Augmenting Free-Form Annotations with Digital Metadata for Close Reading of Poetry

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Declaration

This work has been undertaken in collaboration with Dr. Mark Hancock and Adam Bradley. All researchers have equally contributed to the design and execution of the observational study of poetry critics' work practices, analysis of the study data as well as derivation of guidelines for the design of literary inquiry and analysis tools.

Parts of this work have been previously incorporated in a paper submitted for review.

Hrim Mehta
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Abstract

Many people, literary critics in particular, practice *close reading*, making annotations by hand while performing a detailed analysis of a text. Current digital tools for literary criticism, however, have many limitations with respect to annotation. In this work, we present an ethnographic study of 14 professional literary critics performing free-form annotations in the context of literary criticism, and a subsequent tool, MetaTation, for enhancing the close reading process, based on our findings. Our study revealed a set of cognitive processes supported through free-form annotation that have not previously been discussed in this context. We derived design guidelines for digital tools which augment active reading and annotation. The resulting system, MetaTation, uses an interactive pen-and-paper system with a peripheral display to provide analytic support while minimizing interference to the cognitive processes that guide the work flow. Through turning paper-based annotations into implicit queries, MetaTation provides well-organized and relevant supplemental information in a just-in-time manner.

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Chapter 1

Introduction

In this work, we explore the problem space of computationally augmenting the practice of close reading through an investigation into the act of annotation that is inherent to this form of sustained analysis. At first glance, the practice of annotation when it comes to literary analysis might appear to be straightforward. But, when asked to analyse a poem, we found that literary critics participate in a very complex cognitive "shorthand" for trying to make sense of the many layers of meaning within a text. It is this process of discerning the meaning of a text that researchers within the digital humanities community have been trying to augment with analysis tools based on close reading.

1.1 Motivation

Literary criticism can be conducted through a multitude of approaches. One such approach, close reading, is the practice of comprehensive and thorough analysis and interpretation of a single text. Traditional literary critics engage primarily in this form of analysis that focuses on paying close attention to syntactic, semantic, structural, rhetorical, and phonetic features of a text and their interactions across the space of the text as well as with each other. This is then followed by reasoning through the observations made to extract meaning from the text. This process is inherently experiential—interpretations of the text vary from one person to another as well as from one context to another. Digital humanities tools such as, WordSeer [20], PoemViewer [1], and Myopia [3], have previously attempted to computationally augment this form of linguistic analysis with limited adoption by the literary community. While not conclusive, it is interesting to note that none of the 14 literary critics participating in our observational ethnographic study had previously used any of these digital tools to support their analyses.

Close reading can be contrasted with the approach of distant reading [18] that harnesses the power of computation to aggregate and quantitatively analyze massive amounts of text corpora for the purpose of sense-making. Tools for distant reading for literary analysis present broad overviews of huge collections of text to support exploration of trends across documents.

Tools like PoemViewer [1] do an excellent job of presenting meta information in a highly stylized and visually appealing way, but end up neglecting the need for allowing critics to *experience* the language by themselves which is critical to the process of sense-making. This gets further complicated by the fact that literary critics often perform multiple readings of a single text with specific lenses or contexts for analysis. In this work, we present the results of an observational ethnographic study and discuss implications for the design of linguistic support tools for augmenting the practice of close reading. We also describe the design and implementation of a tool, MetaTation, based on these design guidelines, with a subtly different interaction paradigm from previous conceptions that allows integration of the process of generation and presentation of just-in-time, context-specific meta information within a literary critic's existing work flow.

We provide evidence that, within the act of free-form annotation for the purpose of interpretation, there are cognitive processes that are universally present and should be supported by tools for literary analysis. We have designed MetaTation—a system that allows literary critics to interact with a text using pen and paper, which generates useful metadata in real-time by interpreting the critic's free-form annotations (see Figure 1.1). In this way, we support the cognitive processes involved in a critic's close reading process, while minimizing interference with their existing work flow, to offer suggestions for further investigations based on what they have highlighted as important.

Previous work in this domain has presented this information up front, before any work has been done by the analyst [1, 3, 17], essentially limiting the possibilities for the types of cognitive engagement required by the task. We found that by instituting a subtle shift in design from offering information before the active work flow has started, to after the critic has already highlighted important components, allows for augmenting the process with minimal disruption. Moreover, while these previous tools provide meta information through an automated analysis of the text being analysed, we interpret the annotations being made by the critic in real time to present only information relevant to parts of the literature that have been noticed and analysed by the critic.

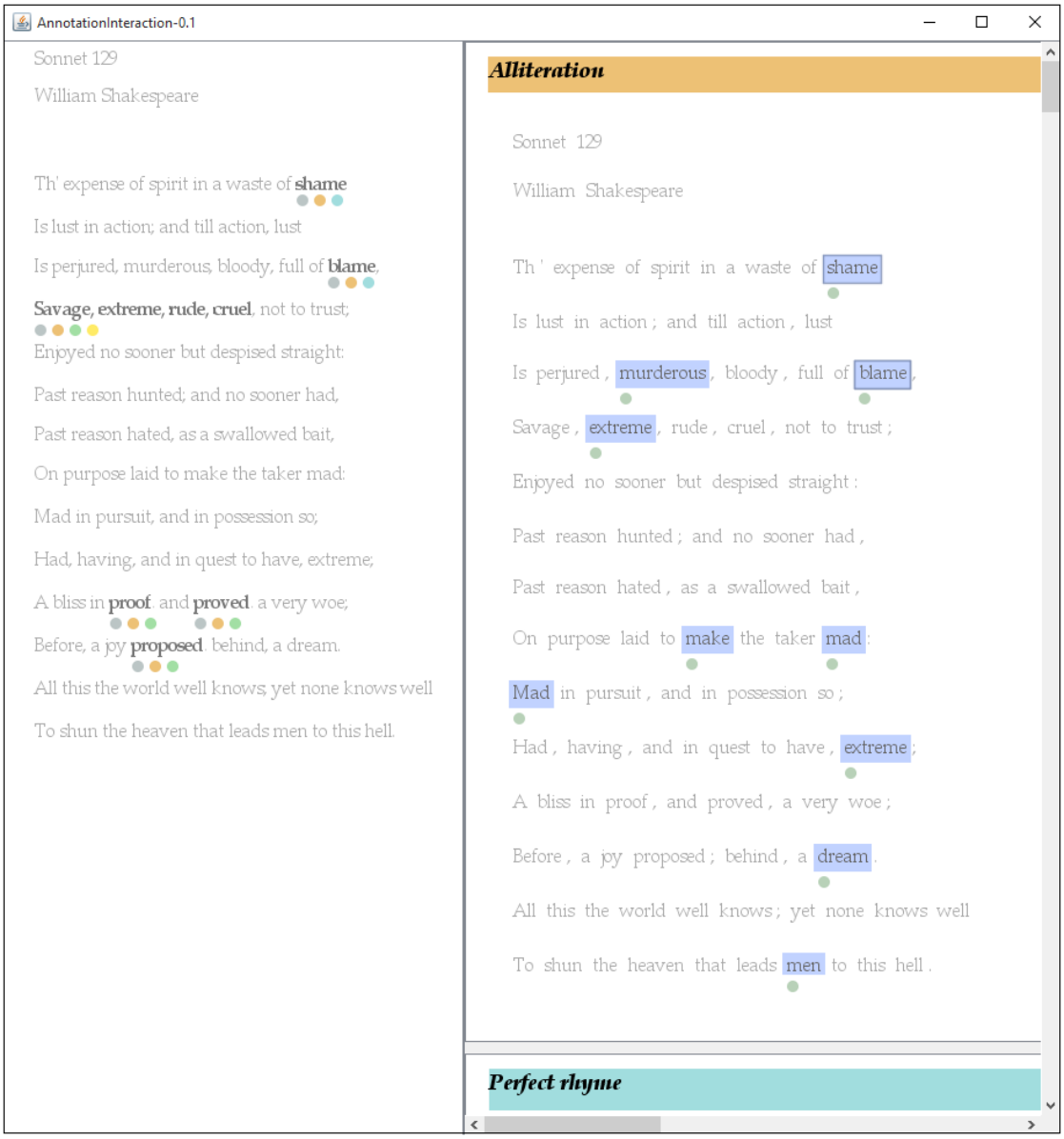

Fig. 1.1 The MetaTation interface. The left worksheet viewer panel shows annotated words in grey, and available query results are indicated by colour-coded dots below the words. The right panel shows a stream of metadata tiles which present query results.

1.2 Contribution

The main contributions of this work are as follows:

- Results of an observational study of expert poetry critics, as they analyse poems, providing insights into the annotation strategies employed to conduct linguistic analysis.
- Design guidelines for the development of digital tools for supporting linguistic inquiry that integrate reader annotations as implicit interactions for invoking supplementary metadata.
- Design and implementation of a prototype system, MetaTation, that provides context-specific meta information to a reader in real-time based on the aforementioned guidelines.
- Results of a preliminary expert review of the developed system.

Our work builds upon research in digital humanities and human-computer interaction to provide digital tools for literary analysis by focusing on closely integrating this technology into existing work practices of annotation.

Chapter 2

Background

In this chapter we review several areas of work that are most related to our own: pen and paper vs. digital documents in active reading, studies of annotation practices, systems using annotations for inference, and tools to support literary analysis.

2.1 Pen-and-Paper vs. Digital Documents in Active Reading

Active reading is the practice of actively and critically engaging with the content of a text for the purpose of extracting its meaning. Active reading has been studied by previous literature with the aim of understanding the effects of substitution of pen-and-paper by digital documents on the process of text comprehension. O'hara and Sellen [23] presented a comparison of active reading practices for performing a text summarization task when using physical and digital documents. It was noted that annotating while reading aids text comprehension by facilitating the development of an internal representation of the text through re-structuring and collation of information, and that annotations also serve as sources for later reference. Physical paper was reported to have better affordances to support active reading practices than digital documents, such as flexibility of free-form in-context ink annotations, ease of switching between annotating and reading, ease of cross-referencing of multiple documents, and bimanual interactions, among others.

Morris et al. [19] employed a similar study design that used paper or digital documents on tablets, that also compared a stylus-enabled horizontal display to a dual-monitor desktop setup. It was observed that paper and tablets were preferred overall for both reading and annotating, with dual-monitor desktop setups performing the worst. Though experience using tablets and horizontal displays was comparable to that of paper, insufficient margin

space and mode switching while inking were noted as challenges. However, no significant difference in terms of the number of annotations made and annotation forms was observed.

Similarly, our observations of poetry critics' annotation strategies when performing close reading also reflected the preference for using paper over digital documents and indicated the need for providing support for free-form annotations.

The benefits of coupling physical and digital documents were explored as early as DigitalDesk [35], a physical desk that allowed interaction with digital documents via a projected display. Since this work, many systems have explored the augmentation of paper notebooks for digitization and assimilation of handwritten notes [13, 33, 37]. Many researchers have specifically investigated the use of predefined regions and pen gestures on interactive paper to support work flow practices in various application domains. Print-n-Link [22] is one such system that uses internal document structure combined with written gestures to access digital information or to search cited documents from a printed version of a publication to support active reading of scientific publications. Along similar lines, Liao et al. [12] support knowledge gathering and assimilation through the use of predefined pen gestures on a user-specified region of a printed document.

Another system developed by Singer and Norrie [30] used hotspots printed on interactive slide paper handouts to control PowerPoint slides when working in a collaborative environment. CoScribe [32] similarly leveraged the benefits of coupling physical and digital documents in the context of academic reading by providing support for sharing of handwritten notes and annotations by students on printed lecture slides, in addition to the use of predefined pen gestures for linking and tagging of various physical and digital documents, aimed at supporting students' work flow. There are also examples of cross-media platforms where annotation and another art form are mixed together within the bounds of tool design. For example, Musink [34] allows predefined or user-defined commands to be associated with different types of annotations made by composers on music sheets to better integrate the various physical and digital tools available for music composition. MouseLight [31], a tool that explores bimanual interaction of a mobile projector and digital pen to augment physical paper with virtual information, is an example of subsequent research focused on closing the feedback loop from digital to physical documents.

These systems are very related to our own work, but focus on materials where the experience of reading itself maybe less relevant (for example, scientific publications, lecture slides). While some of our design decisions use known technology (for example, Anoto, stroke recognition), and elements of our design have been seen in other domains (for example, implicit queries), our observational study highlights the need to support the experience of language in the analysis of literature as primary. Our work differentiates itself through the

goal of supporting the experience of close reading, paramount to the sense making process, without interfering with the work flow common in literary criticism by analysing free-form annotations in real time.

2.2 Studies of Annotations

There is a also a subset of previous work that deals specifically with ink annotation that has implications for digital design. Marhsall [15] examined the form and function of annotations made by university students in used textbooks. It was noted that annotations made by students were either a part of a personal coding system, rendering their meaning to be non-apparent, or explicit enough for their meaning to be clearly understood. A distinction between the observed annotations was also made based on their spatial location on the page. Annotations were identified to be functioning as place-markers or memory aids, interpretations of the original text, problems being worked out in context, a visible trace of a reader's progression through the text, or just reflections irrelevant to the text content. Based on these observations, design guidelines for the development of annotation tools were presented, such as the need for support of idiosyncratic annotations, and interleaving the process of annotating with reading while ensuring minimal distraction from the reading task, among others.

Marshall and Brush [16] also characterized annotations made by students when reading papers and compared them with annotations that ended up being shared online. Paper was identified as the preferred medium for reading. Interleaving of annotation with reading was the observed norm, and annotation practices were reported to vary based on the purpose of reading. Annotations were coded as being anchor-only (e.g., underline, circle, margin bar, etc.), content-only (e.g., notes, marks (such as *), doodles, etc.) and compound (anchor + content). It was observed that the majority of the annotations were anchor-only with less than 20% of the total annotations being content-only or compound. It was also noted that annotations were more frequently anchored at the sub-sentence level than at sentence-level or even longer segments of text. We found our study to be consistent with the findings. Even though our context was slightly different we recognized the same phenomena when it came to anchoring and content.

Our work extends this literature by considering annotations made in the domain of poetics, with specific attention to the experience of reading the language, which from our study we know to be reflected in the practise of annotation. We make use of the external cognition framework [27] to determine the role of annotations in text comprehension with the aim of resolving annotation form-function ambiguity for generating context-specific supplementary data to augment the close reading process.

2.3 Using Annotations for Inference

Most of the work on reading practices has so far focused on moving from paper to digital, and thus many tools have been developed to support paper-like annotations on digital devices [24, 36]. There are fewer examples of research that explore the idea of using physical annotations on a page as direct input to a digital tool, but some work has also explored this idea. XLibris [28], a pen-enabled tablet display with paper-like affordances for supporting active reading, was the first to make an attempt at using annotations made by a reader to generate additional relevant content. Words annotated by a single pen stroke were used as keywords to retrieve research papers relevant to the one being studied. These papers were then presented to the reader as links in the margin close to the pen stroke that invoked this retrieval. Our system also aims at using annotations made by a reader during the analysis process as cues to generate real-time context-specific supplementary data to augment active reading. However, our system differs from this work in that we focus on physical pen strokes on paper, and process information specific to the words on the page, rather than higher-level concepts like related literature to the entire document or context.

We also find applications in other fields, which makes a case that even domain-specific tasks can be considered generalizable. Shipman et al. [29] analysed annotations made by students when preparing briefs on legal cases for a moot court session and characterized high-value annotations that can be used to identify important passages from a document. While their tool is similar to our work, as they also extract meaning from annotations made by hand on documents, their tool is intended to automate the process of summary and extraction when reading, rather than the processes involved in a focused analysis of literature.

2.4 Tools to Support Literary Analysis

Jänicke et al. [10] present an in-depth review of existing digital humanities tools for supporting close as well as distant reading. The subset of tools that are focused primarily on literature often look to demonstrate patterns across huge collections of texts. Text visualization tools like TextArc [25], Docuburst [6], WordSeer [20], and Compus [8] are highly effective at supporting exploratory analysis of literary texts through distant reading. These tools present broad overviews of massive amounts of text corpora based on quantitative linguistic analyses, while also supporting exploration of finer connections that reveal patterns within and between documents. Our work takes an opposite approach, focusing on close reading and the relationships between individual words.

Poetic language defies the general rules of syntax and semantics observed in prose, resulting in a complex dynamic system that exhibits a variety of highly charged semantic, syntactic, structural, and phonetic features. Several visualization tools have thus been developed specifically for supporting the analysis of poetry. PoemViewer [1] supports close reading of poetry by allowing an exploration of semantic and phonetic relations in a poem through the use of rule-based visual mapping techniques. It visualizes semantic relations such as, word repetitions, parts-of-speech, and sentiment, as well as presents various types of phonetic relations such as, assonance, consonance, alliteration, end rhyme, etc. in addition to providing information about the physiology of sound production. Myopia [3], a visualisation tool for close reading of poetry, presents poetic elements such as, meter, sound, syntax, metaphor, and personification to support literary analysis of TEI(Text Encoding Initiative)-encoded[1] texts. ProseVis [5] allows interactive exploration and visualisation of sonic features in a text such as, phrase boundaries, parts-of-speech, phonetic spelling, stress, and rhythm markings, to aid the discovery of phonetic patterns within a text at different levels of granularity. Poemage [17] is another such tool that supports visualization of the interaction of complex sonic patterns across a poem.

While the existing tools provide highly detailed meta information through visualizations of poetry, they are disconnected from the existing work flow and provide little support for annotations, which previous literature shows to be intrinsic to close reading [23]. Moreover, these systems do not currently allow the analyst the space to experience the text. These systems instead tend to present information up front, without providing an opportunity to reflect and contemplate the words. In our work, we attempt to address this problem; we designed a study to specifically look at the moment of interaction that is required by the work flow. And although the change is subtle, allowing the user to first interact with the text and then with the system, allows for the type of thinking and experience of language that is required by literary criticism.

[1] http://www.tei-c.org/index.xml

Chapter 3

Observational Study: Annotation Practices in Poetry Criticism

Although most of the current linguistic support tools offer exhaustive analytic assistance in the form of stylized visualizations, they tend to present the processed data prematurely[1] without providing readers the opportunity to reflect upon the content on their own while also being disconnected from the readers' existing work flow. To address these shortcomings, we explore the possibility of leveraging annotations, intrinsic to the practice of active reading [23], as cues for identifying the type of computational support apt at augmenting the analysis process as well as to infer the appropriate moment in time to invoke the assistance and present the generated supplementary data to the reader. Close reading is inherent to the work of literary scholars and thus an investigation into their work practices could help us determine ways to improve support for linguistic inquiry and analysis. To this end, we conducted an observational ethnographic study probing into the work flow of literary critics as they analysed poetry.

3.1 Study Design

In order to better understand the role of annotation and the use of external resources (digital or otherwise) in active reading and literary criticism, we designed an observational study as described in the following sections.

[1] as evident from the results of our study

3.1.1 Participants

We recruited 14 participants (11 male and 3 female), comprising of 3 PhD students and 11 university professors with varied areas of expertise who publish works of literary criticism and/or teach literature, from three different universities in Canada. The practice of annotating while analysing poetry was reported as being intrinsic to the current work flow of 9 of our participants. For the remaining participants, this practice was noted to be more prevalent when analysing poems they were to teach, but was nonetheless an important part of their routine.

3.1.2 Dataset

Literary critics generally possess expertise in specific literary time periods and thus a critic specializing in Modernist literature would not have comparable proficiency in Elizabethan literature. Consequently, ensuring the inclusion of works of diverse poetic styles from different eras was essential to mitigate the effects of expertise bias in our study. Since the division of literary history into appropriate epochs and a subsequent selection of specific works of poetry of recognized scholarly import from each of these epochs would have been contentious, we deferred to the well-respected Norton Anthology of Poetry [9] to generate the poetry dataset to be used in our study.

We randomly selected 14 poems, two from each of the seven time periods (1510–1620, 1620–1690, 1690–1780, 1780–1830, 1830–1880, 1880–1920 and 1920–), from the aforementioned anthology. These 14 poems were then randomly grouped into seven pairs such that each pair comprised of poems from two different time periods. Pairs of poems were counterbalanced and randomly assigned to the participants for analysis so that each pair was analyzed by two participants, once in each ordering. Requiring each participant to analyse two poems and the use of a common pair of poems between two participants permitted us to observe how the annotation practices varied with the work being analysed as well as with the reader.

3.1.3 Task & Procedure

Each participant was requested to perform a close reading (analysis) on an assigned pair of poems. Each poem was printed on a single sheet of Anoto paper and participants were provided with a Livescribe[2] Anoto pen for annotations. The Anoto pen tracks pen position

[2]http://www.livescribe.com

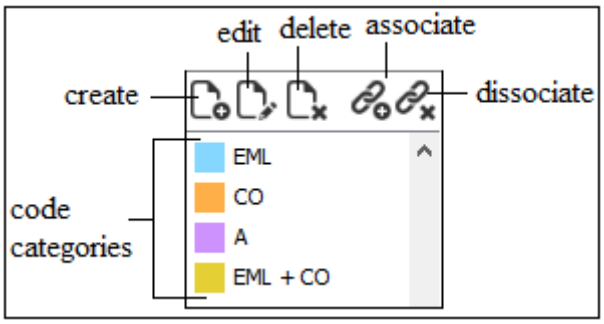

Fig. 3.1 The code set panel allows us to create, edit or delete code categories and supports association or dissociation of code tags to annotation units defined in the poem sheet panel. Filtering of code tags in the poem sheet and session video panels is achieved by selecting code categories of interest in this panel.

on the Anoto dot pattern permitting us to record pen strokes made by our participants as they annotate the printed sheets of paper.

Observational sessions were conducted in the usual work environment of the participants and were audio and video recorded. The video was recorded from two separate angles: one from directly above the desk to capture how the participant analysed a poem and a second facing the participant to capture facial expressions when analysing. We also logged pen strokes made by the participants using the Livescribe software and collected the physical paper at the end of the analysis session.

Participants were instructed to conduct a close reading, in accordance with their existing work practices, on each of the assigned poems until they were finished or until 15 minutes had passed. In our pilot studies we discovered that this analysis process was a highly personal experience and that the presence of an experimenter was distracting. Therefore, the participants were left alone to work during each of the 15 minute sessions. Participants were not required to annotate the poem as they performed the analysis, but if they did, they were requested to use the provided Livescribe Anoto pen. Participants were also permitted to access any form of available external resources that they would normally use. At the end of an analysis session, participants were asked to explain the function of the annotations they made during the session through retrospective think aloud with the physical annotated poem as a guide. The same procedure was then repeated for the second poem assigned to the participant.

The observation sessions concluded with a brief recorded interview regarding participants' current annotation practices with respect to close reading.

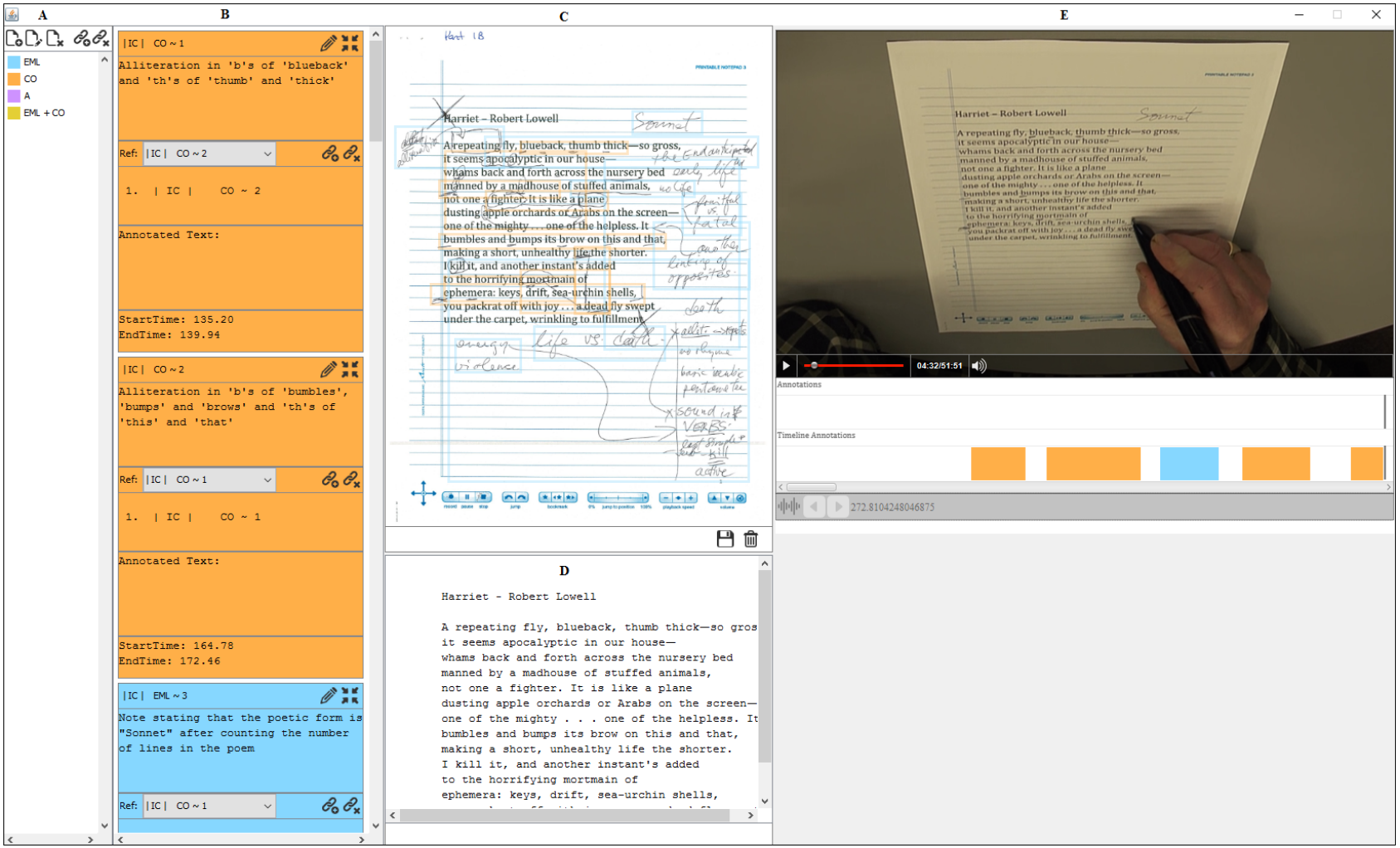

Fig. 3.2 The data analysis tool comprising of five components namely, code set panel (A), code tags panel (B), poem sheet panel (C), poem text panel (D), and session video panel (E).

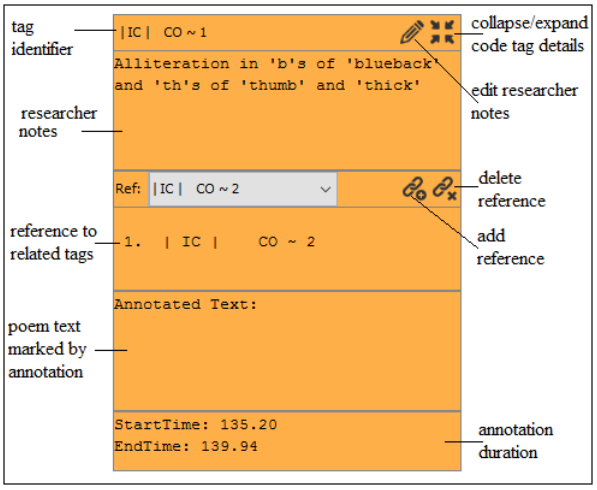

Fig. 3.3 The code tag identifier allows us to determine data source type, code category and identifier of the annotation unit to which it has been assigned. It also serves as a link to the annotation unit defined in the original source. Each code tag carries researcher notes, references to related tags as well as the duration of and the poem text marked by the corresponding annotation unit.

3.2 Study Data Analysis

We used open coding for qualitative analysis of the recorded observation sessions. We developed an interactive tool to support assimilation of the gathered data comprising of logs of pen stroke data from Livescribe, scans of the final annotated sheets of poems, videos of the analysis sessions, and videos of the retrospective think aloud sessions. This tool enabled categorisation of the raw data based on a user-specified code set and exploration of the trends in the coded annotations for a given participant.

3.2.1 Data Analysis Tool

The data analysis tool is comprised of five panels, as shown in Figure 3.2. The code set panel is used to define and edit categories of a code set as well as for assigning code tags to annotations in the original data source (see Figure 3.1). This panel also supports filtering of the annotations and their associated code tags based on the defined code categories. The code tags panel docks all code tags assigned to a participants' annotations. Code tags carry information about the data source type (scanned sheet or video), researcher notes, annotated poem text (if any), duration of the annotation, and references to other related code tags in addition to serving as links to the annotations in the original data source (see Figure 3.3). The poem sheet panel is used to delineate annotation units to be coded and to display assigned code tags overlaid on these units in the scanned sheet of poem to permit comparison of

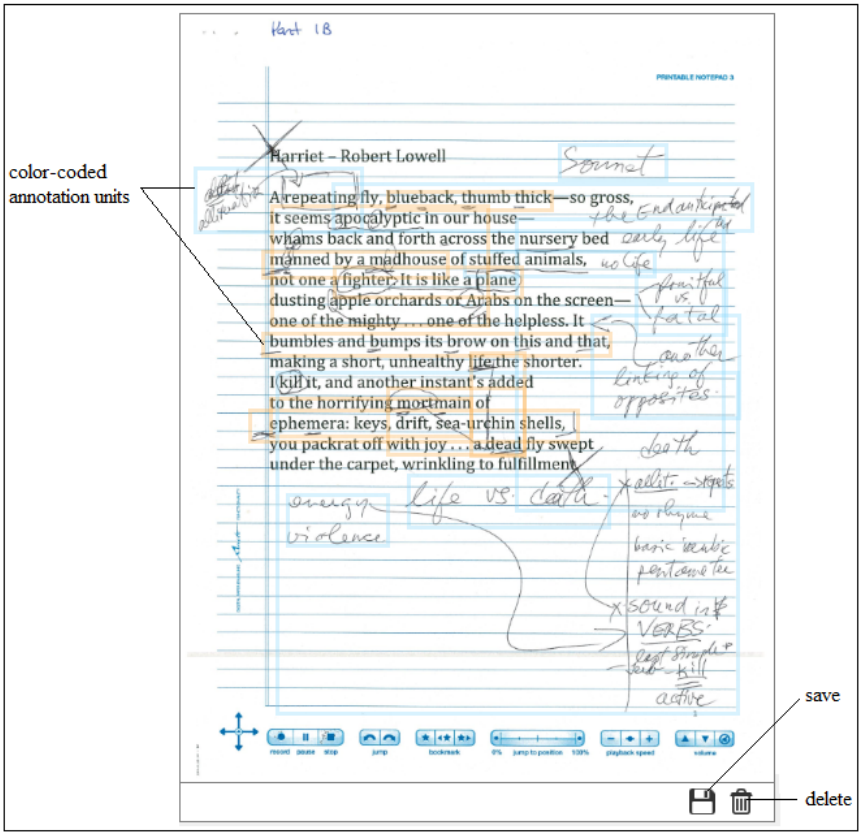

Fig. 3.4 The poem sheet panel is used to manually define annotation units to be coded and indicates the code tags associated with each of the units through color-coded bounding boxes.

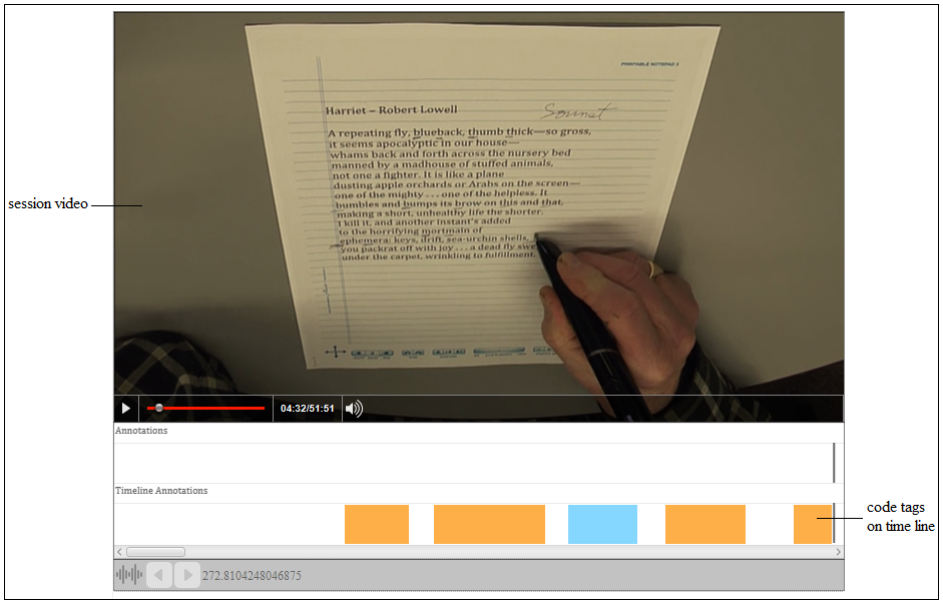

Fig. 3.5 The session video panel embeds a video of the analysis session and displays code tags assigned to annotation units in the order of their occurrence on a time line.

Table 3.1 Categories of codes in the final code set.

Code Category	**Code Subcategory**
Form	Ellipses, polygons, connectors, brackets, text, miscellaneous notations
Cognitive Purpose	CO, EML, EML+CO, A

distribution of the code categories across the space of the page as shown in Figure 3.4. The poem text panel facilitates entry of the text of a poem marked by an annotation in the code tags. The session video panel (see Figure 3.5) comprises of two components: a video of the analysis session with controls for noting the duration of annotations in the code tags and a time line that displays code tags based on the occurrence of their respective annotations during the session to facilitate comparison of temporal pattern of the code categories.

Logs of pen stroke data recorded by the Livescribe software were individually processed prior to the coding task to generate axis-aligned minimum bounding boxes for the pen strokes and for grouping the pen strokes into clusters to automatically delineate annotation units to be coded. This was done to prevent coder disagreement on what makes a single annotation unit. However, since the clustering process is error prone, it was decided to instead refer to the retrospective think aloud sessions to manually define annotation units for both the pen stroke logs as well as the scans of the final annotated sheets of poems. While coding, we noticed that for overlapping pen strokes, the pen stroke logs were inaccurate in noting the pen strokes' time stamps. In addition to that, pen strokes that crossed over the printed words were not at all captured by the pen. These issues however were not observed during our pilot studies since the participants were careful to minimize overlaps with other pen strokes as well as avoided crossing over the printed words. We consequently decided to eliminate the pen stroke logs from the coding process and instead only reference them in the cases when the analysis session videos were unclear. For example, if the sheet was momentarily moved outside of the frame of the camera when writing.

3.2.2 Coding of Study Data

Two researchers iteratively worked on randomly selected samples of data to develop a mutually agreeable code set and guidelines for categorisation of the annotations. The final code set comprised of two categories of codes, *form* and *cognitive purpose*, each of which consisted of several subcategories of codes (see Table 3.1).

The *form* code category was defined with the aim of supporting an exploration of the forms of annotations. In the initial iteration of the coding process, *form* code comprised of 29

Table 3.2 Subcategories of form codes.

Form Code Category	Form Code Subcategory
Ellipse	Circles, spirals, concentric circles
Polygons	Squares, rectangles, triangles, others
Connectors	Arcs, angular arcs, single-headed arrows, double-headed arrows, cross-headed arrows, arrow-headed wavy arcs, circle-begin and underline-end arcs, circle-headed arcs, lines
Brackets	Regular square, half-square, round, double round, curly, vertical line
Text	Letters, numbers, special characters
Miscellaneous Notations	Squares, rectangles, triangles, others

Table 3.3 Initial code categories for examining annotation function.

Purpose Code Category	Purpose Code Subcategory
Poetic Elements	Connections, grammar, syntax, semantics, diction, sound, rhyme, alliteration, consonance, assonance, repetition, syllable counts, stress, rhetoric, allusions, bibliographical information
Reading Habits	Reading the poem out loud, reading the poem silently, pausing to look up information, idiosyncratic habits while reading

subcategories of codes (see Table 3.2) that were grouped and refined in subsequent iterations to generate the final form code categories listed in Table 3.1.

To identify the cognitive processes involved in active reading, we examined the functions of annotations. We started by categorising annotations based on the poetic elements they identified in addition to noting participants' reading habits, generating the code categories listed in Table 3.3. We realised however that while these codes helped us identify the type of supplementary data that could be of interest to poetry critics, they were inadequate at indicating the higher level cognitive processes involved. We then reviewed frameworks for external cognition that explain the role of external representations in supporting cognition to investigate the possibility of the identification of the cognitive processes involved through the use of annotations that serve as a visible trace of a participant's thought process.

Codes based on the *cognitive purpose*, served by the process of annotation in text comprehension, included: computational offloading (CO), externalizing to reduce memory load (EML), both computational offloading and externalizing to reduce memory load (EML+CO) and ambiguous (A). CO and EML codes have been derived, in the context of annotations and active reading, based on the main cognitive benefits of using external representations identified by the external cognition framework presented by Preece et al. [27]. CO represents the act of thinking through the content by annotating whereas EML refers to the act of tracking intermediate conclusions through the use of annotation. EML+CO is used to denote those annotations for which both CO and EML are being performed as a contiguous unit while A marks those annotations whose purpose is unclear. Descriptions of the purpose of

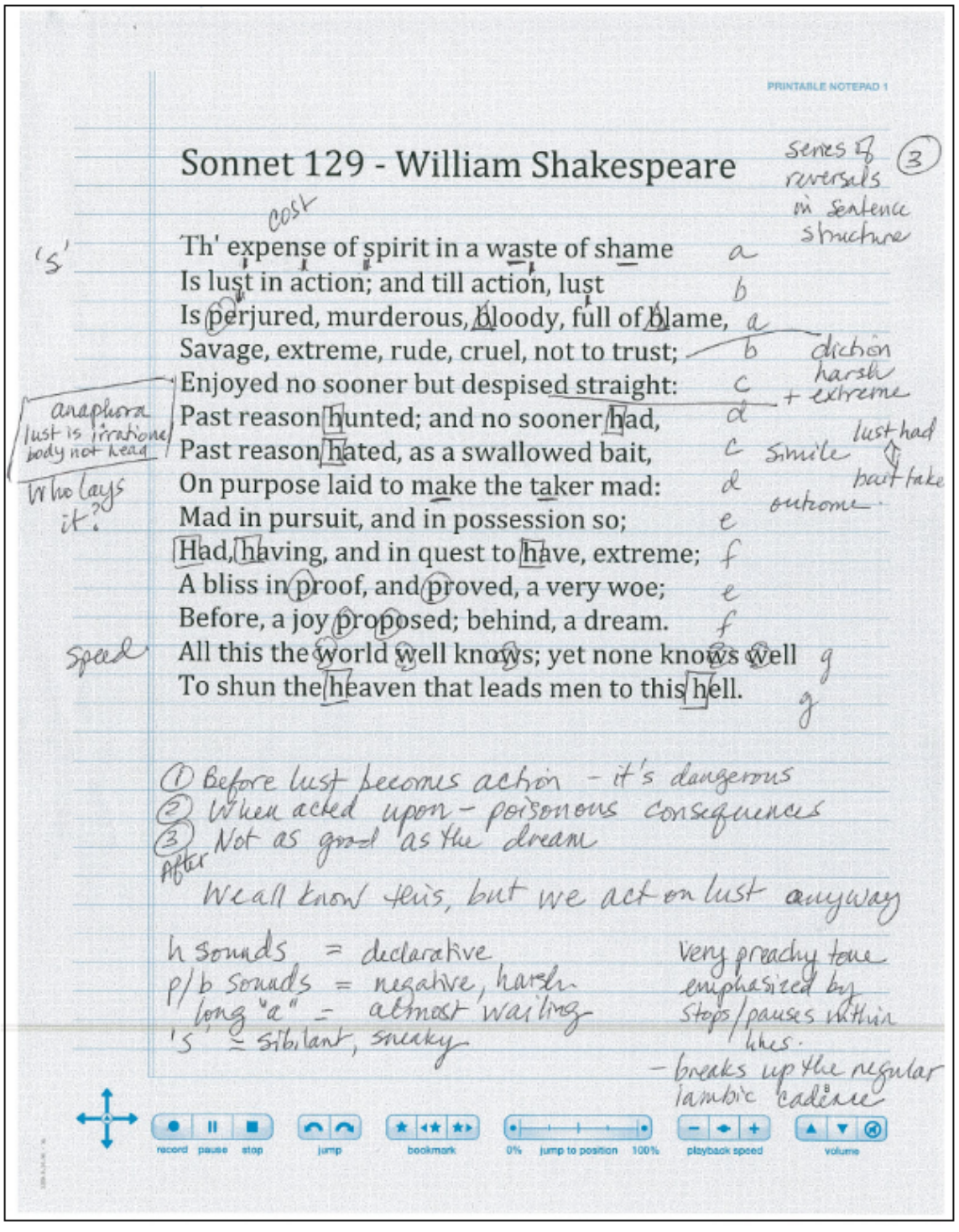

Fig. 3.6 Scan of the final annotated poem sheet for P11/D7.

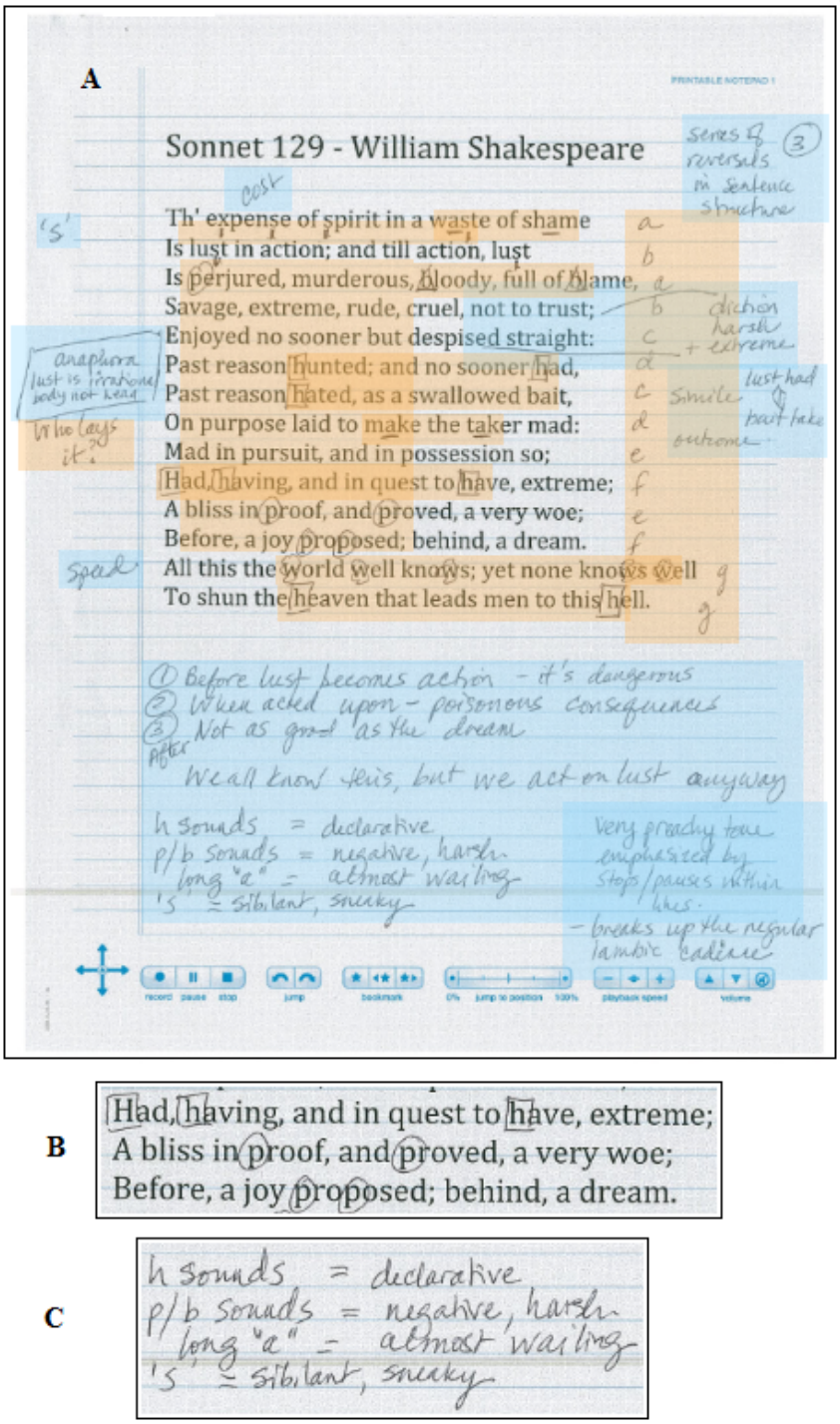

Fig. 3.7 Annotations made during close reading of poetry. (A) shows *cognitive purpose* codes assigned to annotation units for one of the participants' annotations, as visualized by our coding tool. Orange and blue bounding boxes represent annotation units categorised as CO and EML respectively. (B) is an example of an annotation unit, identifying the repetition of sounds, categorised as CO. (C) shows an example of an annotation unit, noting observations about repetitions of sound across the poem, coded as EML.

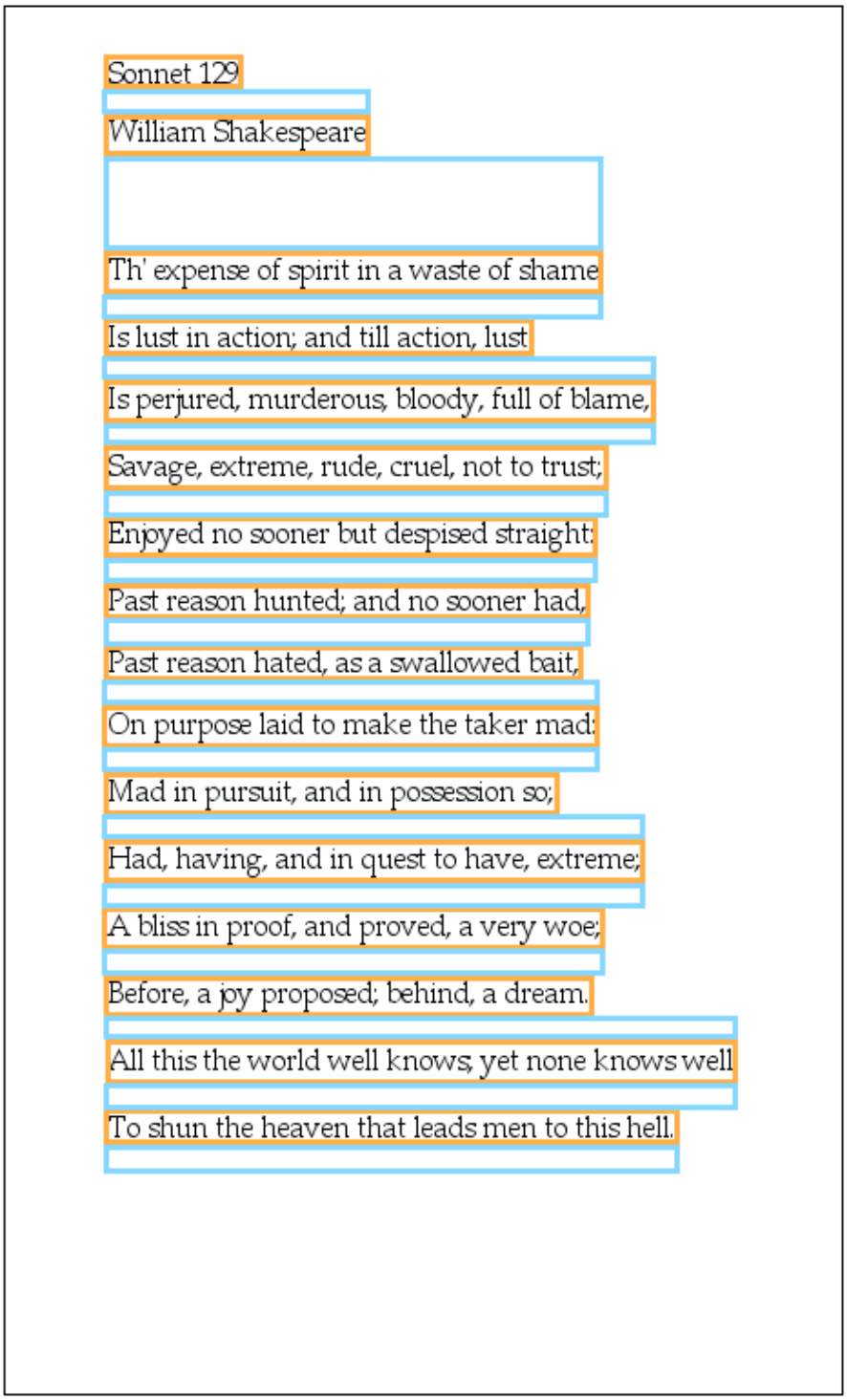

Fig. 3.8 Spaces on the page. Orange bounding boxes delineate the space categorised as word space whereas blue bounding boxes demarcate the space identified as white space. Parts of the page not covered under either of the aforementioned spaces correspond to the margin space.

annotations, elicited through the retrospective think aloud sessions, were referenced to guide this *cognitive purpose* based categorisation. Figure 3.7 shows an example of the result of the coding process, based on *cognitive purpose*, when applied to the final annotated poem sheet for participant P11 (see Figure 3.6).

Annotations were coded as being located either on the text itself (word space), between the lines and stanzas of a poem (white space) or in the margins. At the outset, we manually coded annotations based on the space they occupied. However, inability to achieve coder agreement due to frequent cross-overs of annotations across the different spaces on the page lead us to decide upon automatic categorisation of annotations based on their location. Annotations, with more than 50% of the area of their axis-aligned minimum bounding box falling under the bounding boxes of the lines of a poem, were categorised as being in the word space. Similarly, if more than 50% of the area of an annotation's bounding box was under the bounding boxes of the spaces between the lines and stanzas of a poem, the annotation was said to occupy the white space. All other annotations were noted as belonging to the margin space (see Figure 3.8).

In addition to logging the space of an annotation on the page, the start and end times of the annotation were also recorded. Finally, annotations were manually grouped into semantic units based on participants' explanations during the retrospective think aloud sessions. For example, three consecutive underlines identifying a repeating sound pattern.

Following the code set development, two researchers independently coded four randomly selected sessions out of the 28 analysis sessions and Cohen's κ was calculated to measure inter-rater reliability. The measure revealed good agreement on the coders' judgements for both annotation form $\kappa = .75$ and annotation function, $\kappa = .66$. The remaining 12 analysis sessions were then independently coded by each of the two researchers.

3.3 Results

Notable results from the analysis of the observational study data are described in detail in the following paragraphs.

[O1] Prevalence of Pen-and-Paper: All of our participants reported a prevalence of the use of pen/pencil to annotate printed sheets of paper when performing a close reading to analyse poetry. Only two of the participants stated that they have previously used a stylus/touch-enabled tablet for the same purpose.

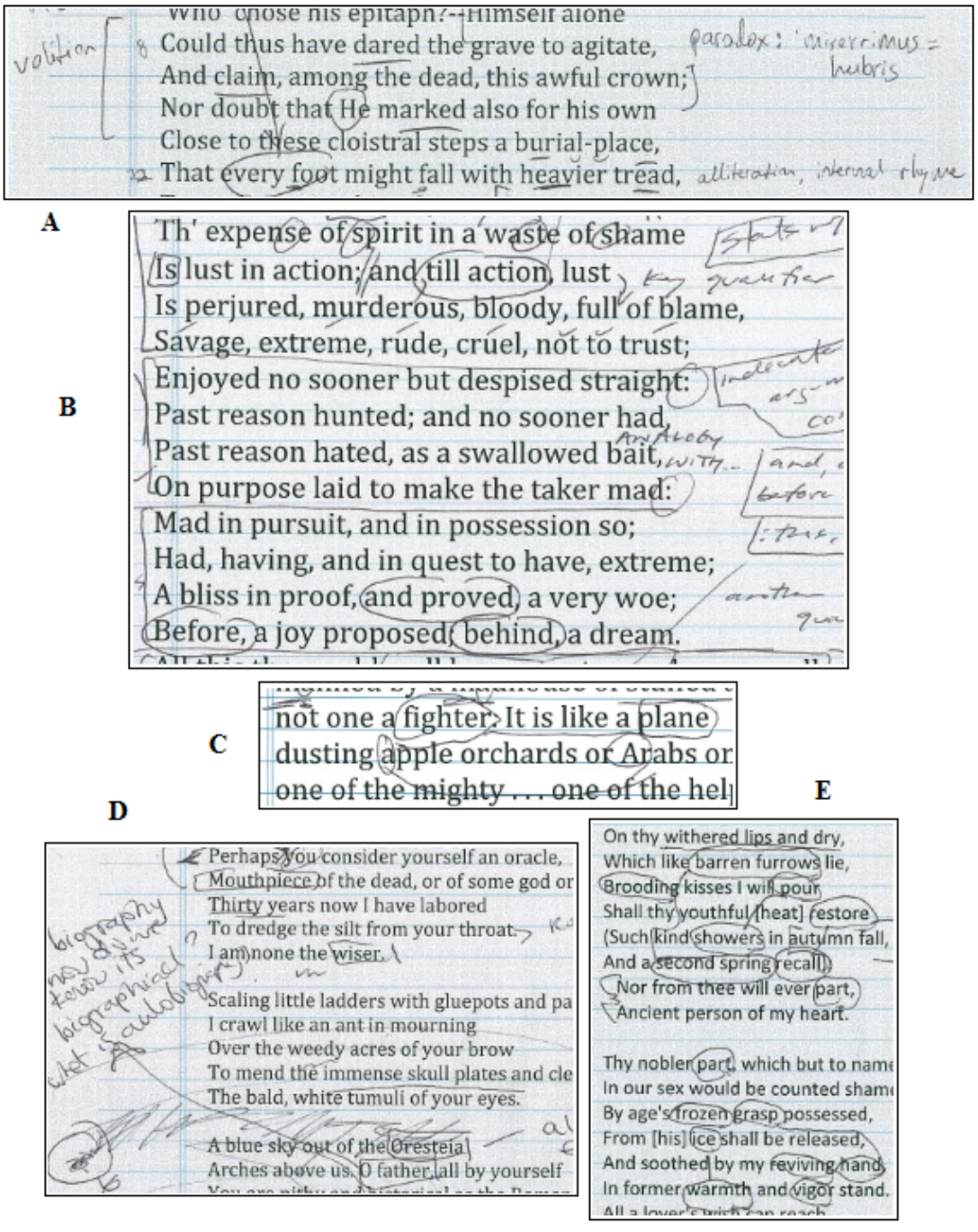

Fig. 3.9 Snippets of participants' final annotated sheets exhibiting annotation polymorphism. Annotation form and function do not hold a one-to-one relation as can be seen in the examples.

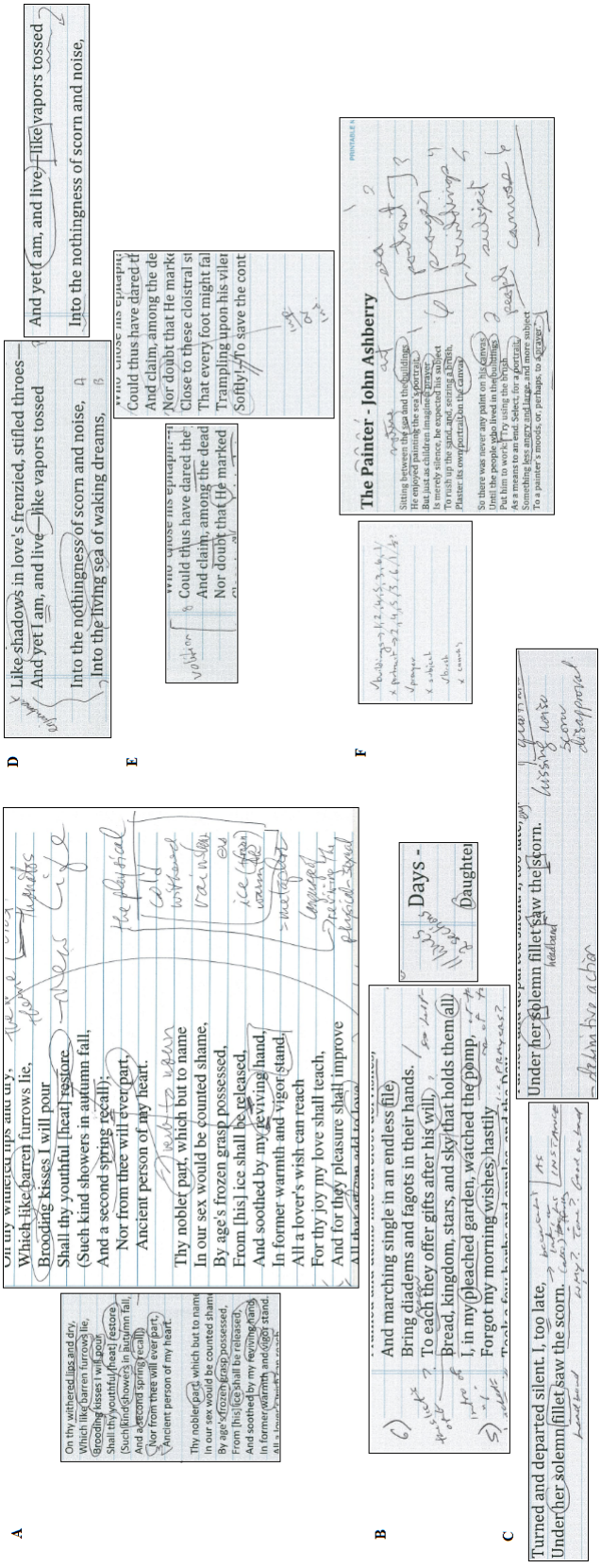

Fig. 3.10 Examples of consistency in the types of activities that participants analysing the same pairs of poems engage in.

Fig. 3.11 Cognitive purpose codes by participant (P1–P14) and poem (D1–D14) and space (colours). Poems are aligned in columns.

[O2] Polymorphism of Annotations: Two of the participants noted that they occasionally use colored pens to visually distinguish annotations made during a current reading of a poem from those made on previous readings of the same poem. However, all of our participants stated that they do not follow a formalized personal system of annotations.

From our observations and analysis of the annotation process it was clear that annotations made by participants were highly idiosyncratic and polymorphic in nature. Annotation form did not consistently hold the same meaning for different participants, or even throughout the annotation process of a single poem for an individual participant. Figure 3.9 (A) shows an example of how underlines are being used by P14 for highlighting both words that are indicative of volition as well as words that exhibit alliteration and internal rhyme. In Figure 3.9 (B), P4 has overloaded the use of circles to indicate repetition of sound patterns, peculiarity of punctuation use, and words employed as qualifiers. Similarly, Figure 3.9 (C) shows how circles and connectors have been used to convey synonymy as well as phonetic relations between words in P1's work. Figure 3.9 (D) is another example of how the meaning associated with an annotation form (square) changes from stanza to stanza for P9. Lastly, in Figure 3.9 (E), P8 has identified both the change in part-of-speech of 'part' and a set of metaphorical words through the use of the same annotation form, circle.

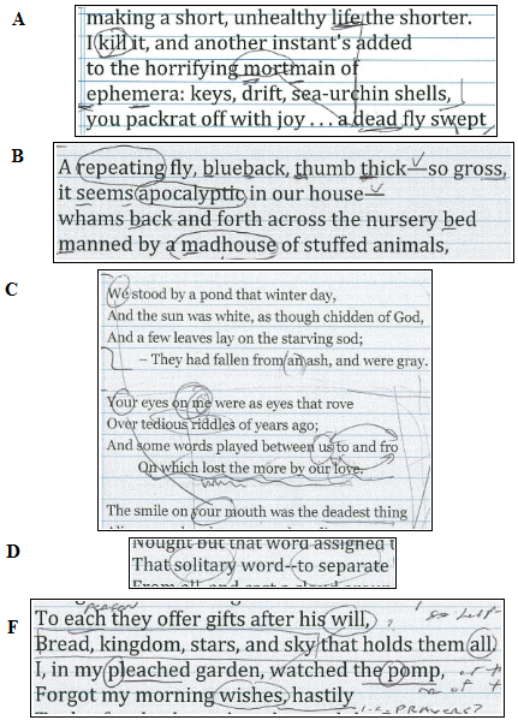

Fig. 3.12 CO annotation snippets of participants' final annotated sheets. As can be seen in the examples, CO annotations tend to occupy the word space and are characterized through the use of common forms in spatial and temporal proximity (implicit connection) as well as explicit connectors for linking words of interest.

[O3] Consistency in Participant Activity: We noticed that all of our participants were engaging in similar activities, although the places on the page and the times in the process varied across participants. For example, both P1 and P8 have identified the use of metaphors in their analysis of D1 (see Figure 3.10 (A)). Figure 3.10 (B) and (C) show notes, on poem structure and pertaining to the meaning of 'fillet' as well as the tone of the line, made by P4 and P11 for D8. P6 and P13 both indicating enjambment between stanzas of D12 as shown in Figure 3.10 (D) is another example of inter-participant consistency. P14 and P7 have used different means for indicating the role of the words 'dared' and 'claim' in D13 as can be seen in Figure 3.10 (E). Similarly, word repetitions in D9 have been tracked and recorded in different ways by P5 and P12 (see Figure 3.10 (F)).

[O4] Annotation Function Disambiguation: We observed that our participants were actively grouping written thoughts and ideas into three main areas of the page: on the text itself (word space), in between the lines and stanzas of a poem (white space), and in the margins. Looking into what function individual annotations served on each area of the page, a clear pattern began to emerge. Annotations that served as a means of computational offloading (CO) were observed to operate mainly in the word space and the white space

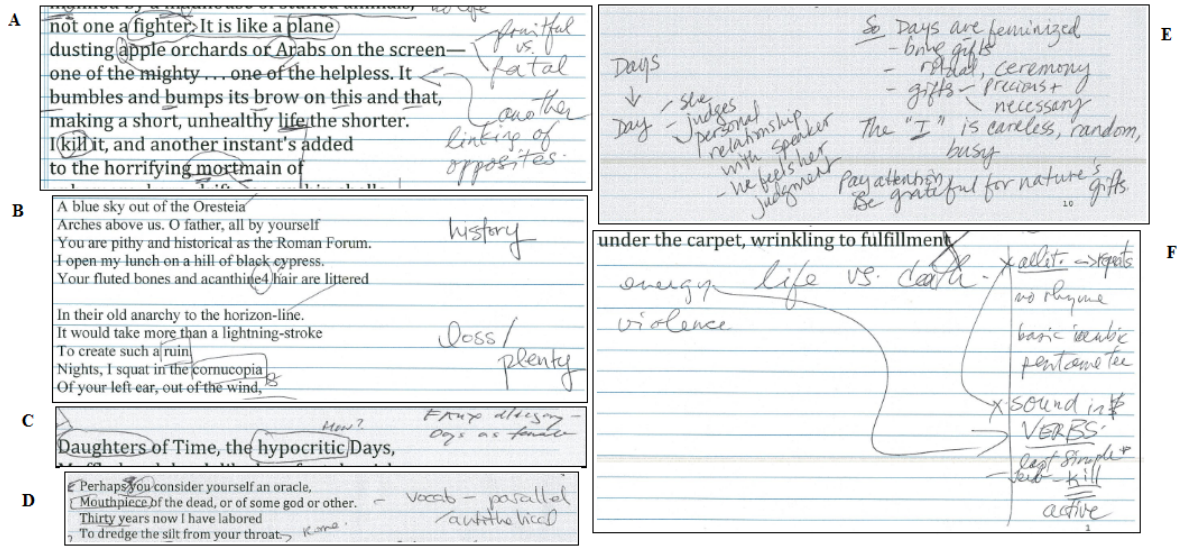

Fig. 3.13 EML annotation snippets of participants' final annotated sheets. As can be seen in the examples, EML annotations tend to occupy the margin space and generally comprise of notes regarding observed patterns of interest or general commentary about the poem.

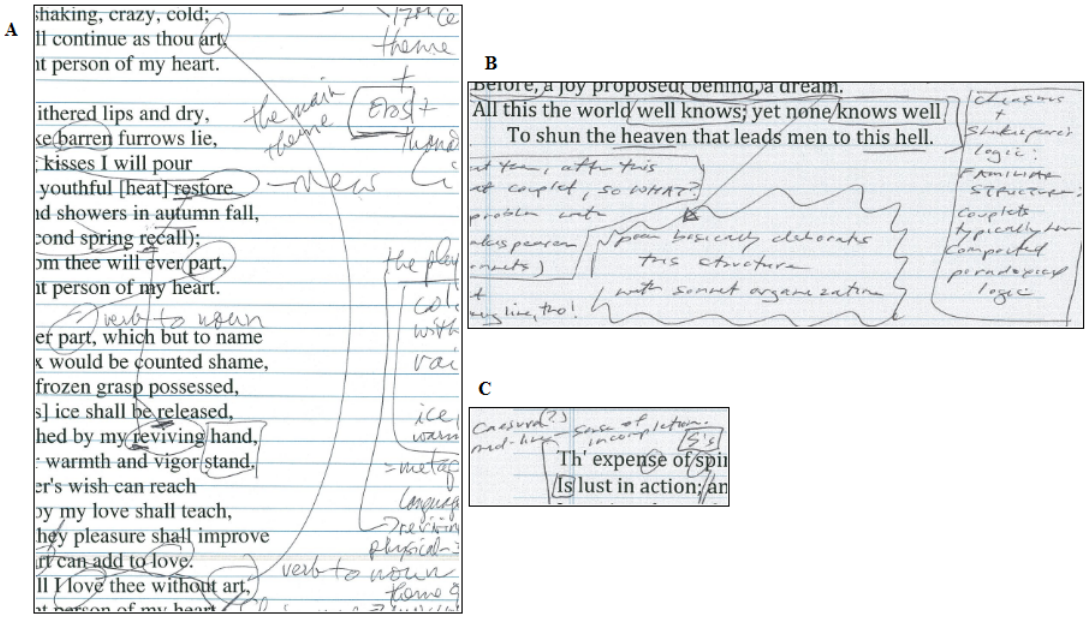

Fig. 3.14 EML+CO annotation snippets of participants' final annotated sheets. As can be seen in the examples, EML+CO annotations comprise of consequent occurrence of CO and EML annotations.

whereas those that served as a means of externalizing to reduce memory load (EML) were noted to occupy mainly the margin space (see Figure 3.11).

Implicit connections of points of interest through the use of similar forms (especially ellipses and underlines) in spatial and temporal proximity, in addition to explicit connection through the use of connectors, was prevalent with CO annotations. Figure 3.12 constitutes of examples of CO annotations made by the participants. In Figure 3.12 (A), P1 has implicitly linked the repetitions of 'm' in 'mortmain' and 'ephemera' through the use of underlines whereas synonymy between 'kill' and 'mort' has been implied via circles. He has also explicitly connected 'mort' and 'dead' and 'dead' and 'life' to point out the synonymy and antonymy relation respectively between the word pairs. Similarly, Figure 3.12 (B) shows how the repetitions of 'b', 'th', 's', and 'm' and those of '—' have been implicitly linked using underlines and check-marks respectively in addition to an emphasis on diction through the use of circles by P8. Figure 3.12 (C) is a snippet from P7's sheet showing how he explicitly connected the occurrences of the pronouns 'we', 'your', and 'me' whereas Figure 3.12 (D) is an example of implicit connection of words of interest through the use of common forms in proximity from P7/D13. Similarly, Figure 3.12 (E) presents an example of implicit linking of the sound in 'pleached' and 'pomp' and explicit connection of synonyms 'will' and 'wishes' in the work of P4.

EML annotations mainly comprised of notes about the participants' interpretations of patterns and themes observed in the poem as well as reminders to look up supplementary information such as, word usage or alluded works. These were linked to the source text through the use of explicit connectors or through spatial proximity to relevant parts of the text. Notes providing general commentary about the poem usually occupied the space towards the bottom of the page. Figure 3.13 (A), (C), and (D) are examples of EML annotations that are notes about patterns observed in the poem whereas Figure 3.13 (B) shows EML annotations commenting about the themes of the stanzas. Notes synthesizing the poem content, placed in the margins at the end of the poem text, are shown in Figure 3.13 (E) and (F).

EML+CO annotations are characterised by the occurrence of an EML annotation, commenting upon the intermediate conclusion about an observed pattern, immediately following a CO annotation, identifying and working through a pattern of interest in the text, and a linking of the two types of annotations through the use of explicit connectors or spatial proximity. For example, Figure 3.14 (A) shows how P1 identified the change in part-of-speech of the words 'art' and 'part' across stanza breaks and accompanied this with a note explaining that the two words have assumed noun form following their usage as verbs. Similarly, in Figure 3.14 (B), P4 has marked the occurrence of chiasmus in 'well knows' and 'knows well' along with a note detailing the effect of its usage in the last couplet. Figure 3.14 (C) is another example of

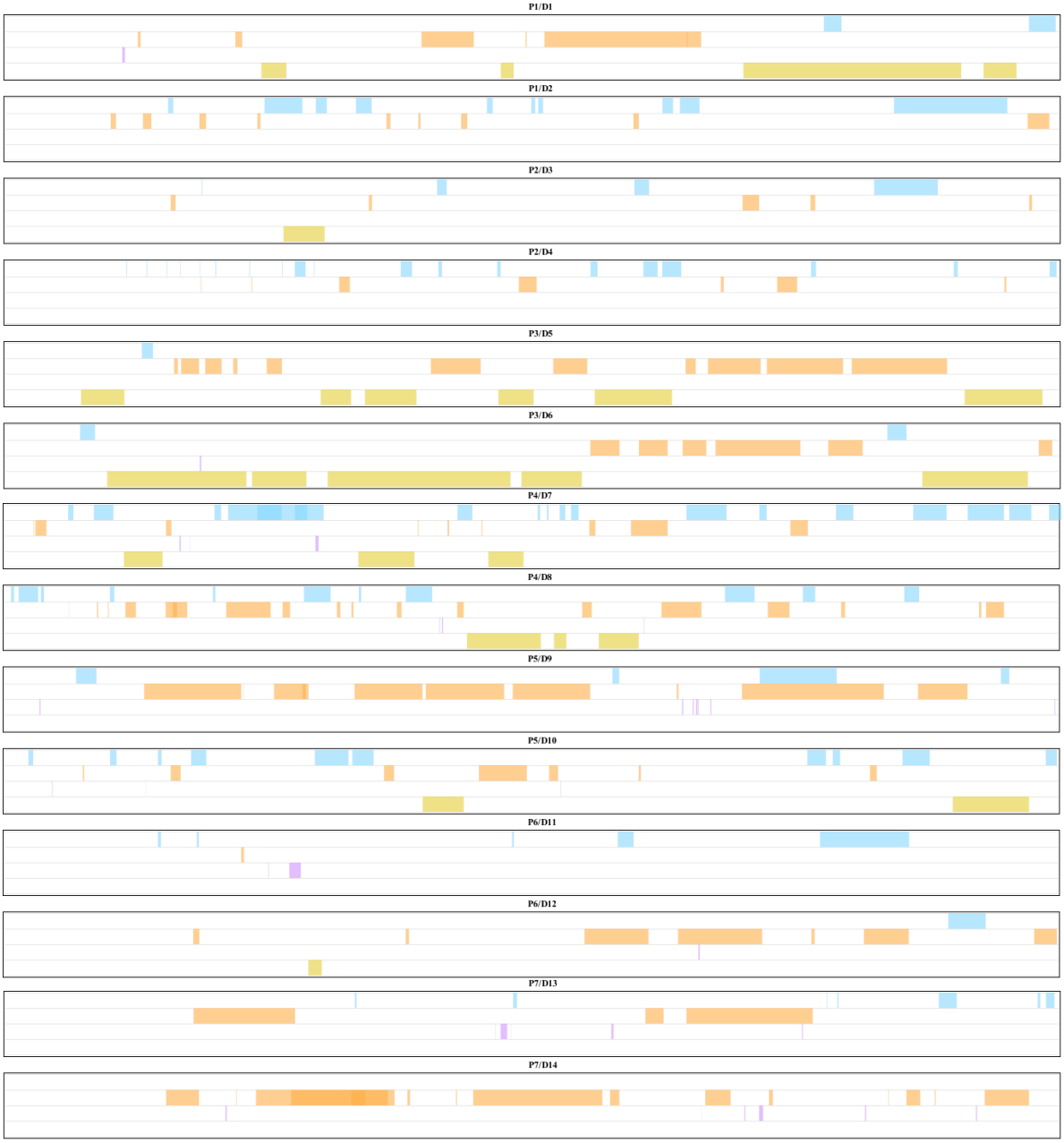

Fig. 3.15 Durations of *cognitive purpose* codes by participant (P1–P7) and poem (D1–D14). For each poem-participant block, individual rows represent EML, CO, A, and EML+CO annotations (top to bottom).

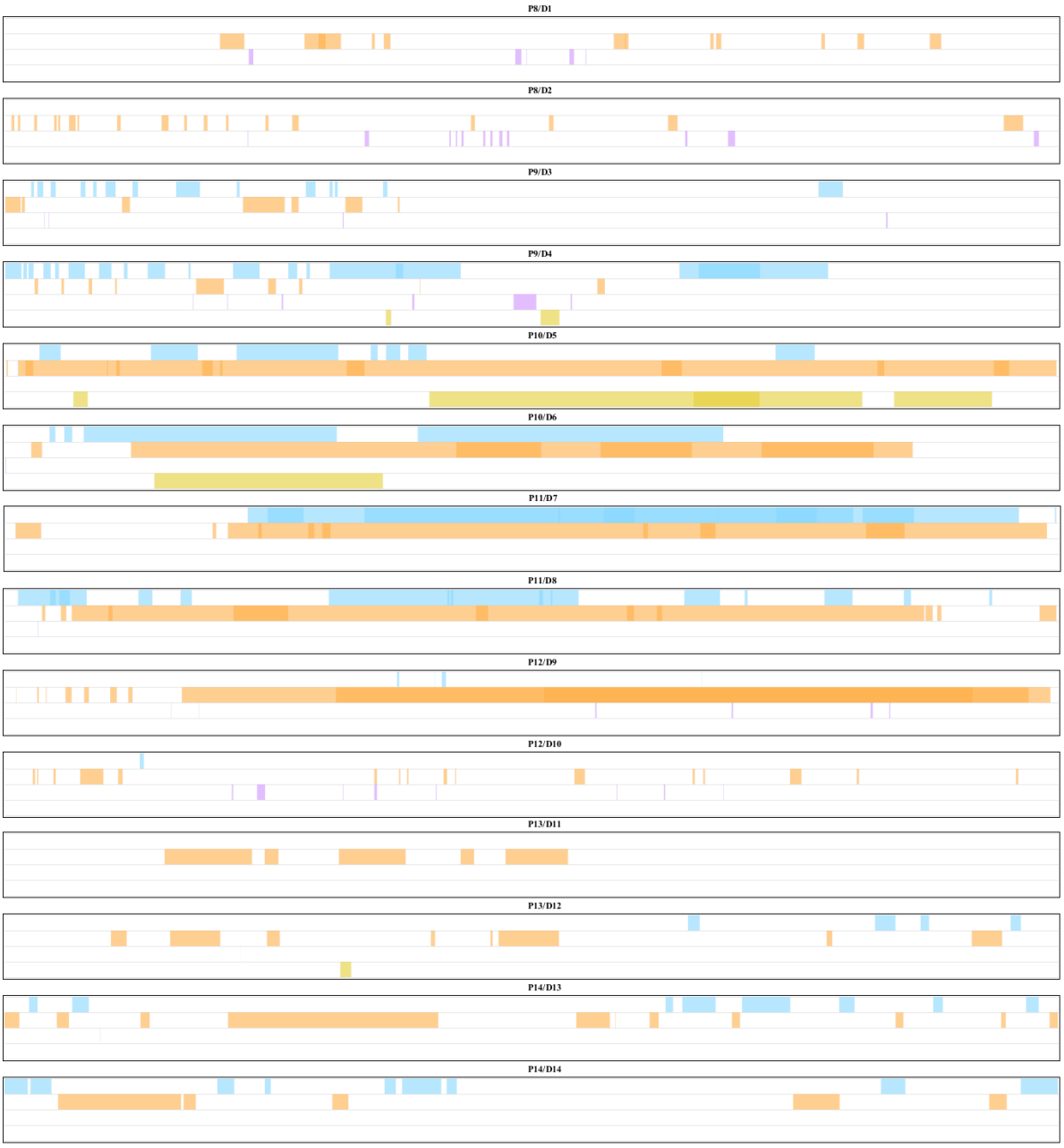

Fig. 3.16 Durations of *cognitive purpose* codes by participant (P8–P14) and poem (D1–D14). For each poem-participant block, individual rows represent EML, CO, A, and EML+CO annotations (top to bottom).

EML+CO annotations where the use of caesura has been highlighted in the word space and discussed in a note placed in the margin.

Both CO and EML annotations were consistently interleaved throughout the analysis session for all of our participants whereas EML+CO annotations were relatively rare, as shown in Figure 3.15 and Figure 3.16.

[O5] Experiential Cognition: Some of our participants stated that there were times when they were unsure as to why certain words of the poem seemed important to them, but these words were nevertheless marked and, at a later time, associated with other relevant points of interest once this understanding was solidified. We frequently observed that the expert readers would have some intuition and identify something as being important, before they knew how or why. For example, both P1 and P8 had initially annotated the adjective "repeating" (D2) for its peculiarity with later realisation that the adjective was used by the poet as a literal indicator of the repeating sound patterns in the poem.

[O6] Use of Resources: Three of our participants accessed external resources (both digital and physical documents) to look up meta data such as word definitions, usage histories, poetic forms, and terminology. In addition, information about the poet, such as era, their other works, and that of their contemporaries, was referenced during the analysis process. For example, both P4 and P11 looked up senses of the word "pleached" (D8) in a physical dictionary. Similarly, P6 referenced an online illustration of a spinning wheel when analysing D11. One of our participants had a tablet with him throughout the analysis sessions for quick web look-up. It is also important to note that external resources were usually accessed at the end of a single reading of the poem, with the exception of those times when supplementary information had to be promptly retrieved in order to proceed further with the analysis process. For example, when coming across archaic usage of words in the poem.

3.4 Discussion

The results of our study highlighted several themes common to many of our participants. These themes will be explored in depth in the following paragraphs, and could help inform the design of tools for linguistic inquiry and analysis.

[DG1] Importance of Free-form Annotations: A majority of participants reported using physical tools (pen/pencil) over digital tools (stylus, computer) for annotation in close reading [O1]. The reason for this preference could be that paper serves well at supporting free-form annotations [23]. Free-form ink annotations are highly suited to the active reading process since they afford the flexibility needed for the idiosyncratic manner of annotating ([O2]) with minimal attentional overload, in contrast with digital ink annotations that require

explicit switching between the available markup tools. Paper also provides additional affordances such as quick navigation, portability, rotation and physical manipulation of pages, and the ease of cross-referencing multiple documents side-by-side, among others, to support the active reading task [23]. On the basis of our observational study, it is clear that the experience of language contributes to the understanding of poetry and is reflected through the practise of annotation [O3, O4]. That is, people "think" by "doing" through annotation in poetics. Free-form annotations are thus a required part of the analysis process of literary critics. Whether or not substituting physical paper with a stylus-enabled tablet for the same is appropriate, is still unclear.

[DG2] Annotations as Cues for Analytic Assistance: Even though annotations made by the participants are polymorphic in nature [O2], we observed that the use of common annotation forms in spatial and/or temporal proximity often indicated related points of interest in the poem pertaining to the current thought process of a reader [O4]. Thus, the form of annotations, coupled with the spatial and temporal distance between them as well as the cognitive purpose they serve, could be used to infer the type of computational support that could augment a reader's analysis process at a given moment in time during close reading.

Relations between the sets of words identified as points of interest by the reader through the use of CO annotations that serve as a visible trace of a reader's contemplation can be used for deducing the type of supplementary data to be generated. CO annotations can be identified through the space on the page that the reader is annotating in as well as through the presence of similar forms in spatial and/or temporal proximity [O4]. However, determining a universal threshold for grouping pen strokes based on spatial and temporal proximity for the purpose of aiding interpretation of annotation function is difficult due to inter-participant diversity and further research is warranted. EML annotations could similarly be leveraged to provide support for linguistic inquiry based on a reader's notes about interpretations of the observed patterns in the poem as well as based on the reminders for look up of additional information [O4].

We believe that this form of user-initiated data generation for analytic assistance would work well in the domain of literary criticism. A follow up with our participants also revealed that they would be amenable to being informed of things that they might have overlooked or simply not known for identifying connections of possible interest relevant to their current thought process.

[DG3] Permitting Experiential Cognition: We observed that sometimes annotation serves as a placeholder for intuition and is thus a visible trace of experiential cognition [21] [O5]. It implies that a reader must be allowed the space to think and interact with his own intuition. Current tools for poetics, which bulk process poems and present results all at once,

do not allow for this. Slowing down the provision of analytic assistance, through just-in-time support, would integrate better with the current work flow.

[DG4] Minimal Interruption: Participants made use of external resources to aid their analysis and usually deferred their use of tools until they finished a complete reading, reducing interruptions [O6]. The use of reader annotations as a means of implicit interaction for requesting supplementary data for analytical assistance as proposed in [DG2] could minimize the disengagement from the analysis process and interruption to the flow of reading that usually results from a switch to the process of retrieval of additional material from external resources.

We have instantiated these guidelines through the design and implementation of a prototype system, MetaTation, for augmenting the practice of close reading in poetry criticism through real time interpretation of reader annotations for generating context-specific analytical assistance as detailed in the following chapter.

Chapter 4

Design of MetaTation

Our observations of poetry critics' annotation strategies when performing close reading revealed the importance of supporting free-form annotations to sustain the experience of interacting with poetic language that is essential to the process of interpretation. We also noted the need to permit critics to reflect upon the content on their own and thus the necessity of slowing down the provision of assistance in the design of a literary analysis tool. Based on these design guidelines, we developed a tool, MetaTation, that couples a desktop-based linguistic support application with physical paper (augmented by the Anoto dot pattern) through the Anoto pen [DG1] (see Section 3.4). The Anoto pen is a digital pen that records its position on a physical sheet of paper, augmented with the Anoto dot pattern, by processing digital snapshots of the pattern generated by an optical lens embedded beneath the pen-tip. Annotations made by a critic while reading initiate interaction with the system. The annotations are processed in real time, taking into account the space they occupy as well as their form and function, as implicit interactions for requesting context-specific supplementary metadata [DG2, DG3]. Specifically, MetaTation interprets CO annotations to deduce reader intent and generates apt assistance based on this interpretation to better support the critic's current thought process. Our system is thus subtle in that critics are not required to create specific pen gestures, such as "rhyme" or "alliteration" annotations, to access analytical support.

Based on the observations of our study, we realize the need to minimize interruptions to the critic's reading process that could arise as a result of presentation of the generated supplementary reference materials. Video recordings of the analysis sessions from our study also indicated that critics, when performing close reading of a poem, tend to focus on the document on their desk with their head bent down. MetaTation thus presents the analytic assistance on a peripheral display to minimize interruptions to the flow of reading, as the data is outside of the critic's field of view and the critic has the choice to decide when to

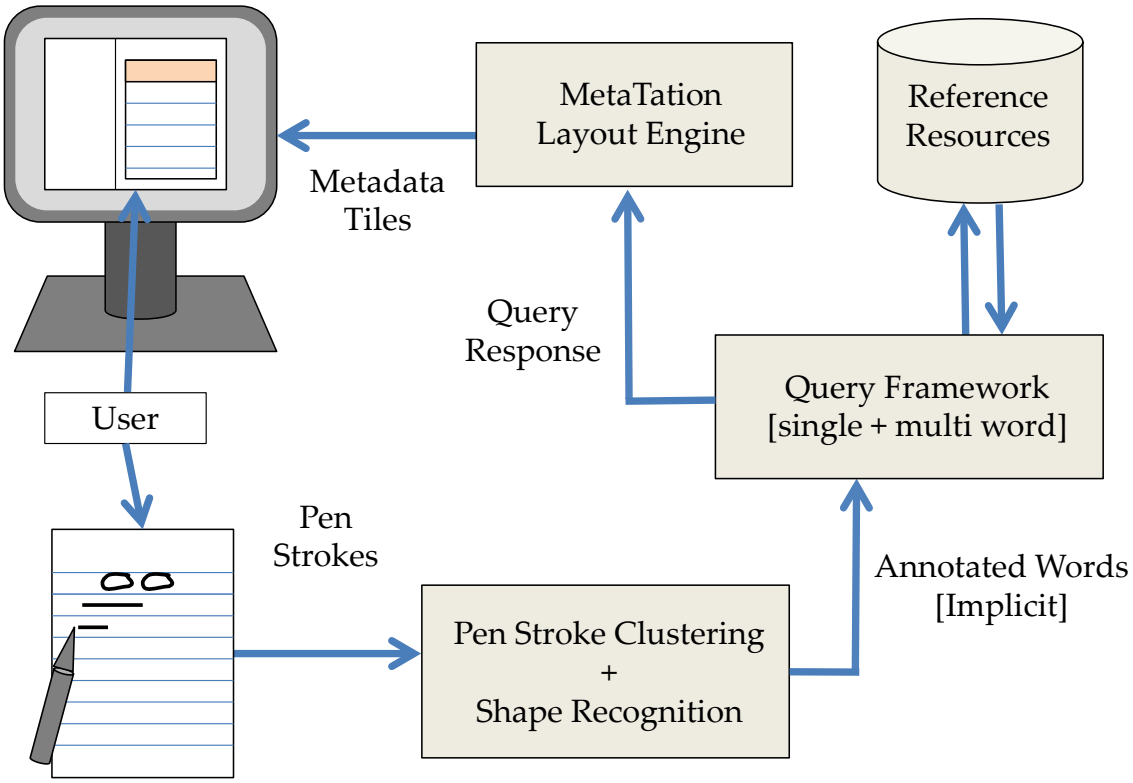

Fig. 4.1 MetaTation system architecture.

look at the computational support provided [DG4]. We considered alternatives where the generated data is projected onto the desk or on the document itself, but decided against them to avoid distraction from even simple visual cues in the reader's field of view.

In the following sections, we describe the design and implementation of our system in detail.

4.1 Description of System Functions

Once a reader specifies a poem to work with, the desktop application generates a printable image file that is a composite of the Anoto dot pattern and the poem. As the reader annotates the poem using an Anoto pen, the pen captures and communicates its position on the paper in real time, via bluetooth, to our application running on a nearby computer. The application groups the received pen points into pen strokes and then clusters these pen strokes based on spatial and temporal proximity. Pen strokes are then categorised as ellipses, underlines or connectors by a geometric recognizer. Words associated with pen strokes are then extracted from the poem.

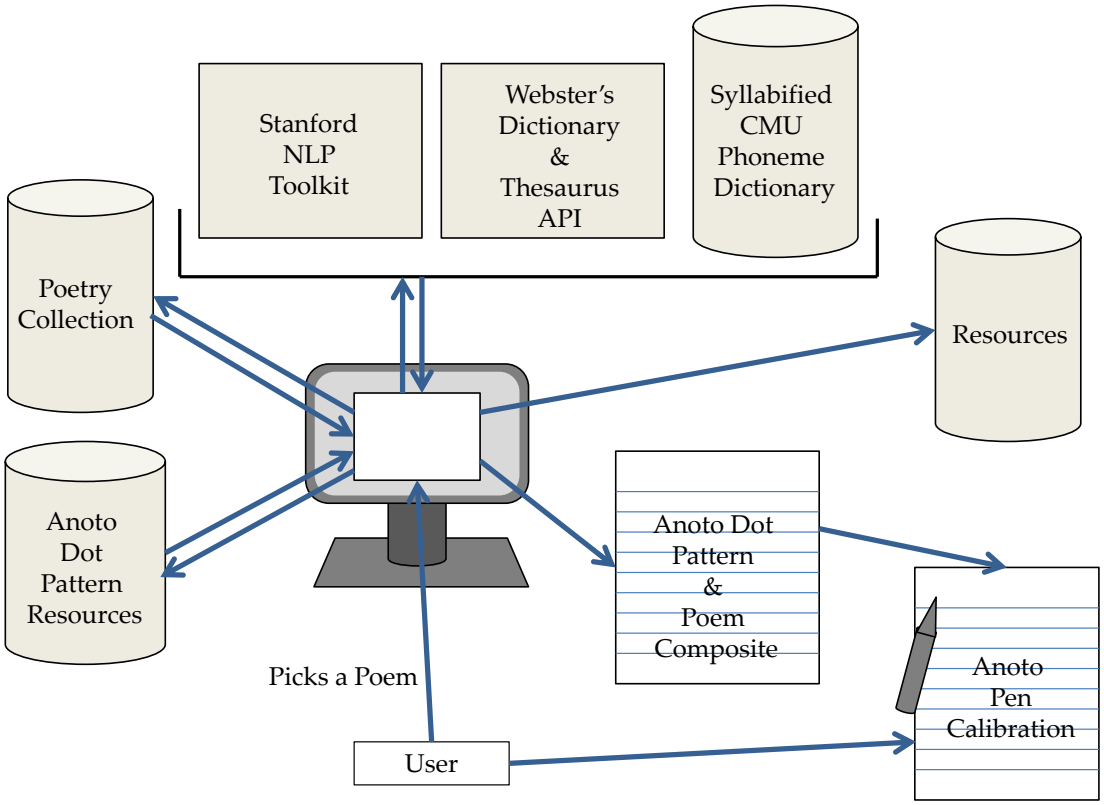

Fig. 4.2 MetaTation preprocessing pipeline.

The query framework then processes the sets of annotated words, either implicitly grouped by pen strokes having a common form in a cluster, or explicitly grouped through connector strokes to identify possible semantic and phonetic relations. On finding a relation, the query framework looks not only for other words in the poem that are similarly related to the annotated words, but also for all other sets of words in the poem that share the same relation. The semantic relations considered are: synonymy, antonymy, and word repetitions. The phonetic relations considered are alliteration, consonance, assonance, and rhyme. The query framework also fetches word definitions, usage history, usage examples, and etymology. Acts of annotation thus become *implicit queries*. For example, through circling two words that rhyme, our system detects the rhyme and propagates a rhyming query across the entire poem. The results generated by the query framework are then formatted into a structured presentation or visualization called a *query tile* and provided to the reader in a non-interruptive manner. The reader can then choose when to pause the process of annotation and reference the fetched metadata, which is provided on a nearby screen for easy glancing. The architecture of MetaTation is illustrated in Figure 4.1.

4.1.1 Preprocessing

An initial calibration of the Anoto pen with respect to the display device being used is essential to ensure reception of accurate position information from the pen by the system. Extents of the Anoto dot patterns used by the system are manually recorded and stored to facilitate a mapping of the raw pen points captured by the pen to locations on a composite of a poem and the dot pattern. Raw text file of a poem to be analysed using the system should be formatted such that the poem title and name of the poet is followed by the content of the poem stanzas with each of the stanzas separated by a newline. An input poem file specified by the user is processed by the system and the poem content is rendered over the Anoto dot pattern image file to generate a printable composite of the dot pattern and the poem, as shown in Figure 4.2.

The system also stores information about the relative position of a word in the poem (stanza, line and word index), extents of the word's bounding box printed on the physical sheet of paper, the part-of-speech (POS) tag assigned to the word by the POS tagger from the Stanford NLP Toolkit [14], word pronunciations from the syllabified CMU phoneme dictionary [2], synonyms and antonyms from Merriam-Webster Thesaurus [7] and word etymology, senses, definitions, usage history and usage examples from Merriam-Webster Dictionary [7] into a json file for quick access by the query framework, as shown in Figures 4.1 and 4.2.

4.1.2 Stroke Clustering & Shape Recognition

As a reader writes on physical paper augmented with the Anoto dot pattern, the Anoto pen generates TUIO events[1] that are received by the desktop client. We group pen points between consecutive pen down and pen up events as pen strokes. These pen strokes are then clustered using hierarchical agglomerative clustering as presented by Chiu and Wilcox [4]. We empirically observed that the single-linkage criterion outperformed both complete-linkage and mean-linkage criteria in terms of clustering accuracy when tested using participant data gathered during the observational study. Thus, we defined the linkage criterion that determines the distance between clusters as the minimum of the pairwise distances between the pen strokes in the clusters. The distance between two pen strokes is defined as a weighted function of the spatial and temporal distance between them.

[1] http://www.tuio.org

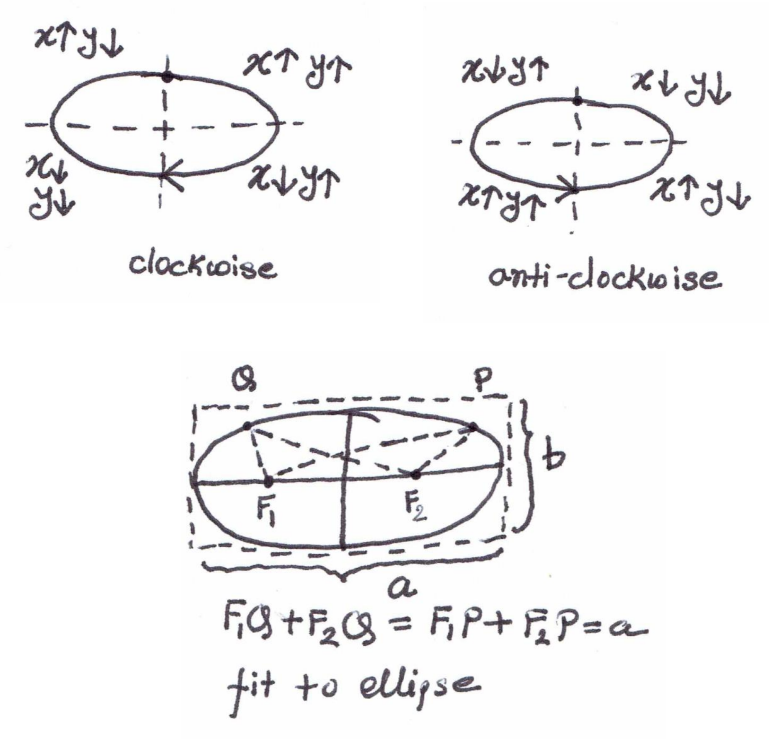

Fig. 4.3 Expected patterns of x and y for an ellipse (top). Measure for fit of a set of points to an estimated ellipse (bottom).

The temporal distance, *time*, between two pen strokes s_1 and s_2, is defined as,

$$time = \begin{cases} 1 & \text{if } t_{start}(s_2) - t_{end}(s_1) > 60\text{s} \\ (t_{start}(s_2) - t_{end}(s_1))/60 & \text{otherwise} \end{cases}$$

where $t_{start}(s_2)$ is the start time of a pen stroke and $t_{end}(s_1)$ is the end time of another pen stroke, assuming that s_1 precedes s_2. The time metric has an empirically determined upper bound of 60 seconds to facilitate its normalization across all pen stroke pairs.

The spatial distance, *space*, between two pen strokes is defined as the minimum distance between the two bounding boxes for s_1 and s_2. The x and y values of bounding box locations are normalized by the extents of the dot pattern printed on the paper prior to their use in the spatial distance calculation. The spatiotemporal distance between two pen strokes is then given by,

$$d = \sqrt{space^2 + time^2}$$

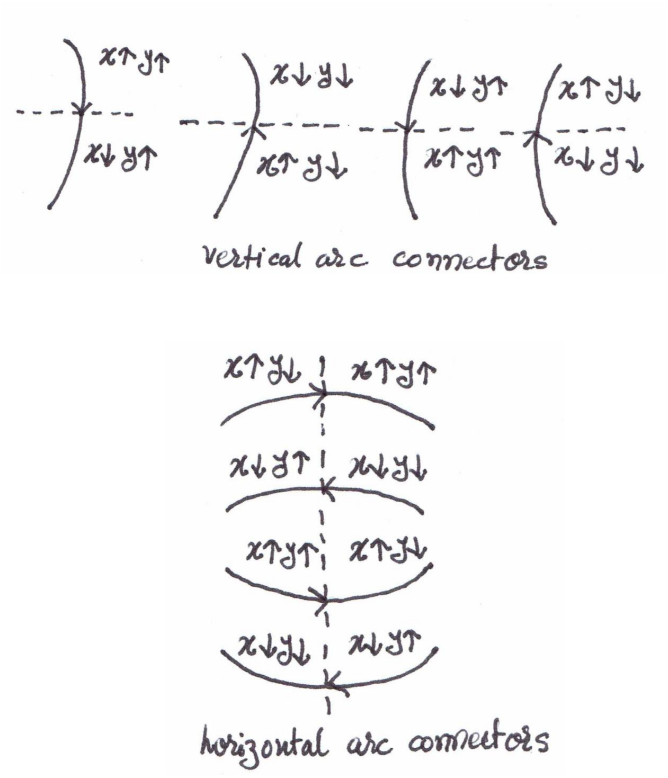

Fig. 4.4 Expected patterns of x and y for an arc connector.

On every iteration, the distance between clusters increases. The clustering process stops at an iteration i for which the ratio $r_{i+1} < r_i$ where r_i is given by,

$$r_i = \frac{(d_{i+1} - d_i)^2}{d_i - d_{i-1}}$$

as proposed by Kara et al. [11].

Prior to stroke type recognition, pen strokes for which more than 50% of the area of their bounding box falls under the margin space are eliminated from further processing since we decided to focus solely on CO annotations [O4]. Pen strokes are then categorised into a small set of predetermined geometric primitives, namely, ellipse, underline and connectors, by a geometric recognizer. The recognizer estimates the fit of the pen points of a pen stroke to an ideal version of the predetermined geometric primitives through geometric tests and formulas. For an ellipse, the first check is to see whether the changes in the x and y coordinates of the pen points follow the expected pattern of changes in x and y coordinates for points along an ellipse (see Figure 4.3 (top)). The second check measures the fit of the pen points to an

estimated ellipse with the width and height of the bounding box of the pen stroke as its major and minor axes (the fit is measured using the fact that the sum of the distances of any point on the ellipse to its foci is constant and equal to the length of its major axis, as shown in Figure 4.3 (bottom)).

For underlines, the first check is to see whether or not more than 50% of the pen stroke falls under the white space between the lines and stanzas of the poem. The second check is to see whether the x and y coordinates of the pen points follow the expected pattern of changes in x and y coordinates for points along a horizontal line connecting the starting and the ending points of the pen stroke with a certain degree of tolerance (to account for slight curvatures).

For line connectors, a check similar to the second check for underlines is performed. For arc connectors, the first check is to see whether or not the changes in the x and y coordinates of the pen points follow the expected pattern of changes in x and y coordinates for points along an arc (see Figure 4.4). The second check measures the fit of the pen points to an estimated arc with half the height or width of the bounding box of the pen stroke as its radius. Pen strokes that don't satisfy the requirements for any of the predefined primitives are ignored and eliminated from further processing.

Following pen stroke clustering and shape recognition, words annotated by each of the pen strokes are extracted. For ellipses, words with their bounding boxes intersecting those of the pen strokes are ranked based on the area of intersection of the bounding boxes and the top most of these words are retrieved. For underlines, words, from the line right above the pen stroke, with their bounding boxes falling within the horizontal extents of the pen stroke's bounding box, are similarly ranked and retrieved. Words annotated by pen strokes having a common form (ellipse or underline) in the same cluster are then grouped together as a single query to be issued to the query framework. Similarly, words annotated by pen strokes explicitly connected through the use of a connector are sent to the query framework as a single unit.

4.1.3 Query Framework

Firstly, the query framework retrieves definitions, usage history, usage examples, and etymology for each of the words in an issued query and sends the results to be displayed. It then inspects the query words to identify the presence of semantic and phonetic relations between them. If the query framework identifies some relation between the annotated words, it searches for other words in the poem that share the same relation with the annotated words, as well as all other sets of words in the poem that also hold this relation.

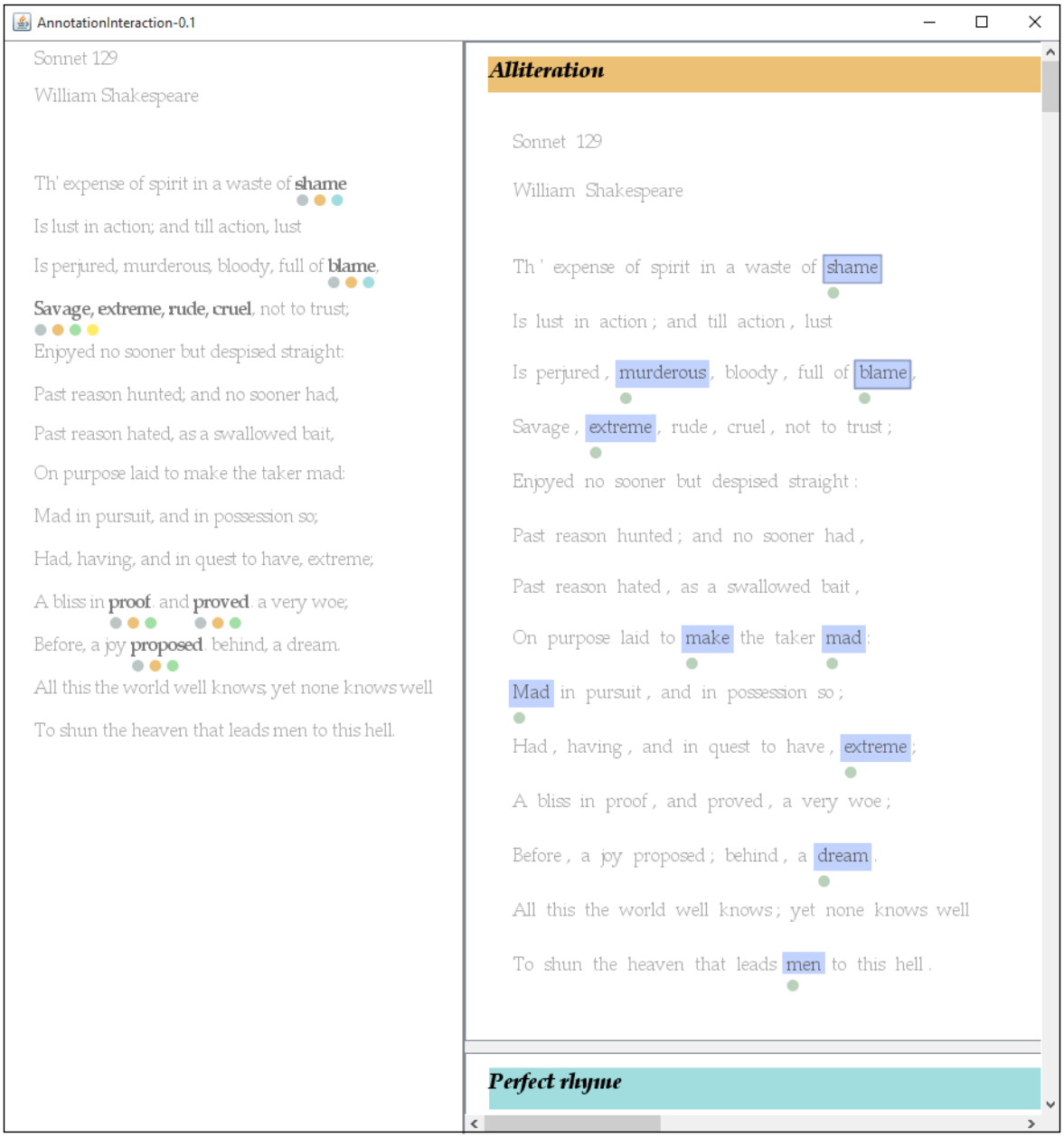

Fig. 4.5 The MetaTation interface. The left worksheet viewer panel shows annotated words in grey, and available query results are indicated by colour-coded dots below the words. The right panel shows a stream of metadata tiles which present query results.

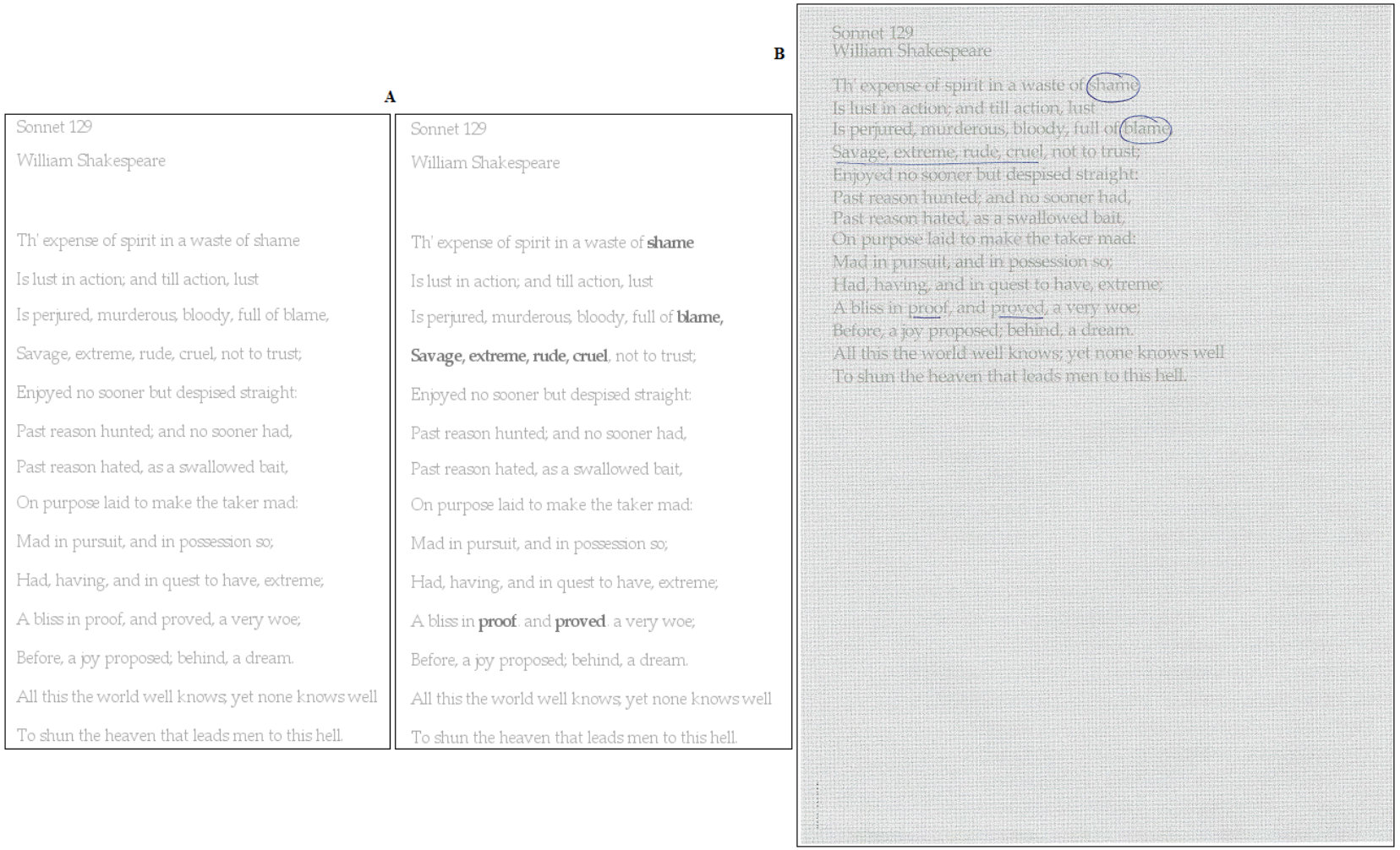

Fig. 4.6 As a reader annotates the physical sheet of paper (B), the worksheet viewer panel (A) highlights the processed pen stroke words.

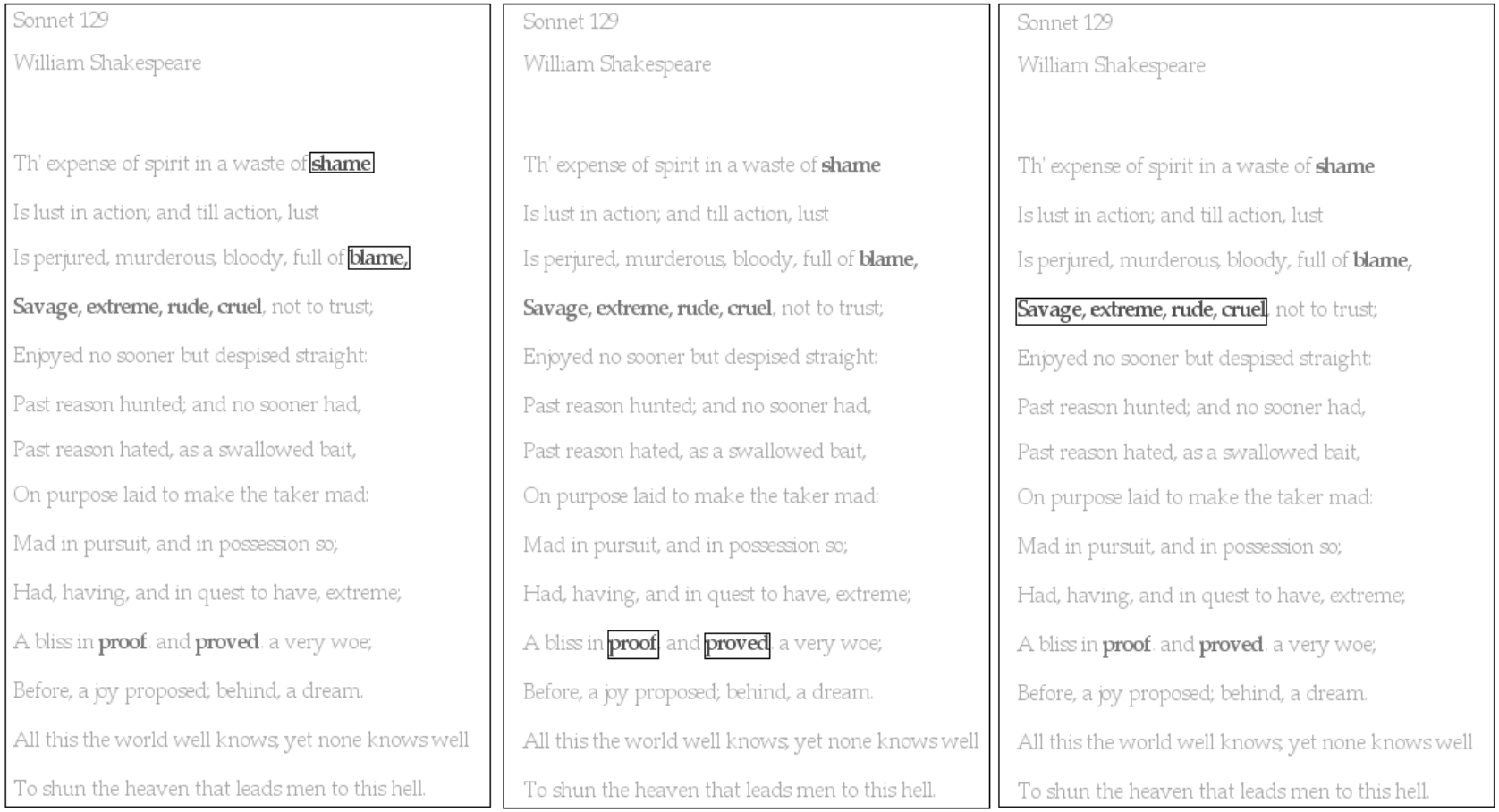

Fig. 4.7 Hovering over the annotated words in the worksheet viewer panel reveals words marked by pen strokes in the same cluster.

Detection of semantic relations between query words is supported by the synonyms and antonyms of the words retrieved from the Merriam-Webster Thesaurus [7]. The syllabified CMU phoneme dictionary [2] is referenced for accessing phonemes of the query words for an investigation of phonetic relations. To check for **perfect rhyme**, the framework first looks for the presence of common vowel phonemes in the stressed syllables of the query words. On finding one or more such phonemes, the framework then checks to see whether all phonemes following the matched ones are identical in both the words and those before the matched phonemes are different. **Alliteration** in the annotated words is detected through the presence of common consonant phonemes in the stressed syllables of the words. **Assonance** is identified by the presence of common vowel phonemes in the query words whereas **consonance** is indicated by the presence of common consonant phonemes. Supplementary data thus generated are then communicated to the desktop application for display.

4.2 MetaTation Interface

The MetaTation interface is comprised of two panels, namely the worksheet viewer panel and the metadata tile stream panel, as shown in Figure 4.5. Interface components are described in detail in the following sections.

4.2.1 Worksheet Viewer Panel

The worksheet viewer panel displays the poem being analysed and conveys the availability of relevant metadata for reference. Before a reader starts annotating the physical sheet of paper, the poem content is grayed out. As the reader annotates, the system processes the pen strokes and highlights the words annotated by these pen strokes creating pen stroke words, as shown in Figure 4.6. Hovering over any of the pen stroke words reveals other words marked by pen strokes grouped into the same cluster as the currently selected pen stroke, shown in Figure 4.7. As metadata generated by the query framework are received by the application, color-coded dots representing the different types of available query results appear below the respective pen stroke words as shown in Figure 4.8. Clicking on any of the highlighted pen stroke words filters the metadata tile stream to show only those tiles wherein the corresponding pen stroke was involved. Similarly, clicking on one of the query result dots permits further filtering of the tiles for a selected pen stroke by query result type.

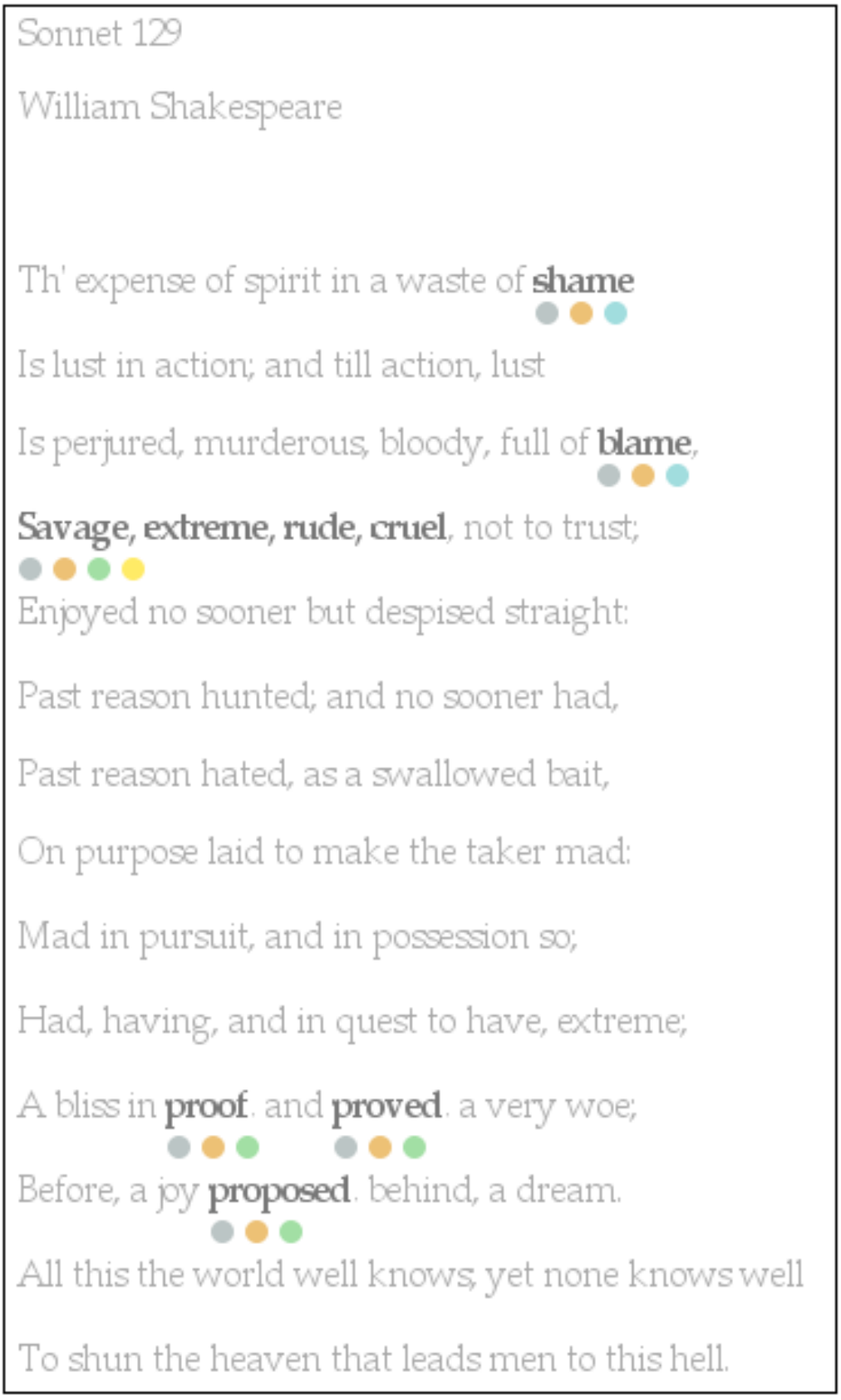

Fig. 4.8 Colored dots below the pen stroke words in the worksheet viewer panel indicate the types of query results available for reference.

Fig. 4.9 Assonance metadata tile highlights words that exhibit assonance. Hovering over a highlighted word reveals its phonetic transcription. Clicking on one of the phoneme selection dots, below any of the highlighted words, brings assonant words composed of the phoneme of interest to attention.

A design alternative considered for the viewer panel was to overlay pen strokes from the physical sheet of annotated poem on the poem content displayed in the panel. If a pen stroke failed to be recognized by the system, the pen stroke would be grayed out to indicate elimination from further processing. Hovering over a pen stroke would reveal other pen strokes in the same cluster as the selected pen stroke and the query results associated with a pen stroke would be indicated by color-coded segments in the outline of the pen stroke based on the result type. We decided against opting for this alternative because the selection of a segment of the pen stroke outline for filtering the metadata tile stream was difficult and the colors of the segments were hard to differentiate for small pen strokes. We did consider the possibility of not presenting the poem text at all but decided against it since it has been noted in previous literature [23] that preservation of the context of annotations is important.

4.2.2 Metadata Tile Stream Panel

The metadata tile stream panel displays the query results as they are generated by the query framework, so the most recent results are visible at a glance. Query results are displayed in interactive tiles which have a layout and visual design appropriate to the query type, as described in detail in the following sections.

Assonance, Consonance & Alliteration Tiles

Pen stroke words received by the query framework are examined to detect the presence of assonance, consonance, or alliteration relation between pairs of words. Successful detection of one such relation for a given pair of words triggers a search for other word pairs in the poem that also exhibit the detected relation.

Query tiles for assonance, consonance and alliteration share the same visual and interaction design. For example, an assonance tile highlights words having one or more of the same vowel phonemes as those identified by the system to be common between the pen stroke words as shown in Figure 4.9. Pen stroke words, contributing to tile generation, are differentiated from the extrapolated words through the use of a faint border around their highlights. Each of the common vowel phonemes, if present in a highlighted word, are represented by colored dots placed below the word. Hovering over a highlighted word reveals its phonetic transcription with the phonemes of interest highlighted. Clicking on one of the phoneme dots brings forth only those of the highlighted words that contain the selected phoneme.

Following the detection of an assonance, consonance or alliteration relation between the pen stroke words, the query framework was initially designed to extract all other word pairs

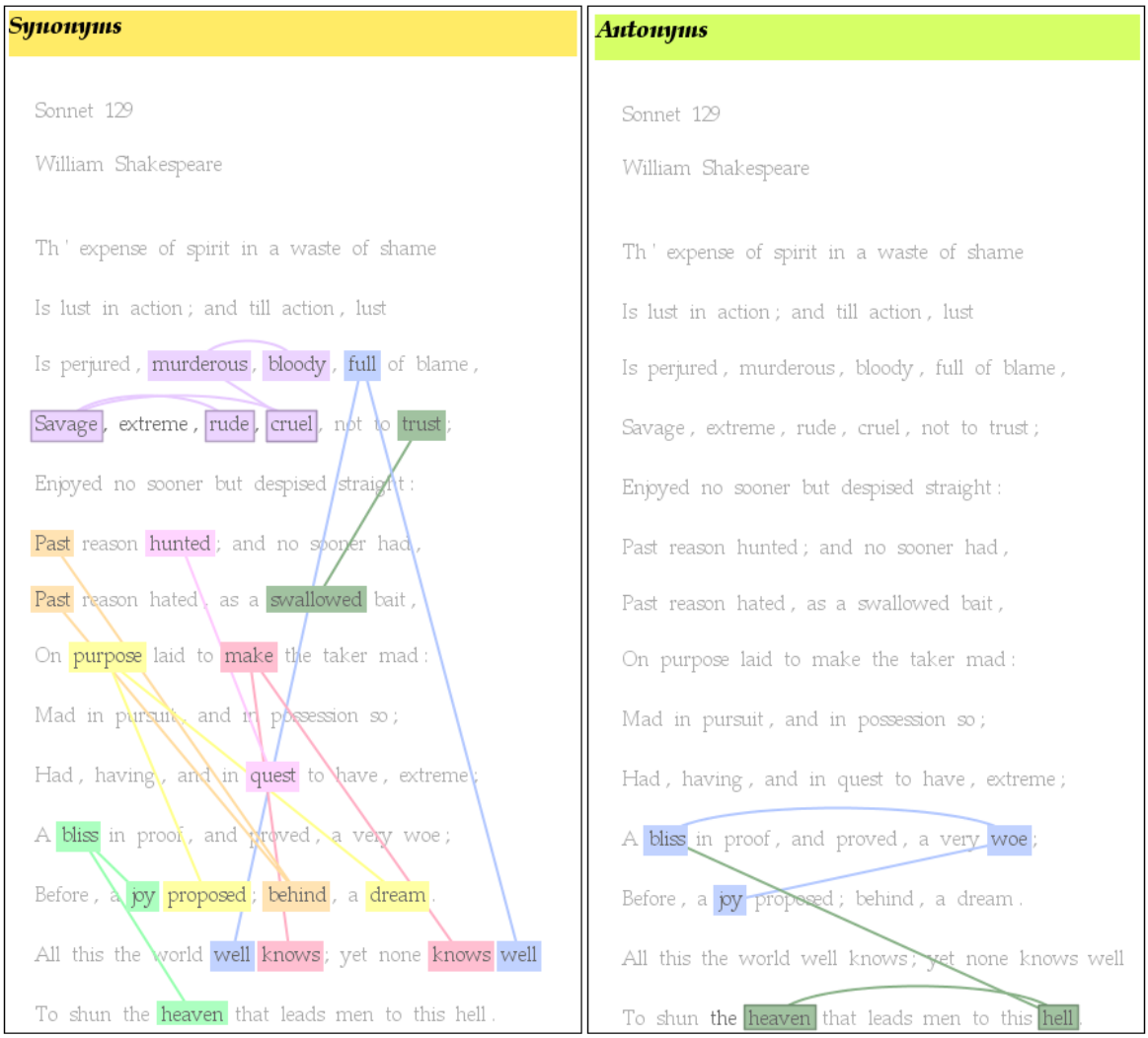

Fig. 4.10 Synonyms and antonyms metadata tile. Both tiles highlight sets of synonyms or antonyms retrieved by the query framework.

in the poem depicting the relation of interest, unconstrained by the set of phonemes identified by the annotated words, and the word pairs thus retrieved were connected by arcs in the query tile. However, not restricting to the set of phonemes explicitly indicated by the annotated words generated a lot of results making it difficult to display them in a comprehensible manner. To address this, we first considered restricting the look up of word pairs of interest within a single sentence but since the results thus generated were not effective at conveying the trends of phonetic patterns in the poem, we decided to constrain the word pair look up by only those phonemes that were explicitly identified by the reader through annotation. This greatly reduced the quantity and increased the quality of the results.

Synonyms & Antonyms Tile

For a pair of pen stroke words, the query framework looks for the presence of one of the constituent words in the set of synonyms or antonyms of the other word. On finding one such relation for a given pair of words, a search for other word pairs in the poem depicting the detected relation is triggered.

The synonyms tile highlights sets of words that are synonymous as shown in Figure 4.10. Word pairs identified as being synonyms by the query framework are each assigned a unique color unless one of the words in the pair has been previously encountered. If a word pair comprises of one of the words from a previously processed pair, the current word pair is assigned the same color as that previous pair to generate sets of synonymous words. One-to-one synonymy relation between a pair of words is indicated by connecting the constituent words by arcs. Pen stroke words, contributing to tile generation, are differentiated from the extrapolated words through the use of a faint border around their highlights. Visual design is consistent across query tiles depicting sets of synonyms and those depicting sets of antonyms.

Following the detection of a synonym or antonym relation between the pen stroke words, the query framework is designed to extract all possible sets of words in the poem depicting the relation of interest, unconstrained by the set of synonyms explicitly identified by the annotated words. However, feedback from the participants indicates a need for presenting only relevant sets of synonyms by default with the activation of an extrapolation to other sets across the poem on explicit user request. For example, the words ‘murderous’ and ‘bloody’ should be returned as a set by the system on underlining ‘savage, extreme, rude, cruel’ while all the other sets from Figure 4.10 should only be revealed on explicit request by the reader through some form of interaction with the tile.

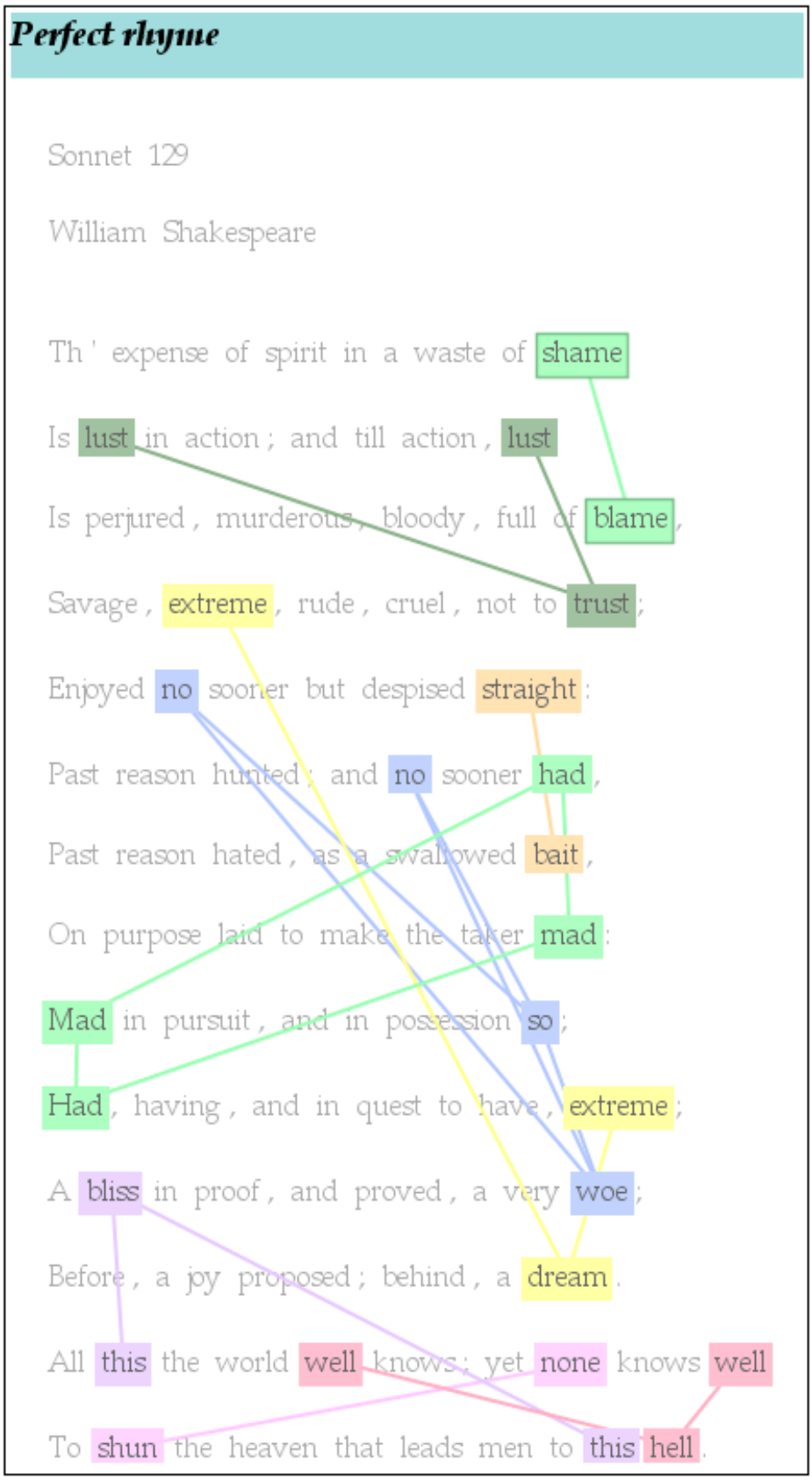

Fig. 4.11 Perfect rhyme metadata tile connects pairs of rhyming words to convey the pattern of sounds in the poem.

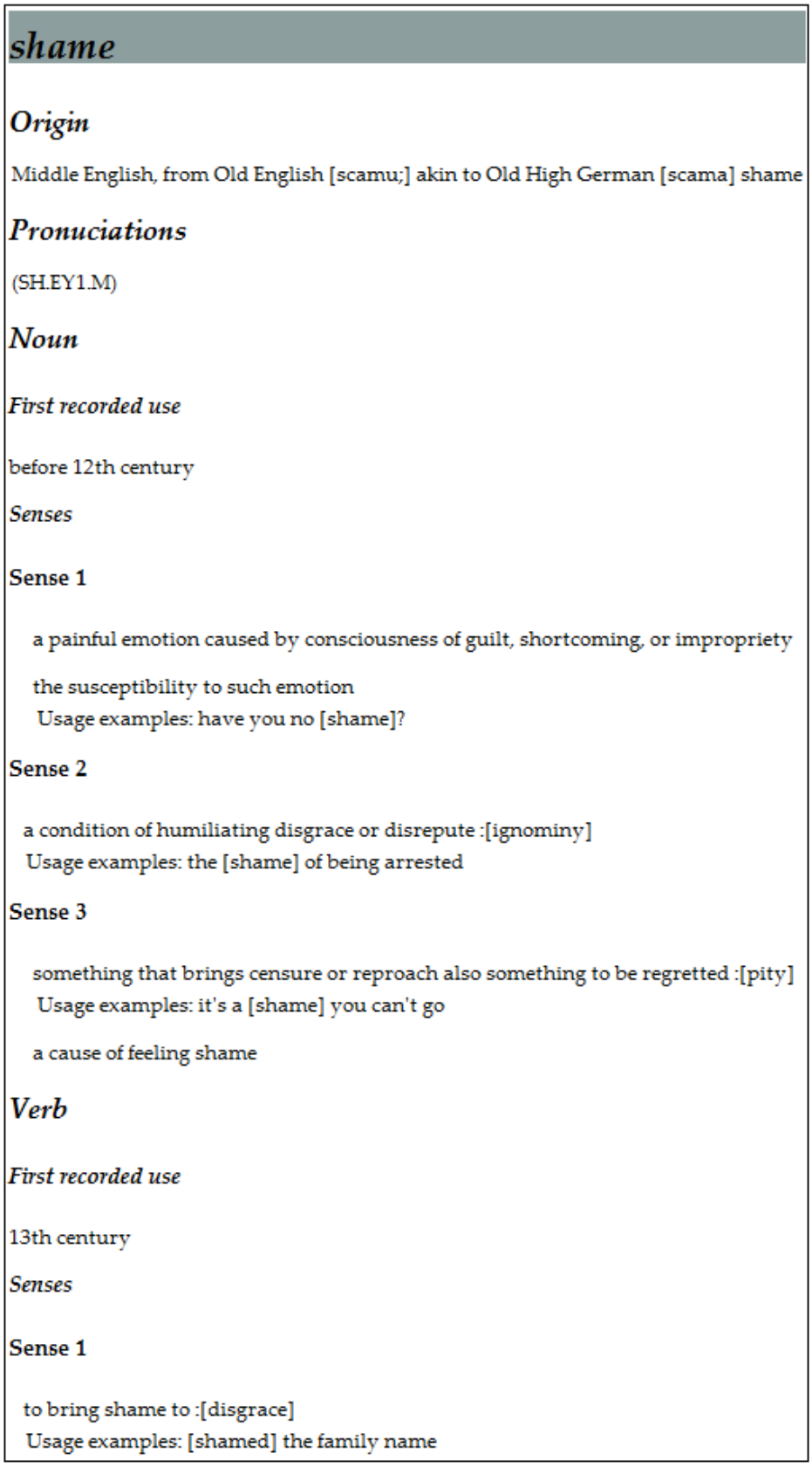

Fig. 4.12 Word details metadata tile provides definitions, etymology, usage history, and usage examples for an annotated word.

Perfect Rhyme Tile

Phonetic transcriptions of pen stroke words received by the query framework are examined to detect the presence of perfect rhyme between pairs of words. On detection of a rhyming relation for a given pair of words, a search for all other word pairs in the poem that rhyme is triggered.

The perfect rhyme tile highlights sets of words that rhyme as shown in Figure 4.11. Word pairs identified as exhibiting perfect rhyme relation by the query framework are each assigned a unique color unless one of the constituent words in the pair have been previously processed. If a word pair includes one of the words from a previously seen pair, the current word pair also receives the same color as that pair to visually group sets of rhyming words. In addition to this, rhyming word pairs are explicitly linked through the use of connecting arcs to convey the pattern of sounds across the poem.

Feedback from the participants indicated a need for going a step further and suggesting the possible poetic forms such as, Shakespearean sonnet, Petrarchan sonnet, or sestina, that a poem adheres to, based on the observed rhyming patterns in the pen stroke words.

Word Detail Tile

A request for word details is triggered for each of the pen stroke words received by the query framework. The word detail tile displays the etymology, senses, definitions, usage history and usage examples of an annotated word as shown in Figure 4.12. Initially, this tile was set to display detailed information corresponding only to a word's part-of-speech (POS) in the poem but was later changed to show details about all possible senses of the word irrespective of the word's POS as the meaning of a word and its POS have been noted to not always coincide in the case of poetic language.

4.3 Scenario

Jane is a university professor who teaches poetic forms and wants to demonstrate the mechanics of a Shakespearean sonnet to her class the next day. She chooses to analyse Sonnet 129 out of her collection of sonnets and loads the poem in MetaTation. The tool prints a composite of the poem and the Anoto dot pattern on a physical sheet of paper for her to annotate. As she reads the poem out loud, she underlines the words 'expense', 'spirit', 'waste', and 'lust' as she notices the repetition of 's' sound in the first two lines of the poem (see Figure 4.13). She also underlines 'Savage, extreme, rude, cruel' as the harshness of the choice of words in that line jumps out to her (see Figure 4.14). She then goes ahead

and circles the ‘p’ s in ‘purpose’, ‘pursuit’, and ‘possession’ to mark the repetition of the ‘p’ sounds (see Figure 4.15).

Briefly glancing at the MetaTation interface running on her laptop placed beside her annotated sheet (see Figure 4.16) on the desk, she realises that the system has identified phonetic relations between the words ‘savage’, ‘extreme’, ‘rude’, and ‘cruel’ in addition to picking up on a synonymy relation. She first filters the metadata tile stream by clicking on the pen stroke words (see Figure 4.17) and locates the synonyms tile by selecting the yellow-colored query type widget associated with the words, as shown in Figure 4.18. She takes a look at the synonyms tile to realise that she had missed the diction of the previous line which seems to be just as extreme as that of the one she had annotated.

Being curious about the assonance relation between the words in ‘Savage, extreme, rude, cruel’, she finds the assonance tile by selecting the green-colored query type widget associated with the words. She takes a note of the different repeating vowel sounds across the tile (see Figure 4.19) and then switches over to the alliteration tile noting the repeating ‘s’ and ‘r’ sounds in the poem (see Figure 4.20). Considering the prevalence of various sound patterns in the phonetic relation tiles, she confirms her initial observation about sound being an important factor for the poem being analysed and continues marking all other phonetic patterns in the poem. She then concludes her first reading of the poem by synthesizing her observations about the sound patterns and their effects in a note at the bottom of the page.

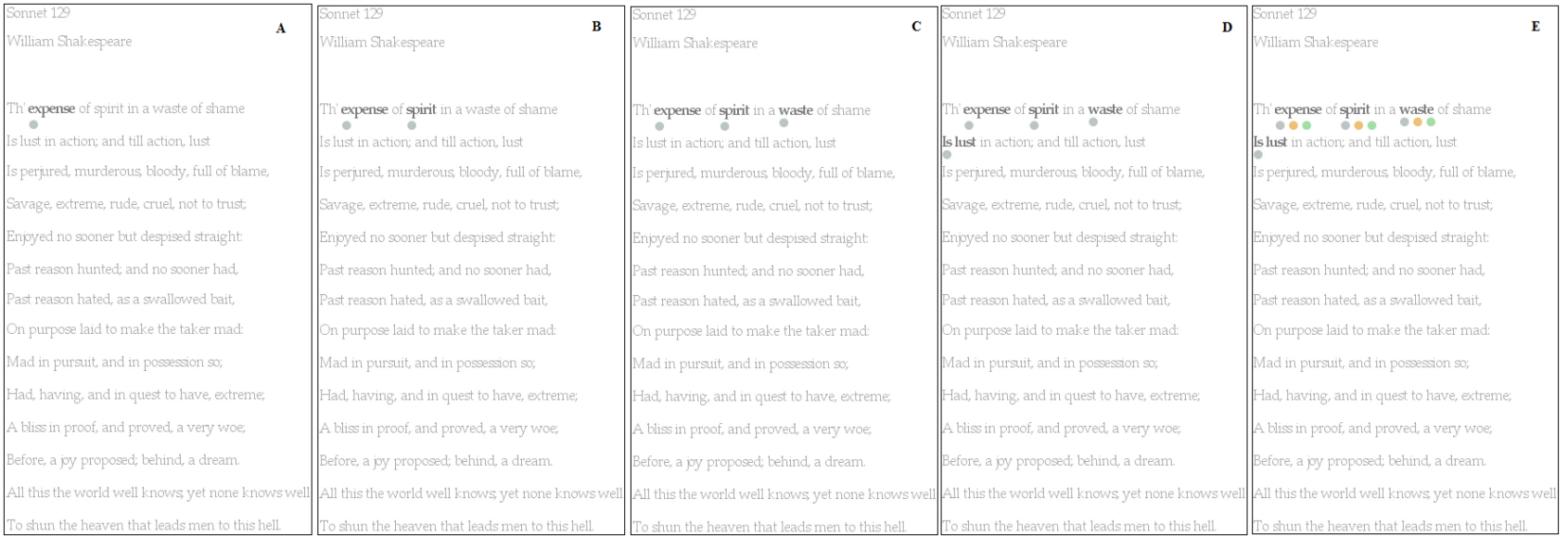

Fig. 4.13 As Jane underlines the words ‘expense’, ‘spirit’, ‘waste’, and ‘lust’ on physical paper, the worksheet viewer panel highlights the corresponding pen stroke words. (A), (B), (C) and (D) show the states of the worksheet viewer panel as Jane makes her annotations. The gray-colored dots below each of the pen stroke words indicate the availability of respective word details metadata tiles. (E) shows the state of the worksheet viewer panel on the generation of alliteration and assonance metadata tiles for the words ‘expense’, ‘spirit’, and ‘waste’ grouped into a single cluster by the stroke clustering algorithm.

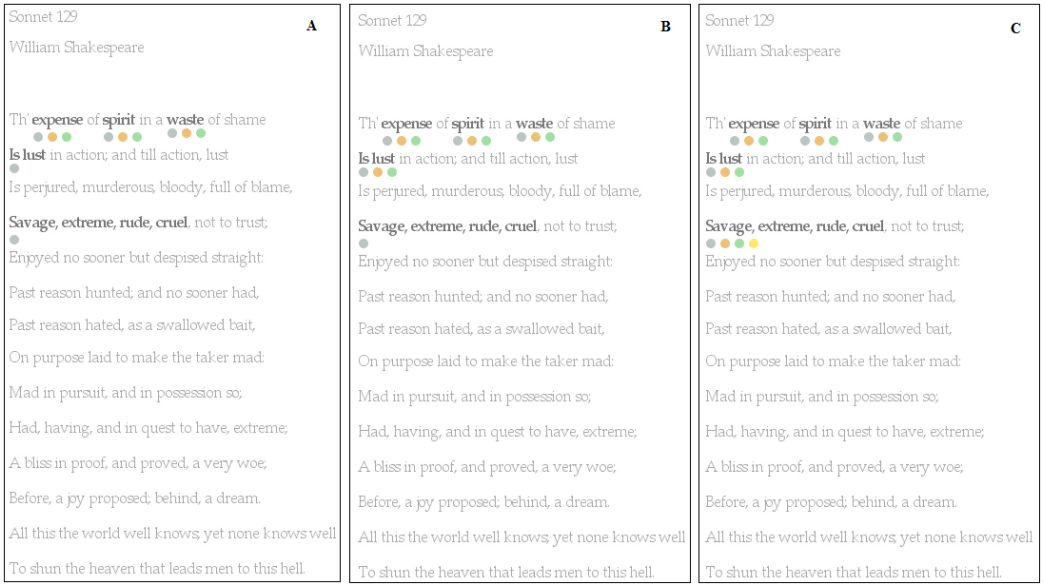

Fig. 4.14 As Jane underlines ‘Savage, extreme, rude, cruel’, the worksheet viewer panel highlights the corresponding pen stroke words and displays query widget dot corresponding to word details metadata tiles (A). (B) Addition of a new pen stroke, prompts the stroke clustering algorithm to run again with ‘expense’, ‘spirit’, ‘waste’, and ‘lust’ now being grouped as a single cluster. Availability of alliteration and assonance metadata tiles for the same is indicated by the color-coded query widget dots. (C) ‘Savage, extreme, rude, cruel’ forms the second cluster and metadata query tiles for these words are displayed by the viewer panel.

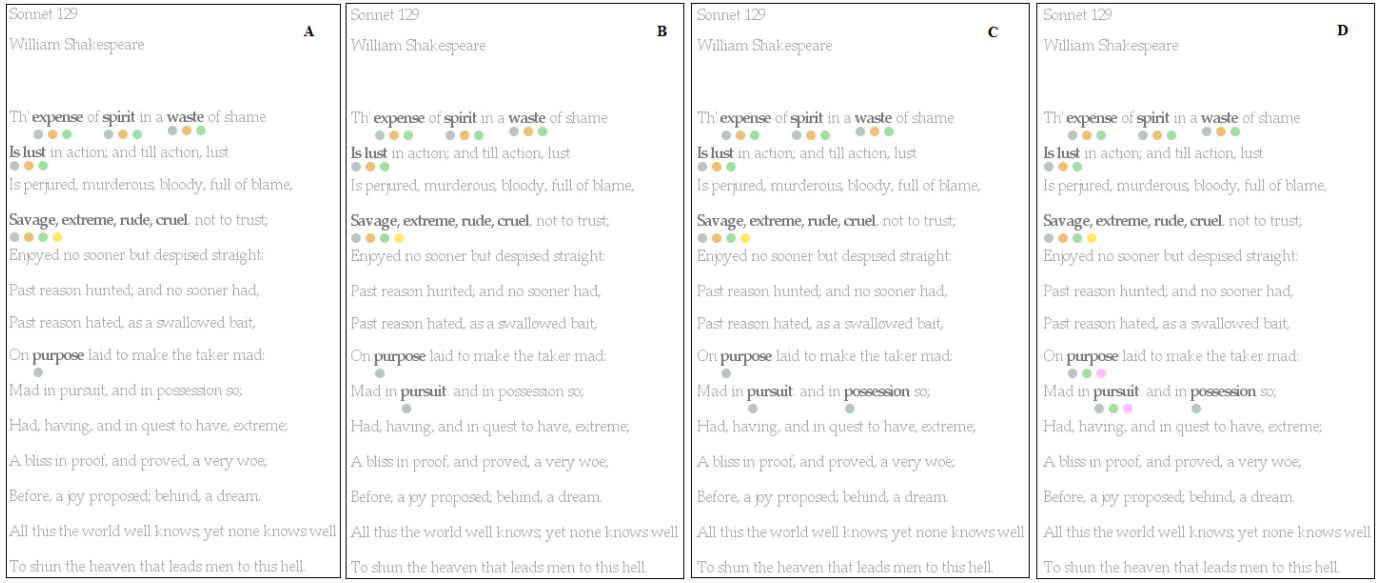

Fig. 4.15 (A), (B), and (C) show the worksheet viewer panel state as Jane circles the ‘p’ s in ‘purpose’, ‘pursuit’, and ‘possession’. (D) shows the availability of assonance and consonance metadata tiles in addition to that of the word details tile for ‘purpose’ and ‘pursuit’.

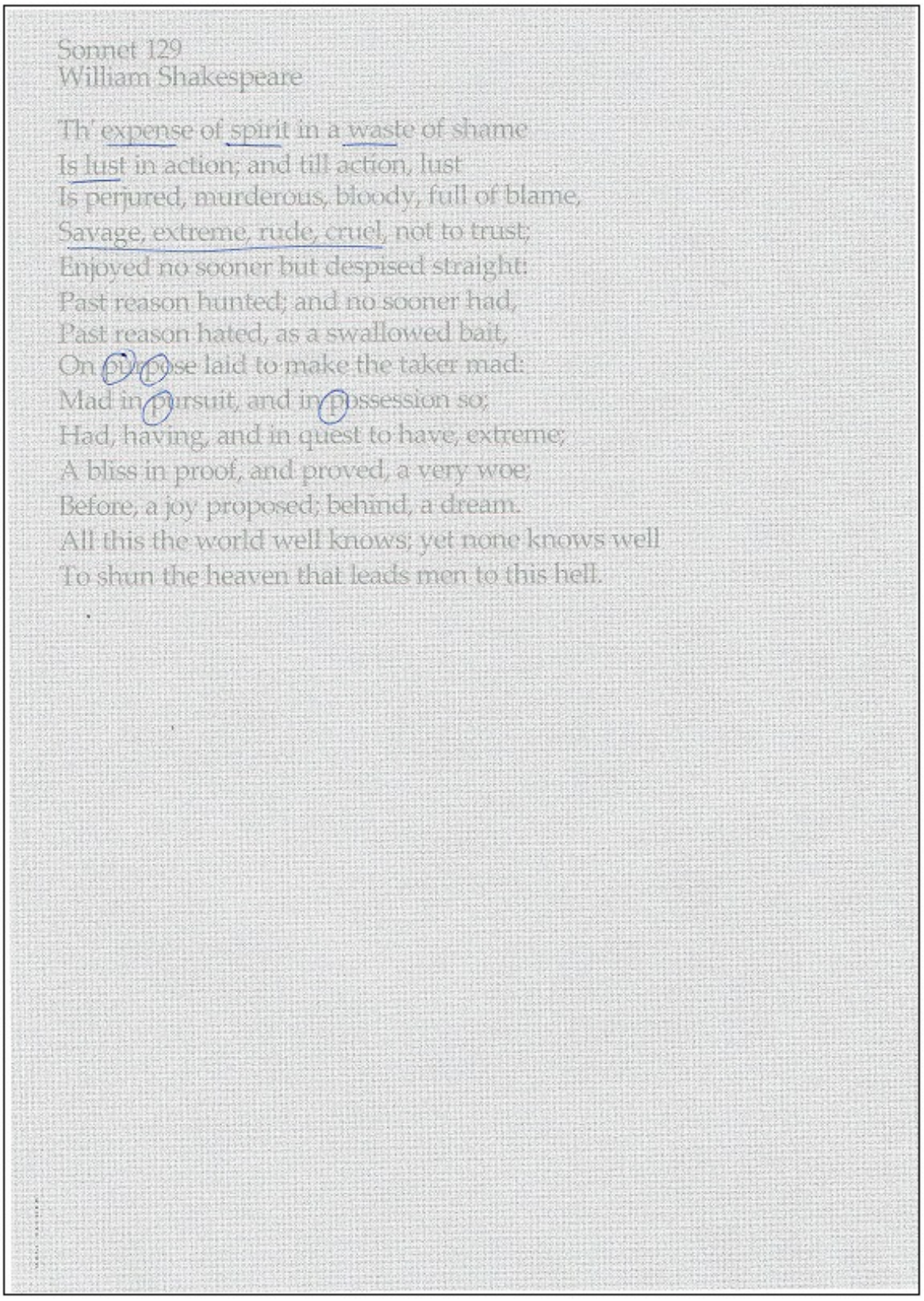

Fig. 4.16 Physical sheet annotated by Jane.

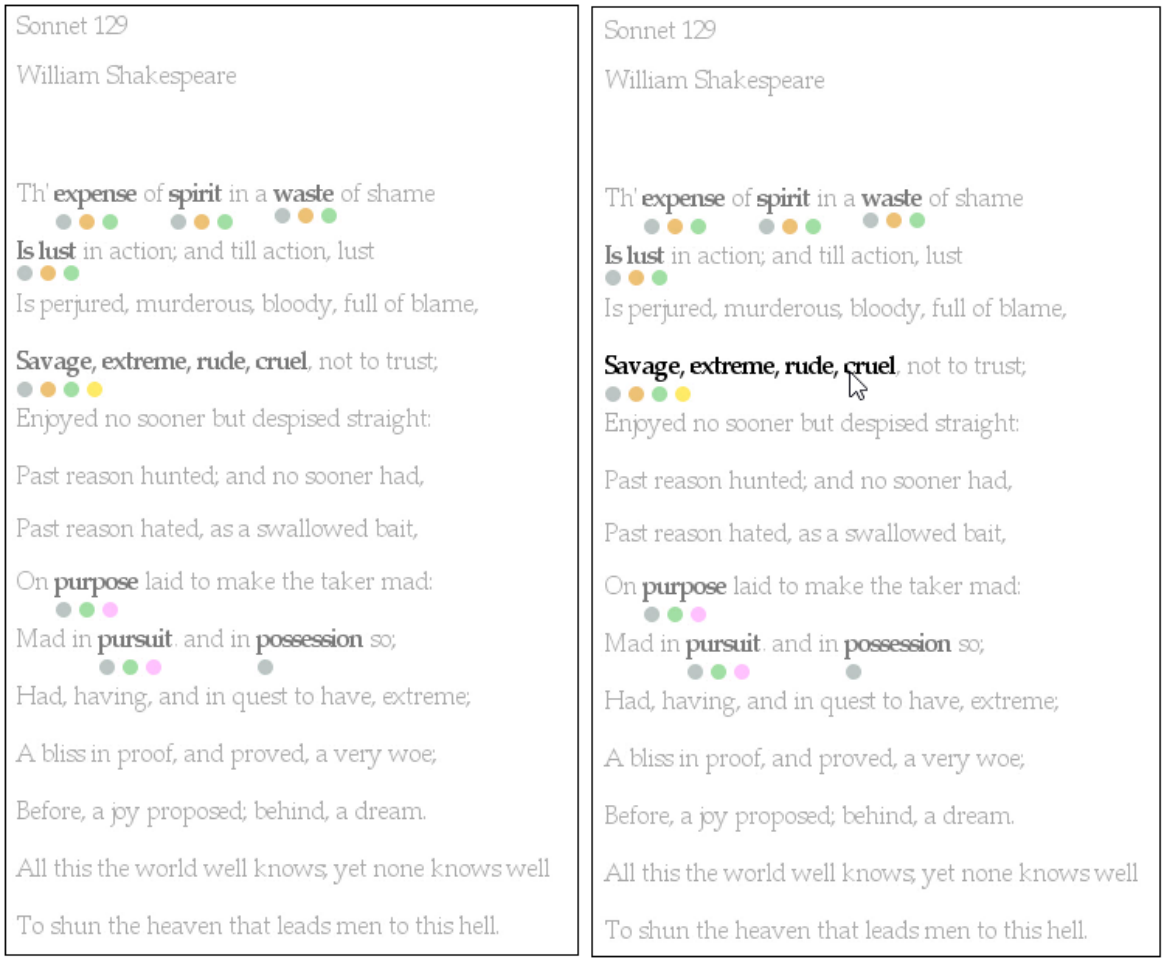

Fig. 4.17 Filtering of the metadata tile stream panel from the worksheet viewer panel is achieved through a selection of one of the pen stroke words.

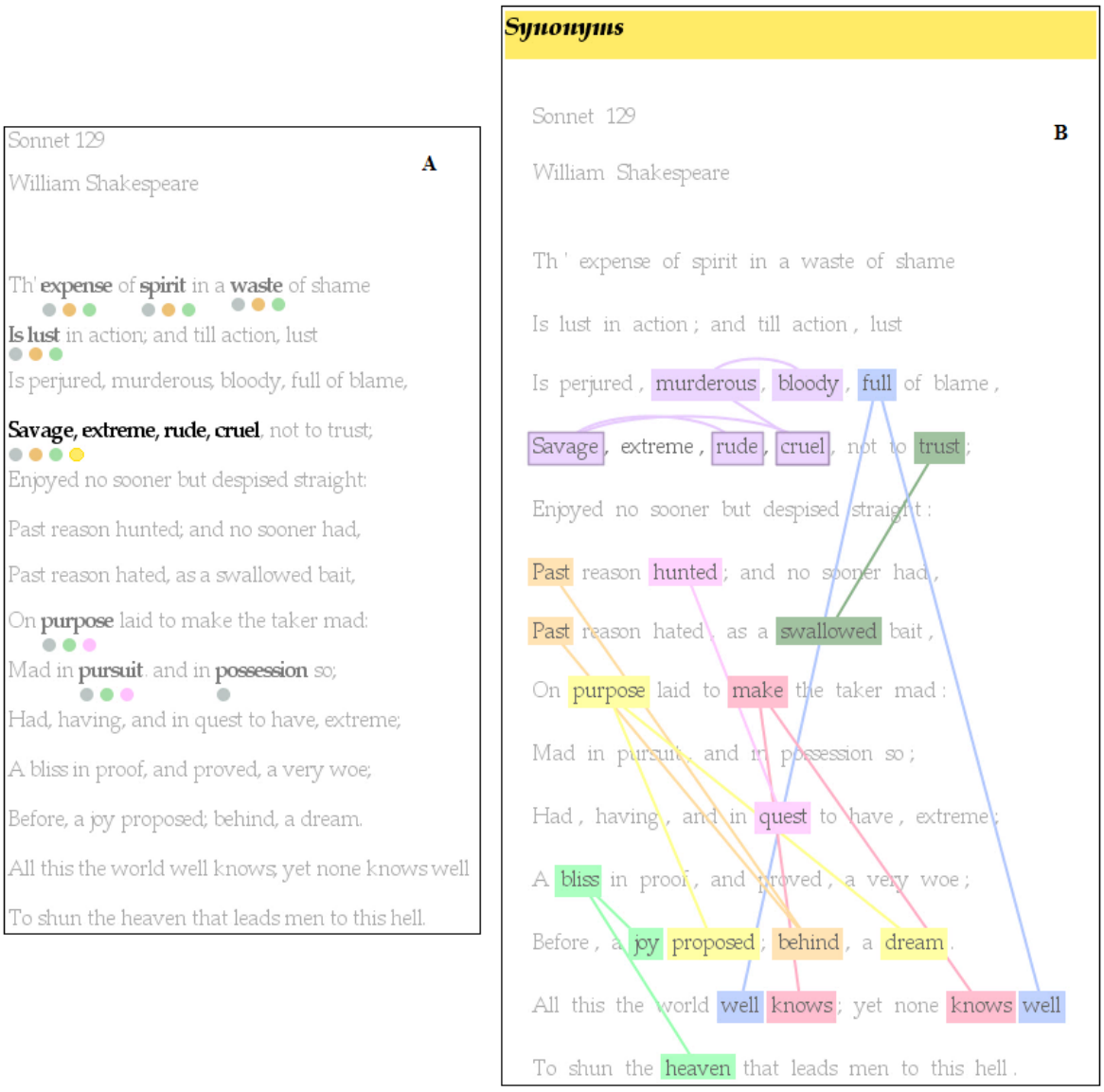

Fig. 4.18 (A) shows the filtering of the metadata tile stream panel from the worksheet viewer panel through a selection of one of the pen stroke words 'cruel' followed by a selection of the yellow-colored query widget dot. (B) shows the synonyms metadata tile generated by MetaTation.

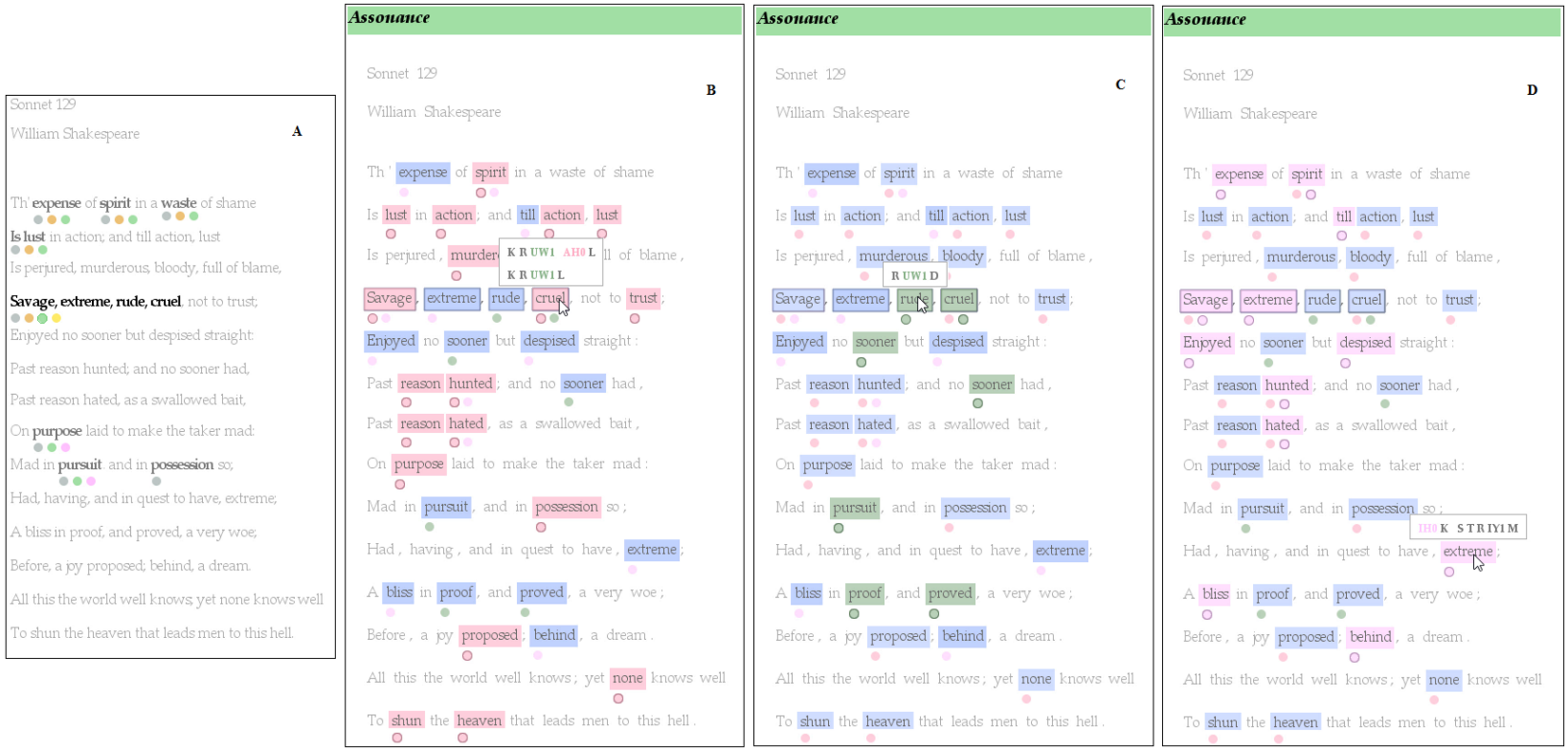

Fig. 4.19 (A) shows the filtering of the metadata tile stream panel from the worksheet viewer panel through a selection of one of the pen stoke words 'cruel' followed by a selection of the green-colored query widget dot. (B), (C), and (D) show the interactions on the assonance metadata tile generated by MetaTation.

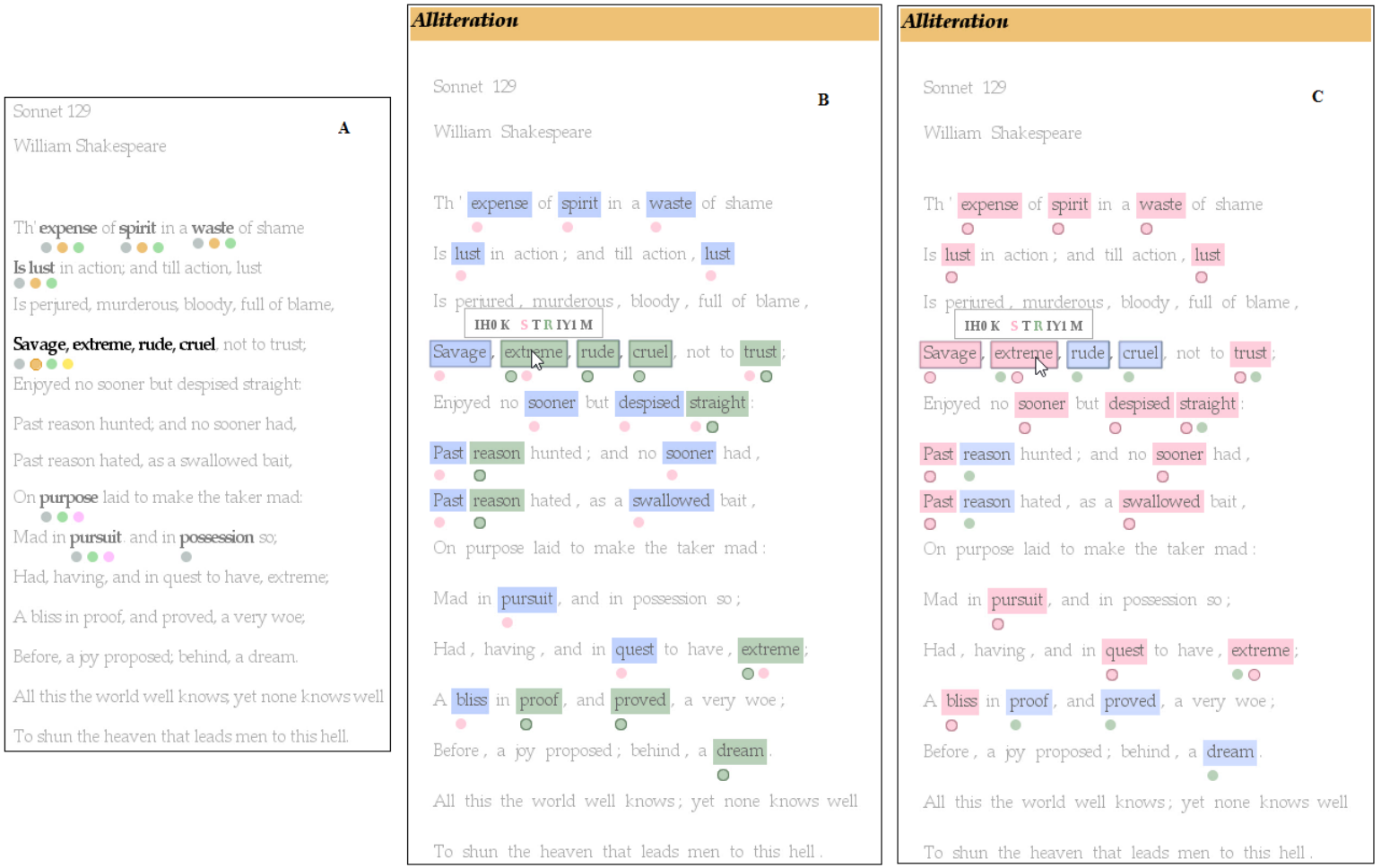

Fig. 4.20 (A) shows the filtering of the metadata tile stream panel from the worksheet viewer panel through a selection of one of the pen stoke words 'cruel' followed by a selection of the green-colored query widget dot. (B) and (C) show the interactions on the alliteration metadata tile generated by MetaTation.

Chapter 5

Preliminary Evaluation of MetaTation

Following the development of our prototype system, MetaTation, we designed a preliminary cooperative evaluation study for an initial investigation into the effectiveness of the tool in leveraging free-form annotations for augmenting the process of close reading for literary criticism, as described in detail in the following sections.

5.1 Evaluation Design

We recruited two of the literary scholars that had previously participated in our observational study for gathering qualitative feedback on the design of the MetaTation system. Both of our participants have been teaching poetics for the past 10 (P6) and 20 (P9) years respectively.

The evaluation process started with a brief explanation of how the MetaTation system was developed based on the results of the study they had previously participated in. They were then given a demonstration of how the system works followed by a session where each participant was allowed to explore the tool while discussing their experience as well as concerns out loud with the researcher as they performed a reading of an assigned poem. We decided to assign the poem Sonnet 129 by William Shakespeare (D7), from the poetry dataset created for the observational study, to both of our participants since the poem exhibits all the semantic and phonetic relations that our system is capable of identifying and providing support for. In addition, neither of the participants had previously analysed this poem during the observational study.

After the participants had a chance to sufficiently interact with the various components of the system, they were requested to elaborate upon their opinions about the usability as well as the design of the tool and their general impressions in a brief interview guided by the following questions:

Q1. What are your general impressions of the tool?
Q2. Did the addition of technology interfere with your process in any way?
Q3. Could you envision using a tool such as this in your daily work? What are some of the problems that you think would crop up when using this tool?
Q4. Can you think of any other modules that could be helpful in supporting the kind of work that you do?
Q5. Do you have any other suggestions for improving the tool?

5.2 Qualitative Results & Discussion

The preliminary evaluation of the system provided helpful insights about the strengths as well as limitations of the current design and helped us identify directions for future work.

One of the participants (P6) had a very telling interaction with the tool as he focused on and analysed the following lines in the sestet:

> A bliss in proof, and proved, a very woe;
> Before, a joy proposed; behind, a dream.
> All this the world well knows; yet none knows well
> To shun the heaven that leads to this hell.

The participant underlined the words ‘bliss’ and ‘dream’ followed by ‘heaven’ and ‘hell’. Looking at the metadata tiles generated by the tool as he analysed these lines, the participant noticed that MetaTation had picked up ‘joy’ as being synonymous with ‘bliss’ and ‘heaven’ as well as indicated the antonymy relation between ‘woe’ and ‘bliss’ and ‘joy’ based on the words he had annotated. He realised that he had missed the connotation of the word ‘joy’, highlighted by the tiles, which when taken together with the other annotated words lead the lines to convey a sense of parallelism. He was genuinely excited about the possibility of using a tool such as this in his daily work that would help him catch insights that he might possibly have overlooked. He commented that the design of the synonyms tile was a bit confusing at first since it revealed all possible sets of synonyms in the poem and not just the ones related to the words he had identified. He also noted that the results of the alliteration tile were in need of refinement since sound patterns other than alliteration were also being picked up by the system.

The participant commented that the ease of use of the interface was paramount at ensuring seamless integration of the tool into the reader’s work flow and added that he was concerned by the influence of constraining the types of marks he can use when annotating on his existing work practices. He did note however that the system does succeed at ensuring

minimal interruption to the flow of reading and added that while he would have generally performed a single pass of reading first followed by a look up of supplementary information, he wouldn't mind concurrently using our system while analysing and was receptive of the results altering or enhancing his thoughts.

The other participant (P9) started by underlining the words 'waste', 'shame' and 'blame' followed by marking the words 'perjured', 'murderous' and 'bloody'. She was particularly impressed by how well the visual design of the tiles, while being very simple, effortlessly revealed and made apparent the patterns of semantic and phonetic relations in the poem. She was highly interested in the possibility of using our tool, in its current form, within a teaching context, "especially in a first year course, like intro to literary genres or even for the creative writing course". She went on to discuss how the visual grouping of words based on their meanings would add greatly to the process of describing the complex functions of words when working with poetic language. She then circled the word 'Is' at the beginning of two consecutive lines in the poem and commented that while the system did not notice that the relation being identified was anaphora, it still picked up repetitions of 'Past' and 'reason' as well as 'well' and 'knows' that represent the use of anaphora and chiasmus respectively. She recommended an addition of tiles suggesting the different poetic forms exhibited by a poem. She was also interested in the possibility of conveying the multiplicity of senses for a rhyming word, in the perfect rhyme tile, to help indicate the presence of a homonym rhyme. She commented that the results generated by the tool seemed serendipitous in a sense since her own annotations were being used to guide metadata generation.

While P9 was very excited about the potential of the tool for teaching poetics, she was less thrilled about the possibilities for supporting research. She expressed that the currently supported metadata tiles were too remedial to be helpful in the research context and suggested that if the tool could be expanded to include things like comparisons across multiple works of a poet or to identify allusions to other authors and literary works, it would greatly improve the task of linguistic inquiry. P9 commented that having the system "present, pinging you like social media" would completely interfere with the analysis process but liked how our tool provided her with the ability to choose when to interact and thus well supported her current work practice of referencing meta information after a single pass of reading.

The difference in participant responses as to when they would prefer to interact with the system during active reading highlighted for us that there are two different modes of use that can be employed with MetaTation. P6 wanted to play with the poem, looking up to see what the tool could tell him as he performed his analysis. P9 on the other hand was vehemently against this and wanted to do her work and then reference the tool. Both of these preferences are already being supported by our design but the strength with which one participant wanted

to engage with the system in real-time and the other participants will to not look at the meta information until after a pass on the poem was surprising.

In regards to general impressions, both participants were pleasantly surprised. Besides a fear of the possibilities of "buggy" technology, P9 said that she would seriously consider using the tool in its current state for teaching undergraduates. P6 expressed his approval for the process and reiterated his excitement at the tool for adding to a set that he had already been thinking about. Overall response from our domain experts was similar in that the tool, in its current form, would be very helpful for teaching poetics but needs to provide more in-depth and sophisticated meta information to be viable for research.

In summary, observations from the initial investigation of the use of MetaTation by literary critics revealed two different modes of use of the system based on when the reader chooses to interact with the system. We also received feedback from the participants on the computational support provided by the system during the close reading process, indicating the need for the development of additional metadata query tiles for research based analysis.

All concerns about misrecognition or failure of recognition of pen strokes by the system, constraints on the types of marks that can be used for annotating as well as those regarding the design of the tool and recommendations for additional types of metadata tiles have been addressed in detail the following section.

Chapter 6

Limitations & Future Work

In this chapter, we address limitations of the MetaTation system and discuss the avenues for future work that we want to explore.

6.1 Limitations

As noted in the results of the observational study, a variety of annotation forms were being employed by the readers when annotating while analysing poetry. The shape recognizer of our system, however, is currently able to process only a limited set of shapes, namely, ellipse, underline and connectors. The reason for picking such a small subset was that these forms were not only consistently prevalent across all of our participants but were also simple enough to be reliably recognised by the system. It is essential to further expand the geometric recognizer to be able to process other annotation forms so as to not constrain the readers and negatively influence their analysis process. Misrecognition or failed recognition of an annotation by the geometric recognizer is simply conveyed to the reader by the system but no means for addressing these are currently available.

Pen strokes made by a reader are grouped for further processing by the system through hierarchical agglomerative clustering based on their spatiotemporal distance. The clustering algorithm runs every time a new pen stroke is received by the system and hence, the results of the algorithm could vary with the addition of each new pen stroke, changing the type of metadata being generated, which could be confusing. In addition to that, the current algorithm starts the clustering process only after a minimum of three pen strokes have been encountered and thus metadata other than word details do not become available until the reader makes more pen strokes. An investigation into alternative techniques for clustering pen stroke data is needed.

Our system currently generates a limited set of basic query types which, as apparent from the feedback from our participants, are sufficient for using the tool as a teaching aid but fall short at supporting linguistic research; development of additional metadata query tiles for research-based analysis is required.

Technological shortcomings such as, the pen points, corresponding to reader annotations, being not picked up at all by the Anoto pen and the necessity of the use of distinct Anoto dot patterns for distinguishing between pages, are also problematic for the adoption of this tool as a part of a literary critic's daily routine.

6.2 Future Work

Shape Recognition

In particular, and as noted in the expert review, our tool is currently limited to a small set of annotation forms. The shape recognizer of our system needs to be further expanded to account for the wide range of marks used by the participants as apparent from our observational study. While a geometric recognizer permits shape recognition without the need for modelling the form of annotations or user involvement and training, it would be difficult to identify appropriate tests for the reliable recognition of such a wide range of shapes in addition to the possibility of the system running across a shape that has not been previously encountered.

One way to address these shortcomings would be to replace shape recognition by unsupervised binary classification based on shape similarity. That is, for a given set of pen strokes grouped in a single cluster, it would suffice to simply detect whether or not a pair of pen strokes have a similar shape based on the properties of their convex hull. However, determining appropriate feature vectors that could provide a reliable similarity metric is challenging. Recognizers that use a hybrid approach combining gesture-based and geometric-based shape recognition as presented by Paulson et al. [26] should also be considered as another means of addressing these issues. An alternative for solving these problems would be to involve the user in the shape recognition process by permitting definition of shape categories as well as correction on misrecognition. This, however, would lead to a disruption of the reading process that is central to the user's work flow. Thus, an investigation into ways for improving stroke type recognition and for informing the reader about misrecognition by the system as well as for addressing this issue through user involvement while ensuring minimal disruption to the reading process is required.

Stroke Clustering & Technological Issues with Digital Pen

Further research into appropriate metrics and algorithms for grouping pen strokes based on spatial and temporal proximity while accounting for inter-participant diversity is required to improve the clustering of pen strokes in order to prevent failures down the stroke processing pipeline.

Use of special IR-based ink for printing text content, overlaid on the Anoto dot pattern, could help address the issue of pen strokes not being picked up when they cross over the printed text. A brief training on how the Anoto pen should be held so that the pen-tip camera faces the pattern could help minimize the possibility of pen strokes not being captured by the pen at all.

Metadata Query Tiles

There is a great potential for the development of new meta information tiles for supporting research-based analysis of poetry. We have considered the addition of tiles to enable comparisons of semantic as well as syntactic context of usage of annotated words across all works of a poet as well as with works of other contemporaries of the poet in addition to poems of the same genre across literary time periods. Metadata tiles hinting at the possible poetic forms exhibited by a poem based on the rhyming patterns and structure observed in the poem as suggested by one of our participants would also be a useful addition to the system. Identification of alluded works or poets in a poem has also been recommended as one of the required tiles for supporting research-based analysis. We are also interested in expanding the limited set of query types with support for identification of forms of rhetoric, such as metaphor and irony, in the poem. Relating the themes of a poem to major historical events during the time of writing the poem is another interesting avenue to explore.

Augmenting Different Types of Annotations

We made a decision to augment only CO annotations with digital metadata for our proof-of-concept prototype. The reason for not doing so with EML annotations was that they comprised mainly of handwritten notes and while a lot of current handwriting recognition systems provide fairly accurate digitization of the input text, further exploration of how the content of these notes could be used to infer the type of relevant metadata is warranted. Augmenting both CO and EML annotations would help better integrate the tool with the existing analysis process of literary critics by allowing the system to be more robust in terms of the range of computational support it provides. An exploration of the possibility of taking into account the semantic context of the annotated words in addition to the spatial

and temporal distance between the respective annotations and their forms could also help refine the metadata being generated by the system. We have also considered the possibility of overloading idiosyncratic reading habits, such as tapping on the desk for counting syllables or when figuring out the stress and sound patterns in a line, as implicit interactions for requesting analytic support.

System Evaluation & Further Studies

We would also like to further evaluate our system through a longitudinal study, involving all 14 participants from the previous observational study, to identify how the use of annotations, made while reading, as implicit interactions for requesting meta information influences their annotation practices and to investigate how well the system integrates with their existing work flow. We are also interested in exploring the possibility of substituting pen-and-paper with stylus-enabled digital tools to further investigate how crucial a role paper plays in the active reading process and to determine whether and how the annotation process gets affected by this change in medium. The transition from Anoto pen and physical paper to stylus-enabled digital tools would not pose any challenges for our system since the system has been developed to function with TUIO events.

Generalization to Other Domains

While our system was informed by the specific domain of poetry analysis, other domains could easily benefit from its use, including the analysis of legal documents to connect cases and provide background on parties, the analysis of patient data in health care, and in newer forms of pedagogical practise, such as computational rhetoric, where the focus is on exploring artistic writing through computer-supported exploration. The software architecture allows for easy addition of query types and metadata tiles based on user needs. The tiles generated for literary critics may not be applicable to the analysis of legal documents, but if the annotation process is similar, new tiles could be quickly designed. In this way MetaTation is robust and customizable while maintaining the flexibility to address the annotation needs of multiple disciplines.

We wish to extend our tool by examining its use in other domains, and providing a mechanism for including a larger variety of meta information, best suited to the specific task at hand. For example, leveraging annotations made during the editing process of a document, issues such as, repetitions or colloquial usage of words, could be quickly identified and presented to the reader. Similarly, in the case of active reading of legal

documents, annotations could be interpreted to extract case details of relevance for a specific court or judge.

Chapter 7

Conclusion

There has been a tremendous growth in the field of digital humanities in recent years in the context of developing computational tools that support distant reading. However, it is the practice of close reading that is at the heart of the work undertaken by literary scholars. Existing tools for supporting close reading provide comprehensive analytic assistance for interpreting the content of a text but are disconnected from a reader's work flow. They also tend to present the generated complementary meta information up front without providing a reader the opportunity to experience and reflect upon the language on his own. In this work, we explored the idea of overloading the act of annotation, inherent to the practice of active reading, as implicit interactions for retrieving meta data about a text being analysed, with the aim of augmenting the literary analysis process while ensuring minimal interference to a reader's existing work flow.

To this end, we presented the results of an ethnographic study probing into the annotation strategies employed by literary critics as they analyse poetry. Based on the results of the observational study, we derived guidelines for the design and development of tools for supporting linguistic inquiry and analysis. The research methodology employed for the investigation into the work practices of literary critics could help guide future inquiry into active reading practices in other domains. Results of the observational study and the design guidelines could help direct the design and development of future digital humanities tools focusing on enhancing close reading.

We also reported on the design and implementation of MetaTation, a free-form annotation tool that generates and presents just-in-time, context-specific meta data, as a reader annotates a poem printed on a physical sheet of paper, in a non-interruptive manner. We then presented the results of a preliminary evaluation of our tool with encouraging feedback from our participants and addressed the current limitations of the system. We concluded with a description of the directions for future development of our work.

Our tool, MetaTation, has the potential to augment existing work practices in the process of active reading of complex documents. In particular, it provides the advantage of supporting an already familiar method of annotating text with a physical pen, and presenting meta information in a separate space to avoid interfering with this annotation process.

References

[1] Abdul-Rahman, A., Lein, J., Coles, K., Maguire, E., Meyer, M., Wynne, M., Johnson, C. R., Trefethen, A., and Chen, M. (2013). Rule-based visual mappings – with a case study on poetry visualization. *Computer Graphics Forum*, 32(3):381–390.

[2] Bartlett, S., Kondrak, G., and Cherry, C. (2009). On the syllabification of phonemes. In *Proc. of Human Language Technologies*, pages 308–316. Association for Computational Linguistics.

[3] Chaturvedi, M., Gannod, G., Mandell, L., Armstrong, H., and Hodgson, E. (2012). Myopia: A visualization tool in support of close reading. *Digital Humanities*, 2.

[4] Chiu, P. and Wilcox, L. (1998). A dynamic grouping technique for ink and audio notes. In *Proc. of the ACM Symp. on User Interface Software and Technology*, pages 195–202. ACM.

[5] Clement, T., Auvil, L., Tcheng, D., Capitanu, B., Monroe, M., and Goel, A. (2012). Sounding for meaning: Analyzing aural patterns across large digital collections. *Digital Humanities*, 2.

[6] Collins, C., Carpendale, S., and Penn, G. (2009). Docuburst: Visualizing document content using language structure. *Computer Graphics Forum*, 28(3):1039–1046.

[7] Dictionary, M.-W. (2006). *The Merriam-Webster Dictionary*. Merriam-Webster, Incorporated.

[8] Fekete, J.-D. and Dufournaud, N. (2000). Compus: Visualization and analysis of structured documents for understanding social life in the 16th century. In *Proc. ACM Conf. on Digital Libraries*, pages 47–55.

[9] Ferguson, M., Salter, M. J., and Stallworthy, J. (2005). *The Norton Anthology Poetry*. WW Norton & Company.

[10] Jänicke, S., Franzini, G., Cheema, M. F., and Scheuermann, G. (2015). On close and distant reading in digital humanities: A survey and future challenges.

[11] Kara, L. B., Gennari, L., and Stahovich, T. F. (2008). A sketch-based tool for analyzing vibratory mechanical systems. *Journal of Mechanical Design*, 130(10):101101.

[12] Liao, C., Guimbretière, F., Hinckley, K., and Hollan, J. (2008). Papiercraft: A gesture-based command system for interactive paper. *ACM Trans. on Computer-Human Interaction (TOCHI)*, 14(4):18.

[13] Mackay, W. E., Pothier, G., Letondal, C., Bøegh, K., and Sørensen, H. E. (2002). The missing link: Augmenting biology laboratory notebooks. In *Proc. of the ACM Symp. on User Interface Software and Technology*, pages 41–50.

[14] Manning, C. D., Surdeanu, M., Bauer, J., Finkel, J., Bethard, S. J., and McClosky, D. (2014). The Stanford CoreNLP natural language processing toolkit. In *Proc. of 52nd Annual Meeting of the Association for Computational Linguistics: System Demonstrations*, pages 55–60.

[15] Marshall, C. C. (1997). Annotation: From paper books to the digital library. In *Proc. of the ACM/IEEE Joint Conference on Digital Libraries*, pages 131–140.

[16] Marshall, C. C. and Brush, B. A. J. (2004). Exploring the relationship between personal and public annotations. In *Proc. of the ACM/IEEE Joint Conference on Digital Libraries*, pages 349–357.

[17] McCurdy, N., Lein, J., Coles, K., and Meyer, M. (2015). Poemage: Visualizing the sonic topology of a poem. *IEEE Trans. on Visualization and Computer Graphics*, 21(12).

[18] Moretti, F. (2005). *Graphs, Maps, Trees: Abstract Models for a Literary History*. Verso.

[19] Morris, M. R., Brush, A. J. B., and Meyers, B. R. (2007). Reading revisited: Evaluating the usability of digital display surfaces for active reading tasks. In *Proc. of the IEEE Workshop on Horizontal Interactive Human-Computer Systems (TABLETOP)*, pages 79–86.

[20] Muralidharan, A., Hearst, M. A., and Fan, C. (2013). Wordseer: A knowledge synthesis environment for textual data. In *Proc. of the ACM Conf. on Conference on Information & Knowledge Management (CIKM)*, pages 2533–2536.

[21] Norman, D. A. (1994). *Things That Make Us Smart: Defending Human Attributes In The Age Of The Machine*. Basic Books.

[22] Norrie, M. C., Signer, B., and Weibel, N. (2006). Print-n-link: Weaving the paper web. In *Proc. of the ACM Symp. on Document Engineering*, pages 34–43.

[23] O'Hara, K. and Sellen, A. (1997). A comparison of reading paper and on-line documents. In *Proc. of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI)*, pages 335–342. ACM.

[24] Ovsiannikov, I. A., Arbib, M. A., and McNeill, T. H. (1999). Annotation technology. *International Journal of Human-Computer Studies*, 50(4):329–362.

[25] Paley, W. B. (2002). Textarc: Showing word frequency and distribution in text. In *Poster presented at IEEE Symp. on Information Visualization*, volume 2002.

[26] Paulson, B., Rajan, P., Davalos, P., Gutierrez-Osuna, R., and Hammond, T. (2008). What!?! no rubine features?: using geometric-based features to produce normalized confidence values for sketch recognition. In *HCC Workshop: Sketch Tools for Diagramming*, pages 57–63.

[27] Preece, J., Sharp, H., and Rogers, Y. (2015). *Interaction Design: Beyond Human-Computer Interaction*. John Wiley & Sons.

[28] Schilit, B. N., Golovchinsky, G., and Price, M. N. (1998). Beyond paper: Supporting active reading with free form digital ink annotations. In *Proc. of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI)*, pages 249–256.

[29] Shipman, F., Price, M., Marshall, C. C., and Golovchinsky, G. (2003). Identifying useful passages in documents based on annotation patterns. In *Research and Advanced Technology for Digital Libraries*, pages 101–112. Springer.

[30] Signer, B. and Norrie, M. C. (2007). Paperpoint: A paper-based presentation and interactive paper prototyping tool. In *Proc. of the ACM Conf. on Tangible and Embedded Interaction (TEI)*, pages 57–64.

[31] Song, H., Guimbretière, F., Grossman, T., and Fitzmaurice, G. (2010). Mouselight: Bimanual interactions on digital paper using a pen and a spatially-aware mobile projector. In *Proc. of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI)*, pages 2451–2460.

[32] Steimle, J., Brdiczka, O., and Mühlhäuser, M. (2009). Coscribe: Integrating paper and digital documents for collaborative knowledge work. *IEEE Trans. on Learning Technologies*, 2(3):174–188.

[33] Stifelman, L., Arons, B., and Schmandt, C. (2001). The audio notebook: Paper and pen interaction with structured speech. In *Proc. of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI)*, pages 182–189.

[34] Tsandilas, T., Letondal, C., and Mackay, W. E. (2009). Mus ink: Composing music through augmented drawing. In *Proc. of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI)*, pages 819–828.

[35] Wellner, P. (1993). Interacting with paper on the digitaldesk. *Communications of the ACM*, 36(7):87–96.

[36] Wolfe, J. (2002). Annotation technologies: A software and research review. *Computers and Composition*, 19(4):471–497.

[37] Yeh, R., Liao, C., Klemmer, S., Guimbretière, F., Lee, B., Kakaradov, B., Stamberger, J., and Paepcke, A. (2006). Butterflynet: A mobile capture and access system for field biology research. In *Proc. of the ACM SIGCHI Conference on Human Factors in Computing Systems (CHI)*, pages 571–580.

Appendix A

Poetry Dataset for Observational Study

Table A.1 Poems assigned per participant for the observational study

Participant	Poem Id	Title	Poet
P1	D1	A Song of a Young Lady to Her Ancient Lover	John Wilmot
	D2	Harriet	Robert Lowell
P2	D3	Adlestrop	Edward Thomas
	D4	Colossus	Sylvia Plath
P3	D5	Ode, Written in the Beginning of the Year 1746	William Collins
	D6	To the Virgins to Make Much of Time	Robert Herrick
P4	D7	Sonnet 129	William Shakespeare
	D8	Days	Ralph Waldo Emerson
P5	D9	The Painter	John Ashberry
	D10	Spring	Edna St. Vincent Millay
P6	D11	Huswifery	Edward Taylor
	D12	I Am	John Clare
P7	D13	A Gravestone Upon the Floor in the Cloisters of Worcester Cathedral	William Wordsworth
	D14	Neutral Tones	Thomas Hardy
P8	D2	Harriet	Robert Lowell
	D1	A Song of a Young Lady to Her Ancient Lover	John Wilmot
P9	D4	Colossus	Sylvia Plath
	D3	Adlestrop	Edward Thomas
P10	D6	To the Virgins to Make Much of Time	Robert Herrick
	D5	Ode, Written in the Beginning of the Year 1746	William Collins
P11	D8	Days	Ralph Waldo Emerson
	D7	Sonnet 129	William Shakespeare
P12	D10	Spring	Edna St. Vincent Millay
	D9	The Painter	John Ashberry
P13	D12	I Am	John Clare
	D11	Huswifery	Edward Taylor
P14	D14	Neutral Tones	Thomas Hardy
	D13	A Gravestone Upon the Floor in the Cloisters of Worcester Cathedral	William Wordsworth

Appendix B

Poem used in Preliminary Evaluation

Sonnet 129
William Shakespeare

Th’ expense of spirit in a waste of shame
Is lust in action; and till action, lust
Is perjured, murderous, bloody, full of blame,
Savage, extreme, rude, cruel, not to trust;
Enjoyed no sooner but despised straight:
Past reason hunted; and no sooner had,
Past reason hated, as a swallowed bait,
On purpose laid to make the taker mad:
Mad in pursuit, and in possession so;
Had, having, and in quest to have, extreme;
A bliss in proof, and proved, a very woe;
Before, a joy proposed; behind, a dream.
All this the world well knows; yet none knows well
To shun the heaven that leads to this hell.