for early jazz solos because much of the expressive content of the solos was accomplished by variations in timbre and manipulation of the pitch rather than purely melodic note choices. The next layer was a regions layer in which the melodic phrases were defined, allowing the Melo-Spy Suite to access this type of segmentation during processing. This segmentation allows information such as the length of phrases and the chaining of phrases to be extracted. It also serves as the basis for the analysis of the Mid-Level Units.

The chord changes, meter, and form parts are attached to beat events. It is assumed that chord changes always happen on a beat, which works well enough for traditional jazz. Chord syntax is transcribed very similarly to standard chord notation, except that alterations to an extension are placed after the interval number instead of before, i.e. when in standard notation a dominant 7th chord with a flat 9th would be written C7b9, in the Jazzomat it is written C79b.²⁷ Meter was assumed to be a basic 4/4 despite the strong two-

²⁷ Frieler, Klaus: “Computational Melody Analysis“ in: *Inside the Jazzomat. New Perspectives for Jazz Research*, Mainz: Schott Music GmbH & Co. KG 2017, p. 50.

beat feel of the groove. This is supported by the motion of the bass and chords; a I-V pattern in the bass is only complete after two beats on each note, and the chords primarily change in multiples of 4, with the occasional acceleration to two beats per chord occurring only at musically significant moments like rounding off phrases. Form is generally straightforward, the main distinction being between Blues (AAB) and 32-bar (usually either AABA or AB).

2.3. Special Challenges and their Solutions

This section will discuss some of the particular challenges which arose in the process of selecting and transcribing the traditional jazz solos. First and foremost, distinguishing between arranged or purely ‘head’ sections and improvised sections caused the most difficulty. Another challenge was determining the chord progressions for many tunes, because they exist only as these old recordings where harmony instruments like piano and guitar/banjo tend to fall into the background and be covered by the melody instruments. Furthermore, the realities of early 20th century acoustic recording techniques made even the determination of beats and overall pitch difficult. Finally, the timing of when recordings were made in relation to the careers and lives of the players under investigation creates a certain skew to the data.

2.3.1. Improv or not?

Because conversations with the musicians on the recordings is no longer possible, there can be no definitive way to say whether a given passage was improvised or planned out beforehand. However, spontaneous improvisation is central to the idiom of jazz, so it can be assumed that the musicians also did it for these recordings. In order to make the best educated guess about what is improvised and what is not, a set of selection criteria was developed.

The first step when processing a given tune is to determine what the melody is. This is especially important given that early jazz musicians were more inclined to stay very close to the contour of the melody during their solos. As Louis Armstrong said of his own education by King Oliver in playing jazz: “He’s the one that stopped me playin’ all those variations - what they call bebop today,’ Louis recalled in 1949. ‘You get yourself a lead

[melody] and you stick to it,' Papa Joe told me, and I always do.'"²⁸ When listening to the early recordings it becomes clear that there are passages which could be described as paraphrase improvisation, where the player sticks very close to the melody but adds ornaments, rhythmic variations, and possibly very short, intricate lines in the gaps between the basic melodic lines. Given that this theme-first approach is of an entirely different type than other, chord progression-first approaches to improvisation, it will be set aside for the purposes of this discussion. The focus will instead be laid on passages of solo improvisation and collective improvisation where the melody is not recognizable.

There are two reasons for leaving out paraphrase improvisation. First, in focusing on non-paraphrase improvisation, this corpus will be more similar to the one already established in the WJD, allowing more initial comparisons between the two. Then, once the traditional style is well-described in terms of low-level features such as rhythm and microtime as well as in terms of certain mid-level features like chordal pitch class and chromaticism, there will be a good foundation upon which to look at paraphrase improvisation. This corpus will serve as a bridge between the later chord-first style and the earlier theme-first style.

Secondly, as Lawrence Gushee argues, "This idea of the hegemony of paraphrase in the New Orleans style appears to be founded on the older practice of such as Joe Oliver, not on that which much evidence suggests was prevalent among younger players coming up after 1915."²⁹ While of course trumpeters in Armstrong's generation could and did apply the paraphrase technique to their improvisations, Gushee highlights that there were other techniques which filled out the toolbox of a younger jazz musician, meaning they were not stuck with only melodic paraphrase. Examples of these might include outlining the chords with runs and expressive alterations of tone and vibrato.³⁰ Thus, by examining the non-paraphrase improvisation of these musicians one can get a sense for the changing style during this transitional period right before the swing era.

²⁸ Hadlock, Richard: *Jazz Masters of the Twenties*, New York: The Macmillan Company 1965, p. 14-15.

²⁹ Gushee, Lawrence: "The Improvisation of Louis Armstrong" in: Nettle, Bruno and Russell, Melinda (eds.), *In the course of Performance*, Chicago: The University of Chicago Press 1998, pp. 300-301.

³⁰ Ibid, p. 301.

Gushee also highlights the significance of the solo break as the crucible in which especially Armstrong's personal style was developed. The topic of breaks and their influence as generators of the elements of what would later become a fully-fledged improvisational style deserves to be addressed, but at another time. Again, this thesis will focus on longer-form, non-paraphrase improvisation as the bridge between traditional and later styles as well as between theme-first and chord-first approaches to improv.

The variety of structures an early jazz tune could have is rather large, but in general the first chorus of a recording will give a relatively straightforward version of the melody. In the corpus under investigation here, the first instrumental chorus is understood as the melody and from there comparisons can be made with later solo or collective choruses to determine if they are mere repetitions of the basic melody or something new. While there are individual cases where it seems fairly certain that not the first chorus, but the final chorus is the unadorned melody, these are extraordinary cases and the overwhelming majority of recordings begin with the melody. Sometimes there is also a vocalist singing the song; in these cases the vocalist's chorus is understood as the melody. Solo choruses are then relatively simple to sort: if the melody is not recognizable, they are assumed to be improvised.

Collective choruses require more careful selection. Firstly, the lines in collective improvisation must be sufficiently independent from one another, i.e. they must not include synchronized riffs or licks between the different instruments. If these are present, it either means that they were decided upon ahead of time and are therefore not improvised, or that one player (usually the trumpet player, who took on the lead role in a traditional New Orleans style ensemble) made one up on the spot and then everyone followed. In this second case, it is again an entirely different category of improvisation than what this investigation is interested in and is therefore excluded from the set of improvised choruses for a particular player. Finally, the line must differ from the melody enough that it is unrecognizable, allowing for the strongest possible case to be made that it was improvised and not pre-arranged.

In reading Lawrence Gushee's article "The Improvisation of Louis Armstrong", the existence of lead sheets for early jazz tunes brought up a question with profound consequences for the selection and transcription of solos: just how much were these tunes

planned, and can one speak of improv in them? On the one hand, lead sheets can show us what the musicians and/or publishers considered the melody of a piece, allowing for direct comparisons to find where spontaneous improv deviates from the notation, while on the other hand some lead sheets are so detailed and match up so exactly with the recordings as to give the impression that the tunes were fully arranged and planned out. Gushee argues that the detail of the lead sheets suggests they were most likely transitional notation, based on the recording of the small ensemble and meant as an intermediary step towards creating an arrangement for a larger band or vice versa.³¹ The possibility that a recorded performance was planned out in as much detail as shows up on the lead sheet is for Gushee the most radical and would mean a dramatic shift in our understanding of some of these early jazz musicians.³²

Another related problem is that of multiple takes. When listening to multiple takes of the same tune it becomes clear that musicians sometimes play quite similarly during their solos, which again raises the question of whether these recordings were completely planned out or not and whether there is any improvisation in them. In answer to both of these problems, Gushee cites a statement from Armstrong in Meryman's *Louis Armstrong – A Self-Portrait*:

*If the people ain't sick of it, I ain't. [...] I do that song 'Hello Dolly!' the same way every night 'cause that's the way the people like it. And even back in the old days it was like that – when everybody was supposed to be improvising. Who knows who's improvising? All trumpet players can hear what you play and they can play the same notes. [...] And always, once you got a certain solo that fit in the tune, and that's it, you keep it. Only vary it two or three notes every time you play it – specially if the record was a hit.*³³

The key sentences are the last two. If one takes what Armstrong says here at face value it could support two arguments: 1) that while some solos and passages may be copied down in notation, the initial conception was through improvisational thinking (“ONCE you got a certain solo that fit in the tune...”) and the solos can thus be considered as part of the soloist's improvisational repertoire. 2) that although some musicians play nearly the same solo on multiple recordings, this is a deliberate choice.

³¹ Gushee, Lawrence: “The Improvisation of Louis Armstrong” in: Nettl, Bruno and Russell, Melinda (eds.), *In the course of Performance*, Chicago: The University of Chicago Press 1998, p. 307.

³² Ibid.

³³ Meryman, Richard: *Louis Armstrong – A Self-Portrait*, New York: Eakins Press 1971, pp. 40-43.

Brian Harker also notes the tendency not only of Armstrong, but other musicians to play very similar solos across multiple takes. In his essay *Telling a Story: Louis Armstrong and Coherence in Early Jazz*, Harker writes:

*“The subtle interactions among the various takes on Why Couldn’t It Be Poor Little Me? reveal Armstrong’s apparent improvisational method: to tinker with already stable designs (whether a preset melody or one of his own) rather than to start fresh with each new performance [...] In this he may have been following a common practice in the 1920’s [...] Paul Whiteman recalled that Bix Beiderbecke ‘would never play a chorus the same way until he got just what he wanted. Then he’d stick to that chorus and play it that way over and over again [...] Similarly, multiple takes of Armstrong’s solos on Copenhagen and Shanghai Shuffle reveal not the searching experimentation of a restless artist, but the finished product of a satisfied one.”*³⁴

The passage from Harker elaborates on the improvisational process of the first argument; these musicians started from a large-scale outline, varying bits and pieces over the course of recording sessions and even over the span of careers until they arrived at the solo they felt fit best. This process of variation can certainly be counted as an improvisational one, even though the basic material stayed the same throughout. The fact that eventually the solos became literal repetitions, without variation, does not discount their origin in improvisational thinking. Then, to the second argument, it is important to remember that the *conscious decision* to repeat similar solos was an artistic choice which was arrived at after having gone through the improvisational process. This was part of the performance practice of the time, and to say that these solos contain no improvisation whatsoever ignores the development they went through and the choice the artists made to play something that fit well to the given song.

As Gushee argues, it is a mistake to look at early recordings through the lens of a modern “jam session aesthetic” where the muse inspires the player to come up with new solos every time they play; given the quotes above, Armstrong and others certainly did repeat themselves, but this was on purpose and does not discount the improvisational nature of their playing.³⁵ Just as later bebop musicians would repeat patterns and licks which were

³⁴ Harker, Brian, “Telling a Story: Louis Armstrong and Coherence in Early Jazz” in: *Current Musicology*, Vol. 63 (1997), p. 57.

³⁵ Gushee, Lawrence: “The Improvisation of Louis Armstrong”, pp. 320-321.

perfected in the woodshed, so too did early jazz players establish their own repertoire of phrases that they then applied when the situation was right, the only difference being perhaps the size and versatility of the building blocks.

2.3.2. Chord Progressions and Tuning

The original Jazzomat corpus relied on lead sheets from sources such as the Real Book in order to annotate the chords into the transcriptions.³⁶ Unfortunately, only the most popular standards tend to be included in the Real Book and none of the songs in this corpus made the cut. This adds another layer of complexity to the transcription process because the progressions had to be annotated by ear. This is not necessarily a problem for modern recordings with elaborate setups designed to capture all instruments so that they can be heard well, but in this case there is a clear foreground-background dichotomy, with the soloists being much closer to the mic than the rhythm section, which means that often the harmonic information is hard to hear. Combining a knowledge of basic jazz chord theory as well as detailed listening to both the bass (usually a tuba, which projects well) and the harmonic implications of the melodic line provided reasonable certainty for the annotated chord progressions.

These were then checked for approximate agreement with the extensive chord books of the modern traditional jazz band The Jazz Pilgrims. They are based in the United Kingdom and have a website with a huge collection of chord books for many traditional jazz songs.³⁷ When comparing these chord books to the original recordings it is clear that they reflect the original arrangements and are indeed made “for the sole purpose of promoting and conserving”³⁸. These chord books were used as corroboration of annotations and as a reference for particularly difficult to hear sections, but in the end the decision on chords was made by ear.

Another, related difficulty was the fact that the recording and playback speeds of these early jazz songs create an individual tuning reference for each song. For example,

³⁶ “How to Annotate Solos using Sonic Visualizer”, in: *The Jazzomat Research Project*, last accessed 24.11.2022.

³⁷ “Burtie’s Chord Book” in: *Burt Butler’s Jazz Pilgrims*, <<https://www.jazzpilgrims.co.uk/Jazz%20Pilgrims%20page%20twelve.htm>>, last accessed: 25.11.2022.

³⁸ “Burtie’s Chord Book” in: *Burt Butler’s Jazz Pilgrims*, <<https://www.jazzpilgrims.co.uk/Jazz%20Pilgrims%20page%20twelve.htm>>, last accessed: 25.11.2022.

Freddie Keppard's "It must be the Blues" is heard at $A = 433$ hz, while his "Salty Dog" is at $A = 450$ hz and King Oliver's "I'm watching the clock" is at $A = 429$ hz. The Sonic Visualizer Vamp plugin *Tuning* made by Matthias Mauch³⁹ was used to estimate the particular tuning for each recording. One can then adjust the global tuning of the midi note layer, allowing the transcribed notes to exactly match the recorded pitches.

In some cases the variation of tuning based on recording/playback speeds, or possibly the digitalization process, was so strong as to push the reference as much as a whole step beyond the actual played pitch. For example, Armstrong's solo on "Chimes Blues" is initially registered by the *Tuning* plugin as being heard at $A = 434$ hz. However, annotating the notes and chords with this reference produces a transcription in the key of (slightly below) B Major, a very unlikely key because it does not lay well at all for most wind instruments in terms of fingerings. What is more likely is that the original key was C Major and the pitch got distorted in the recording and/or digitalization process. This is corroborated by comparing other digital versions of the same recording, which do sound in C Major at $A = 440$ hz. In such cases, the transcriptions were adjusted such that the chords and notes reflect the key the piece was most likely played in originally, and then the pitch of the MIDI layer was adjusted to make the transcription comfortable to listen to with the original audio. For Chimes Blues this means the original Notes Layer, transcribed in B Major, was shifted up one half step and then the A reference for the MIDI notes was changed to $A = 410$ hz.

2.3.3. Timing: Trumpeters past their prime

Jazz has existed since before the turn of the 20th century but was only captured on recordings starting in the 1920s. It is an unfortunate fact that some of the early titans of jazz, such as King Oliver and Freddie Keppard, were in the sunsets of their careers by the time their sound was preserved for later generations to hear. What this means is that the few recordings we have of them are not necessarily representative of their full capabilities and that we only have an impression of their later style after full careers of development, experimentation, and change.⁴⁰ On the other hand, for Louis Armstrong and Bix Beiderbecke these recordings document their entire path, from their earliest entrance onto the jazz

³⁹ „Find and Download Plugins“ in: *Vamp Plugins*, <<https://www.vamp-plugins.org/download.html?search=key&go=Go&platform=other>>, last accessed: 25.11.2022.

⁴⁰ Gioia, Ted, *The History of Jazz*, New York: Oxford University Press 1997, p. 37.

scene until their final performances. What is lacking is a picture of the developmental stages of Oliver and Keppard, and what is available must be taken with a grain of salt before drawing definitive conclusions about their particular styles. Since this deficit cannot be fixed, one must do the best one can with what is available. However, it is important to acknowledge the skew that this gives to the recording data in the corpus before proceeding with the analysis.

3. Musicians

As mentioned in the introduction, it is a goal of this thesis to expand the corpus of solos in a Traditional style for the WJD. A further goal is to examine the improvisational styles of trumpet players who were contemporaries and for whom a lineage of mutual influence can be traced. The four musicians under investigation are Joe “King” Oliver, Freddie Keppard, Louis Armstrong, and Bix Beiderbecke. This chapter will introduce these musicians, examine their connections as documented in the literature, and identify trends in the descriptions of their individual styles. A set of quotations, statements about each player’s unique style, has been drawn from the literature. The results of the analysis will allow either the verification or falsification of these claims based on the transcriptions in the WJD and in this corpus.

3.1. Joe “King” Oliver

As his title would suggest, there is a great deal of legend surrounding Joe Oliver. The oldest of the four trumpet players, Oliver’s birth year of 1885 is relatively certain while the exact date and place remain unsure.⁴¹ While some sources place him in New Orleans from the outset,⁴² others have him born outside the city, to which his family moved while he was a child.⁴³ What is agreed upon in the literature is that Oliver grew up in a deeply musical environment, what with the traditions of brass and marching bands in the New Orleans of the late 1800s. He showed considerable dedication to practice and followed in the footsteps of the mythical father of jazz, Buddy Bolden, by taking up the mantle of ‘Cornet King’ of New Orleans after supposedly ‘cutting’ Freddie Keppard in a

⁴¹ Giddins, Gary: *Visions of Jazz: The First Century*, Cary: Oxford University Press 2000, p. 77.

⁴² See: Shipton, Alyn: *Jazz Makers: Vanguard of Sound*, New York: Oxford University Press 2002, p. 23.

⁴³ Fontenot, Kevin: “Joseph ‘King’ Oliver” in: *64 Parishes*, < <https://64parishes.org/entry/king-oliver>>, last accessed: 13.12.2022.

contest.⁴⁴ The two were contemporaries and rivals, Keppard just four years younger. The story goes that in 1911 one evening the two were playing gigs in different cafes on the same street when Keppard's playing was tying up the crowds. Frustrated at this, Oliver stood up and blew his heart out, eventually drawing all the people away from Keppard and securing his place in the New Orleans music scene.⁴⁵ Of course, these legends are propagated in the interest of image-building, and there are just as many people who would name Keppard king as would name Oliver. Though accounts differ as to who indeed was the best cornetist in New Orleans, the bottom line is that Oliver soon became an important figure in the development of jazz. It was during his reign in Storyville that he met the young Louis Armstrong, who was an up-and-coming new talent. This marked the beginning of a years-long mentor/disciple relationship between the two, where Armstrong learned the jazz repertoire of the time and became familiar with Oliver's particular style.

Having established himself as a leader in New Orleans, Oliver then moved north to Chicago and began performing in jazz clubs there starting in 1918.⁴⁶ After a brief stint in California he returned to Chicago in 1922 and established his famous band, *King Oliver's Creole Jazz Band*, with which he began to record.⁴⁷ This is also when he brought Armstrong up from New Orleans to join the band, and the two were said to have "worked up a system of cornet breaks during which they seemed to read each other's mind".⁴⁸

As some of the earliest jazz recordings, these tracks give a glimpse not only into what the genesis of jazz *may* have sounded like, but also into what Oliver might have sounded like in his New Orleans days. The operative word here is 'might', and there are a few reasons why the Creole Jazz Band recordings of 1923 require critical listening. First, as Gunther Schuller points out, "the music that became known as jazz existed for many years as a multi-faceted music whose character *depended largely on geographical disposition and the social and racial constitution of its audience* [*italics mine*]."⁴⁹ Jazz and race relations were and are inextricably woven together, especially when it came to commercial

⁴⁴ Giddins, p. 78.

⁴⁵ Gerler, Peter: "Rite of Swing" in: *American Legacy: The Magazine of African-American Life and Culture*, June 2007, New York: RJR Communications Inc., p. 26.

⁴⁶ Shipton, Alyn: *Jazz Makers: Vanguard of Sound*, New York: Oxford University Press 2002, p. 23.

⁴⁷ Gerler, "Rite of Swing", p. 29.

⁴⁸ Gerler, "Rite of Swing", p. 29.

⁴⁹ Schuller, Gunther, *The History of Jazz: Volume 1, Early Jazz: Its Roots and Musical Development*, New York: Oxford University Press 1968, p. 71.

enterprises such as recordings. Oliver most certainly played differently in Peter Lala's Café in New Orleans than he did for one of Tulane University's white dance events. As part of the 'race records' wave, the Creole Jazz Band recordings were explicitly created for a certain black audience, but after a long period of primarily white consumption of jazz.

Schuller argues that the Oliver heard with the Creole Jazz Band in Chicago gives just a general idea of what his New-Orleans-self sounded like, with the 'down home' sound coming more from the freshly imported Armstrong.⁵⁰ Secondly, contemporaries already speak of Oliver's waning abilities in reference to the Creole Jazz Band recordings. Though by no means an old man at the time of recording, it was the general consensus that gum disease had begun to cripple his playing such that he was a mere shadow of the Oliver who dominated that night in New Orleans.⁵¹ Again, the facts cannot be changed and the material is still worth considering as long as one keeps the context in mind and remembers that it only offers a partial view of Oliver's style and abilities.

Martin Williams in his *Jazz in its Time* offers an interesting counterpoint to the claims that Oliver lost his chops by the 1920's. He points out a series of recordings done by Oliver in New York between 1929 and 1930 which contain some overlooked but interesting trumpet solos.⁵² These deserve attention and could serve as the material foundation for future investigations into traditional New Orleans jazz improvisation.

Oliver's sunset years were spent struggling to make a living as a band leader. His final recording date was in 1931 in New York City, after which he battled the increasing severity of his gum disease while trying to tour around the Midwest and South.⁵³ By the late 1930's he was completely out of the music scene, and he died in 1938.

The connections between Oliver and the other trumpeters are varied and direct. As mentioned in the anecdote about Oliver's 'arrival' on the New Orleans scene, he and Keppard were contemporaries and also in a certain sense rivals. In this context there are three driving forces which one would expect to show up in their playing. First, both having grown up at the same time, learning from the original styles of players like Buddy Bolden

⁵⁰ Schuller, p. 73.

⁵¹ Gerler, "Rite of Swing", p. 29.

⁵² Williams, Martin, *Jazz in its Time*, New York: Oxford University Press 1991, p. 174.

⁵³ Shipton, p. 24.

and Bunk Johnson, one would expect a certain amount of common ground in their approach to improvisation and their musical choices. Second, assuming the competitive atmosphere implied by the cutting anecdote, one expects commonality as well as one-upmanship when comparing their playing. Though there are no extant recordings of battles between the two players, in such a situation it is not hard to imagine that they would be aware of what the other was doing and would want to prove, either to themselves or to others, that they could do anything the other could, just better. This would manifest concretely in recordings as effects or ideas which are similar between players but are amplified in one way or another. Finally, in order to establish an idiomatic style, a niche, an artistic calling card in the growing commercial world of jazz recordings, one would expect certain unique devices or ideas to show up in their improvisation. These would serve to stake out territory that was theirs and theirs alone.

While the relationship between Oliver and Keppard seems to have been a peer/rival one, Oliver's connection to Armstrong is primarily that of a mentor and role model. Given this dynamic and statements made by Armstrong himself, in early recordings with both Armstrong and Oliver one expects to hear even more similarity in approach and ideas than between Oliver and Keppard. Recall the quote in Chapter 2.3.1. about what Armstrong said of Oliver's influence on his playing⁵⁴

On the other hand, Armstrong's unique style is also said to shine through even in his recordings with Oliver. As Gushee writes: "Although much of his [Armstrong's] phrasing follows Oliver with uncanny exactitude, in the spaces left by Oliver there is a constant presence of another musical personality, one with a different sense of time and a different vibrato."⁵⁵ Exactly what these differences are show not only what made each player's style characteristic, but also hint at what makes up the global shift from traditional jazz to swing and later styles on which Armstrong is said to have had enormous influence.

Anecdotes about Oliver's style abound in the literature. Across sources there seem to be three main pillars of Oliver's playing: 1) a unique rhythmic feel, 2) an approach to variation based firmly on themes, either drawn directly from the melody of the tune or

⁵⁴ Louis Armstrong, quoted in: Hadlock, Richard: *Jazz Masters of the Twenties*, New York: The Macmillan Company 1965, p. 14-15.

⁵⁵ Gushee, Lawrence: "The Improvisation of Louis Armstrong", p. 295.

developed slowly chorus by chorus, and 3) an emphasis on expressive effects, be it manipulation of tone color, the use of mutes, or techniques such as bends, slides, growls, etc. The following paragraphs will introduce some specific quotes about Oliver's playing which will serve as examples of what critics and listeners hear in his recordings.

Rhythm is clearly central to our understanding of Oliver and of Jazz in general. For Oliver the secret sauce was a mix of regularity and flexibility which always included forward energy. Martin Williams writes:

*The truly phenomenal rhythmic momentum generated by Oliver is just as much dependent on continuity of rhythmic pulse - only reinforced by uniformity of accentuation in the rhythm section and relaxed playing [...] Oliver's swing is exciting after a different fashion: it is predictable, positive, and consistent.*⁵⁶

Contrast this statement with one from Rudi Blesh:

*Oliver's cornet lead is in a beautiful clear open tone; his phrasing is the very epitome of the jazz phrase; one moment it drives the ensemble, the next it is wayward, lingering and then catching up in imaginative figures. This phrasing was the rhythmic gift of Bunk Johnson to New Orleans jazz. Armstrong inherited it, too.*⁵⁷

In both author's views, the ensemble serves as a foundation and foil for Oliver, around which he dances but which he also pushes forward with his rhythmic conception. In more concrete terms, based on these and other statements one would expect Oliver's rhythm to move on both sides of the pulse established by the ensemble, perhaps with more bias towards 'front-of-the-beat' playing. Another expectation is that his lines involve a high degree of syncopation (based on the assumption that this gives music both a lively as well as forward-pushing feeling), and finally that within a song and possibly even across songs his rhythmic feel will remain consistent.

Gunter Schuller writes of Oliver's use of thematic improv:

⁵⁶ Williams, Martin: "King Oliver", in: Green, Stanley (ed): *Kings of Jazz*, New Jersey: A.S. Barnes and Co. 1978, p. 256.

⁵⁷ Blesh, Rudi: *Shining Trumpets. A History of Jazz*. New York: Alfred A. Knopf 1946, p. 225.

*Not only does each chorus develop out of variations or embellishments of the composition's theme, but from chorus to chorus there is a real sense of progression within an over-all pattern. This is especially true of Oliver's own playing, as Martin Williams has shown in his excellent monograph on King Oliver. The key word here is theme. In all the early New Orleans performances the original composition played a predominant role in 'improvisation'... Oliver was a master of this referential kind of improvisation.*⁵⁸

The consensus across the literature is that Oliver's preferred approach to improv was long-form, gradual variation with the melody as the departure point and glue that held it all together, i.e. paraphrase improvisation. This is expanded and generalized by some scholars to a melodic approach to improvisation, where the theme isn't necessarily the melody of the tune, but there is a clear melodic idea which guides the choruses as they go by. This latter description fits best to the current corpus and as a consequence a midlevel analysis would be expected to show one or two mainly melodic ideas per solo which are then varied and developed.

In an interesting counterpoint to the majority of accounts on Oliver's playing, Williams writes:

*Another and perhaps more crucial point Jackson made immediately followed [in a story on Oliver in Hot News]: 'He played the variation style too; running chords I mean. His ear was wonderful - that helped a lot,' and trumpeter Louis Metcalfe has said that Oliver first made him aware of chord structures and of playing on them! [...] But in the blues and rag-like themes which he recorded, he did not use an arpeggio style as Jimmy Noone so often did; in none did he simply 'open up' chords by playing the notes in them as they passed.*⁵⁹

So in addition to theme one could expect some hints of a chord-first conception to show through in Oliver's playing, especially in moments of non-paraphrase improvisation. Such hints from a low-level analysis could be liberal use of arpeggios, a preference for movement in thirds, and particular emphasis of color notes like chromatic alterations.

The final pillar of Oliver's style is made of the expressive effects for which he was best known. As Rudi Blesh writes, "He used more variety of tone, however, supplementing open horn with the use of mutes and he was a very early exponent of the 'wa-wa,' produced

⁵⁸ Schuller, Gunther: *Early Jazz. Its roots and musical development*, p. 80.

⁵⁹ Williams, Martin: "King Oliver", in: Green, Stanley (ed): *Kings of Jazz*, New Jersey: A.S. Barnes and Co. 1978, p. 261.

by the cupped hand moved in front of the cornet or trumpet bell.”⁶⁰ In this vein, Oliver’s solos would be expected to contain noticeably more bends, scoops, falls, growls, etc. than the other players. Another, more specific distinction between the four trumpet players is hinted at in a quote from Martin Williams: “Joe also had that lip shake or trill – New Orleans trumpeters created it – that could make people jump out of their seats.”⁶¹ As an inheritance of the New Orleans style of trumpeting this lip shake can be expected to show up more often with Oliver, Armstrong, and Keppard than with Beiderbecke. Additionally, expressive effects like this can be expected to be exactly that material which makes up a signature sound, to either set oneself apart from rivals or pass on to one’s disciple. Therefore Oliver’s use of this is expected to be more exaggerated than Keppard’s and indeed quite similar to Armstrong’s.

3.2. Freddie Keppard

Keppard stands beside Oliver as a member of the ‘old guard’ of jazz musicians, that group which learned from the likes of Bolden. He is also part of the first cross-racial generation of jazz musicians, being a Creole of color and thus possessing a different social status than other Black people in New Orleans.⁶² Born on February 27 1890, Keppard is the second oldest of the four trumpeters and belongs to the same generation as Oliver.⁶³ Like Oliver, he grew up in a musical environment and soon began playing himself. His first foray into music-making was on the violin, but he soon took up cornet as well as mandolin and accordion.⁶⁴ This breadth of musical experience put him in a position to be a bandleader at an early age. His first known band gig was with the Olympia Orchestra/Band sometime around 1905-1907, after which he soon became an active and popular player in “the district”.⁶⁵ This was what is also referred to as Storyville, the district in New Orleans which included a lot of clubs, bars, and other nightlife establishments.

⁶⁰ Blesh, Rudi: *Shining Trumpets. A History of Jazz*, p. 183.

⁶¹ Williams, Martin: *Jazz Panorama*, p. 80.

⁶² Gioia, Ted, *The History of Jazz*, p. 37.

⁶³ “Freddie Keppard” in: Larkin, Colin, *The Encyclopedia of Popular Music* (4 ed.), Oxford University Press Online Version 2016, < <https://www-oxfordreference-com.uaccess.univie.ac.at/display/10.1093/acref/9780195313734.001.0001/acref-9780195313734-e-47813?rskey=AZ7d6r&result=1>>, last accessed: 06.02.2023.

⁶⁴ Gushee, Lawrence, *Pioneers of Jazz: The Story of the Creole Band*, Cary: Oxford University Press 2005, p. 49.

⁶⁵ *Ibid.*, p. 49.

As seen in the anecdote with Oliver, Keppard had his hat in the ring for the title of Cornet King of New Orleans. The camps were divided, but the bottom line is that it was a question of Oliver or Keppard and no one else in that period from 1907-1914. During this time Keppard played with the Creole Jazz (or Jass) Band, carrying the torch of New Orleans trumpeting as set down by Buddy Bolden.⁶⁶ This group toured around the States, from New York to the Midwest, where they played on the Western Vaudeville Manager's Association circuit.⁶⁷ With this move Keppard became the first cornet player to export New Orleans style beyond the delta and to the broader USA. Keppard's touring activities took him to both coasts, from Los Angeles to New York City and many places in between. Wherever he went he left a lasting musical impression; for example, the California-based band the Black and Tans were heavily influenced by Keppard and his band.⁶⁸

At some point he departed for Chicago, either in 1911⁶⁹ or 1914⁷⁰, and was in doing so the first to bring New Orleans jazz to the windy city. There he stayed into the 1920's, performing and eventually (thankfully) recording. The fact of the matter is that there remain very few recordings of Keppard. The usual story told is that he actively avoided recording at first; upon being approached by Victor about a potential record deal, Keppard refused because he didn't want anyone to steal his stuff.⁷¹ Another similar tale holds that it was about money and not intellectual property, and according to Sidney Bechet's recollection Keppard simply didn't want to record.⁷² Whatever the case, he did eventually start to make records, beginning as a sideman with Doc Cook in 1923.⁷³

Chicago remained Keppard's home base until his death in 1933.⁷⁴ During this period he made a handful of recordings and continued performing with various ensembles in clubs and dance halls. Like Oliver, many contemporaries were of the opinion that Keppard's power diminished from the splendor of the New Orleans and touring days. Of the four trumpeters, Keppard is the most mysterious due to both the lack of detailed

⁶⁶ Williams, Martin, *Jazz in its Time*, New York: Oxford University Press 1991, p. 170.

⁶⁷ Bomberger, E. Douglas, *Making Music American : 1917 and the Transformation of Culture*, New York, NY: Oxford University Press 2018, p. 7.

⁶⁸ Williams, Martin, *Jazz Masters of New Orleans*, New York: The Macmillan Company 1967, p. 209-210.

⁶⁹ Shipton, Alyn: *Jazz Makers: Vanguards of Sound*, New York: Oxford University Press 2002, p. 23

⁷⁰ Gioia, Ted, *The History of Jazz*, New York: Oxford University Press 1997, p. 45.

⁷¹ Bomberger, E. Douglas, *Making Music American : 1917 and the Transformation of Culture*, p. 29.

⁷² *Ibid.*, p. 29.

⁷³ Williams, Martin, *Jazz in its Time*, p. 170.

⁷⁴ Williams, Martin, *Jazz Masters of New Orleans*, p. 23.

biographical information available about him as well as the small number of recordings he left behind. Luckily though, he does live on in at least a small handful of takes which can give a small impression of his vision of New Orleans jazz trumpet style.

During the Chicago phase of his career Keppard remained in close contact with the other players, especially Oliver and Armstrong. They would drop in on each other's sets at various clubs, and of course there were occasional cutting contests to get the audience riled up. The battle for the title of Cornet King followed Keppard and Oliver up the Mississippi, and now Oliver's protégé put his hat in the ring too. E. Simms Campbell recalls: "I wished to tell about the old Vendome Theatre in Chicago – with Weatherford at the piano, playing his eccentric solos – how a fellow by the name of Freddie Keppard could blow rings around Armstrong, and when Louis was given the featured spot, we youngsters booed."⁷⁵ It's unclear whether Campbell is referring to the early 20's or later, but the anecdote does serve to illustrate that Keppard probably still had 'it' when he started recording in Chicago, meaning that the impressions drawn from the takes can give a reliable idea of how he played.

Another consequence of the lack of documentation about Keppard, whether biographical or records, is that little has been written about his playing style. Still, there are a few claims floating around in the literature which could be examined with the Jazzomat method. Most of the anecdotes or remarks about his playing revolve around his musical conception and imagination. For example, Alan Lomax quotes Jelly Roll Morton on Keppard: "There was no end to his [Keppard's] ideas; he could play one chorus eight or ten different ways.' [He had] 'great imagination...any little place in the music that didn't have any notes on, he would fill right up.'"⁷⁶ Martin Williams adds that Keppard's construction of choruses was systematic, with a thematic-cell base which was then developed into a long-form, internally referential solo.⁷⁷ From both of these descriptions one would expect to find, first of all, a great variety in the musical formation of Keppard's solos, that is to say a large breadth of intervals, chord tones, etc. Another related expectation would be that no particular building block or device would stand out as something Keppard preferred or

⁷⁵ Campbell, E. Simmons "Blues" in: Ramsey, Frederic and Smith, Charles Edward eds., *Jazzmen*, New York: Harcourt, Brace and Company 1939, p. 116.

⁷⁶ Jelly Roll Morton, quoted in: Lomax, Alan, *Mister Jelly Roll: The Fortunes of Jelly Roll Morton, New Orleans Creole and "Inventor of Jazz"*, New York: Duell, Sloan, and Pearce 1950, p. 126.

⁷⁷ Williams, Martin, "King Oliver", in: Green Stanley (ed), *Kings of Jazz*, p. 248.

used overly repetitively, thus giving the impression to listeners of a deep and inexhaustible musical imagination.

Recurrent words which pop up in multiple descriptions of Keppard's style are "power", "clipped", and "ragtime". Martin Williams draws a contrast between Keppard's rhythmic style and ragtime, stating that: "In Keppard's buoyant, staccato horn, we hear jazz finding its way out of the clipped and limited accents and rhythms of ragtime[...]"⁷⁸ Other authors make mention of his unique swing, with Bomberg putting it like this: "His phrasing and rhythmic style seem to have been "excitable, even tense" in contrast to the relaxed swing popularized by Armstrong. His playing has been described as a bridge between the ragtime style of Buddy Bolden and the swing style of later players."⁷⁹ Based on these statements one expects Keppard to stand out in his use of shorter note lengths when compared to the other players and for his swing to contrast with Armstrong's, probably in that he plays more on top of or ahead of the beat than Armstrong and that his swing ratio might tend more towards 3:1 (a dotted eighth-sixteenth feel) than Armstrong's.

One contentious aspect of Keppard's musicianship which potentially set him apart from contemporaries was whether or not he was able to read music. According to a small number of contemporary anecdotes, he did have at least basic reading skills.⁸⁰ Still more analyses suggest that he possessed formidable aural skills which allowed him to learn a piece quickly and merely give the impression he was reading. In the jazz scene at the turn of the century it was not a given that musicians could read music. In fact, most bands comprised members of differing capabilities. These can be divided into 3 groups: those who could read written music, Readers, those who could only follow chord progressions, Spellers, and those who could not read music at all and only played by ear, Fakers.⁸¹ While most people who made it big did eventually learn to read music, here we think of Armstrong as an example, it is important to remember that in the majority of cases the jazz idiom was learned and developed aurally, with reading music being a secondary skill which more served the dissemination of music rather than the creation of it. That is to say,

⁷⁸ Williams, Martin, *Jazz in its Time*, p. 170.

⁷⁹ Bomberg, E. Douglas, *Making Music American*, p. 208, quoted after Gushee, Lawrence, *Pioneers of Jazz*, pp. 255-260.

⁸⁰ Gushee, Lawrence, *Pioneers of Jazz: The Story of the Creole Band*, p. 50.

⁸¹ Raeburn, Bruce: „Traditional New Orleans Jazz" in: *64 Parishes*, < <https://64parishes.org/entry/traditional-new-orleans-jazz>>, last accessed: 07.02.2023.

Readers were valuable in so far as they could bring the latest popular tunes hot off the Tin Pan Alley presses into the repertoire of their bands, where the band then put their own unique spin on the tune.⁸² This again supports the argument that early jazz recordings are still likely to contain improvisation, because the musicians wouldn't have been able to read from sheet music and also idea of a fixed arrangement as commonly seen in the Swing Era was still far in the future. For Keppard it seems that he combined a strong aural basis with at least rudimentary skills in reading music, something that it's uncertain Oliver or Armstrong possessed in any meaningful way in the early 1920's. Surprisingly, despite being a white man from a musical and well-off family, Beiderbecke also had a just a limited ability to read. Though he did receive some formal training, indeed more than the others, it was still very little, and the general consensus is that he relied more on his ear to play than any real skills at reading written music.

3.3. Louis Armstrong

With Armstrong the lineage of star trumpeters with mythical birth stories continues. He was prone to spreading the story that he was born on an auspicious date, July 4 1900, but this has been brought back down to earth by Gary Giddins, who found Armstrong's baptismal certificate where the date August 4, 1901 is given.⁸³ His formal musical training, like that of Oliver and Keppard, was in the context of brass bands and military music, while his informal training involved intense listening to the music being played in the district, especially by King Oliver, and eventually lessons on the cornet from his idol.⁸⁴ The crown which had passed from Bolden, to Keppard, then to Oliver would finally land on Armstrong's brow after the latter moved away to Chicago. The northward migration of musicians created a power vacuum to be filled by the younger generation, and Armstrong was in the ideal position to take up the mantle and play in the band at Peter Lala's cabaret.⁸⁵ As Oliver's protégé he was the natural successor to the throne of New Orleans Cornet King, and he did indeed take over Oliver's spot in the band with Kid Ory by decree of Oliver himself.⁸⁶ There he remained, playing the home-grown style, establishing himself, and honing his craft until the next big shift.

⁸² Ibid.

⁸³ Giddins, Gary, *Satchmo: The Genius of Louis Armstrong*, New York: Dacapo Press 1986, p. 22.

⁸⁴ Williams, Martin, *Jazz Masters of New Orleans*, p. 167-170.

⁸⁵ Russell, William and Smith, Stephen W., "New Orleans Music" in: Ramsey jr., Frederic and Smith, Charles Edward, *Jazzmen*, New York: Harcourt, Brace and Company 1939, p. 33-34.

⁸⁶ Gioia, Ted, *The History of Jazz*, p. 49.

In 1922 Oliver summoned Armstrong to Chicago to come play in his Creole Jazz Band.⁸⁷ This coming after a period of independence for Armstrong, the dynamic of the relationship between the two certainly had changed by the time they met in Chicago, despite what either may have felt. While in New Orleans, Armstrong was clearly in the role of disciple under Oliver, but after those years of development apart from his former teacher, Armstrong had made a name for himself and for good reason. His style and abilities were blossoming and anyone who heard him knew it. So, it is accurate to say that in New Orleans Armstrong was but the learner, while in the Chicago years he had perhaps already become the master. By Oliver's own admission, Armstrong was bound to surpass him and by keeping Armstrong on second cornet in his own band Oliver was able to preserve his title as the best for a little while longer.⁸⁸

The Lincoln Gardens Café served as the home base for the Creole Jazz Band in Chicago and the group consisted of Joe Oliver, Louis Armstrong, Honoré Dutrey, John Dodds, Lillian Hardin, Minor Hall, Edward Garland, and James Palao.⁸⁹ The others having been part of the group under Oliver for a couple of years already, Armstrong was the most recent import from the south. Of particular note was Lillian Hardin, or Lil, who would later marry Armstrong. She was handpicked by Oliver to play the piano with his newly formed Creole Jazz Band.⁹⁰ She clearly fulfilled the role of the Reader in the group thanks to her formal education in music, and her handwriting shows up in multiple lead sheets attributed to the Creole Jazz Band.⁹¹ As one of the few or perhaps the only person in the group who could actually read music, she was instrumental in shaping their repertoire and Armstrong learned the basics of reading and writing music from her over the course of their relationship.

During the early phase, though, Armstrong was still very much Oliver's protégé, working mainly by ear and using the New Orleans vocabulary they shared to wow audiences in the clubs. Officially second cornet, it was Armstrong's task to support Oliver and

⁸⁷ Williams, Martin, *Jazz Masters of New Orleans*, p. 173-174.

⁸⁸ Williams, Martin, *Jazz Masters of New Orleans*, p. 174.

⁸⁹ Ramsey Jr., Frederic, „King Oliver and His Creole Jazz Band”, in: Ramsey, Frederic and Smith, Charles Edward eds., *Jazzmen*, New York: Harcourt, Brace and Company 1939, p. 68-70.

⁹⁰ Ramsey Jr., Frederic, „King Oliver and His Creole Jazz Band”, p. 67.

⁹¹ Gushee, Lawrence, „The Improvisation of Louis Armstrong”, p. 295-298.

fill in the harmonies to his melody lines. He obviously grew beyond this limitation, as many scholars note the inventiveness of his accompanimental lines, and at a certain point he was also able to break free and record his very first solo on *Chimes Blues* under the Gennett label.⁹²

After two years of playing under Oliver, Armstrong left the band to get better, more glamorous gigs after some pushing by Lil to spread his wings and fly.⁹³ After a short stint at the Dreamland in Chicago with Ollie Powers' band, the next big shift which marked a new chapter was Armstrong's move to New York to play with the Fletcher Henderson band.⁹⁴ This marked the phase where Armstrong started to make his name as a solo artist. He was out from under Oliver's foot and had the freedom to explore his musical ideas more fully and in the way he wanted to. It also marks a transition in style away from traditional New Orleans jazz towards Swing. Henderson's band, which had already begun using the format of fully arranged band charts with opportunities for soloists to step out and improvise, was the harbinger of the coming swing era.⁹⁵ Because the recordings made by Armstrong with Henderson at this time already depart from the traditional style, they were left out of this investigation.

Following his engagement with Henderson, however, Armstrong returned to Chicago and made what is considered some of the most pivotal jazz recordings of history: the Hot Fives and Hot Sevens. Beginning their first session on November 12, 1925, the Hot Five was a long-term recording group which included Johnny Dodds, Kid Ory, Johnny St. Cyr, and Lil and Louis Armstrong, and excepting Lillian every musician was born and raised in New Orleans.⁹⁶ For a handful of recordings, the personnel was expanded/altered to include Pete Briggs, Baby Dodds, and John Thomas, who replaced Kid Ory, thus forming the 'Hot Seven'.⁹⁷ The prodigious amount of recordings put out by the group over the course of three years mark a clear transition period in jazz style from a collectivist towards an individualist emphasis. While there are still very recognizable characteristics of traditional jazz, such as the front line, there is a distinct increase of focus on solos which

⁹² Ramsey Jr., Frederic, „King Oliver and His Creole Jazz Band”, p. 73.

⁹³ Ibid. p. 75.

⁹⁴ Williams, Martin, *Jazz Masters of New Orleans*, p. 176.

⁹⁵ Schuller, Gunther, *Early Jazz: Its Roots and Development*, p. 90.

⁹⁶ Giddins, Gary, *Visions of Jazz: The First Century*, pp. 93-94.

⁹⁷ Ibid. p. 97.

foreshadowed the days of jazz soloist giants like Charlie Parker, John Coltrane, and of course Armstrong himself. The ensemble-first approach so present in the work of Oliver and Keppard starts to take a backseat to the new soloist-first style of the younger generation in these recordings.

From this point Armstrong's career took off and included many facets and engagements, playing in various ensembles and touring around the States and the world. The contexts Louis played in moved towards a distinct increase in commercial genres, but there was always the home-grown flavor of traditional New Orleans in his playing. However, most of the recordings from the next 2 decades depart so much from traditional jazz that they don't match up with the type of playing in the rest of this corpus. One collection which would be interesting to compare with is the set of sides he cut with the All Stars, in which he went back to his roots. This would serve as a good material basis for a future investigation to include later manifestations of traditional jazz during and after the 'revival' of interest in this older style.

Armstrong proved to be one of the most influential jazz musicians of all time. His long and storied career left behind a mountain of recordings in which his take on many jazz styles is preserved, from which jazz analysts are benefiting from still today. He passed away in 1971, having stayed an active player right up until the end.

Louis' connection to Oliver is fairly clear by this point. Beginning as teacher-pupil, moving on to mentor-protégé, then towards a peer relationship by the end of Oliver's days with the caveat that Louis seemed to have always still felt like a student. They grew up in the same musical context, had a shared understanding of New Orleans jazz that was developed and deepened over years of playing together. As many of their fellow musicians noted, it seemed like they could read each other's minds, that was the degree of similarity in their conception of jazz. Only after the push from Lil did Armstrong move on and explore other, different styles. However, Armstrong carried the lessons learned from Oliver with him through his whole career, as the quote in chapter 2.3.1 demonstrates.

Keppard had already departed New Orleans for Chicago when Louis really started to come onto the scene. As hinted at in the chapter on Keppard, though, the two were in much closer contact once Armstrong moved to Chicago. E. Simms Campbell's recollection

of the clagues cheering Keppard and booing Armstrong in Chicago dance clubs shows that they played with and against each other on a regular basis, thus continuing the culture of cutting contests from the early days of jazz. The fight for the crown continued in the windy city, this time with young Armstrong taking on the role of challenger to the established monarch, making for what seems to be a mostly rival relationship between the two.

An interesting, indirect connection between Keppard and Armstrong comes up in the fact that Lil actually played with Keppard in Chicago for a while before joining Oliver's band. As Preston Jackson recalls: "Getting back to Lil [...] one month later she joined the New Orleans Creole Band with such men as Freddie Keppard, Ed Garland, Paul Barbarin, Jimmie Noone, and Eddie Vincent."⁹⁸ As most scholars and contemporary musicians agree, Lil had a huge influence on Armstrong, not only in the sense of encouragement and career-building but also in a concrete musical sense. She also had a hand in shaping the repertoire for multiple bands that Armstrong played in, and it seems possible that this early work with Keppard contributed to shaping her conception of jazz, which then would influence her future work with Oliver and Armstrong.

Armstrong is probably one of the most recognizable musicians in jazz history; as soon as one hears his playing, it's obvious whose sound it is. The general consensus in the literature is that the core of this characteristic sound is his use of vibrato and shakes. As Gunther Schuller writes:

It was during this period [late 1924/early 1925] that Armstrong began to work out one of the most important technical components of his conception and tone: his vibrato [...] It was a personal touch he undoubtedly acquired initially from his (or others') vocal techniques. To the vibrato were soon added two other Armstrong trademarks, the 'shake' and the 'terminal vibrato'. The shake was simply a more extreme way of enlivening and swinging the tone. The terminal vibrato was frequently used on longer notes, which started relatively 'straight,' and gradually 'loosened up' to end in a wide vibrato or shake or, in its most extreme form, in a 'rip'.⁹⁹

As mentioned in chapter 3.1, the use of a wide shake was characteristic of New Orleans players and is thus expected to show up more in Oliver's, Keppard's, and Armstrong's

⁹⁸ Preston Jackson in: Shapiro, Nat and Hentoff, Nat (eds.), *Hear Me Talkin' to Ya: The Story of Jazz by the Men Who Made It*, New York: Rineheart & Company, Inc. 1955, p. 95.

⁹⁹ Schuller, Gunther: *Early Jazz. Its roots and musical development*, New York: Oxford University Press 1968, p. 97.

playing than in Beiderbecke's. Given that Armstrong's sound is so strongly associated with the shake, one would expect that he makes even more liberal use of it than his fellow NOLA trumpeters.

Other typical devices strongly associated with Armstrong are frequent rips, a high degree of syncopation, and a preference for the upper register of the horn. To the last point, Richard Hadlock quotes Armstrong on his experiences in the Roseland Ballroom in New York: "'Vincent Lopez came in there [Roseland Ballroom] as a guest one time,' Louis has recalled. 'B.A. Rolfe was with him, and he would play a tune called Shadowland an octave higher than it was written. I observed that, and it inspired me to make *When You're Smiling* [...] The way I look at it, that's the way a trumpet should play. If something's supposed to be played high, you play it that way, or you play it in whatever register it should be.'"¹⁰⁰

One key question is the extent to which Armstrong's and Oliver's playing styles diverge. Given the long-term mentor/disciple relationship the two shared, one would expect there to be noticeably more similarities between them than the other players. Martin Williams captures the dynamic in the following passages:

*Louis' prime elder was Joe Oliver, and Louis' early development out of (or on) Oliver's style is what this album [Young Louis Armstrong, Riverside RLP 12-101] gives us [...] as we can compare the two trumpeters side by side, hear how much Louis owes to Oliver and just how much he added himself.*¹⁰¹

*...it is Railroad Blues on which Louis sounds most like Oliver. Except for the unmistakable vibrato, it could be Oliver on the eight-bar introduction.*¹⁰²

*Oliver is his [Armstrong's] model in the ensemble, but to Oliver's style he has added a subtler sense of time, a more imaginative structure to his lines, and the expert use of hesitations and grace notes completely foreign to Oliver's playing.*¹⁰³

¹⁰⁰ Hadlock, Richard, *Jazz Masters of the Twenties*, pp. 16-17.

¹⁰¹ Williams, Martin T. (ed), *Jazz Panorama. From the Pages of The Jazz Review*, New York: Da Capo Press 1979, p. 105.

¹⁰² Ibid, p. 110.

¹⁰³ Ibid, p. 107.

On the one hand, the pair is described as playing with a very similar rhythmic feel and freedom.¹⁰⁴ On the other hand, Armstrong's swing comes across as unique and separate from Oliver's as well as being more consistent than his mentor's.¹⁰⁵ Taken altogether, it seems that the two were most similar on a rhythmic level and we would expect there to be only small differences in the analysis. As already mentioned, the expressive devices Armstrong used (rips, shakes, vibrato) certainly came out of their shared NOLA Jazz tradition, but Armstrong's use of these devices set him clearly apart from Oliver. Therefore, one should expect a bigger difference here, with Armstrong making more use of these expressive devices.

Finally, the area of biggest difference between Armstrong and Oliver certainly lies in their overall approach to improvisation. Gunther Schuller writes:

*The key word here is theme. In all the early New Orleans performances the original composition played a predominant role in 'improvisation.' The younger men like Armstrong, Sidney Bechet, and Johnny Dodds gradually broke away from the theme-improvisation concept, and after the mid-twenties solo improvisation, with few exceptions, came to mean extemporizing on chords rather than melodies.*¹⁰⁶

The generational divide between Oliver and Armstrong has already been mentioned; Oliver belongs to the theme-first camp, while Armstrong (despite his claims to always follow his mentor's example) would eventually come to represent at least the beginning of the chords-first camp. The period of the 1920's, especially comparing Armstrong when he was playing with Oliver to the recordings of the Hot Fives and Sevens once he was more independent, can give an impression of how this transition took place. One would therefore expect there to be a noticeable increase in gestures like arpeggios in Armstrong's playing as well as more linear, stepwise figures (though this last one would depend somewhat on the melody of the tune, i.e. if the theme itself is quite scalar, then Oliver's improv would likely reflect that too). Another aspect which could come to the surface in Armstrong's playing more is the preference for certain harmonic tones over others; in a harmony-first paradigm it would be more likely that a soloist emphasize the guide tones of the underlying harmony

¹⁰⁴ McCarthy, Albert: "Louis Armstrong", in: Green, Stanley (ed): *Kings of Jazz*, New Jersey: A.S. Barnes and Co. 1978, p. 14.

¹⁰⁵ See: Schuller, Gunther: *Early Jazz. Its roots and musical development*, New York: Oxford University Press 1968, p. 91 and Williams, Martin T. (ed.): *Jazz Panorama. From the Pages of The Jazz Review*, New York: Da Capo Press 1979, p. 110

¹⁰⁶ Schuller, Gunther, *Early Jazz: Its Roots and Musical Development*, p. 80.

(3rds and 7ths) and possibly higher extensions. This is because the guide tones are the ones that most definitively express the underlying harmony and higher extensions are the most distanced/abstracted from the simple melody, meaning that if a soloist emphasizes them it can provide good evidence that the player is thinking in terms of chords and not theme. In a theme-first paradigm the weight would likely fall on the lower side of the chord, emphasizing roots, thirds, and fifths because these are the materials from which the melodies are most likely to be made and are the landmarks which a theme would emphasize the most. However, the overlap on the thirds could prove to be a confounding variable which muddies the ability to make a distinction between the two approaches.

3.4. Bix Beiderbecke

Beiderbecke is both the youngest of the four trumpeters and the only white musician in the group. He was born on March 10, 1903 in Davenport, Iowa, to a wealthy family where musical training was a normal part of one's upbringing.¹⁰⁷ Surprisingly, he received very little formal musical training, the bulk of his music development coming through close, even obsessive study of the records of bands such as the Original Dixieland Jazz Band.¹⁰⁸ Thus his first and perhaps deepest impression of jazz was of a white version of the black artform which was specifically commercial in its positioning. Despite this, Beiderbecke's treatment of the artform is worth considering because, as Martin Williams put it, "he took jazz seriously."¹⁰⁹ He also eventually became a jazz musician who was widely respected by his peers, both black and white, which speaks for the argument that his contribution was not a caricature, but a heartfelt engagement with the music.

The location of Davenport on the Mississippi River seems to have played an influential role in his exposure to music. As a major commercial and transportation corridor between the Gulf and the north, the Mississippi brought both recordings and musicians by Davenport, and Beiderbecke availed himself of the opportunity to listen to artists such as Louis Armstrong playing in bands on the riverboats.¹¹⁰ Of course, he eventually also was

¹⁰⁷ Nichols, Edward J., "Bix Beiderbecke" in: Ramsey Jr., Frederic and Smith, Charles Edward (eds.), *Jazzmen*, New York: Harcourt, Brace and Company 1939, p. 145.

¹⁰⁸ Perhonis, John Paul, *The Bix Beiderbecke Story: The Jazz Musician in Legend, Fiction, and Fact: A Study of Images of Jazz in the National Culture, 1930-the Present*, PHD Dissertation, University of Minnesota 1978, p. 31-32.

¹⁰⁹ Williams, Martin, *The Jazz Tradition*, p. 64.

¹¹⁰ Shipton, *Jazz Makers: Vanguards of Sound*, p. 35.

exposed to the recordings of Oliver's Creole Jazz Band, providing another black musical influence during his formative years.

After being sent off to school near Chicago, Beiderbecke was known to haunt the concerts of the newly-formed and soon-to-be-famous Austin High Gang, another white group which followed the model of the ODJB.¹¹¹ In 1922 Beiderbecke moved to Chicago, leaving his schooling behind and beginning his new path as a career musician.¹¹² The next and, as it turned out, last 9 years of his life were spent immersed in the jazz scene and circuit, with gigs and trips taking Beiderbecke around the Midwest and of course also to New York city. After his move to Chicago Beiderbecke came into intensive contact with the musicians from New Orleans, both black and white, who had moved up for more opportunities, and with a handful of white players he formed his first band, the Wolverines.¹¹³ The quality of their music soon made them known throughout the jazz scene, and it seems that Beiderbecke was making an impression on jazz musicians just about as much as Armstrong was. Importantly, despite the racial disparity these two players heard and played with each other regularly during jam sessions late at night in the Chicago clubs.¹¹⁴

Bix' career was short- the shortest of the group because it lasted only 9 years. Also, like his peers, the last few years of his career were marked by poor health and a reported diminishing of his musical abilities. However, he was active with some important groups and left behind a decent number of recordings from his prime which give a good impression of his take on jazz music. With his first group, the Wolverines, he made his first record in 1924, and already so early in his career he became known as a real soloist, like Armstrong.¹¹⁵ Following this he joined up with the Jean Goldkette Big Band, partnered with Frankie Trumbauer for a stint, then eventually played with the Paul Whiteman orchestra, all the while making recordings as a featured soloist in increasingly larger ensembles.¹¹⁶ Thus, Beiderbecke's work straddles the two styles of jazz in the 20's: in general his small

¹¹¹ Shaw, Arnold, *The Jazz Age: Popular Music in the 1920's*, New York: Oxford University Press 1989, p. 31-32.

¹¹² Shipton, *Jazz Makers: Vanguard of Sound*, p. 35.

¹¹³ Perhonis, *The Bix Beiderbecke Story*, p. 32.

¹¹⁴ Hentoff, Nat, *At the Jazz Band Ball: Sixty Years on the Jazz Scene*, Berkeley: University of California Press 2010, p. 32.

¹¹⁵ Shipton, *Jazz Makers: Vanguard of Sound*, p. 35.

¹¹⁶ Shaw, *The Jazz Age*, p. 37-38.

ensemble work was closer to traditional New Orleans jazz and his work with the big bands was already part of the new wave of swing.

It is an all too familiar story that vice and disease cut the lives of excellent musicians short, and unfortunately that is the case for Beiderbecke as well. He was said to have been a heavy drinker, and around 1929 the stress of keeping up with commercial demands started to wear heavily on him. He began drinking more, performing less, and eventually succumbed to pneumonia on August 7, 1931.¹¹⁷

Beiderbecke's contact with the other players is both more disparate and more compact when compared to the connections between the rest of the musicians. Firstly, he wasn't from New Orleans, so his exposure to each player was separate and spaced out. After all, the other three basically grew up together, whereas Beiderbecke heard and was influenced by them individually over the course of years. It was then more compact due to the fact that, once he moved to Chicago, all four were in the same place as active players at the same time, meaning he had contact with the others all at once.

His first exposure was to Armstrong playing live with Fate Marable's band on a riverboat passing by Davenport in his early teens.¹¹⁸ It is unclear if this was a one-time occurrence or if he heard Armstrong play often. Given the timeline of Armstrong's career (Louis toured with Marabel from 1918-1921¹¹⁹), Beiderbecke probably heard him a few isolated times over the course of a couple of years, meaning that while these meetings were certainly inspiring, it's unlikely that Armstrong's specific style influenced Beiderbecke's own very much early on. Once Beiderbecke made it to Chicago, however, the two enjoyed a fruitful peer relationship, playing with each other frequently and certainly influencing each other. Armstrong said of their jams:

Now you talking about jam sessions [...] huh... those were the things [...] with everyone feeling each other's note or chord, et cetera... and blend with each other instead of trying to cut each other... nay, nay, we did not even think of such a mess [...] we

¹¹⁷ Nichols, "Bix Beiderbecke", p.158-160.

¹¹⁸ Shipton, *Jazz Makers: Vanguard of Sound*, p. 35.

¹¹⁹ Schuller, Gunther, *The Swing Era: The Development of Jazz. 1930-1945*, New York: Oxford University Press 1989, p. 785-786.

*tried to see how good we could make music sound which was an inspiration within it-
self.*¹²⁰

The feeling was mutual, for as Hoagy Carmichael recalled: “Louis Armstrong was Bix Beiderbecke’s idol.”¹²¹ The two moved in different commercial circles out of necessity due to their race, but on an artistic level they found in each other a worthy colleague. This de facto separation made for a context where they did not have to see each other as commercial rivals and could instead lean into the artistic exchange for its own sake, making it likely that one would freely adopt ideas from the other.

In Chicago Beiderbecke also of course heard and was influenced by Oliver. He was one of a handful of white musicians who dove deep into the black jazz scene and would engage with the founders of the music, be it going to their concerts or jamming with them. He was also very well-regarded by his Black peers. Armand Hug recalled: “Another tribute to his [Beiderbecke’s] genius came one evening when Bix sat in with King Oliver’s Band at the Plantation Club. Lynn Harrell, of Dallas, Texas, who was present that evening says that tears rolled down Oliver’s face and Oliver said that Bix was the greatest he had ever heard.”¹²² Just as with Armstrong, Bix also had high mutual respect for Oliver and considered him to be a role model, although it is important to note that this did not express itself in either instance in Beiderbecke copying the others’ styles.¹²³ The relationship between Beiderbecke and Oliver seems also to have had a peer-peer dynamic, but with a generational divide and lacking the fears of usurpation Oliver felt towards Armstrong. Unfortunately, there is very little detailed literature about the two together, so the social context of their musical influence on each other is simply lacking.

Sadly, we know even less about interactions that Beiderbecke and Keppard might have had. The best guess would be that, like he did with Oliver, Beiderbecke heard and jammed with Keppard in the Chicago clubs. They probably had a similar relationship to the one Oliver and Beiderbecke shared, and through Keppard Beiderbecke received a third original take on the New Orleans style.

¹²⁰ Louis Armstrong quoted in: Shapiro, Nat and Hentoff, Nat eds., *Hear Me Talkin’ to ya: The Story of Jazz by the Men Who Made It*, New York: Rinehart & Company, inc. 1955, p. 159.

¹²¹ Hoagy Carmichael quoted in: Shapiro, Nat and Hentoff, Nat eds., *Hear Me Talkin’ to ya*, p. 142.

¹²² Armand Hug quoted in: Shapiro, Nat and Hentoff, Nat eds., *Hear Me Talkin’ to ya*, p. 160.

¹²³ Williams, Martin, *Jazz Masters of New Orleans*, p. 34.

Beiderbecke is somewhat of an outsider in this group of trumpet players. Not only is he the only white musician, but he is also the only one who did not grow up in New Orleans and who did not grow up in direct contact with the other players. Oliver, Keppard, and Armstrong learned their craft through listening to each other in New Orleans, before the export of the music really began, whereas Beiderbecke's first extended contact was through recordings and only after this did he hear the music live. As mentioned before, his first impression of jazz is thus an entirely different one compared to the other three; Beiderbecke studied commercial recordings which were designed to sell, and on top of that these were recordings made by a white band for a white audience, meaning that the material Beiderbecke learned from is from a completely different context than the material the other players learned from. Beiderbecke learned Jazz from a (perhaps poor) photocopy of the original, meaning that his style in a sense is a photocopy of a (bad) photocopy. Despite this it seems like he succeeded in participating in the art to the satisfaction of the originators, but at the same time it would be reasonable to expect that in general Beiderbecke would prove to be the outlier in nearly every analysis and comparison within the group.

In all descriptions of Beiderbecke's style, control and beauty are the most recurrent terms. Beiderbecke's calling card was a pretty, bell-like tone about which Armstrong swooned: "[...]and all of a sudden Bix stood up and took a solo [...] and I'm tellin' you, those pretty notes went all through me [...] you take a man with a pure tone like Bix's and no matter how loud the other fellows may be blowing, that pure cornet or trumpet tone will cut through it all."¹²⁴ Already here one of the consequences of Bix not having learned from an authentic New Orleans style shows up; he lacks the characteristic vibrato or shake of New Orleans players, and was said to not be a 'hot' player, but instead a 'sweet' one. This means that certain expressive devices like the vibrato, shake, as well as dirty notes and other effects are expected to be significantly less with Beiderbecke than the others. However, one effect does seem to have been Beiderbecke's alone: the half-valve squeeze. While rips were bread and butter for New Orleans players, Beiderbecke is the only player described as using a "sudden octave flare-up through the valves" with "a touch of the half-valve technique".¹²⁵ The basic idea of a large interval decorated by some ornament

¹²⁴ Louis Armstrong quoted in: Shapiro, Nat and Hentoff, Nat eds., *Hear Me Talkin' to Ya*, pp. 158-159.

¹²⁵ James, Burnett, "Bix Beiderbecke", in: Green, Stanley (ed), *Kings of Jazz*, p. 67.

certainly stemmed from the original New Orleans players, and it seems like Beiderbecke adopted and adapted this particular device to his aesthetic of a cleaner tone and cleaner execution with half-valves rather than the dirtier, hotter rip technique.

Along with the ideas of control and beauty come descriptions of Beiderbecke's musical ideas. Martin Williams writes: "[...] although he didn't conceive very sophisticated patterns, he managed to play the ones he did conceive absolutely perfectly [...]", and later: "There's a tremendous kick in listening to him skip a large interval flawlessly at a fast tempo, or make a subtle, lacy thing out of a Dixieland tune like Sensation Rag just through the delicacy of his slight variations and the perfection of his control [...]"¹²⁶ From these passages one would expect Beiderbecke's playing to be in a general sense simpler than that of the other players. His playing was characterized by understatement and a restriction to a small set of building blocks, including simple rhythms, small range (of just around a middle octave, not extreme highs or lows), and few notes.¹²⁷

Especially in terms of rhythmic sense, Beiderbecke differs from Oliver, Keppard, and Armstrong. The consequence of learning from a photocopy meant that "Bix's time was based on the white Dixieland style; his rhythmic displacements were usually crude syncopations next to those of the most advanced Negro players of the twenties like Louis..."¹²⁸ The tendency for understatement also shows up here, as Gunther Schuller notes: "His sense of time, for example, was an essentially uncomplicated one, seldom leading him to explore [...]"¹²⁹ Thus the expectation would be that Beiderbecke swings less, syncopates less, and has less rhythmic variety than the others.

The previous passages have presented the players, their connections, and the concrete musical aspects of their improvisation which one would expect to be the case based on their biographies and mutual influence. In the next chapter, the results of the Jazzomat analysis will be presented with the goal of confirming or contradicting these expectations.

¹²⁶ Williams, Martin, *Jazz Panorama*, p. 117.

¹²⁷ James, Burnett, "Bix Beiderbecke", in: Green, Stanley, *Kings of Jazz*, p. 60-61.

¹²⁸ Williams, Martin, *Jazz Panorama*, p. 117.

¹²⁹ Schuller, Gunther, *Early Jazz*, p. 188.

Below is a timeline of the important turning points in the lives and careers of the four trumpeters, to better understand the events and connections between the players. Following this, Table 4 provides an overview of the characteristics of each player as described in the literature and summarized in this chapter. This will allow a compact side-by-side comparison of the main features of each musician's playing. The aspects are divided into 3 categories: Rhythm, Musical, and Expression. Rhythmic aspects are self-explanatory. The Musical category includes things like note choice, range, intervals, certain patterns like arpeggios and scales, etc. Expression then covers aspects like special effects (rips, shakes, mutes)

Timeline of Careers

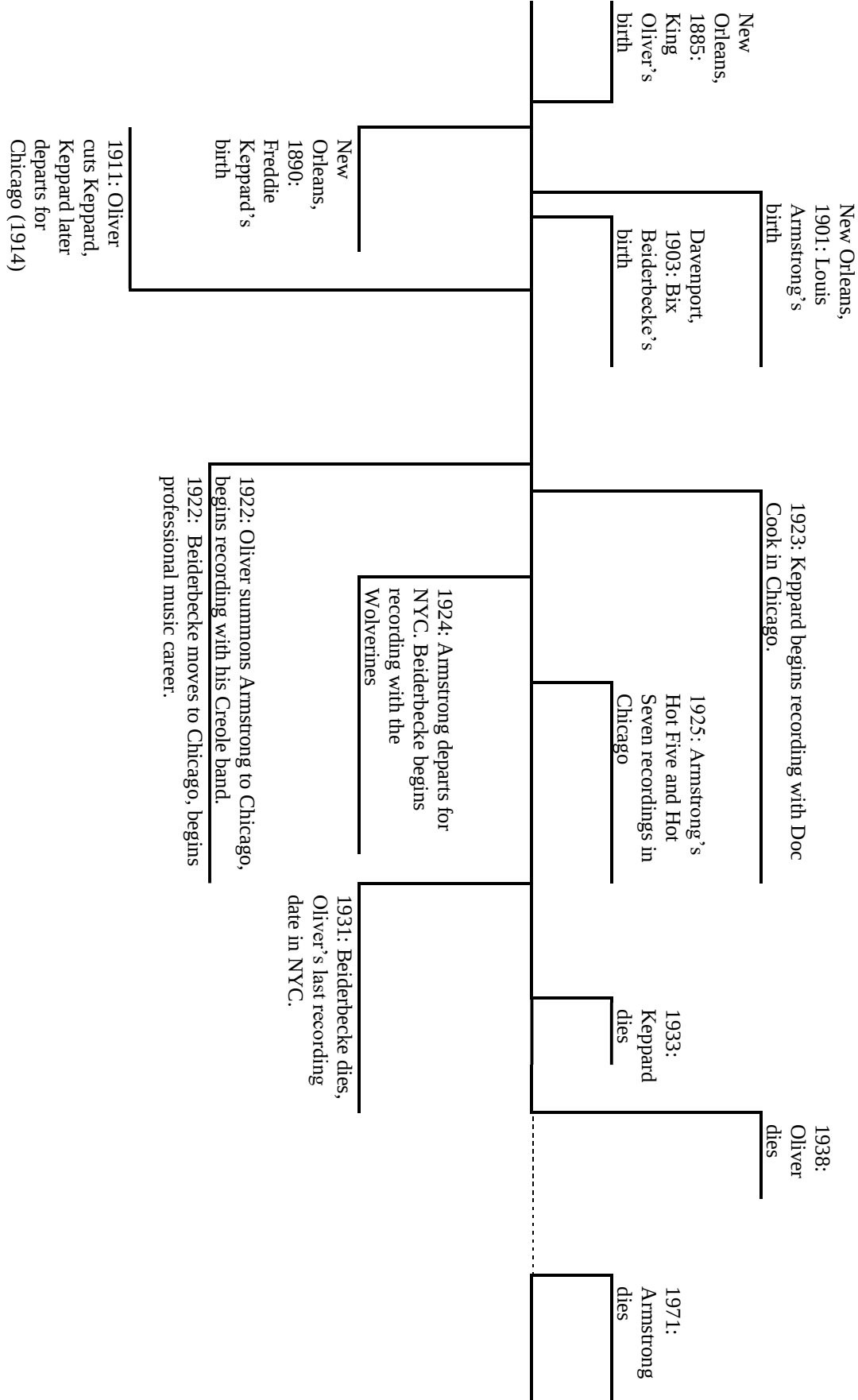


Table 5: Overview of Musician Characteristics

Category	Oliver	Keppard	Armstrong	Beiderbecke
Rhythm	• Driving, front-of-the-beat • High syncopation	• High use of short notes • Front-of-the-beat • Swing ratio contrasting to Armstrong and less syncopated	• Very high syncopation	• Simple rhythms • Less syncopation • Less swing → swing ratio closer to 1:1
Musical	• Strongly thematic improvisation • Hints of chordal conception, i.e. color notes and gestures like arpeggios	• Highly varied; broad and even distribution of chord tones and intervals	• Preference for upper register • More harmonic conception than Oliver or Keppard, i.e. more color notes and higher extensions, plus gestures like arpeggios	• Small range • Few notes
Expression	• Heavy use of expressive effects, especially mutes, growls, and 'wa-wa's. • Characteristic 'New Orleans lip shake'	• Characteristic 'New Orleans lip shake'	• Heavy use of exaggerated 'New Orleans lip shake' • Frequent use of rips	• Fewer 'hot' effects like rips, and no 'New Orleans lip shake' • Cleaner, more controlled effects like half-valve squeezes

4. Results

The solos were first processed in the MeloSpySuite and values were calculated for the following features:

1. Chordal Pitch Class (CPC)
2. Intervals
3. Chromatic Sequences
4. Ratio of Ascending:Descending Intervals
5. Ratio of Chromatic Sequences
6. Arpeggios
7. Note Duration Classes
8. Inter-Onset-Intervals (IOI)
9. Event Density
10. Swing Ratio
11. Syncopicity
12. Onset Difference

Some categories contain within them subdivisions, providing for a very broad spectrum of musical aspects with which to compare the musicians.

Then the data was analyzed in JASP using 3 methods. First, pairwise t-Tests were performed to establish the aspects in which the musicians contrasted the most. Then all four players were compared as a group with a MANOVA analysis. A correlation analysis was performed on the individual musicians to sort out idiomatic trends for each player, and finally a correlation analysis was performed over all musicians to discover general trends in traditional New Orleans Jazz trumpet style.

This chapter will look at the results and interpret them on their own terms for what they say about the style of each player. When connections to the literature can be found, they will be pointed out. Chapter 5 will then return to the statements and expectations discussed in chapter 3, showing what can be proven or disproven, and chapter 6 will outline what questions remain open and what next steps could be taken to answer them.

4.1. t-Tests

This sub-chapter will present and interpret the data for the t-Tests of each musician pair. Only results of $p < 0.05$ are considered significant and examined here. The t-value describes the direction and intensity of the difference, and the factors in each table have been arranged by t-value from largest to smallest. We consider the comparisons between the New Orleans natives first, then those between Beiderbecke and the rest.

4.2.1 Armstrong vs. Oliver

Table 5

Independent Samples t-Test		Armstrong vs. Oliver	
	t	p	
Step Up	-2.16	0.048	

It is quite telling that there is only a single significant difference between Armstrong and Oliver, namely that Armstrong played fewer Step Up intervals than his mentor. The rest of the categories showed p-values much too high to be considered significant. Given what is known about how intimately Armstrong and Oliver were connected, this result is hardly surprising and only serves to confirm the claims that their playing was at times virtually indistinguishable. This single difference is not at all apparent on the surface when purposefully listening and comparing the two players for their use of upward step-wise motion, thus it is safe to say that while the difference is fundamentally there, in all practical sense these two musicians played identically based on the features analyzed here.

4.2.2. Keppard vs. Oliver

Table 6

Independent Samples t-Test		Keppard vs. Oliver	
	t	p	
Swing Ratio Mean	-2.95	0.012	
Swing Ratio Median	-2.79	0.016	

Keppard and Oliver also show very little difference in the t-test, really only differing in one musical aspect: swing ratio. On the one hand this is an unsurprising result, given that the two were so close in terms of musical influence and development. They came up in the same tradition, learning from the same players at the same time. On the other hand, the fact that it is exactly their swing which differentiates them is somewhat surprising, given that both are said to have had a rhythm that drove the ensemble. However, it could be argued that the more relevant feature for creating a feel of ‘drive’ would be Onset Difference

and in this respect Keppard and Oliver enjoy virtually the same overall average Onset Difference (.0153 and .0154 seconds respectively).

Keppard swings less than Oliver, which could be an expression of the tension in his rhythm as noted by Bomberg above.¹³⁰ It would seem that there are different zones on the spectrum of swing ratio which correspond to either tense or relaxed feels. Authors often connect a strong swing (2:1 or even more) with a relaxed feel, meaning that the closer Keppard got to playing straight eighths, the less likely the feel would be relaxed.

Another interesting aspect of this comparison comes to light when remembering Martin Williams connecting Keppard with the ragtime tradition. In the ragtime idiom, the rhythmic complexity comes more from the shapes of the lines and the timing of the accents, in other words surface level features, and less from subsurface features like micro-time. The result here falls right in line with Williams' claim that Keppard's rhythmic conception is rooted in ragtime (and thus straight, or at least straighter, eighths) while also showing some elements of swing, which players like Oliver and especially Armstrong would then develop further.

4.2.3. Armstrong vs. Keppard

Table 7

Independent Samples t-Test		Armstrong vs. Keppard	
	t	p	
Relative IOI: Medium (reference = annotated beats)	2.765	0.015	
Step Down	-2.22	0.043	
Relative IOI: Short (reference = annotated beats)	-2.26	0.04	
Step Up	-2.59	0.021	

There are a couple more significant differences between Armstrong and Keppard, but given the number of features considered, the two can be said to still have played quite similar. There are two takeaways which can be drawn from this t-test. First, given that

¹³⁰ Bomberg, E. Douglas, *Making Music American*, p. 208.

Armstrong tended towards more medium-length Inter Onset Intervals and Keppard tended towards more short ones, it can be said that Keppard played ‘denser’ than Armstrong, with less space between his notes and lines. When listening to compare for this specific feature, the first overall impression is indeed that Keppard’s onsets are closer together than Armstrong’s, though on this author’s listening it is only really apparent when one explicitly looks for it. More interestingly, Keppard’s use of ornaments and his approach to time seem to be bigger contributors to the higher density of onsets. Keppard, like Armstrong, plays lots of arpeggio figures in his solos, but Keppard also throws in noticeably more neighbor note ornaments around his arpeggios. These fast decorations, usually mordents, increase the density of onsets within a short period of time. On top of this, Keppard has the most noticeably free approach to time of the four players. He often shifts into rubato or even simply plays outside the strict time, departing at point A and landing back in time at point B (usually at a significant harmonic change), with the notes in between tending to get pushed closer together. These two factors, Keppard’s frequent use of quick ornaments and his freer time leading to compressed lines, contribute the most to the higher density of his playing when compared to Armstrong.

Second, Keppard played more steps in both directions than Armstrong, suggesting that his lines are generally more conjunct than Armstrong’s. This matches with a few factors which are reported to be typical of Armstrong. First, Armstrong made heavy use of arpeggio figures, stemming both from his more harmony-focused approach to improvisation as well as his time spent playing harmony lines to Oliver, where outlining chords was a natural accompanimental technique. Second, the typical rip figures that signify an Armstrong solo are as disjunct as a melodic figure can be, further contributing to this difference between him and Keppard. On listening to compare how conjunct each musician plays, it does come across that Keppard played more stepwise than Armstrong. Another contrast which stands out when listening and looking at this specific feature is that, while Keppard sometimes travelled across a wide range during his solos, just about as often he would stay within a smaller ambitus, while Armstrong covered a much larger tonal space on every solo in this corpus. The realities of working withing a smaller range necessitate more stepwise motion just as covering such wide ranges requires one to make more and larger jumps.

4.2.4. Beiderbecke vs. Oliver

Table 8

Independent Samples t-Test		Beiderbecke vs. Oliver	
	t	p	
CPC 6	4.403	< .001	
rel: short (Ref. = annotated beats)	3.411	0.004	
avg Tempo (BPM)	3.004	0.009	
Event Density (Notes per Sec)	3.001	0.01	
Leap Up	2.753	0.016	
CPC 5	2.527	0.024	
Swing Ratio Mean	-2.41	0.03	
rel: very short (Ref. = annotated beats)	-2.43	0.029	
Syncopicity	-2.57	0.022	
abs: medium (Ref. = 0.5 sec)	-2.68	0.018	
Swing Ratio Median	-2.72	0.017	
IOI abs: medium (Ref. = 0.5 sec)	-2.75	0.016	
avg Onset Difference	-2.81	0.014	

Once we start considering Beiderbecke in comparison with the others it becomes clear how the musicians are grouped. Here there are twelve significant differences between Beiderbecke and Oliver, suggesting by the sheer amount that there is something fundamental that is separating Beiderbecke from the New Orleans natives. As we will see here and in the comparisons with Keppard and Armstrong, that certainly is the case.

There are a few interesting conclusions to draw from this t-test. The ultra-significant result that Beiderbecke plays more sixths of the harmony than Oliver can be explained by a few things. First, it is known that Oliver was steeped in a blues tradition of jazz, meaning that the color notes he was most likely to add were flatted thirds over major harmonies (in Jazzomat notation CPC B, for Blues), Tritones (CPC T), and flatted sevenths (CPC 7). That Beiderbecke played more fifths and especially more sixths is a natural consequence of the lack of blues influence on his playing but also shows that he was using some color tones in his more harmony-based approach to improvisation. When listening

for this it becomes clear that Beiderbecke does indeed favor the 6th of a chord, usually the tonic, and he uses the 6th to decorate either the first or fifth scale degrees. One typical figuration from Beiderbecke is a line which lands on the first scale degree by the penultimate measure of a phrase, then oscillates between the root and sixth to finish out.

Both CPC results are confirmed by listening because, as discussed in the previous paragraph, blues harmony plays a very minor role in Beiderbecke's improvisation. In all the transcriptions of this corpus there may be at most a handful of moments where Beiderbecke uses blues thirds or tritones. A listener will detect some color in his harmony, though it is not the edgier, spicier harmony of chromatic alteration. Rather it is the more mellow, closer-to-home harmony of emphasis on scale degrees like 6 which make up the majority of Beiderbecke's color pallet. One possible reason for this could be Bix's documented preference for the modal harmonies of such composers as Ravel and Debussy; as Arnold Shaw writes: "Bix's partiality to the whole-tone harmonies of Ravel and Debussy [...] found expression in a group of piano pieces he improvised [...]"¹³¹ It is not far-fetched to think that his harmonic thinking didn't just show up in piano pieces like *In a Mist*, but also a bit in his trumpet improvisation.

Beiderbecke also played more densely than Oliver, i.e. more notes per second. This can in part be explained by the fact that Beiderbecke generally played faster tempi than Oliver and thus almost necessarily played more notes per second, but it is my impression that that is not the whole story. Beiderbecke's lines tend to be quite scalar and are often comprised of streams of eighths going by, whereas Oliver's ideas quite often include rhythmic variation on small thematic ideas. This thematic focus caused there to be more space between repetitions of the ideas for Oliver and that also contributes to a lower event density for the King.

The most interesting differences are found in the rhythmic aspects. First of all, Beiderbecke swings on average less than Oliver, which indeed lines up with the aural impression of Beiderbecke's lines that was gained during the transcription process. On many scalar passages it seemed that Beiderbecke played almost straight eighths, whereas Oliver swung hard on everything he played. This is exactly what one would expect from a player

¹³¹ Shaw, *The Jazz Age*, p. 37.

who had learned second-hand like Beiderbecke did. The true swing feel was something one could only learn from long, direct absorption of examples played by masters. Since the Original Dixieland Jazz Band, the commercial white band whose records were Beiderbecke's 'schoolbooks', never quite captured real swing, it is natural that Beiderbecke had no chance to be able to imitate it.

The next rhythmic difference of note is that Oliver made more use of syncopation than Beiderbecke, which is right in line with the statements about Oliver's particular rhythm. As noted above, he was known to drive and syncopate liberally, naturally outstripping Beiderbecke in this regard. This result also aligns perfectly with the somewhat disparaging remark made by Martin Williams that "Bix's time was based on the white Dixieland style; his rhythmic displacements were usually crude syncopations next to those of the most advanced Negro players of the twenties like Louis, Earl Hines and Jimmy Harrison."¹³² A concentrated listening to Beiderbecke's lines while focusing on syncopation gives the impression that he tends to emphasize downbeats and in fact tends to emphasize the stronger beats, 1 and 3, instead of backbeats. Many of his figurations start directly on the beat and comprise lines which seem to aim at beats rather than the spaces in between.

Finally, Beiderbecke's relationship with the beat (Onset Difference) is different than Oliver's. Oliver tends to play very much on the front of the beat, as testified by the remarks in the literature about his 'drive', while Beiderbecke plays more on top of the beat. Again, such subtle features of microtime can only really be learned by internalization of examples over the long term. Oliver's examples were mostly black musicians coming out of a different musical and rhythmic tradition than those from whom Beiderbecke learned, namely white musicians with roots in European classical music. It is therefore natural that the two would differ in how they placed their rhythms in relation to the beat established by the rhythm section. This aspect of Beiderbecke's playing connects with the observations from the previous paragraph that his lines tend to start on and aim at strong beats. On the macro level that expresses as relatively lower syncopation and on the micro level it

¹³² Williams, Martin T. (ed.): *Jazz Panorama. From the Pages of The Jazz Review*, New York: Da Capo Press 1979, p. 117.

expresses as a more squared-off approach to the beat; the rhythm section defined the beat, and Beiderbecke aimed his notes right at it.

4.2.5. Beiderbecke vs. Keppard

Table 9

Independent Samples t-Test		Beiderbecke vs. Keppard	
	t	p	
CPC 1	3.799	0.002	
CPC 4	3.377	0.005	
avg Tempo (BPM)	3	0.01	
IOI rel: medium (Reference = annotated beats)	2.908	0.011	
CPC 6	2.642	0.019	
CPC 5	2.481	0.026	
IOI abs: medium (Reference = 0.5 sec)	-2.15	0.049	
Metrical Event Density (Notes per bar)	-2.18	0.047	
CPC B	-2.25	0.041	
rel: very short (Reference = annotated beats)	-2.54	0.024	
CPC L	-2.62	0.02	
avg Onset Difference	-3.2	0.006	

Yet again with twelve significant differences between Beiderbecke and Keppard, the divide between Bix and the rest is clear. The comparison of note choices here supports the conclusions drawn from the comparison with Oliver; Keppard shows more blues influence with his higher use of blues thirds while Beiderbecke displays a mellower harmonic pallet, the only real color notes being 6ths and 4ths.

Once more the rhythmic aspects mark most of the differences between Beiderbecke and Keppard. For one, Beiderbecke's use of more Medium Relative IOIs in combination with Keppard's higher Metrical Event Density suggests that Beiderbecke had more 'air' in his solos than Keppard did. This connects with the observations about Keppard from the

comparison with Armstrong; Keppard's figures of fast mordents decorating his arpeggios increase his note density and lower IOIs. This is an aspect absent in Beiderbecke's playing; his lines tend to range from streams of eighths, or sometimes triplets, to figures around one note and squared off to land directly on beats, meaning that the space between each beat stays empty. Thus, his lines will sound like there is a bit more openness in them. That Keppard plays with more Medium Absolute IOIs can be explained by the fact that the Beiderbeck solos in this corpus are generally faster than Keppard's.

The final aspect of note is the difference in Average Onset Difference. Similar to the comparison with Oliver, Beiderbecke plays more on top of the beat than Keppard, who played more in front of the beat, this being a result of the differences in their development of rhythm. Microtime seems to be a key factor that can almost diagnose a player's artistic pedigree; if one were closer to the pre-jazz music of black musicians, it is likely that there was more freedom taken with the beat than if one were closer to either classical music or the white commercial reproduction of jazz. Again, it is this author's impression that Beiderbecke's lines mostly start on and aim directly at beats, involving little syncopation on the surface and little push/pull on the beat under the surface.

4.2.6. Armstrong vs. Beiderbecke

Table 10

Independent Samples t-Test		Armstrong vs. Beiderbecke	
	t	p	
Syncopicity	2.791	0.013	
IOI abs: very long (Reference = 0.5 sec)	2.461	0.026	
IOI abs: medium (Reference = 0.5 sec)	2.454	0.026	
CPC T	2.331	0.033	
CPC b6	2.207	0.042	
CPC 4	-2.46	0.026	
CPC 2	-2.54	0.022	
CPC 6	-2.54	0.022	
avg Tempo (BPM)	-2.58	0.02	
Step Down	-2.64	0.018	
CPC 1	-2.68	0.016	
Asc	-3.76	0.002	
CPC 5	-4.6	< .001	

With the final comparison between Armstrong and Beiderbecke it is clear that the musicians can be split into two groups: New Orleans players and the man from Davenport. With thirteen significant differences, Armstrong and Beiderbecke show the most contrast of all despite their belonging to the same generation of jazz musicians. However, it should be noted that, in the big picture, the differences between all the players are relatively small and these musicians certainly all played in a similar style to one another.

Beiderbecke once again displays a more conservative harmonic pallet, favoring more tones belonging to the scale of the chord and especially favoring the rather bland fifths and roots. Indeed some color sneaks in with his use of fourths, seconds, and sixths, perhaps a result of scalar lines which include the ‘extension’ notes beyond the seventh of a chord. However, the spicy chromaticism clearly belongs to Armstrong with the tritones and flatted sixths.

One surprising result is that Beiderbecke is shown to use more ascending arpeggios (in Jazzomat notation: asc) than Armstrong. Arpeggiated lines were known to be particularly favored by Armstrong and are often mentioned when describing his idiomatic style, while in the descriptions of Beiderbecke's playing they are not mentioned as often. This result seems to almost contradict a listening test; both players play arpeggios often, but it is this author's impression that Armstrong does indeed come in with more than Beiderbecke. The contradiction could come from the way the Jazzomat detects and labels arpeggios because Armstrong often ornaments his with repeated notes or neighbor notes as he works up and down, which could confuse the algorithm. Beiderbecke did not decorate his arpeggios as much in this way, and so it would be easier for the machine to detect them. The bottom line is that the gestalt of ascending arpeggios exists more in Armstrong's improv, though it is also more decorated and altered. In any case, what this serves to show is that both Beiderbecke and Armstrong were incorporating arpeggios into their improvisation, gestures which stem directly from a harmony-first approach to solos and which were becoming bread and butter for their generation of improvising jazz musician.

Finally, the difference in Syncopicity underscores previous observations about the fundamental differences between Beiderbecke and the New Orleans group. That Armstrong plays more syncopated is only to be expected; his particular use of syncopation is a key factor in his unique swing and also connects with the aspects of rhythmic drive he inherited from Oliver. Not only that, Armstrong's increased syncopation is a result of a significant difference in phrasing between him and Beiderbecke. When listening to the lines of the two players with Syncopicity in mind it quickly becomes apparent that Armstrong leads in nearly every phrase with a syncopated intro, while Beiderbecke tends to start his phrases directly on the downbeat. Such differences in musical 'dialect', while more explicit and on the surface than microtime, are nevertheless aspects which result from long-term absorption of rhythmic ideas. Here a certain parallel with Onset Difference can be seen; the New Orleans players have a looser approach to the beat with a preference for leading ahead while Beiderbecke is closer to squarely on top. Both the surface-level Syncopicity and the subsurface Onset Difference point towards the fact that these musicians felt the time differently; the New Orleans players seem to treat the beat more freely and/or conceive of their own time as a tool to push the time of the ensemble, while Beiderbecke plays more reactively, respecting the beat of the ensemble and fitting his own time into it.

4.2. MANOVA Analysis

The MANOVA Analysis returned a set of ultra-significant results, all with a p-value of <0.001 , for 4 features which allow a clear visualization of the grouping of the musicians as mentioned in the t-test discussion. These features are CPC 5, CPC 6, Average Tempo, and Average Onset Difference. Below are two 3D plots, one with the CPCs and Average Tempo, then one with the CPCs and Average Onset Difference.

Figure 1: 3D Graphing of top MANOVA Features

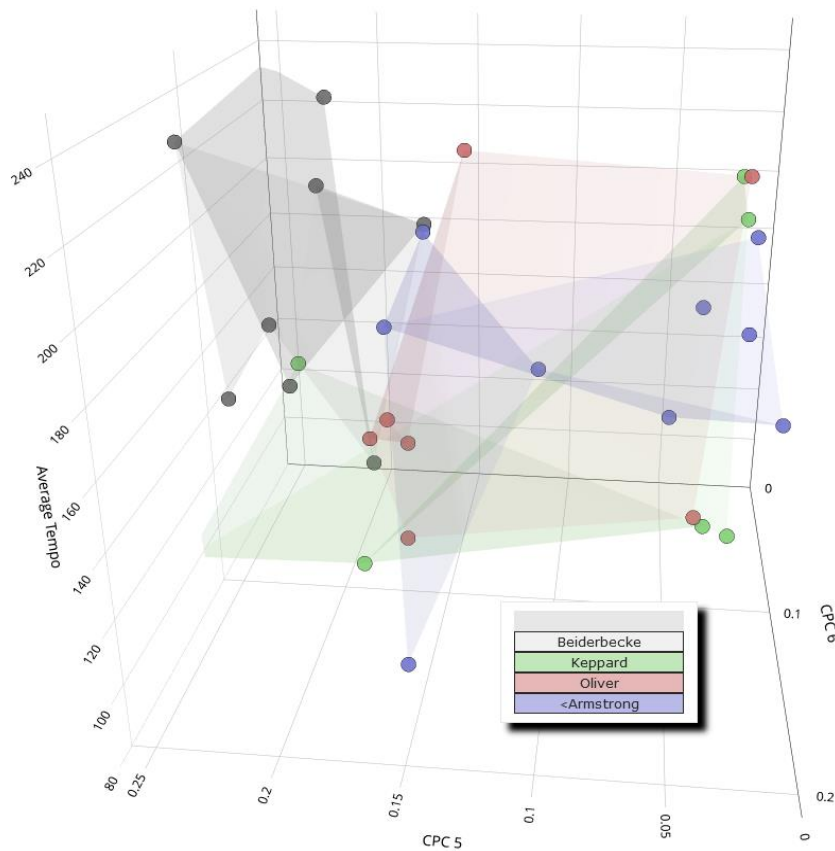
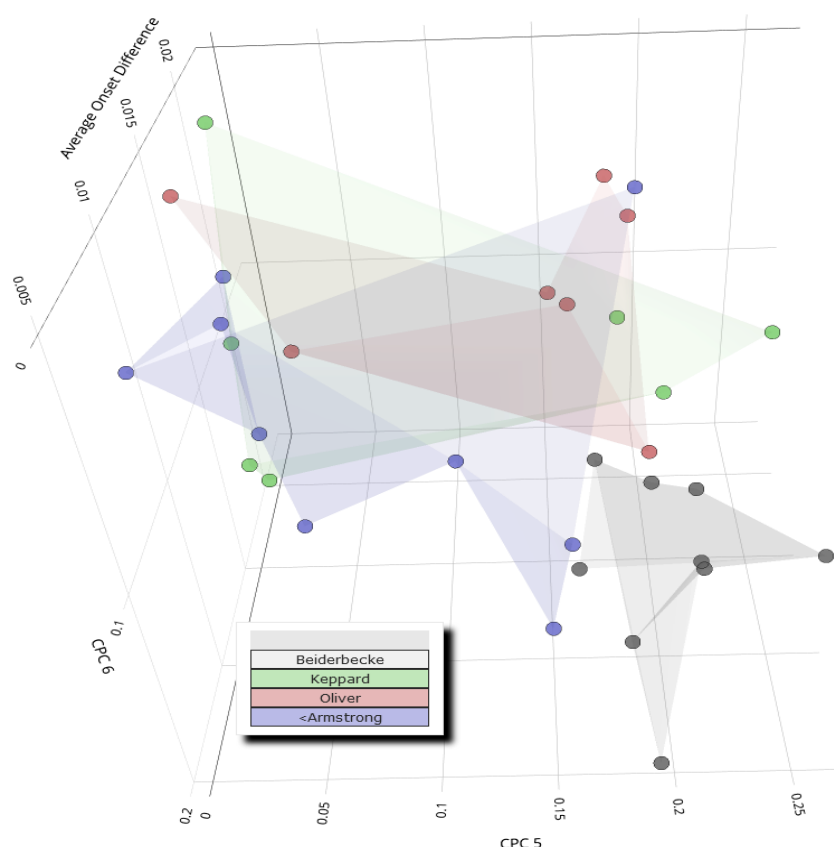


Figure 2: 3D Graphing of top MANOVA Features



What is immediately apparent is that Beiderbecke stands apart from the other three. On certain features, most significantly CPC 5, CPC 6, Average Tempo, and Average Onset Difference, Beiderbecke really occupies a wholly different musical space than the New Orleans players, not just individually but also in a more big-picture sense. Beiderbecke plays significantly more CPCs 5 and 6, significantly faster tempi, and more on top of the beat than the others. These observations, which already came to the fore during the individual comparisons, serve to underscore that there are fundamental differences between Beiderbecke and his peers, these differences certainly resulting from how Beiderbecke came to jazz and how each group learned their craft.

In sum, the results of the t-Tests and MANOVA Analysis show that there is a clear grouping of the musicians into New Orleans players and Beiderbecke alone. Among the three NOLA musicians, the differences are particularly small and the distinguishing features tend to be mostly melodic or surface-level rhythmic. Features from deeper-level categories such as harmony and microtime are so similar as to be insignificantly different between Oliver, Keppard, and Armstrong.

Between Beiderbecke and the rest, the differences are much more and larger. Here there are many categories which separate Bix from the others, from melodic features, especially note choice, to multiple rhythmic features such as syncopicity, microtime, and the density of line. However, it is important to note that in the big picture these differences are relatively small; some are certainly audible, but many only become apparent when one listens specifically for them, and some are not audible at all. This fact does highlight the power of the Jazzomat tool, though. By having the machine find the significant differences between two artists, one can uncover previously unnoticed aspects of a musician's playing.

4.3. Individual Correlations

The next analysis was a correlation function run over all features for each individual player in order to find connections between features that are idiomatic or unique for each musician. The correlations presented here are a selection of the more interesting results.

Table 11: Oliver

Pearson's Correlations	Pearson's r	p
CPC b6 – Descending	0.998	< .001
CPC T – Descending	0.977	0.004
CPC b2 – Descending	0.959	0.01
CPC 1 – CPC b2	-0.799	0.031
CPC 3 – CPC b6	-0.82	0.024
CPC 5 – CPC b6	-0.822	0.023
CPC 3 – CPC T	-0.84	0.018
CPC 5 – CPC T	-0.967	< .001
CPC 5 – CPC b2	-0.969	< .001

One of the first things that stands out when looking at the correlations for Oliver's playing is that within the top 10 positive correlations, the CPCs b6, T, and b2 all have very strong positive relationships with descending chromatic lines. These results suggest that when Oliver uses color notes, he uses them very often as passing tones in the context of downward lines. According to this author's aural impression, this does somewhat correspond with what the listener hears; a very typical figure for Oliver is punctuating the end of

an idea with an eight-eighth-quarter descending by half steps and aiming at a main chord tone (root, third, or fifth), which could be the material that is generating such a strong correlation in the analysis. This is especially audible on tunes such as *I'm Watchin the Clock*, *Showboat Shuffle*, and *Snag It*. However, it is also true that Oliver uses ascending chromatic lines frequently, if not as often as descending. A good example of this can be heard on his solo on *Aunt Hagar's Blues*, where nearly every chromatically altered note is in a line going upwards. The fact that these did not make it into the significant results of the analysis means that more transcriptions would be needed to determine if Oliver indeed had a preference for descending or ascending chromatic lines.

Table 12: Keppard

Pearson's Correlations	Pearson's r	p
Absolute Event Density – Descending Arpeggios	0.98	0.02
Very Short Relative IOI – Syncopicity	0.897	0.006
Very Short Relative Note Length – Syncopicity	0.877	0.009
Very Long Relative Note Length – Swing Ratio Mean	0.763	0.046
Average Tempo – Metrical Event Density	-0.833	0.02
Short Relative Note Length – Syncopicity	-0.899	0.006

The very strong correlation between Absolute Event Density and Descending Arpeggios is an aspect of Keppard's playing that only really comes to the surface when one listens specifically for it. For that reason, the Jazzomat tool is quite useful because it can help guide intentional listening to discover both new aspects of an idiomatic style which wouldn't be as apparent otherwise, and it also simply points to new layers of nuance to be enjoyed when listening for pleasure. On solos such as *It Must Be the Blues 2* and *Salty Dog 2* the feature is especially audible. In this case the correlation is indeed between two features which appear in conjunction; Keppard does tend to fall through the arpeggios quickly, leading to pockets of higher event density when he does so.

The results for Very Short Relative IOI, Very Short Relative Note Length, and Syncopicity connect very nicely to the statements about Keppard's roots in Ragtime- the idioms of the style include dense lines made of many short notes which lead to a high degree of syncopation, which is exactly what is coming together in the results in the table above.

Martin Williams' description of Keppard as a particularly staccato player with clear ties to the clipped sound of Ragtime seems to be supported by these particular correlations.¹³³

It is during slower blues tunes that Keppard is at his most swinging, as is demonstrated by the correlation between Very Long Relative Note Length and Swing Ratio Mean. In such songs, Keppard would use his longest note lengths and also employ his hardest swing, as opposed to the straighter but more syncopated lines of his faster numbers.

Tempo affected Keppard's improvisational approach, as seen in the negative correlation between Tempo and Metrical Event Density. On a faster song like *Stockyard Strut*, one can hear that Keppard is working very much with thematic cells which are repeated. The statements themselves are generally short and simple, leading to a low score for Metrical Event Density, and there are often pauses between the repetitions, which would also lower his average for this feature. As discussed in chapter 4.2.3., Keppard's approach on certain tunes (the slower ones) was to be very free with the time and compress his lines, leading to a higher Metrical Event Density on slower tempi. This also relates to the negative correlation between Short Relative Note Length and Syncopicity; Keppard is at his most obviously syncopated on faster tunes, while on the slower tunes he uses his freetime, compressed melody approach. This means that not only are the notes on the slower tunes in fact shorter, they also fall outside the bounds of an onbeat-offbeat dichotomy. They do not sound like syncopations to the listener, nor does the algorithm label them as syncopations.

¹³³ Williams, Martin, *Jazz in its Time*, p. 170.

Table 13: Armstrong

Pearson's Correlations	Pearson's r	p
CPC B – CPC T	0.792	0.011
Very Long Absolute IOI – Syncopicity	0.782	0.013
Syncopicity – Leap Down	0.762	0.017
Very Short Relative Note Length – Swing Ratio Median	-0.691	0.039
Very Short Relative Note Length – Swing Ratio Mean	-0.695	0.038
Metrical Event Density – Repeated Notes	-0.738	0.023
Absolute Event Density – Syncopicity	-0.847	0.004

Armstrong's strongest positive correlation between blues thirds and tritones is only to be expected from a player so rooted in a blues tradition. Another effect of the blues showing up in these results is the connection between Syncopicity and Leaps Down (Jazzomat's description of major/minor thirds). Blues phrases will often include syncopated intervals between the blues third and the tonic. In addition to this, Armstrong's reputation as a syncopator and arpeggiator (meaning he moved around in thirds quite often) come together to support this second result.

Three correlations come together to point towards a big-picture trend: the negative relationships between Metrical Event Density – Repeated Notes and Absolute Event Density – Syncopicity as well as the positive relationship between Very Long Absolute IOI – Syncopicity. The big-picture trend is that when there are denser lines and more notes, in other words more melodic complexity, Armstrong's rhythmic complexity will decrease, and vice versa. When there is more 'air' in his lines, aka longer IOIs, he generally plays more syncopated. The same counts for when he plays fewer notes. Then, considering the fact that Armstrong's most obviously syncopated solos include ones like *King of the Zulus*, which is a solo built on hopping up and down arpeggios while repeating notes over and over again, focusing on rhythm much more than melody, the negative relationship between Metrical Event Density and Repeated Notes falls into place. It is not an exaggeration to say that whenever Armstrong repeated notes, he did so to play with the rhythm and to spice things up with syncopation. These passages were necessarily less dense; you have to leave space between the notes to create the syncopation. Then, when Armstrong played straighter rhythms, on tunes such as *Weatherbird*, his lines were also denser, with a stronger focus on

line and melodic shape. It can be said that there is an overall negative correlation between melodic and rhythmic complexity in Armstrong's playing.

**Table 14: Beiderbecke
Pearson's Correlations**

	Pearson's r	p
Very Long Relative IOI – Ratio of Chromatic Sequences	0.921	< .001
Short Absolute IOI – Ratio of Chromatic Sequences	-0.677	0.045
Metrical Event Density – Ratio of Chromatic Sequences	-0.714	0.031
Average Tempo – Metrical Event Density	-0.796	0.01

Beiderbecke stands out in that his use of chromatic sequences connects strongly with multiple rhythmic factors. Firstly, the very positive correlation between Very Long Relative IOIs and Ratio of Chromatic Sequences stems from the fact that, as mentioned above, Beiderbecke's playing is very downbeat-oriented and therefore often leaves lots of 'air' between the beats, pushing the values for IOI higher. On top of this, on certain solos there is a clear juxtaposition of long notes floating over the background interspersed with fast and dense chromatic lines. Prime examples include both his solos on *Tiger Rag*, and this connection is likely a big contributor to the result above.

That the Short Absolute IOIs would then have a negative correlation to the Ratio of Chromatic Sequences seems at first glance like a simple repetition, a mirroring of the first result. If Very Long IOIs correlate strongly, it makes sense that Short IOIs would have a negative relationship. However, there is more to this story. Beiderbecke has the largest maximum value and highest average for Absolute Event Density in the raw data as well as the highest average tempo, which goes to support the listener's impression that Beiderbecke tended to play faster and more notey than the other players. All of these factors contribute to a large proportion of Short Absolute IOIs in his solos. But at the same time, as has been noted before Beiderbecke tended to play more diatonic than chromatic. This helps explain the reason for why Short Absolute IOI and Metrical Event Density correlate negatively with the Ratio of Chromatic Sequences. Beiderbecke played many notes close together, but kept them in the scale and only occasionally did he throw in chromatic alterations.

Finally, the negative relationship between Average Tempo and Metrical Event Density points towards an important limiting factor in jazz improvisation. Beiderbecke played many quite fast tunes, but when listening to them it becomes apparent that on all of them his smallest subdivision was at the eighth note and in fact he often stuck to nailing quarter notes right onto beats or even to playing long held notes over the background of blistering tunes like *Tiger Rag*. At the speeds Beiderbecke played, it would have been indeed quite hard to play clear lines at anything smaller than an eighth note subdivision, so Beiderbecke saved that for the slower tunes. On *Jazz Me Blues* one can hear him running up and down in triplets, gestures which come across nice and flowing at the slower tempo. With streams of eighths at fast tempos next to runs of triplets at slower ones, Beiderbecke's tempo-based restriction of subdivisions left him with a negative relationship between tempo and notes-per-bar.

4.4. Overall Correlations

The final analysis was a correlation function sent over all musicians and all features. By selecting interesting correlations that all four players share it may be possible to detect concrete musical features which are typical of trumpet improvisation in traditional jazz in the overarching sense, including the New Orleans and Beiderbecke 'dialects'. The results included a set of significant results with $p < .05$ and $\geq .001$ as well as a set of ultra-significant results with $p < .001$. These two groups are presented in Tables 16 and 18 respectively.

Table 15: Significant General Correlations

Pearson's Correlations	Pearson's r	p
Descending Chromatic Sequences – Ascending Arpeggios	0.816	0.007
Medium Abs. Durclass – Syncopicity	0.462	0.008
Syncopicity – Repeated Notes	0.447	0.01
Swing Ratio Median – Avg. Onset Difference	0.439	0.012
Swing Ratio Standard Deviation – Syncopicity	0.43	0.014
Swing Ratio Mean – Avg. Onset Difference	0.37	0.037
Very Short rel. IOI – Syncopicity	0.369	0.038
Syncopicity – Mixed	-0.359	0.047
Very Short abs. IOI – Syncopicity	-0.392	0.027
Abs. Event Density – Avg. Onset Difference	-0.448	0.01
Short rel. IOI – Syncopicity	-0.546	0.001

The first three results from Table 3 point towards surface-level musical gestures which seem to be typical for the trumpeters; Descending Chromatic Sequences and Ascending Arpeggios have a very strong positive correlation, while Syncopicity moderately correlates with both Medium Absolute Note Length and Repeated Notes. The connection between Descending Chromatic Sequences and Ascending Arpeggios in the results is a half-truth; while it is the case that the players all do have a certain preference for descending chromaticism and ascending arpeggios, these two ideas were used separately and not in conjunction with one another. There are few to no moments in the corpus where descending chromaticism leads into rising arpeggios or where rising arpeggios finish off with falling chromatic lines. The two ideas, separate from one another, seem to be high on the list of preferred figurations for the players and in fact it is this author's impression that the strongest use of both occurs with Oliver and Armstrong. Beiderbecke's and Keppard's solos do not deliver an audible impression of preference for these two devices, while Oliver's and Armstrong's do.

As to the connection between Syncopicity and Absolute Medium Note Length as well as Repeated notes, these results do correspond to the aural impression. Taking Armstrong as an example, one can clearly hear his penchant for playing 'fat' offbeat notes on solos like *King of the Zulus*. Of course, the absolute values for any duration class will depend on the tempo, but overall the tendency for offbeat notes, especially those which

precede longer pauses, seems to be long rather than short across all players. When it comes to syncopicity in connection with repeated notes one must again think of Armstrong, and *King of the Zulus* is again a perfect example of how strong this connection of the two features was. Of all the players, Armstrong leaves the clearest and most lasting impression with his use of repeated notes where he digs into rhythm, stripping away melodic considerations and using his articulation as a percussive element to spice up and syncopate his solos.

In order to determine how much of an influence Armstrong alone was having on the results for Syncopicity, Absolute Medium Note Length, and Repeated notes, the statistical analysis was performed again while leaving Armstrong's data out. In the new analysis, the data were as follows:

Table 16

Pearson's Correlations	Pearson's r	p
Medium Abs. Durclass - Syncopicity	0.498	0.016
Syncopicity – Repeated Notes	0.331	0.122

Without Armstrong the correlation between Absolute Medium Note Length and Syncopicity actually increases slightly while still staying significant. There could be a few explanations for this. First, Armstrong has the third-highest average for Absolute Medium as well as second-highest for Long Note Length in the raw data while at the same time being first in the Short and Very Long categories. What this translates to is that, while Armstrong did make ample use of Absolute Medium Note Lengths, he also made extensive use, in fact even more use, of many other note lengths. When excluding Armstrong from the analysis we also take away the larger values for the other note lengths, leaving proportionally more Medium Note Lengths to correlate with Syncopicity.

Another possibility becomes apparent when looking at Syncopicity across all players and all solos. While Armstrong does have the highest overall average Syncopicity and highest average within a single solo, he also shows the largest standard deviation and in fact has the second lowest minimum Syncopicity value. What this means is that Armstrong varied the most in his use of syncopation and at times played the most non-syncopated of the New Orleans natives (Beiderbecke holds the smallest minimum for Syncopicity as well

as the lowest average). This points towards two possibilities for Armstrong: 1) that more syncopations would fall into passages where he used more non-medium note lengths and 2) that in passages with higher use of medium note lengths, Armstrong could have been in a phase of lower syncopation. For the rest of the players, the possibility exists that since they were a little more consistent with their syncopation, whenever they used medium note lengths those values would necessarily correlate and lead to the statistical result presented above.

In light of these results it is also important to remember that a correlation does not necessarily mean that the two features appear in conjunction with one another. As of now there is no function in the Jazzomat that can extract only syncopated notes and their lengths at the same time, which would be the necessary dataset to confirm the actual dynamic which is at play here.

That the new correlation between Syncopicity and Repeated Notes decreases when excluding Armstrong is exactly what one would expect based on reports from the literature and the aural impression from the listening tests. However, the p-value is much too high to give this result anything more than a passing acknowledgement. So, to the question of how much Armstrong alone is influencing the correlations of Syncopicity, Absolute Medium Note Length, and Repeated Notes, the jury seems to still be out and more data would be needed to firmly establish an answer.

The correlation of both Swing Ratio Median and Mean with Average Onset Difference is particularly interesting given previous results reported in “A Swingogram Representation for tracking micro-rhythmic variation in jazz performances”. Here, the Jazzomat team notes a tendency for soloists to play in a different (usually lower) swing ratio than that of the drums, but also that soloists will tend to synchronize their offbeat onsets with that of the drums.¹³⁴ Therefore, the flexibility in swing ratio comes more from the freer placement of the downbeat onset in relation to the fixed offbeat onset. In the case of traditional jazz, the constant ‘ring-ding-a-ding’ pattern of the drums is absent, but often the chordal instrument, be it piano or guitar/banjo will express swung eighth notes from the

¹³⁴ Christian Dittmar, Martin Pfeleiderer, Stefan Balke & Meinard Müller (2018) A swingogram representation for tracking micro-rhythmic variation in jazz performances, *Journal of New Music Research*, 47:2, 97-113, DOI: 10.1080/09298215.2017.1367405, last accessed: 07.05.2023.

rhythm section, thus giving the soloist a fixed offbeat onset with which to synchronize. Recalling that positive values for the Average Onset Difference feature translate to the soloist playing ahead of the ensemble beat and that Swing Ratio is calculated by the relation of the long to the short eighth, the results here suggest that harder swing for these four traditional jazz trumpeters is a result of the displacement of the downbeat eighth note in front of the beat. Future investigations using the swingogram representation to look at the microtime interaction between soloist and rhythm section in traditional jazz would help understand this dynamic in even more detail.

The next interesting correlation is between Syncopicity and Mixed Chromatic Sequences, which enjoy a moderate to low negative correlation. While admittedly small, this result does point towards an important dichotomy in the improvisation of these players; it seems that rhythmic variety and tonal color were somewhat separate concerns of the soloists and that when one was in focus, the other took a back seat. In other words, the soloists would play fewer color notes when their lines were rhythmically complex and would play tamer rhythms when they incorporated more chromaticism. What stands out when listening for this dichotomy is that all players display a similar approach to playing over tunes with more static harmonies. Beiderbecke's second solo on *Tiger Rag*, Oliver on *New Orleans Shout*, Keppard's second solo on *High Fever* or his solo on *Stockyard Strut*, and Armstrong on *King of the Zulus*; in every case when either the harmonic rhythm is extremely slow or the changes allow a player to linger on the same pitch across multiple chords, the trumpeters will repeat chord tones extensively, playing with the rhythm on a single pitch or arpeggio and clearly making use of syncopation. When doing this the solos also noticeably lack extensive use of chromaticism, the aural impression supporting the result as detected by the Jazzomat. However, in solos with more melodic shape to them as well as more chromaticism it is very difficult to say that the listener hears *less* syncopation. The correlation according to the numbers and to the aural impression is indeed a small one.

The final interesting correlation among the sufficiently significant results is the moderate negative relationship between Absolute Event Density and Average Onset Difference. There are two aspects of this to note. First, when playing more notes at whatever tempo, it seems that the soloists turned their focus significantly towards melodic shaping, leaving microtime on the back burner and playing more on top of the beat. This is in the same vein as the correlation between Syncopicity and Mixed Chromatic Sequences; in the

categories rhythm and melody, when playing highly complex in one, the soloist will play simpler in the other. The second aspect is a result of tempo considerations. Recalling that Absolute Event Density will almost necessarily increase with higher tempos, one can extrapolate that the higher the tempo, the straighter and more evenly the traditional jazz soloist will tend to play.

Table 17: Ultra-Significant General Correlations

Pearson's Correlations	Pearson's r	p
CPC > – CPC b2	0.697	< .001
Step Up – Ratio Chromatic Sequences	0.668	< .001
Very Long abs. IOI – Syncopicity	0.652	< .001
CPC B – CPC T	0.649	< .001
CPC b6 – Jump Down	0.648	< .001
Medium abs. IOI – avg. Onset Difference	0.617	< .001
Syncopicity – CPC b2	0.599	< .001
CPC T – CPC b6	0.589	< .001
Medium rel. Durclass – Syncopicity	0.563	< .001
Long rel. Durclass – Swing Ratio Median	-0.558	< .001
Long rel. Durclass – Swing Ratio Mean	-0.563	< .001
CPC 5 – CPC b6	-0.568	< .001
Short rel. Durclass – Syncopicity	-0.574	< .001
Very Short abs. IOI – avg. Onset Difference	-0.58	< .001
Avg. Tempo – avg. Onset Difference	-0.588	< .001
CPC 5 – CPC B	-0.59	< .001
Very Short abs. Durclass – avg Onset Difference	-0.603	< .001
Abs. Event Density – Syncopicity	-0.655	< .001
CPC 1 – CPC b2	-0.666	< .001
CPC 5 – CPC b2	-0.695	< .001
CPC 1 – CPC T	-0.775	< .001
CPC 5 – CPC T	-0.79	< .001

The negative correlation between rhythmic and melodic complexity is further supported by the results from the ultra-significant group. Here Average Onset Difference shares a strong positive correlation with both Medium and Very Long Absolute IOI, while at the same time a strong negative correlation with Very Short Absolute IOI, Average Tempo, and Very Short Absolute Duration. Additionally, Absolute Event Density and Syncopicity enjoy a strong negative correlation. In other words, when there is more ‘air’ between the notes, more space in the lines, the musician will play more (micro)rhythmically complex, and vice versa. Faster tempi and denser lines will lead to a stricter treatment of

the beat as the focus turns more towards shaping melodies or even just getting notes out at breakneck speeds.

That stepwise motion upward correlates with increased use of chromaticism is interesting given the results from Oliver discussed in chapter 4.3. As noted there, it is this author's impression that Oliver makes just as much use of chromaticism going upwards as he does going downwards. This is also the case when listening to the other players' use of chromaticism; for the listener there is no clear preference of the group for chromaticism upwards, and so this result seems to again be a connection which is only apparent to the machine. While lower neighbor semitones do seem to be a typical gesture for the group, these figures do not always get picked up by the Jazzomat because a chromatic sequence needs at least 3 notes in order to be labeled that way by the software. Another confounding factor is that the feature Ratio of Chromatic Sequences takes into account chromaticism in all directions, so this result does not at all mean that the group should have an audible preference for only upwards chromaticism. Both descending and, most importantly, mixed sequences count towards the ratio. When thinking of the tags of some songs, where a player will oscillate between two notes one half-step away from each other (for example Beiderbecke at the end of *Tiger Rag 2*), it becomes clear that these moments are pumping up the correlation. The miniature phrases are counted as mixed chromatic sequences, and each time the player moves from the lower note to the higher another step up is registered. So once again, while the correlation may be there, the listener does not hear it as a clear surface feature.

Finally, the grouping of 'vanilla' notes and color tones stands out in the ultra-significant results. The table shows that the core notes of a harmony, the root, third, and fifth, stand in a clear negative relationship to color tones, in this case CPCs B, b2, and T. Additionally, the color tones share a very strong positive correlation among themselves. At a first glance this may seem strange; when thinking about how color tones are most often used, the typical figuration has them resolving to a core note or being used as passing tones in order to either depart from a core note or land on one. In this time period, playing notes like b2 and b6 as stand-alone anchors for an improvised melody was certainly not the norm, nor does it correspond to the aural impression of the solos in this corpus. The closest one gets to using non-resolving color in a solo is in Beiderbecke's *Way Down Yonder in*

New Orleans. Even there, though, the color is of a modal kind, not a chromatically altered kind.

So, where are these correlations coming from then? Looking at the color tones first, the easiest to explain is the positive relationship between Blues thirds (B) and tritones (T). These are two of the most defining notes of the Blues idiom, so it is natural that they would correlate in a corpus which includes 3 players steeped in the Blues tradition. Regarding the other color tones, it is this author's impression that chromatic alterations occur mostly in scalar runs up and down, a linear and connected use as opposed to a pointillistic one. Notice that the other two correlations are between color tones separated by only a whole step (> means major third over minor chord in Jazzomat notation). Thus it is easy to see that, during these connected chromatic runs, the color tones right next to each other would correlate most strongly.

This last explanation still does not answer the question of why the color tones do not strongly correlate with the core notes and instead have a strong negative relationship. One possibility could be that the improvisational strategy on some solos is skewing the data. Certain solos in the corpus are extremely arpeggio-heavy and on the rest, arpeggios are a common and preferred figuration. Whenever arpeggios are heavy in the mix, the amount of core notes will naturally increase and the amount of chromatic alterations will decrease. This would cause the correlation to skew away from a connection between core notes and their neighboring color tones, even if the connection was indeed there in solos with more linear melodic contour. In order to test this possibility, the following solos were removed from the correlation analysis because of the dominance of arpeggios in them: *Tiger Rag 2*, *High Fever 2*, *It Must be the Blues 2*, *Aunt Hagar's Blues*, *New Orleans Shout*, *Chimes Blues*, *King of the Zulus*, and *Yes! I'm in the Barrel*. Of particular interest are the correlations for 1-b2, 5-T, and 5-b6 because the adjacent notes are most likely to appear in conjunction with one another in a chromatic line. Under the new analysis all three negative relationships stayed negative and only decreased in intensity by a negligible amount, meaning that a predominance of arpeggios is likely not the fundamental cause of the original result. It seems that more transcriptions and more data are needed to determine what is happening with these groupings.

5. Discussion

This chapter will return to the statements made by authors about the musicians as outlined in chapter 3 and examine them in the context of the data and analyses of chapter 4. Here the goal is to support or call into question the various claims made about a player's particular style or the connection between two players on the basis of this first lower-level analysis.

5.1. Joe “King” Oliver

Let us recall the aspects of Oliver's playing which were highlighted in the literature:

Rhythm	Musical	Expression
• Driving, front-of-the-beat • High syncopation	• Strongly thematic improvisation • Hints of chordal conception, i.e. color notes and gestures like arpeggios	• Heavy use of expressive effects, especially mutes, growls, and ‘wa-wa’s. • Characteristic ‘New Orleans lip shake’

Some rhythmic points have already been touched on in chapter 4.2.2. Oliver averages 0.015422 seconds Onset Difference overall with a range of 0.008553 to 0.02326 seconds (the averages of individual solos). The takeaway is that he rarely if ever played behind the beat, which would support the claim that he played with drive. This result seems to contradict the statement by Rudi Blesh that Oliver mixed drive with moments of lingering and catching up.¹³⁵ However, given the size of the corpus it could very well be the case that with more data the lingering aspect of Oliver's playing would start to show up in the analysis.

The claims about Oliver's high use of syncopicity are borne out in the data, with Oliver averaging 22% syncopated notes across the whole corpus, higher than Keppard's 18% and Beiderbecke's 13%. Only Armstrong beats out Oliver in average syncopicity with 25%, but this does not detract from the fact that Oliver can easily be counted as a player who made liberal use of syncopation.

¹³⁵ Blesh, Rudi: *Shining Trumpets. A History of Jazz*. New York: Alfred A. Knopf 1946, p. 225.

One final point about Oliver's rhythm comes up when considering the statement by Martin Williams that Oliver's swing was unique because it was "predictable, positive, and consistent."¹³⁶ This seems to fly in the face of some comparative results from this corpus. Oliver has the highest standard deviation in Onset Difference at 0.005383, the second-highest standard deviation in Syncopicity at 0.082901, and the highest overall standard deviation in Swing Ratio at 0.427737. While these differences are admittedly small, the fact is that Oliver is the most variable musician with regard to these three rhythmic factors which seem to be the most relevant to conveying the impression of swing to the listener. That Williams categorizes Oliver as particularly predictable and consistent in terms of swing raises the question of what part of Oliver's repertoire he is referring to and with whom he is drawing the comparison. Again, with a larger corpus from all these players and more contemporaries, perhaps the comparative consistency would start showing up in the analysis.

Of the expressive factors attributed to Oliver, the characteristic New Orleans Lip Shake certainly is his preferred device. Across tempos and genres, Oliver uses the shake noticeably more often than Keppard and of course Beiderbecke. Only Armstrong uses more shakes, which serves to support the dynamic sketched out in chapter 3.1. that these parts of a signature sound are the kind of material which is passed on from mentor to disciple.

Regarding other expressive effects like scoops, bends, falls, rips, mutes, and growls, surprisingly Oliver does not make much use of them in this corpus. He only used a handful of scoops and bends, there is only one questionable instance of a mute (on *Snag It*: it almost sounds like a mute, but it could also be that Oliver just had a bad day for his tone), and there are no rips or growls to be heard. This is of course a consequence of the solos selected, and with a corpus covering the entirety of Oliver's output the other effects are likely to show up in greater numbers.

Now turning to the question of chordal thinking behind Oliver's improvisation, the factors which would most strongly suggest this are certain uses of color notes and the use

¹³⁶ Williams, Martin: "King Oliver", in: Green, Stanley (ed): *Kings of Jazz*, New Jersey: A.S. Barnes and Co. 1978, p. 256.

of arpeggios. It has already been noted that Oliver did make some moderate use of arpeggios in his solos, though clearly less than the younger generation of Armstrong and Beiderbecke. As to his use of color notes, we have pointed out that Oliver uses blues notes often and the other color tones are usually passing notes within his lines. Both of these uses do not necessarily suggest a chord-first approach behind his improv; the blues notes suggest at most modal thinking, and passing tones belong more to a melodic-linear conception than a chordal-outline conception. As mentioned by multiple authors, the core of Oliver's approach was melodic-thematic, and in order to investigate that a further, mid-level analysis is required. What the current low-level analysis shows is that there is some, although small, evidence for chordal thinking in Oliver's improv.

5.2. Freddie Keppard

The signifying aspects of Keppard's playing as described in the literature are these:

Rhythm	Musical	Expression
• High use of short notes • Front-of-the-beat • Swing ratio contrasting to Armstrong and less syncopated	• Highly varied; broad and even distribution of chord tones and intervals	• Characteristic 'New Orleans lip shake'

As seen in the t-tests, there were no significant differences between the players in their use of short notes. The classification by Martin Williams of Keppard's playing as particularly 'clipped' compared to other players¹³⁷ seems to not show up in this feature, though that doesn't necessarily mean that the statement is wrong. It could be the case that the articulation and release contribute more to the clipped sound than the duration of the notes. This aspect of Keppard's tone requires a more detailed analysis of individual notes than the Jazzomat can provide, but even just listening to compare Keppard's and Beiderbecke's articulations shows a clear difference. Beiderbecke's bell-like tone is dominant in most of his solos in this corpus and, though the onsets of some notes may be hard, the releases are almost always round, suggesting articulations like 'dah' or 'tah'. By contrast, Keppard's onsets are mostly hard and his releases are universally sharp, suggesting articulations like 'daht' and 'taht'. This seems to be the strongest contributing factor to Keppard's clipped sound.

¹³⁷ Williams, Martin, *Jazz in its Time*, p. 170.

In chapter 4.2.2. it was shown that Keppard and Oliver have virtually the same values for overall average onset difference (.0153 and .0154 seconds respectively), and though there is no statistically significant difference between all the players on this feature, it is the case that Oliver and Keppard are slightly more ahead of the beat than Beiderbecke and Armstrong (.0091 and .0117 seconds respectively). Bomberg's contrast of Keppard's 'tense' swing with Armstrong's 'relaxed' swing¹³⁸ would therefore seem to be supported by these results, based on the assumption that more front-of-the-beat playing contributes to a feeling of drive and detracts from a laid-back feeling.

The second expectation which was drawn from Bomberg's contrast was that Keppard's swing ratio would be different than Armstrong's, perhaps closer to 3:1 with the assumption that a strict dotted-eighth + sixteenth rhythm would translate to a tenser, more square feel. Interestingly, there was no statistically significant difference between the two in terms of swing ratio, and Keppard in fact came in at an overall average of 1.40:1 compared to Armstrong's 1.45:1. Virtually identical values, with Keppard actually being on the straighter side. As suggested in chapter 4.2.2., perhaps there are varying zones on the spectrum of swing ratio which correspond to feelings of tension, and it seems that one of these zones is closer to straight eighths at a 1:1 ratio.

Another feature related to a relaxed swing feel seems to be Syncopicity, and here the difference was more pronounced; Keppard came in at an overall average of 18% syncopated notes while Armstrong led the pack with 25%. Though still not a statistically significant difference, the contrast here is greater and it could be the case that with more data the results would become significant. It seems that Syncopicity is a more promising feature for determining the foundation of the contrast between Keppard's tension and Armstrong's relaxation.

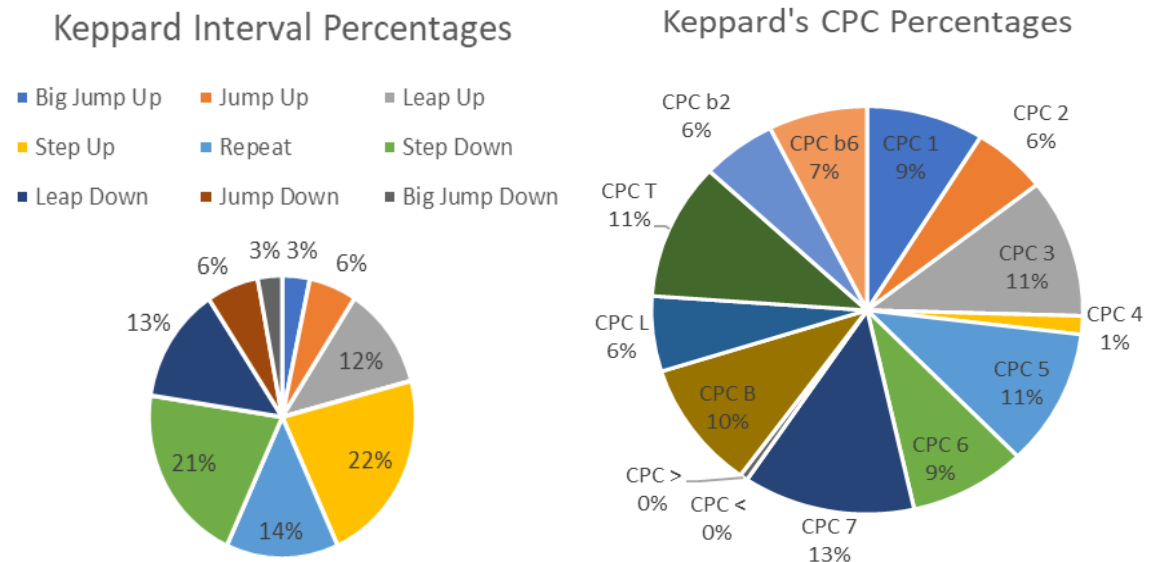
Recalling what Jelly Roll Morton said of Keppard's improvisation, that his ideas were seemingly limitless,¹³⁹ one expectation was that Keppard would display a wide range of intervals and chordal pitch classes and that no particular feature would stick out from the rest, this based on the assumption that a particularly varied set of musical ideas would

¹³⁸ Bomberg, E. Douglas, *Making Music American*, p. 208.

¹³⁹ Jelly Roll Morton, quoted in: Lomax, Alan, *Mister Jelly Roll: The Fortunes of Jelly Roll Morton, New Orleans Creole and "Inventor of Jazz"*, New York: Duell, Sloan, and Pearce 1950, p. 126.

necessarily mean broad use of many possible intervals and chordal pitch classes. Below are two charts showing Keppard's average percentages of each interval and CPC.

Figure 3



There is a noticeably symmetric bell-curve structure centering around repeats with two sub-peaks on step up and step down in Keppard's intervals. All intervals are present, but there is a clear preference for smaller intervals as opposed to large ones. This makes sense because melodies involve lots of stepwise motion and Keppard belongs to the camp of theme-first improvisers. It is interesting to note that stepwise motion and repeats make up 57% of his intervals, and still he was characterized as having unending new ideas. Though these results can't say anything conclusive, they would suggest that maybe it doesn't take much raw musical material to create a huge variety of melodic ideas.

The CPC distribution is a little more even, though the blues notes (B, T, and 7) are notably prominent. As noted before, this is to be expected from New Orleans players of the first generations of jazz. Keppard's pitch classes fit the expectation of broad distribution, though there are some gaps when it comes to generally rarer classes like > (major third over minor chord) and < (Minor 7 over major 7 chord). Again, the CPC results here don't seem to give any clear support for the expectation of a broad distribution. When considering that blues notes make up 34% of Keppard's pitch classes, it could again be the case that a big variety can come from few building blocks.

Because the results for Intervals and CPCs seems to be ambiguous, it has to be admitted that this particular question is better answered with a mid-level analysis. Then the units making up the melodic and thematic lines of the solos can be marked and systematically compared, showing how Keppard strung together smaller ideas into bigger structures.

Finally, Keppard differs from Oliver and Armstrong in his use of the New Orleans Shake. While it does show up occasionally, across this corpus Keppard's total comes to a mere 18 shakes compared to Oliver's 55 and Armstrong's 78. Much more than the shake, Keppard uses what could be described as a wide, muscular vibrato which especially comes to the fore on particularly long notes. The pace of oscillation tends to be slower with Keppard, giving him a very distinct sound in comparison to Oliver and Armstrong. Here we see once more a feature turned into a unique calling card for the musician which distinguishes them from other rival players. Keppard seems to have found his signature sound in this vibrato, contrasting Oliver and Armstrong, though Keppard occasionally showed that he too could employ the New Orleans Shake.

5.3. Louis Armstrong

Here are the main points about Armstrong's improvisation as documented in the literature:

Rhythm	Musical	Expression
• Very high syncopation	• Preference for upper register • More harmonic conception than Oliver or Keppard, i.e. more color notes and higher extensions, plus gestures like arpeggios	• Heavy use of exaggerated 'New Orleans lip shake' • Frequent use of rips

As has become clear through our examination of Oliver and Keppard, Armstrong earned his reputation as a highly syncopated player honestly; with his overall average of 25% syncopation in this corpus, the data support what the ears can hear immediately. Other rhythmic aspects which were attributed to Armstrong were that he inherited drive from

Oliver¹⁴⁰ and that his sense of time was more ‘subtle’ than his mentor’s.¹⁴¹ Recalling that Armstrong’s overall average onset difference comes to .0117 seconds, this places him 3rd in the ranking of front-of-the-beat players. The raw data would suggest that he did play with drive, and a larger corpus might bring the values for onset difference up, but it is important to establish the baseline of perception to put these results into context. Timo Fischinger provides a good summary of research into the psychology of rhythm; previous studies have shown that two events can be detected as non-simultaneous when there is a 2-5 millisecond (.003-.005 seconds) difference, that one can start to place the events in order at differences beginning between 30-50 milliseconds (.03-.05 seconds), and that a reliable ordering of events only starts at differences of 100-120 milliseconds (.1-.12 seconds) or even higher.¹⁴² What this means is that Armstrong, as well as the other three players, falls in the gap between perceptible non-simultaneity and the very beginnings of determining event order. This would suggest either that the perception of Armstrong or any of the group playing with drive comes more from a gut feeling in the listener than a concrete perception, or that there are other factors at work in conveying a feeling of drive. Determining what those factors are deserves its own dedicated investigation.

Then, it is unclear exactly what Williams means by subtlety in sense of time, but here it shall be understood as a wider and more fine-grained spectrum of variability on features such as Onset Difference, Swing Ratio, and Syncopicity. The following is a table summarizing the relevant raw data on these three features for Armstrong and Oliver:

¹⁴⁰ Blesh, Rudi: *Shining Trumpets. A History of Jazz*. New York: Alfred A. Knopf 1946, p. 225.

¹⁴¹ Williams, Martin T. (ed), *Jazz Panorama. From the Pages of The Jazz Review*, New York: Da Capo Press 1979, p. 105.

¹⁴² Fischinger, Timo: *Zur Psychologie des Rhythmus. Präzision und Synchronisation bei Schlagzeugern*. Dissertation Universität Kassel 2008, p. 48-49.

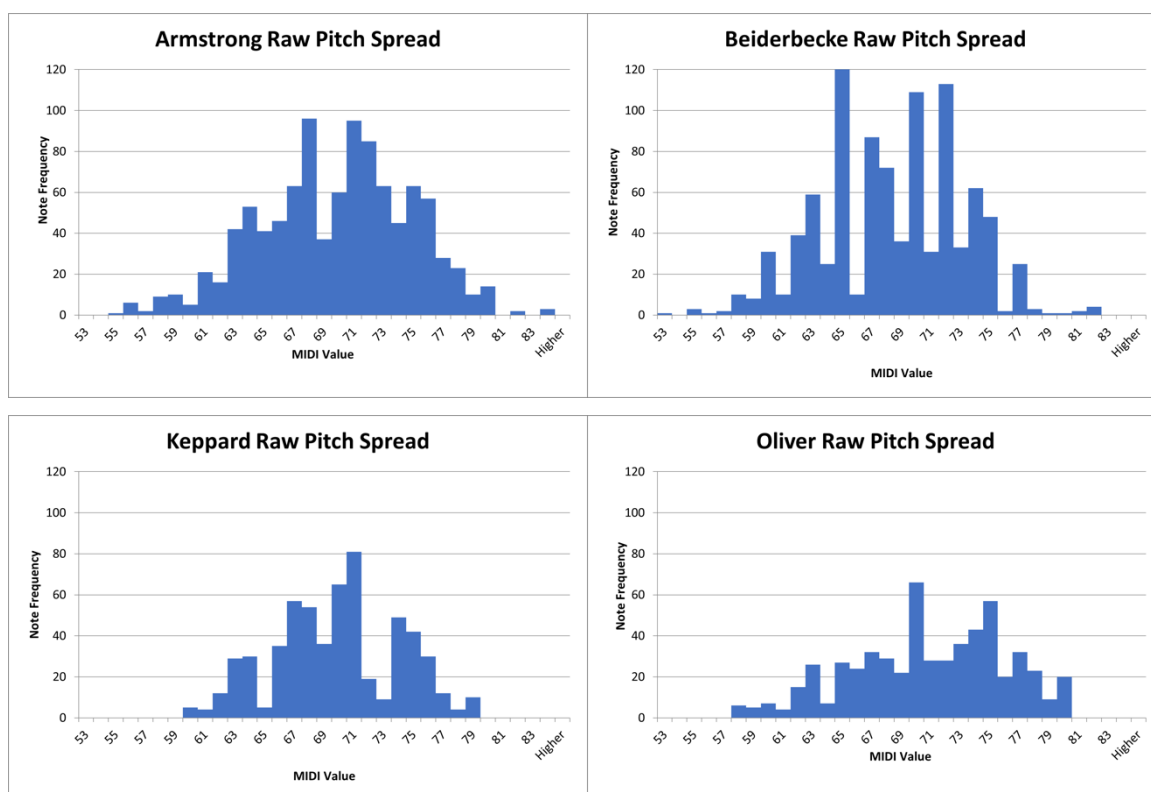
Table 18

	Armstrong	Oliver
Onset Difference: Range	0.005782 – 0.017628 seconds	0.008553 – 0.02326 seconds
Onset Difference: Standard Deviation	0.004428	0.005383
Swing Ratio: Range of Averages	1.068356 – 1.737399:1	1.432567 – 1.700851:1
Swing Ratio: Overall average Standard Deviation	0.358273	0.427737
Syncopicity: Range	10.4167% – 48.2759%	11.1111% – 34.6667%
Syncopicity: Standard Deviation	0.111582	0.082901

There are a few points to notice about the comparison of these three features. First, Armstrong is only more variable (i.e. has a higher standard deviation) in Syncopicity. Second, Armstrong shows a narrower range in Onset Difference and a wider range in both Swing Ratio and Syncopicity. So, in some certain ways Armstrong is more ‘subtle’ than Oliver, but in other ways he isn’t. Importantly, on the most surface-level and therefore noticeable factor, Syncopicity, Armstrong is both more variable and has a wider range. This would be something that a listener could hear most clearly, while microtime features like swing ratio and onset difference are less likely to play an obvious role in the aural impression. However, microtime is exactly the kind of feature one would think of when considering a ‘subtle’ approach to time, and in respect to that Oliver at least equals Armstrong, if not surpasses him because, though his swing falls into a narrower range than Armstrong’s, Oliver makes more varied use of it.

Looking at the question of Armstrong’s use of the high register, the MIDI note values of all notes across all solos was extracted for each player and plotted for comparison below:

Figure 4



The vertical axes show the number of notes and the horizontal axes describe the MIDI values. The first thing to notice is that Armstrong has a very dense spread; lots of notes in the first place, and fairly well distributed, showing a nice bell curve around the middle range of the horn. However, Armstrong's highest pitch is MIDI 84, which corresponds to C6 on the piano and the D above the staff on a Bb trumpet, and that is the highest note of the group. The question of where the high range of the trumpet begins exactly can be disputed, but for this paper it shall be said to start at Eb5, or MIDI 75, this based on the general consensus in orchestration treatises summarized by Christoph Reuter in *Klangfarbe und Instrumentation. Geschichte – Ursachen – Wirkung*.¹⁴³ Armstrong's pitch distribution shows that he plays 200 notes in this range, compared to Oliver's 161, Beiderbecke's 86, and Keppard's 98. The absolute numbers show that Armstrong does indeed play more and higher notes than any other player in the corpus. However, this observation needs to be qualified with the fact that, as a percentage of all notes played, Armstrong only shows moderate favor for the upper range. In fact, Oliver leads the pack with 28% of his notes in

¹⁴³ Reuter, Christoph: *Klangfarbe und Instrumentation. Geschichte – Ursachen – Wirkung*, Frankfurt am Main a.o.: Peter Lang 2002 (Systematische Musikwissenschaft Band 5), p. 368-369.

the high range, then comes Armstrong with 20% closely followed by Keppard with 17%, and finally Beiderbecke with 9%.

Why, then, was Armstrong so strongly associated with the high range of the trumpet? Of course, with more transcriptions this percentage could turn out to support the association, but there might be more at work here than sheer numbers. Armstrong was known for a very powerful, loud, and clear tone. When listening to solos like *West End Blues* one can't help but admit that his sound in the high register has a sizzle and force which stands out among the tone of his contemporaries. Perhaps because of this, listeners hear a power and control in Armstrong's high notes which they don't in other players', and so they mark Armstrong as a high note player.

Determining whether a player was thinking of the harmonies while they soloed is a difficult task when only analyzing the low-level musical features of a solo. However, there are a few clues which can give evidence for a harmonic approach behind the improvisation. Primary among these is the presence of arpeggios; nothing shouts chordal thinking more than outlining them as they go by, so frequent and long sequences of arpeggios can serve as a good determiner of a harmony-first approach to improvisation. A related but less precise determiner could be the use of thirds; if thirds turn out to be a predominant interval for a soloist, this is likely a result of moving around often in arpeggios. Finally, the use of chromatic notes may also point to some harmonic thinking, although this provides the weakest evidence because chromatic alteration can also result from passing tones in a melody-first paradigm.

As has already been noted, Armstrong and Beiderbecke both play noticeably more arpeggios than Oliver and Keppard, though all players make use of the figuration. Important also is what was learned from the t-tests; the players do not show a statistically significant difference on the arpeggio feature. This result needs to be qualified with some further details. The software extracts data for average length of arpeggios but does not count instances of arpeggios, meaning that really the players do not differ significantly in the lengths of their arpeggios, but it could be the case that the statistics would support the listener's impression that some players used arpeggios more often if there were a tool for counting them. This is why the predominance of thirds may provide a little more clarity. Again, there was no statistically significant difference between the players with regard to

the intervals, but the raw numbers do show an interesting grouping. Thirds make up about 33% of Armstrong's intervals in this corpus. He is then followed by Beiderbecke at 31%, Oliver at 26%, and finally Keppard at 25%. Here we see exactly the generational grouping one would expect when assuming that the younger, harmony-first players use more arpeggios. While these results cannot serve as definitive proof, it seems there is a trend which may become significant with more data.

Finally, Armstrong's use of expressive gestures as outlined in the literature lines up perfectly with the data from this analysis. First, Armstrong's characteristic sound and vibrato, the epitome of the New Orleans Shake described by Gunther Schuller,¹⁴⁴ is displayed in his total of 78 shakes in this small corpus, a sizeable sum given that there were only 9 Armstrong solos and the most shakes by far among the musicians examined. Then, the other characteristic component of Armstrong's sound according to Schuller, the rip, shows up 23 times compared to Keppard's 1 and Oliver's 0. Giving Beiderbecke the benefit of the doubt and counting his squeezes as rips too only leaves him with 3 in this corpus. What this goes to show is that no one was making use of rips in the way Armstrong was; that expressive device belonged to him alone. So, it would seem that Armstrong appropriated the shake from Oliver and he pushed it to such an extreme that it became most associated with him instead of his mentor and then, on top of that, Armstrong added the rip as a second calling card of his personal sound.

¹⁴⁴ Schuller, Gunther: *Early Jazz. Its roots and musical development*, New York: Oxford University Press 1968, p. 97.

5.4. Bix Beiderbecke

Here is the summary of Beiderbecke's characteristic features:

Rhythm	Musical	Expression
• Simple rhythms • Less syncopation • Less swing → swing ratio closer to 1:1	• Small range • Few notes	• Fewer 'hot' effects like rips, and no 'New Orleans lip shake' • Cleaner, more controlled effects like half-valve squeezes

Certain statements about Beiderbecke's rhythm are definitely supported by the data. Recalling Williams' claim that Beiderbecke's syncopations were crude imitations of those of the Black players¹⁴⁵ as well as Schuller's observation that Beiderbecke's rhythm was simple¹⁴⁶, Beiderbecke's Syncopicity score of 13%, the lowest of the group, would seem to support both authors. In addition, when considering his percentages on Relative Duration Class, Beiderbecke has most of his eggs in the 'Short' Duration Class basket (81%) and displays lower or equivalent values for the other categories. What this means is that Beiderbecke tended to use mostly one note length in relation to whatever tempo he was playing at, while the other players spread their note values out a tad bit more. Then, regarding Swing Ratio, recall that it was only a significant difference between Beiderbecke and Oliver. Looking at the raw data, Beiderbecke is nearly identical to Keppard in values for average Swing Ratio (both averaging 1.4:1 overall) and quite comparable to Armstrong (who comes in at an average of 1.45:1). So, in this sense Beiderbecke defies the claim that his rhythm was significantly different from that of the New Orleans players.

Let us turn now to Green's view of Beiderbecke's playing, that he used few notes and a small range.¹⁴⁷ Beiderbecke's stats on Event Density tell a split story. On the one hand, he clocks in at the highest overall average Absolute Event Density with 3.85 notes per second. This is a natural consequence of him also playing generally faster tempos than the rest in this corpus. On the other hand, Beiderbecke's overall Metrical Event Density is the lowest at 4.7 notes per bar, though it is still comparable with Armstrong's, who came in

¹⁴⁵ Williams, Martin, *Jazz Panorama*, p. 117.

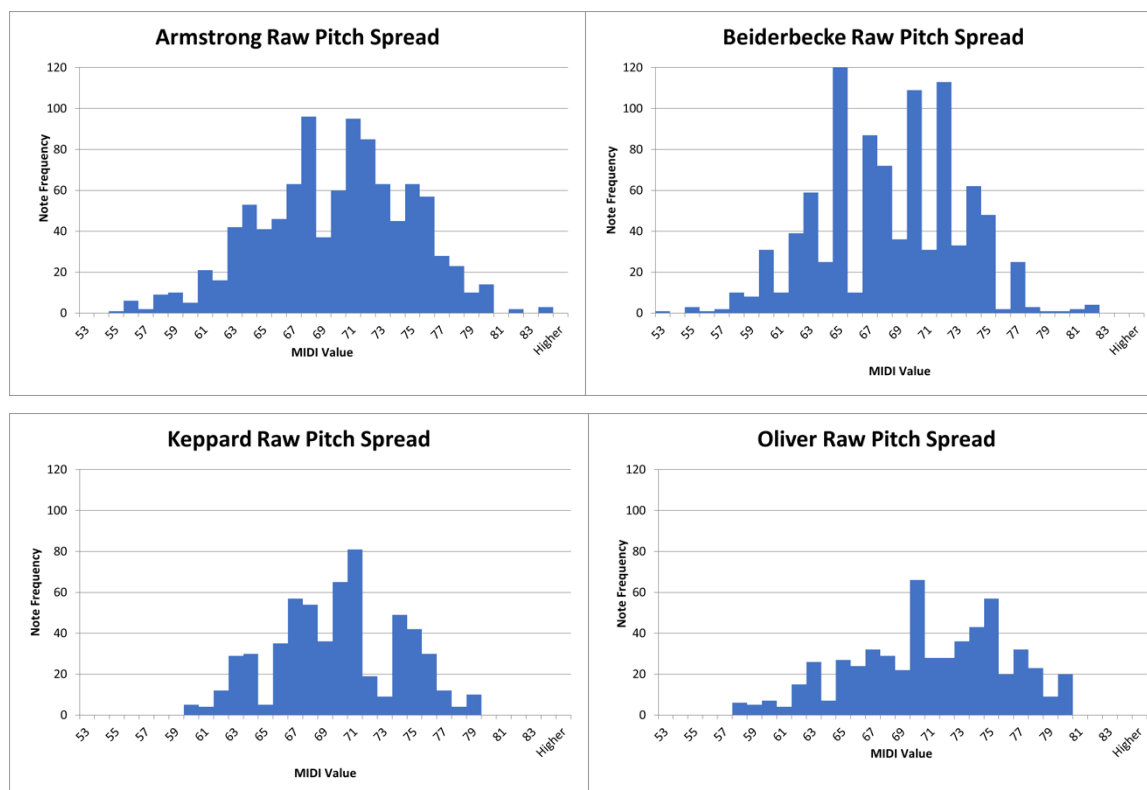
¹⁴⁶ Schuller, Gunther, *Early Jazz*, p. 188.

¹⁴⁷ James, Burnett, "Bix Beiderbecke", in: Green, Stanley, *Kings of Jazz*, p. 60-61.

3rd with 4.9 notes per bar. Recall also that Metrical Event Density was a statistically significant difference between Beiderbecke and Keppard, with Beiderbecke playing fewer notes per bar. What may be going on here is a distortion of perspective by analysis of written transcriptions instead of directly analyzing the audio material. When looking at a written transcription, even when a tempo is marked fast the solo will appear to have a low note count because, as we have seen in chapter 4.3. both Beiderbecke and Keppard tended towards fewer notes per bar at higher tempos. They turned to larger note values out of practicality, because subdivisions smaller than an eighth note at high tempos become very difficult to play. However, for the listener even solos with larger subdivisions can sound very note-dense if the tempo is fast enough, and the argument can be made that the aural impression is more important in this case than what a written transcription might show. Beiderbecke was probably not thinking “I want to be a minimalist and play a cool solo with few notes”. Instead he was likely trying to keep a flow of ideas going at a difficult tempo and chose a flow that fit the character of the groove while not getting unmanageable or unplayable, resulting in fewer notes per bar but more per second. In sum, it is somewhat misleading to characterize Beiderbecke’s playing as making use of few notes.

Let us recall the graph of Beiderbecke's pitch spread when looking at the claim that he used a small range:

Figure 5



The bell curve that was so visible in Armstrong's spread is somewhat present here, but the large spikes between [65] and [72] are interesting because of the clear gaps which were not as present in Armstrong's set. The majority of Beiderbecke's notes fall in this range, a total of 64%. What is apparent is that the slopes of the bell curve are steepest for Beiderbecke, which does support the idea that his range was noticeably more concentrated than that of the other players.

The control and beauty attributed to Beiderbecke by Williams¹⁴⁸ and Armstrong himself¹⁴⁹ show up most noticeably in the expressive effects Beiderbecke uses. With regard to the New Orleans Shake, one could at most say that Beiderbecke hinted at it with his fast vibrato, but really he did not use the shake in this corpus. Instead most of his notes were played with that straight tone which cut through the ensemble just as Armstrong described it. Then, including rips, scoops, bends, and falls, Beiderbecke employs only 13 across the whole corpus, by far the lowest count among the four players. This would go right along

¹⁴⁸ Williams, Martin, *Jazz Panorama*, p. 117.

¹⁴⁹ Louis Armstrong quoted in: Shapiro, Nat and Hentoff, Nat eds., *Hear Me Talkin' to Ya*, pp. 158-159.

with the idea that Beiderbecke was more of a straight-edge player than the New Orleans natives. Interestingly though, Beiderbecke uses three quite hot rips in this corpus (listen for example to the one in *Way Down Yonder in New Orleans*) and zero half-valve squeezes (recall that Armstrong actually used one squeeze here). With a larger data set the numbers might start to turn out as one would expect, but these results do go to show that Beiderbecke was certainly capable of employing hot techniques when the moment was right.

6. Summary and Outlook

This chapter will point out what was learned about each of the players through this first analysis, what can be said about traditional jazz trumpet improvisation in general, what questions remain open and unanswered, as well as what the sensible next steps would be to pursue these analyses further.

Oliver

The analysis delivered multiple interesting take-aways about Oliver. First of all, it can be said with confidence that Oliver's status as central to the jazz family tree is borne out by the data. His style and idiomatic approach to jazz was taken up by Armstrong, who was able to play essentially identical to his mentor, as shown by the t-test comparison. Since Armstrong exercised an indisputable influence not only on later trumpet players, but all jazz musicians of the following decades, to a certain degree this also reflects on Oliver's influence across the field of Jazz.

Then, there were several ambiguous results in Oliver's correlations. Firstly, while chromaticism and descending lines seemed to correlate in the data very strongly, the aural impression left the question open as to whether Oliver actually preferred descending chromaticism to ascending chromaticism. But, whichever way that question ends up going, the bigger-picture take-away was that Oliver's use of color notes seems to line up well with his reputation as a melodic-thematic improviser. In other words, the way he uses color notes mostly as passing tones suggests a more melodic and linear approach to improvisation, rather than a chordal-harmonic approach. While there were hints of an awareness of chords, not only in quotes relaying his advice to younger players but also in his use of arpeggios, the data still support the idea that Oliver preferred a melody-first approach to improvisation

rather than a harmony-first approach. With a further analysis of the MLUs this idea will likely be confirmed.

Another ambiguous aspect of Oliver's playing was his rhythm. Authors attribute feelings of both drive and lingering to his playing, but in this corpus only the drive appeared in the data. Then, in the comparison of his rhythm with Armstrong's, it would seem that Oliver operated on a subtler level, with more variation and nuance in his microtime than Armstrong, even though it is said of Armstrong that his time was subtler. These questions of microtime and its effects on the groove and on the listener demand extensive investigation to figure out what goes into making that feeling of Swing.

Keppard

Keppard's contrast to Oliver manifested itself in some surprising ways that seem to square with the characterizations of Keppard's musical roots which show up in the literature. The contrast in their rhythmic approaches, that Keppard swung less than Oliver, is at first glance quite unexpected because of the assumption that when musicians grow up and develop in the same context, their approach to such subtle things as microtime should be more similar than not. As noted before, perhaps this is a manifestation of Keppard's roots in the Ragtime idiom.

Another interesting feature of Keppard's playing which was highlighted in his comparison to Armstrong; here the data showed that Keppard played generally note-denser than Armstrong and the proposed reason for that is that Keppard's idiomatic use of ornamentation and his free treatment of the time led to his lines being occasionally compressed, with many notes falling into smaller time periods. This gives a characteristic shape to Keppard's lines which no other player in the group displayed, so it can be said that high ornamentation and free treatment of the time/beat are part of Keppard's signature improvisational style.

An additional take-away from the comparison to Armstrong was that Keppard both played more conjunct than Armstrong did. When pursuing the cause of this difference, it became apparent that Keppard and Armstrong occupy different tonal spaces in their improv. Keppard tended to stick with a more restricted ambitus on each solo, and it was proposed that this is part of the reason why he comes across as a more conjunct player than

Armstrong; when moving in a smaller tonal space the steps will almost necessarily be closer together. By contrast, Armstrong sails up and down, moving across clearly larger tonal spaces on almost every solo, giving him more space to play disjunct but also pointing towards characteristic shapes for the solos of each player; Keppard's solos will tend to set small boundaries and stay there while Armstrong's solos tend to involve large sweeps across the full range of the horn.

The correlation analysis showed the power of using the Jazzomat tool as an aid to focused listening. While a correlation result does not always necessarily mean that the two factors appear in conjunction, in the case of absolute event density and descending arpeggios it is the case that Keppard tends to move through his descending arpeggios quickly. While this result alone is merely an interesting point, it could be the beginnings of objectively describing Keppard's unique jazz 'dialect', to be expanded on with other trends which show up in other analyses.

Williams'¹⁵⁰ claims about Keppard's connection to Ragtime were indeed justified by the correlation results which connected Syncopicity with Very Short IOI and Very Short Relative Note Length. This constellation of results connected nicely too with his correlation of Swing Ratio Mean and Very Long Relative Note Length. On slower tunes, Keppard expressed more of the free, swinging rhythm which was to become so central to later branches of Jazz music, while on faster tunes he showed his Ragtime roots with straighter eighths and more syncopation. What this grouping of results points towards is that Keppard embodied the transition which was starting to show up in the style itself; the roots of Jazz, among them Ragtime, were making way for the Swing era and a new rhythmic paradigm with new values and emphasis. Keppard stood at this transition, being one of the last big names holding onto Ragtime and among the first testing the waters of Swing.

Armstrong

Through the comparison to Beiderbecke, Armstrong's use of arpeggios was illuminated in an important way. The software labeled Beiderbecke as playing more arpeggios, a result which defies both the literature and the listener's impression. The proposed

¹⁵⁰ Williams, Martin, *Jazz in its Time*, p. 170.

explanation is that the way Armstrong played his arpeggios confused the algorithm, causing his lower score. As Armstrong moves through his arpeggios, he throws in many neighbor note decorations and syncopated repetitions of notes. Both of these features would mask the presence of the arpeggio to the machine, but for the human listener the gestalt of the arpeggio is still clearly present. The takeaway is that Armstrong indeed made heavy use of arpeggios, but he treated them as scaffolds for both melodic and rhythmic decoration.

Another important take-away for Armstrong's playing was the fact that he used syncopation in some quite specific and idiomatic ways. On almost every phrase in this corpus, Armstrong leads in with a syncopated figure. This syncopated lead-in belongs to Armstrong's particular 'dialect' of rhythm and phrasing, something that characterizes his solos and distinguishes him from other players, particularly Beiderbecke.

During the individual correlation analysis an interesting global trend in Armstrong's playing became apparent. The negative correlations among multiple rhythmic and melodic features suggest that there is a dichotomy present in Armstrong's playing, specifically that in the domains of rhythm and melody, when playing complex in one he will tend to play simpler in the other. When examining this closer it came out that Armstrong's use of note repetition is almost universally in conjunction with syncopation, which is another idiomatic feature of his playing. During these moments of high note repetition Armstrong sets melodic considerations to the side and turns his focus towards rhythm and percussion in his use of syncopation and articulation. At times when he uses this approach the solos will have more air in them, while when playing with a more scalar focus such as on *Weatherbird* he will revert to simpler rhythms and denser lines.

Beiderbecke

Beiderbecke's position as the outsider of the group was clearly supported by the data and the analyses highlighted some interesting ways in which he differed from the New Orleans crew. First of all, his choice of notes stood out as a distinguishing factor. Not only did he clearly show a lack of influence from the Blues tradition, his playing hints at a diatonic-modal foundation due to his de-emphasis of blues notes and emphasis instead on scale degrees like 4, 5, and 6. Through listening specifically for this emphasis, a figuration which seems to be an idiomatic feature of Beiderbecke's phrasing came to the fore; using the last measure or so of a phrase to oscillate between scale degrees 1 and 6 is something

that Beiderbecke makes clear use of and which does not show up particularly in the phrasing of the other players.

Beiderbecke contrasted Oliver in a few key ways. The man from Davenport played more notes per second, and it was suggested that this has 2 causes. Obviously, because Beiderbecke played generally faster tempi, his absolute event density will be naturally higher. However, the structure of Beiderbecke's lines also contributes to this difference. Beiderbecke plays much more scalar, running up and down in a more constant stream of eighth notes while Oliver played more motivic-thematic, stating ideas and gradually varying them, but with space in between which lowers his values for absolute event density. This falls in line with what is suggested in the literature about the change in approach to improvisation that these two represent; Oliver is the standard-bearer for thematic and paraphrase improvisation, while Beiderbecke belongs to the generation which focused more on harmony and scales. At the same time, when comparing Keppard and Beiderbecke, Beiderbecke comes out with lower note density, most likely due to Keppard's use of ornaments and rubato as mentioned before. This means that while Beiderbecke generally plays streams of notes for his solos, there can still be a certain open quality to them depending on the tempo, where there seems to be lots of air or lift in his lines.

Another important contrast between Beiderbecke and Oliver was their rhythm. Not only did Beiderbecke swing and syncopate less than the New Orleans players, his general treatment of rhythm and the beat was fundamentally different. When focusing strictly on rhythm it becomes apparent that Beiderbecke has a much more squared-off approach to the beat and phrasing. While the New Orleans players will tend to focus on the between-the-beat moments, Beiderbecke very much launches from downbeats, especially from the strong beats 1 and 3, and aims at them too, giving his rhythm a uniquely square flavor. In addition, Beiderbecke's values for Onset Difference place him closer on top of the beat than any of the other players, reinforcing the idea that he had a stricter treatment of the beat and the rhythm than the NOLA group.

From the individual correlations we learned that Beiderbecke tends to play faster and more note-y than his peers. This trend may have more to do with the corpus that the analysis was done on, though, and a larger sample from Beiderbecke's repertoire may change this result. What was clear and more independent from the corpus is that

Beiderbecke's note choices differ fundamentally from those of the other players. Beiderbecke tends to shy away from chromatic alterations of nearly every kind, tending to stay in the diatonic scale and emphasizing those colors rather than the colors of the Blues or other spicier alterations. The correlations also pointed out a trend in how Beiderbecke shaped the rhythm of his lines in relation to tempo. When the tempo was slow enough, he would make use of small subdivisions like triplets, whereas at higher tempi he would restrict himself to eighths and nothing smaller.

What did we learn about the players?

One overall trend which was noticeable was that rhythm is a fundamentally distinguishing factor between the New Orleans players and Bix Beiderbecke. A collection of various results points toward the trend that the New Orleans musicians treated the beat with much more freedom than Beiderbecke. This almost certainly stems from the music traditions which the two groups grew up in and learned from. The New Orleans players came up in the Blues and Ragtime traditions, which in turn had their roots in West African music and rhythmic traditions. Beiderbecke by contrast learned primarily from a white commercial reproduction of jazz music played by musicians with roots in various European musical traditions, including classical music. That is to say, the two groupings of jazz musicians learned in entirely different rhythmic contexts and this is reflected in multiple results from the analysis here.

The MANOVA Analysis was a particularly good visualization of the grouping. Here it becomes very clear that the New Orleans players belong together and differ only on small points and at small scales, while Beiderbecke stands apart, occupying literally a different musical space than the others. The New Orleans players are more likely to differ on surface-level features like use of syncopation, ornamentation, or expressive devices while overlapping on subsurface features like microtime or approach to harmony (especially capturing the sound of the Blues). Beiderbecke, on the other hand, is more likely to differ both on the surface and on subsurface features.

What did we learn about trad jazz trumpet?

The overall correlations delivered many significant results, allowing some broad statements about trumpet improvisation in the traditional Jazz idiom. First of all, the

software pointed out a positive relationship between ascending arpeggios and descending chromaticism. While upon listening for this connection it became clear that these two phenomena are not actually connected to each other, it is also the case that the figurations occur quite often in most of the solos. This means that while they weren't really used in conjunction, rising arpeggios and falling chromaticism are two of the more popular gestures in a trad Jazz solo. The Jazzomat then pointed out that for these players, syncopated notes tended to be medium in length and not too short.

When considering the swing of these four players, the correlation between Onset Difference and Swing Ratio Median/Mean in light of the Swingogram paper by the Jazzomat team pointed towards the dynamic of how these players created the swing feel in their solos. For trad Jazz players, stronger swing came from a displacement of the first eighth note ahead of the beat. This dynamic could then be further explored by applying the Swingogram approach to this corpus.

The dichotomy of melodic and rhythmic complexity which showed up in Armstrong's individual results is also hinted at in the group results. Firstly, The negative relationship between Syncopicity and Mixed Chromatic Sequences suggested that perhaps it is true for all trad Jazz players that they focused selectively on melodic or rhythmic complexity. In following up with listening tests it also became apparent that all the players applied similar strategies to tunes with static harmony or very slow harmonic rhythm; on such tunes the trad Jazz players are more likely to highlight rhythm by repeating notes more often, allowing the syncopation to sit more on the surface. At the same time, though, it is difficult to say that the solos with more melodic shape also have less syncopation. But it is the case that the rhythmic features get covered by the melodic ones such that for the listener, the harmonically slow tunes sound more syncopated.

The second aspect of the melody-rhythm dichotomy shows up in a whole suite of positive and negative correlations. As noted before, when a solo is more notey and/or faster, and therefore more melodically complex, the trad Jazz player will simplify the rhythmic and in particular the microrhythmic aspects of their playing. Conversely, when there is more breathing space between the notes, when there is less going on melodically, the rhythmic and microrhythmic complexity will increase.

What questions are still open?

When examining Oliver's correlations the data pointed towards him having a particularly prominent preference for descending chromatic lines. This did not fully square, however, with the aural impression of his solos, and so it seems that more data and more transcriptions are needed to really say whether Oliver played more descending chromatic lines or not.

The positive overall correlation between Syncopicity, Absolute Medium Note Length, and Repeated Notes led to the question of how much impact Armstrong alone had on the results. Following an analysis which left Armstrong out, the correlations actually increased in intensity, which is the opposite of what was expected. Syncopation and the details of how it is used by the trad Jazz players still demands some closer inspection, because there is no clear explanation for the results.

Another big unanswered question was why color notes correlate so negatively with the core notes of the harmony, such as CPC 1, 3, and 5. The proposed reason, that heavy use of arpeggios skewed the proportions of each CPC, turned out unlikely to be the cause. This is a dynamic which certainly requires closer inspection with more data and transcriptions.

The claims of certain players having drive led to another open question. While the raw data suggest that these players did indeed play ahead of the beat, thus with 'drive', the limitations of human perception caused some second-guessing. Relying on Onset Difference alone seems to be insufficient to say there is perceptible drive in a soloist's playing, and so there remains the question: what else contributes to the perception of 'drive'?

In terms of next steps, a mid-level annotation of the transcriptions followed by a mid-level analysis would illuminate more details of each musician's improvisation style and strategy. For example, certain questions, like did Keppard really have such an unending reservoir of ideas or to what extent did theme-first improv play a role in each musician's improv, are best answered with the mid-level data. Once the mid-level annotation is complete, the corpus will be ready to integrate into the WJD.

Another further set of analyses involving other groups of musicians from the WJD will give more clarity on each player and traditional Jazz improv in general. Especially for musicians like Armstrong and Beiderbecke, whose output also included solos in the Swing style, comparing their results from trad Jazz and other styles could yield insight into how they changed over time and across styles. Additionally, comparing the body of all trad Jazz solos with those from the Swing and Bebop eras would allow contrasts to be drawn and perhaps a developmental line would become apparent, showing how improvisational strategies and musical values changed from the early Jazz period, through Swing and Bebop, and beyond.

The corpus and analysis presented in this thesis serves as the starting point for a more detailed investigation into the beginnings of Jazz music. From here, more paths open up to explore how this music developed, how it worked, where it came from and where it went. The work shown here is another part of the picture sketched out, to be filled in with details by subsequent inquiries. One more block laid in the foundation of our knowledge about one of the world's most influential artforms and one more step towards a deeper understanding of four of Jazz' most important musicians.

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Appendix

Abstract

The goal of this thesis is to investigate trumpet improvisation in the traditional New Orleans Jazz style using the method of the Jazzomat Project. Solos by four representative players, Joe “King” Oliver, Freddie Keppard, Louis Armstrong, and Bix Beiderbecke, were transcribed and analyzed using the MeloSpy software, then compared using statistical analysis tools in JASP. The social and musical connections of the musicians as documented in the literature are presented, and a set of statements about the idiomatic styles of each player are tested and either confirmed or questioned by the results of the data analysis. Additionally, interesting stand-alone results of the analysis are presented. The similarities and differences between each trumpeter are discussed, overall trends for trad jazz trumpet improv are identified, and new questions for further investigation are presented.

Zusammenfassung

Ziel dieser Arbeit ist es, die Trompetenimprovisation im traditionellen New Orleans Jazz mit der Methode des Jazzomat-Projekts zu untersuchen. Solos von vier repräsentativen Spielern, Joe "King" Oliver, Freddie Keppard, Louis Armstrong und Bix Beiderbecke, wurden transkribiert und mit der Software MeloSpy analysiert und anschließend mit statistischen Analysewerkzeugen in JASP verglichen. Die in der Literatur dokumentierten sozialen und musikalischen Verbindungen der Musiker werden dargestellt, und eine Reihe von Aussagen über die idiomatischen Stile der einzelnen Spieler werden geprüft und durch die Ergebnisse der Datenanalyse entweder bestätigt oder in Frage gestellt. Darüber hinaus werden interessante Einzelergebnisse der Analyse vorgestellt. Die Gemeinsamkeiten und Unterschiede zwischen den einzelnen Trompetern werden erörtert, allgemeine Trends für die Improvisation auf der traditionellen Jazztrompete werden aufgezeigt und neue Fragen für weitere Untersuchungen gestellt.