

Comparing Three Designs of Macro-Glyphs for Poetry Visualization

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Abstract

Glyphs have been successfully used in poetry visualization for depicting the characteristics and positions of each phonetic articulation in relation to the human vocal system. While existing glyph designs provide visual representations for detailed observation and external memorization of the dynamics throughout a poem, they are less effective for observing the relationship and variance between different lines in a poem and in comparing different poems. In this short paper, we present three designs of macro-glyphs for summarizing the spatio-temporal dynamics at the level of poetic lines. In particular, we use statistics of a collection of poems to guide and optimize the designs. We report our comparative study on the effectiveness of these three designs.

1 Introduction

In poetry, close reading is a literary form of “data exploration”, in which scholars pay concerted attention collaboratively to various individual linguistic, literary and sociological features, as enumerated above, as well as to the interplay and relationships among these features [ARLC*13]. Poetry visualization can support close reading by enabling more effective observation and external memorization of a collection of features, allowing scholars to devote more cognitive capacity to explore different interpretations and hypotheses. This work focuses on the visualization of phonemic features, the details of which are difficult to see and remember because such features are by nature auditory and temporal, but not visual; and in English, they are indirectly encoded in the original text. Some poetry scholars refer the process of study phonemic features in close reading as “chewing the sound”.

In [ARLC*13], mini-glyphs were used to represent three phonemic variables of vowels and consonants, and the transition between two consecutive vowels or consonants. When visualizing a poem, these mini-glyphs annotate all phonetic symbols translated from the original text. While they are particularly useful for detailed observation and external memorization of the phonetic dynamics of a poem at the level of phonemes and words, they are less effective in observing the relationships between the different lines in a poem, e.g., the level of dynamics of a poem and individual lines, similarity, diversity and changes of phonetic structure at the level of

lines. Hence it is desirable to provide visual representations at a level higher than the mini-glyphs in [ARLC*13].

In this paper, we propose to introduce *macro-glyphs* for encoding multivariate time series associated individual lines in a poem. We considered three main glyph designs, namely *static radial glyph*, *animated transitions*, and *static transitions with temporal highlight*. We used various statistical indicators of 35 poems (range from sonnets, nursery rhymes and free-verse) to guide our designs, and we evaluated the three designs by consulting humanities scholars.

2 Related Work

There is a large collection of previous work on text and document visualization. The dominant techniques in this area have been statistics graphics (e.g., [VCPK09, AC07]), network visualization (e.g., [Mil95, WV08, vHWV09, Pal02, CCP09]), and pixel-based visualization (e.g., [KO07, OBK*08]).

There have been several pieces of existing work on poetry visualization. For example, in [CGM*12] and [CAT*12], pixel-based visualization was used to display the poetic forms and variables, such as meter and rhyming patterns. In [MFM13], radial-based visualization was used to guide poem composition in a collaborative visualization. In [ARLC*13], a web-based interactive system was developed allowing scholars to display some 26 variables using a combination of visual channels (including glyph, network, color and texture). In terms of visualizing phonemic vari-

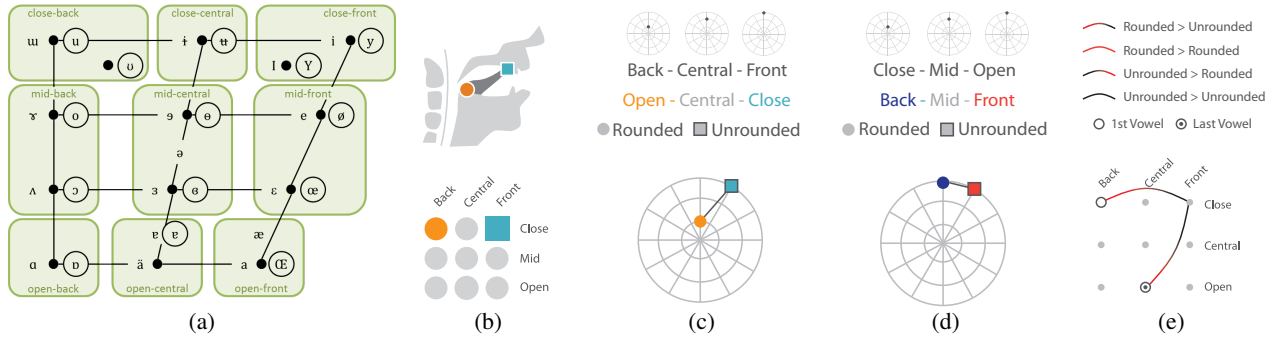


Figure 1: (a) The vowel chart (from left to right) back, central and front (which part of the tongue is raised) and (from top to bottom) close, mid and open (how far the tongue is raised). (b) A representation of a vowel position transition from a close back rounded to a close front unrounded. (c)-(e) The mapping of a vowel transition to the macro-glyph designs.

ables, apart from the mini-glyph used in [ARLC*13], line graph, density plot, and animated trajectories were used to display two phonemic variables of vowels for visualizing sung vowels in music [FAW11]. As discussed early, mini-glyphs are ineffective in conveying phonetic dynamics at the level of poetic lines. Meanwhile, with line graphs, each poetic line would be displayed as a few time-series corresponding to different variables. Comparing different poetic lines would mean comparing different sets of multivariate time series. Density plots were effective for observing statistical pattern of a large number of vowels, for instance, in a poem or a piece of reasonably long text. Hence they are not suitable for visualizing phonetic dynamics at the level of poetic lines. In [FAW11], animated trajectories, which were referred to “vowel worm”, were considered to be promising. We adapted this approach in one of our three designs.

The existing literature on visual encoding has offered us ample guidance in narrowing down our design options. Due to the constraints of the space, here we highlighted those which have brought about most significant influence. Bertin [Ber83] examined a set of basic glyph designs from a cartographer’s point of view. Ware [War12] discussed many perception considerations in visualization designs. Ward [War08] provided a technical framework for glyph-based visualization, covering aspects of visual mapping and layout methods, as well as addressing important issues such as bias in mapping and interpretation. Much of existing work in the area of glyph-based visualization can be found in the recent survey by Borgo *et al.* [BKC*13]. Radial-based projection has been used to depict temporal data [DBS*11, WAM01, DH02] and the visualization of human movements [ZFAQ13]. Curved flow symbols [WSD11] have been used to visualize traffic movements. Time-series visualization, such as ThemeRiver [HWN02], has been deployed to depict temporal patterns in a large collections of messages or documents. Maguire *et al.* used statistics in the source data to guide the visual design [MRSS*12, MRSS*13]. Several authors, e.g., [RFF*08, Fis10], have discussed the uses of animation in visualization.

3 Visualization & Design Approach

In this paper, we consider only poems in English, and use the International Phonetic Alphabet (IPA) [Int99] to represent the sound and pronunciation of words in poems. We focus on vowels sounds, though the proposed designs can easily be adapted for consonants. Figure 1(a) illustrates three phonemic features of different vowels annotated using the IPA. The *x*-direction encodes the variable *frontness* or *backness*. The vowels displayed along the line on the left are the *back vowels*, in the middle the *central vowels* and on the right the *front vowels*. The positions correspond to the back, central, and front parts of the tongue respectively. Different vowels were produced when different parts of the tongue move up or down [Hou98, LD12]. The *y*-direction encodes the variable *vowel height* that is defined by both the mandible and the tongue. The vowels displayed along the top line are the *close vowels*, in the middle are the *close-mid vowels* and *open-mid vowels*, and at the bottom the *open vowels*. A vowel is said to be closed if the tongue is raised high and the mandibular is closed. It is said to be open if the tongue is rested at the floor of the mouth, and mandibular is open [Hou98, LD12]. The third variable is *lip rounding*, which refers to the shape of the lips during the production of a vowel [Hou98, LD12]. In Figure 1(a), all rounded vowels are shown in a circle.

Consider a line in a poem. Let L denote a multivariate time series, which is an ordered set of phonemic features of all vowels in the line, i.e., $L = \{(f_i, h_i, r_i) \mid i = 1, 2, \dots\}$, where f_i defines the frontness (front, central, back), h_i defines vowel height (open, mid, close), and r_i defines lip rounding (rounded, unrounded). The common goal of the three designs to be described in the following sections is to encode L using a macro-glyph.

Static Radial Glyph. In this design, we use clockwise angular positions to depict temporal ordering of vowels in a poetic line. In addition, we utilized three other visual channels, namely radial position, color and shape. Our first design decision is how many radial lines in each glyph. With a circle, we may consider 4, 8, 12, 24, 30, and 60. Using our collection of poems, we compiled the statistics about the

number of vowel phonemes per line. Among the 465 lines in the collection, 84.3% contain ≤ 12 vowel phonemes, while the maximum number of vowel phonemes is 22. Based on the statistics, we decided that 12 radial lines per circle is the most suitable option, because (i) it is consistent with the clock metaphor, (ii) it offers an appropriate density of radial lines, and (iii) most poetic lines need 84.3% of lines need only 1 macro-glyph and 15.7% need 2. If 8 were chosen, 47.1% lines need 2 macro-glyphs and 2.4% need 3. If 24 were chosen, the radial lines would be too densely packed, while 84.3% would use only half of the circle.

Our second design decision is to decide the pairing of phonemic variables and visual channels. A few poetry scholars advised us during the design stage that vowel height and frontness may be more interesting than lip rounding. To help us decide the mapping, we calculated the average difference and standard deviation for vowel height (avg diff: 0.8704, std dev: 0.6699) and frontness (avg diff: 0.7709, std dev: 0.7073). According to the average difference, vowel height may have a slightly higher priority, while according to the standard deviation, frontness may be more favourable. As the statistics is inconclusive, we created two variations of the static radial glyph as illustrated in Figure 1(c,d). As rounding is considered least important by the poetry scholars, we assigned the color channel to frontness in (c) and vowel height in (d), while mapping lip rounding to the shape channel in both variation. We created a logological link between phonemic features and colors to help memorization, i.e., O for Open/Orange, C for Close/Cyan, F for Front/Fire and B for Back/Blue. Naturally, we used circle for rounded and square for unrounded vowels.

Animated Transitions. We explored two variations of animated transitions: turbulence and beat. We used the abstract representation of 3×3 positions in Figure 1(a) as the 9 main reference points. When a vowel is moved from one position to another, a transition line is drawn. For the turbulence variation, we trace out the movements using trailing circles as it moves across the line (similar to [FAW11]). We used two different colors to encode lip rounding, i.e., black (unrounded vowels) and red (rounded vowels). The color and gradient of a trace line encodes the relationship between the two consecutive vowels, e.g., a gradient line from red to black indicates the change from a rounded vowel to an unrounded vowel. For the beat variation, the transition lines are represented by a worm-like shape. In addition, we used the line opacity to encode the frequency of a transition, i.e., the more transitions take place between two positions, the darker the residual line becomes.

The advantage of this design is that only one macro-glyph is needed for any line. We anticipated some disadvantages of using animation. For example, it is hard to detect if there is no change in vowel positions. Nevertheless, as some scholars were enthusiastic about animation, we decided that it is better to include both variations in our evaluation.

Static Transitions with Temporal Highlight. This design uses the same 3×3 layout as the Animated Transitions, but place more emphasis on the transition lines and less on animation. All transition lines are static while a small marker moves along the transition lines to convey the temporal ordering. As shown in Figure 1(e), three different circles indicate the first, last and intermediate vowel positions. A self-loop is used when there is a repetition of the same vowel position. Similar to the design of animated transitions, we used color and gradient of the transition lines to indicate four types of transitions. We also created a variation that encodes lip rounding by placing rounded or unrounded markers at the beginning and end of transition lines.

To help us determine the optimal paths to draw transition arcs and self-loops, we computed the statistics about the frequencies of transitions between different vowel positions. In our collection of poems, we found that there are no edges leaving or entering open-central and close-central vowel positions. This is likely because these vowel positions are more commonly used in non-English languages, such as Norwegian *butt* [but] ‘blunt’ [Int99], or in accented English dialect. Using the statistics, we created a lookup table for all 81 valid transitions, specifying the curve parameters for each transition.

4 Evaluation

Observing sound dynamics in poems requires a fair amount of general knowledge about linguistics and literature, specialized knowledge about poetry and experience of close reading. A controlled user study with arbitrary participants may not reflect the presence of such knowledge and experience. We hence evaluated the three designs of macro-glyphs by consulting four domain experts, including a Professor in Italian Literature (with research interest in educational and poetic theory), and three postgraduate students (in English and French literatures) who studied poetry in the past. The evaluation started with our explanation and live demonstration of the three designs and their variations. This was followed by a multiple-choice questionnaire with 43 questions. Among these, 6 were common questions that were repeated for each of the three designs and their variations, 9 questions were asked individually for specific designs, and 4 general questions were asked at the end, featuring comparison across three designs. The structured survey was followed by free-form discussions. Participants were offered the opportunities to provide alternative answers to the questionnaire after the discussion. A qualitative summary of the experts’ answers to the questionnaire, and their comments and suggestions made during the discussions is given below.

Static Radial Glyphs

- It is helpful to the tasks of identifying similar phonetic patterns among poetic lines, and differentiating dynamics and sound structures in poems.
- The two different visual mappings are both important as

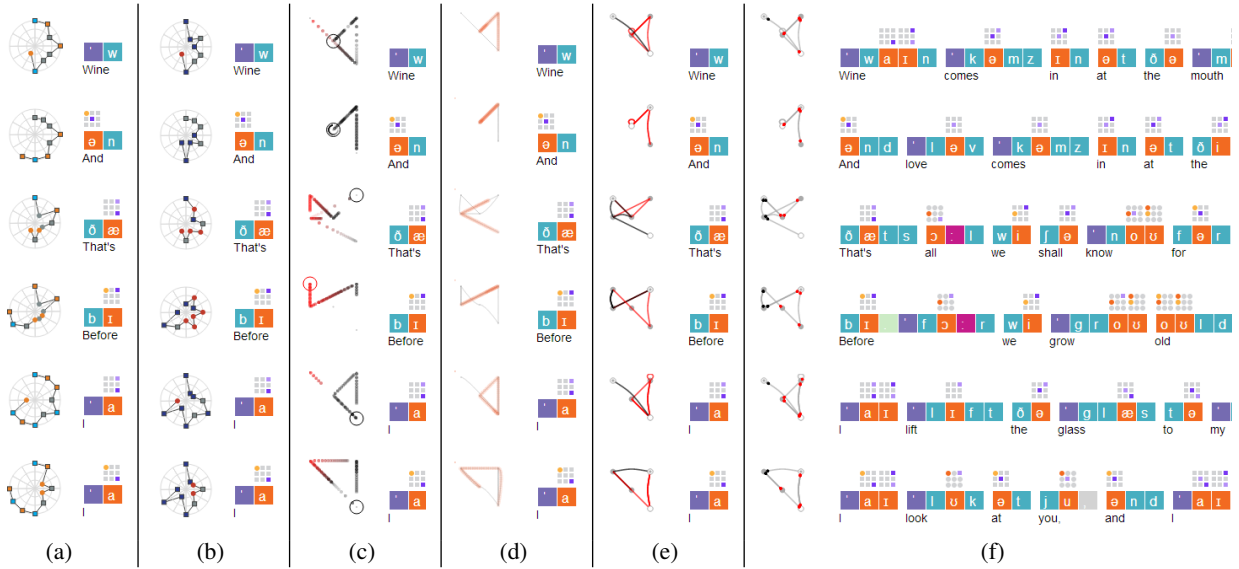


Figure 2: Visualization of a short poem “A Drinking Song” by W. B. Yeats with macro-glyphs. (a) Static radial macro-glyph with a frontness layout while (b) static radial macro-glyph with a vowel height layout. (c)-(d) Animated transitions macro-glyphs with its variations (e)-(f) Static transitions with temporal highlight macro-glyphs with its variations.

different types of poems may exploit different part of the vowel system in a language. Having both variations enables scholars to explore different hypotheses.

- Making a logical link between phonemic features and colors helps in remembering the color coding.
- The differentiation between circles and squares are sufficient for scholars to differentiate rounded and unrounded vowels.

Animated Transitions

- It is fun to watch.
- It is intuitive for observing the transitions in the flow of sound, but after a while, one tends to lose the tracking of the temporal ordering.
- It is not easy to follow the movements. The residual line patterns do not convey temporal order or direction.
- Using the line opacities to encode the frequencies of the movement is helpful but can be ambiguous.

Static Transitions with Temporal Highlight

- It is helpful to the tasks of observing some kind of similar phonetic patterns among poetic lines, such as the frequencies of certain phonemic features and transitions.
- It is intuitive for observing transitions in the flow of sound, but after a while, one tends to lose the tracking of the temporal ordering.
- The residual line patterns convey adequate directional information and frequency, but do not show temporal ordering.
- The moving highlight is helpful but not sufficient for remembering the temporal ordering.

In general, macro-glyphs with animation are fun to work

with. Nevertheless, for the task of analyzing the phonetic dynamics in poems, macro-glyphs that convey most information statically are more useful. The domain experts considered that no single phonemic feature is important by itself. An individual feature may become interesting and significant in relation to other phonemic features, or other aspects of poems. The macro-glyphs allow scholars to observe and make connections between these features.

5 Conclusions and Future Work

This design study has shown that it is feasible to use macro-glyphs to encode a small amount of temporal information while depicting multivariate features. In visual analysis of phonetic dynamics of poems, it is important for a visual representation to support the observation and external memorization of temporal ordering, and directions of the movement. The domain experts prefer to have different visual representations for observing different types of dynamics (e.g., emphasizing vowel height or frontness), while having an essential requirement for observing different multivariate features at individual phonemes in a temporally connected manner. The study also confirms the disadvantages of animation at least from the perspective of analyzing phonetic dynamics in poems, while echoing the previous findings in [RFF*08, Fis10]. Our future work will focus on the visualization of temporal patterns of poetic lines while preserving the spatial context of phonetic features.

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