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Rhythmicalizer: Data Analysis for the Identification of Rhythmic Patterns in Readout Poetry (Work-in-Progress)

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Abstract: The most important development in modern and postmodern poetry is the replacement of traditional meter by new rhythmical patterns. Ever since Walt Whitman's Leaves of Grass (1855), modern (nineteenth- to twenty-first-century) poets have been searching for novel forms of prosody, accent, rhythm, and intonation. Along with the rejection of older metrical units such as the iamb or trochee, a structure of lyrical language was developed that renounced traditional forms like rhyme and meter. This development is subsumed under the term *free verse prosody*. Our project will test this theory by applying machine learning or deep learning techniques to a corpus of modern and postmodern poems as read aloud by the original authors. To this end, we examine "*lyrikline*", the most famous online portal for spoken poetry. First, about 17 different patterns being characteristic for the *lyrikline*-poems have been identified by the philological scholar of this project. This identification was based on a certain philological method including three different steps: a) grammetrical ranking; b) rhythmic phrasing; and c) mapping rubato and prosodic phrasing. In this paper we will show how to combine this philological and a digital analysis by using the prosody detection available in speech processing technology. In order to analyse the data, we want to use different tools for the following tasks: PoS-tagging, alignment, intonation, phrases and pauses, and tempo. We also analyzed the *lyrikline*-data by identifying the occurrence of the mentioned patterns. This analysis is a first step towards an automatic classification based on machine learning or deep learning techniques.

Keywords: modern and postmodern poetry; free verse prosody; rhythmic patterns; automatic classification

1 Introduction

Classic poetry has been analyzed by focusing its prosodic structure which comprises rhyme and metrical schemes such as iambic or trochaic meter. The large amounts of manually analyzed works of such poetry have lead to tools like *Metricalizer* [Bo11] which proposes metrical patterns given in a poem's text and *Sparsar* [DP14] which uses such patterns for speech synthesis of metric poetry. These tools, however, do not work for *free verse poetry* which was started by modern and post-modern poets like

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Whitman, the Imagists, the Beat poets, and contemporary Slam poets, as long as these poets developed a postmetrical idea of rhythmic patterns. Regarding this kind of *free verse poetry*, [Fi00][Be97][Si97][MS12][LMSJ14] and many others identified manually a number of postmetrical prosodic forms and styles, providing a narrow but detailed view into modern and postmodern *free verse prosody*. At the same time, original recordings of modern and post-modern poets reciting their poetry are available. Till now, there was neither a digital approach towards the analysis of free verse prosodic patterns nor a philological analysis of read out poetry. We set out to change this. Therefore, in this paper we will describe the differences between free verse and more traditional metric poetry. This will highlight why traditional meter analysis tools cannot be used for free verse and why standard speech processing tools are more suitable for the task.

The paper is organized as follows: Section 2 gives an overview on the project *Rhythmicalizer* for recognition of rhythmic patterns in modern and postmodern poetry. The data are presented in the section 3. The theoretical (philological and digital) background and the rhythmical patterns are described in section 4. Section 5 reviews the philological method and digital tools. The analysis of data is described in section 6. Finally, conclusions and future work are presented in Section 7.

2 Rhythmicalizer

The aim of the project *Rhythmicalizer* (`http://www.rhythmicalizer.net/`) is the recognition and classification of rhythmic patterns in modern and postmodern poetry. Through a collaboration with "*lyrikline*" (`https://www.lyrikline.org/`), we want to use their speech and text database of modern and contemporary poetry, giving us access to hundreds of hours of author-spoken poetry. We will create a text-speech alignment for the spoken and written poems. Then we will extract and annotate a wide range of prosodic as well as textual features. In this paper, we will identify these rhythmic patterns which are typical for modern and postmodern German as well as US-american Poetry. The machine learning or deep learning techniques will be used to learn the rhythmic patterns, and to identify 'outlier poems' which deserve further analysis. By considering the alignment informations and by using various tools mentioned below, we will be able to bridge the gap between manual annotation and automatic annotation of prosodic patterns. The results of automatic analysis are to be presented in a visual and understandable form to a human philological analyst. The interface will be developed to allow the annotation of particularities and the addition of markables to annotate newly found types of noteworthy information. These will then be fed back to the machine-learning back-end and be used in the next cycle of automatic analyses. This human-in-the-loop approach for poetry analysis combines the strengths of human and machine analyses. The software is planned to be developed into a web-based client and server architecture. the human-in-the-loop hermeneutical analysis and interaction can be performed via any computer (and annotations can be parallelized). The three-year project is funded by the Volkswagen Foundation in the 'Mixed Methods' program by the interaction of qualitative hermeneutic methods and digital humanities in the Humanities.

3 Data

The database of our project is a huge collection of modern and postmodern readout poetry taken from the internet website of *lyrikline*. The *lyrikline* was created by the Literaturwerkstatt Berlin and hosts contemporary international poetry as audio files (read by the authors) and texts (original versions & translations), so it offers the melodies, sounds, and rhythms of international poetry, recited by the authors themselves. Users can listen to the poet and read the poems both in their original languages and various translations, the digital material covers more than 10,000 poems from about 1000 international poets from more than 60 different countries. Nearly 80% of the *lyrikline*-poems are postmetrical poems. We will use all the poems in english and german language (about 3500 poems).

4 Theoretical Approach

Our project intends to identify the rhythmical patterns of modern *free verse poetry* by using hermeneutical as well as digital methods. The methodological added value of our project is gained by this combination, which allows us for the very first time to estimate the real impact of *free verse prosody* on (post-)modern American as well as German poetry by analyzing a very large digital corpus of spoken audio poems.

4.1 The Philological Background: Theory of Free Verse Prosody

The theory of *free verse prosody* was developed in the USA by literary scholars like Annie Finch, Walter Sutton, Alan Golding, Rosemary L. Gates, Timothy Steele, Donald Wesling, Eleanor Berry, Derek Attridge or Nathalie Gerber. In [Hr60] the author marks the beginning of this theory, which named as 'The Prosodies of Free Verse' in [We71]. The theory reacts on a very important development in modern and postmodern poetry: the replacement of traditional meter by new rhythmical patterns. Modern as well as postmodern poets renounced traditional forms like rhyme and meter, developing novel forms of prosody, accent, rhythm, and intonation based on the rhythms of contemporary American Speech [Ga85][Ga87]. Music was another important influence, especially jazz, as well as efforts to visually register distinct free verse prosodies in print [Pe83]. Prosody, as a specifically literary rhythm, was thus crucially redefined in modern American and European poetry. This new kind of *free verse prosody* is marked by a new interplay of line and stanza, which may vary in different ways – line length, line integrity, line grouping, the dismemberment of the line, or systematic enjambement.

Charles O. Hartman defined metre as "a prosody whose mode of organization is numerical" [Ha80], and argued that free verse is prosodically, but not metrically, ordered: "the prosody of free verse is rhythmic organization by other than numerical modes" [Ha80]. Three aspects of *free verse prosody* are important. First, Emma Kafalenos assumed that (post-) modern

poetry uses isochronous units beyond the metrical patterns. In addition to the isochronous metrical foot, there is an "isochronous line" resp. a "breath-controlled line" [Ka74]. Second, Alan Holders developed a theory on 'phrasalism' as an alternative to foot theory, claiming that phrases and lines are the most important organizational and rhythmic units in poetry. And third, Rosemary Gates defined the prominence within a poetic line as being realized by three simultaneously occuring features: pitch range, duration, and loudness [Ga87].

4.2 The Digital Background: Theory of Speech processing

Prosodic features such as intonation, accent, tempo, rhythm, and pauses have become increasingly important in Natural Language Processing (NLP), in particular when a full understanding of speech and language is desirable such as for human-machine interaction or speech-to-speech translation. For example, conversational speech recognition profits from prosodic analysis as in the *Verbmobil* speech-to-speech translation system [Wa00] which used prosodic features for semantic decoding. Pauses can help to resolve referents and prosodic features help to segment dialog interactions into utterances. In text-to-speech (TTS) software, textual analysis is used to infer prosodic features to make the artificial production of speech from text sound sufficiently natural. A typical task in NLP is the text segmentation, i.e., the classification of units like words, sentences or utterances in a textual sequence. An automated phrase break prediction sub-divides a number of sentences into meaningful chunks to copy the way in which a native speaker might phrase the utterance.

4.3 Prosodic Classes (Rhythmic Patterns)

The greatest challenge for our project is to identify each individual poem as a variety of sequential data. We will need to transform each line of a poem into a sequence of prosodic elements in order to develop a statistical model. In a first step, each poem will be separated into prosodic segments; then the combination of these prosodic segments will be assigned to a particular type of rhythm. These patterns remain to be developed, since the existing research only discusses certain "figures of sound" or "figures of rhythm," both of which involve the repetition of some key linguistic component: a sound, a sequence of sounds, a method of forming words, a phrase structure, a line structure, or an intonational melody [Co98]. Following Cooper, our rhythmical types will focus on different styles of poetry, such as the:

1. **longline poem**, as it is used in Alan Ginsbergs Howl and adapted by Durs Grünbein, Jürgen Becker, Franz Hodjak, Paul Celan, or Stephan Hermlin;
2. **cadence**, a sentence-based prosodic repetition coined by the American Imagists (Fletcher, Hulme, Pound, H.D.,Lowell), which was highly influential for German Poets like Gottfried Benn, Enzensberger, Nicolas Born, and Franz Mon;

3. **variable foot**, an colon-based prosodic repetition developed by WC Williams in his later poems, and used by German authors like Nicolas Born, Richard Anders, Ernst Jandl, Hans Magnus Enzensberger, and Harald Hartung;

4. **syncopation**, a placement of rhythmic stresses or accents where they wouldn't normally occur, as used in the prosody of Jazz and Rap poetry by poets such as Hughes, Brown, and Jones, or Members of 'The Last Poets' like Bin Hassan, and German Rap-Poets like Bas Böttcher;

5. **permutation**, a permutative rhythm based on the combination of two (or more) types of rhythms which overlap. The permutation was developed by John Cage and is used in the poems of Jandl, Czernin, Becker, Gomringer, and Pastior;

6. **parlando**, a litany-like speech-song adopted by the rhythms of ordinary speech, which was very famous during the 1970s. The Parlando is used in poems of Benn, Rühmkorf, Enzensberger, Hodjak, Krüger, Haufs, or Kolbe;

7. **stressed enjambment**: an incomplete syntax at the end of a line, when the meaning runs over from one poetic line to the next. To stress the enjambement has a long tradition in the poetry of the former German Democratic Republic (GDR). It was invented by Bertolt Brecht and continued by Karl Mickel or Kerstin Hensel;

8. **unstressed enjambement**, used by postmodern poets like Heiner Müller, Thomas Kling, Nicolas Born, Jürgen Becker, Elfriede Czurda, Marcel Beyer, Jan Völker Röhnert or Ann Cotten;

9. **loop**, on which the 'rapping' prosody of Slam poetry (Edwin Torres, Bob Holman, Sapphire, Saul Williams, Maggie Estep, Dana Bryant, Sekou Sundiata, Amir Sulaimanis, Paul Beatty, Linton Kwesi Johnson, or Bas Böttcher) is based;

10. **ellipse**, caused by the omission of one or more words in a clause. The elliptic rhythm can be found in intertextual and experimental poetry (Wühr, Mayröcker, Becker, Beyer, Kling, and Papenfuß);

11. **lettristic decomposition**, an art of letters which operates beyond spoken language, the lettristic decomposition was invented by Isidore Isou and adapted by international Sound-Poets like Henri Chopin, Bob Cobbing, Amanda Steward, Jaap Blonk, and Valeri Scherstjanoi as well as German Poets like Gerhard Rühm, Ernst Jandl, Hans G Helms, Franz Mon, Oskar Pastior, and Michael Lentz;

12. **phonetic decomposition**, a kind of Sound Poetry which is more based on phonemes and was developed by Kurt Schwitters, Bernard Heidsieck, Helmut Heißenbüttel, Franz Mon, Gerhard Rühm oder Michael Lentz;

13. **sprung rhythm**, based on a number of stressed syllables in a line and permits an indeterminate number of unstressed syllables. It was developed by G.M. Hopkins,

W.C. Williams, and the Black Mountain poets, and was influential for German poetry since the 1960s (Born, Brinkmann, Kiwus, etc.);

14. **free association**, which forms the prosody of the écriture automatique of Surrealist authors such as Breton, Éluard, Desnos, Arp, and Soupault, and was highly influential for Mayröcker, Beyer or Kling;
15. **staccato**, which forms an abrubt, detached and choppy poetry like in John Berryman, Thomas Kling or Walter Mehring;
16. **cut-up-rhythm**, an aleatory literary technique in which a text is cut up and rearranged to create a new text. The concept can be traced to at least the Dadaists of the 1920s, but was popularized in the late 1950s and early 1960s by William S. Burroughs and Brion Gysin; and adapted by Brinkmann;
17. **dialect**, as it is used by Axel Karner, Ernst Jandl, HC Artmann, Wulf Kirsten and Franz Hohler.

5 Method

Our methodology is to employ automatic analysis based on computational speech and language processing in combination with manual hermeneutical analysis. We will use automatic techniques in a human-in-the-loop approach, in which we cycle between building (or extending) computational models and manual philological analysis of phenomena (and the annotation of these phenomena). The automatic analysis will, of course, be based on automatically extracted features that are potentially useful to describe and differentiate *free verse prosody*. Our goal is to find exactly those features and combinations that constitute *free verse prosody*.

5.1 Philological Method

Step 1: Grammetrical Ranking

The term grammetrics, coined by Donald Wesling, is a hybridization of grammar and metrics: the key hypothesis is that the interplay of sentence-structure and line-structure can be accounted for more economically by simultaneous than by successive analysis [We96]. In poetry as a kind of versified language, the singular sentence interacts with verse periods (syllable, foot, part-line, line, rhymed pair or stanza, whole poem), a process for which Wesling finds 'scissoring' an apt metaphor: "Grammetrics assumes that meter and grammar can be scissored by each other, that the cutting places can be graphed with some precision. One blade of the shears is meter, the other grammar. When they work against each other, they divide the poem. It is their purpose and necessity to work against each other [We96]."

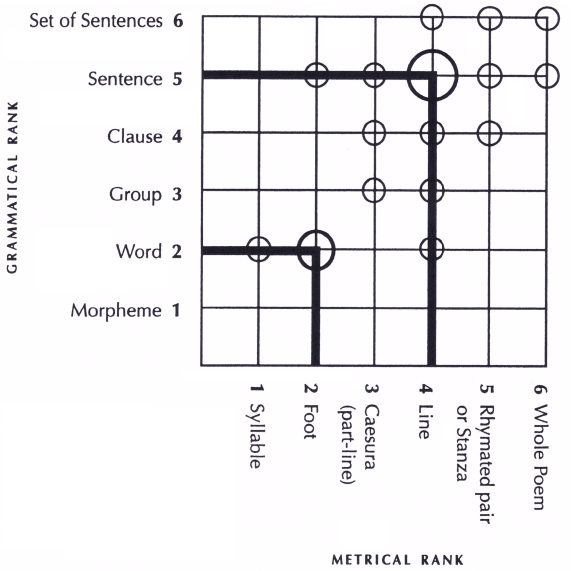

Fig. 1: The vertical axis is that of grammatical rank; the horizontal axis is that of metrical rank. Intersection points help to identify the poem, for instance the line arrangement [We96].

Step 2: Rhythmic Phrasing

The concept of rhythmic phrasing was developed by Richard Cureton. For Cureton, rhythm embraces what has traditionally been regarded as very different kinds of perceptual phenomena. Cureton divided rhythm - a global term covering all relations of strength and weakness - into three distinct components, which he terms meter, grouping, and prolongation. Meter involves the perception of beats in regular patterns; grouping involves the apprehension of linguistic units organized around a single peak of prominence; and prolongation involves the experience of anticipation and arrival. Curetons claimed a hierarchical, multi-dimensional, and preferential treatment of poetic rhythm, going back to [LJ83] treatment of rhythm in Tonal Music. Lerdahl and Jackendoff claimed four different rhythmic dimensions: a) The grouping structure in terms of a hierarchical segmentation, b) the metrical structure in terms of a regular alternation of strong and weak beats at a number of hierarchical levels, c) the time span-reduction in terms of an organizations uniting time-spans at all temporal levels of a work, and d) the prologational reduction in terms of a ‘psychological’ awareness of tensing and relaxing patterns in a given piece.

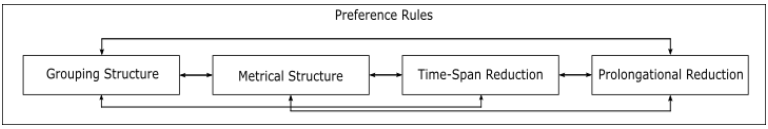

Fig. 2: Lerdahl and Jackendoffs theory of music is based on four separate hierarchical structures and reductions: a grouping structure, a metrical structure, a time-span reduction, and a prolongation reduction (after [LJ83]).

Step 3: Mapping Rubato and Prosodic Phrasing

As a result, the prosodic hierarchy to be considered for free verse is considerably more complex than for metric poetry and our working hypothesis of this hierarchy is depicted in Figure 3 (left). As can be seen, all levels of the linguistic hierarchy can carry poetic prosodic meaning, from the segment up to the periodic sentence. Based on this prosodic hierarchy, Figure 3 (right) depicts a categorization of some poets' works along two axes, the governing prosodic unit (x-axis) and the degree of iso/heterochronicity, or regularity of temporal arrangement (y-axis), according to the concept of grammetrical ranking mentioned in Figure 1. The respective rhythm derives from the combined prosodic units and the degree of its isochronic (or heterochronic) succession. The green lines are meant as a localization of poets according to the interplay of grammetrical ranking and prosodic succession. The blue brackets mark the time span reduction (Rubato) as well as the prolongational reduction (Phrasing). According to the idea of time-span-reduction, the rubato is caused by a deviation from the isochronous rhythm. And according to the idea of prolongational reduction, the phrasing is divided into three different articulation techniques (legato, portato, staccato).

5.2 Digital Method

A prerequisite for computing the patterns mentioned is to create a text-speech alignment for the written poems and spoken recordings. In a next step, we extract phonological prosodic features such as ToBI labels [Si92]. Regarding higher-level prosodic analysis and feature extraction, poems will be split into prosodic segments and the combination of these prosodic segments will be assigned to types of rhythm. These patterns are mentioned in 4.3. In addition, we use unsupervised learning, such as clustering techniques and outlier detection in order to steer the manual philological analysis towards potentially interesting parts and phenomena in the large corpora. We use existing meta-information (e.g. poetic type) to train classifiers. In our procedure, we will analyze classifier models with the aim of generating explanations for poetic categorization (e. g. RIPPER [Co95] induces rule-based models that are easy to analyze), and these explanations can be valued (and in the strongest case rejected) by the human analyst. In this way, the human expert is able to steer the prosody modeling process away from computationally optimal but philologically ungrounded decision-making towards those aspects of poetic prosody that are deemed philologically relevant. Focussing

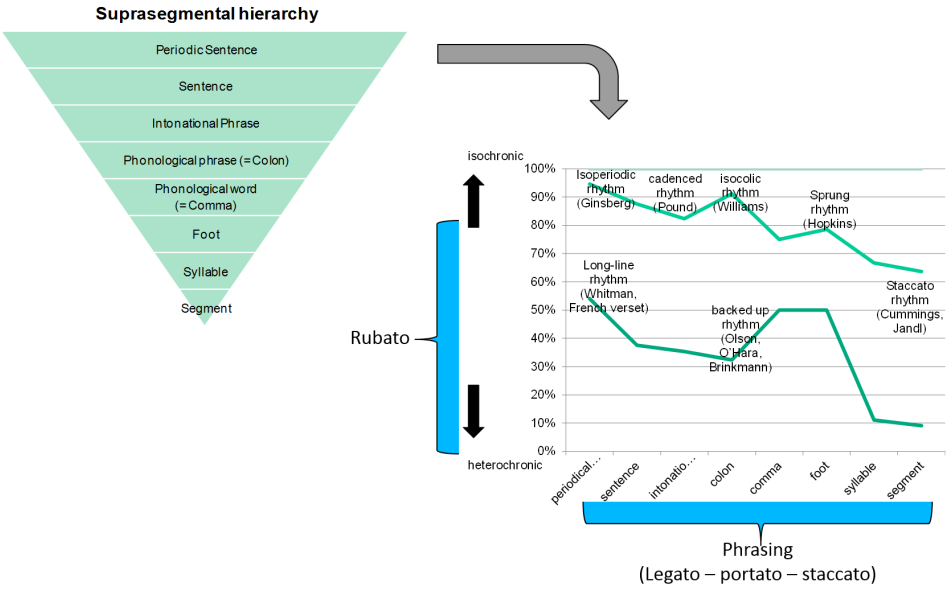

Fig. 3: Working hypothesis for a prosodic hierarchy for *free verse poetry*, as well as a placement of poetic styles along the two axes governing unit and regularity of temporal arrangement.

on the 17 rhythmic patterns in section 4.3, we will identify all of them by using either manual or automatic detections. We will use the following tools (we write also the related rhythmical patterns which can be extracted using these tools):

1. **PoS-Tagger**: the PoS tagging tool (e.g. [Sc17]) will identify the linguistic unit dominating each line of a poem. This could be a periodic sentence (Pattern 1), a whole sentence (Pattern 2), a clause (Pattern 3, 7 and 8), an elliptic phrase (7, 8, 10, 16), or an agrammatical expression (11, 12, 15, 16).

2. **Forced Alignment**: the forced alignment toolkit (Sphinx [Wa04]) will help us to combine audio and text analysis for the Batch Alignment as well as the Disfluency detection (7, 15, 16). In these cases the audio contains skipped words as well as repeated words or phrases.

3. **Intonation Annotation**: the AuToBI [Ro10] toolkit will be use to identify the intended prosodic grouping of a poem as well as the pitch accents and boundary tones in order to differ between stressed and unstressed enjambements (7, 8).

4. **Pause and Phrase Recognition**: The *Praat* [BW17] or *Wavesurfer* programs are used for prosodic phrase recognition as well as break identification (3, 5, 7, 8).

5. **Tempo**: The *Sonic Visualizer* [Vi17] tool will help us to annotate the Bar and Beat Numbers as well as to map Rubato and Loudness.

6 Data Analysis

A total of 358 poets (210 german and 148 english) will be analyzed, each of them reading about 12 poems, so we have 2292 german poems and 1239 english poems resulting a total of 3531 poems. By now, we structured and analyzed the data as follows: The acquired audio data is manually annotated by using a combination of tools including *Praat*, *Sonic Visualizer*, and PoS-Tagger. The number of audio files fitting to the categories mentioned above is as follows: longline poems (30), cadence (50), variable foot (70), syncopation (20), permutation (10), parlando (60), stressed enjambement (10), unstressed enjambement (100), loop (10), ellipse (50), lettristic decomposition (40), phonetic decomposition (30), sprung rhythm (40), free association (30), staccato (25), cut-up-rhythm (6), dialect (20). As long as we talk about patterns, we expect that the rhythmical patterns mentioned will appear in each poem at least 5 times. Figure 4 shows an example of the automatic analysis of pattern number 7 (a stressed enjambement). The break index indicates the incomplete syntax at the end of the first line (break index "4" at the end of "Als ich bei ihm war rückte er").

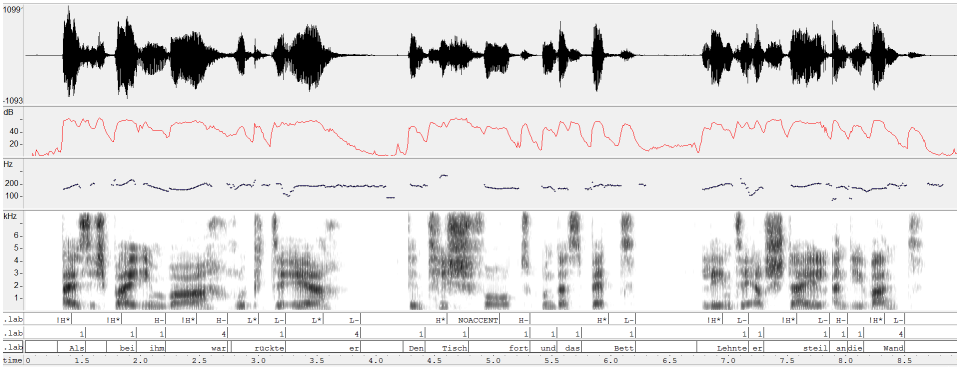

Fig. 4: Analysis of the first two lines in the poem "ALS ICH BEI IHM WAR" for the poet "Kerstin Hensel" shown from top to bottom: speech signal, intensity (dB), pitch (Hz), spectrogram, ToBI tones, ToBI breaks, word alignment, and time.

7 Conclusion and Future Work

In the long run, our project will focuse on pattern understanding using a supervised form of learning. The philological "teacher" gives examples for the automatic classification: first some examples to bootstrap ToBI analysis, then the poetic classification as outlined above. Our learning technique may be based on machine learning techniques like Hidden Markov Models (HMMs), general Bayesian networks, other techniques available in common tools

such as WEKA [Ha09], or deep learning techniques like Convolutional Neural Networks (CNN oder ConvNet). We will then analyze the computational models' success (in terms of the correctness of the decisions taken on previously unseen data) and their reasoning (in terms of the decision criteria used and how well they align with philological intuition). As one further point, we will make use of unsupervised machine learning techniques (e.g., clustering) to discover further hidden patterns in the audio and textual data, in particular for poems that are not well represented by any of the rhythmical types (1-17) mentioned and which may potentially enhance our understanding of *free verse prosody*. This step will use the machine-learned model by looking at borderline cases, analyzing miscategorizations, examining 'outliers', and using search patterns for prosodic aspects of poetry rather than a laborious manual search.

8 Acknowledgements

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