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Posted Date: 18 July 2023

doi: 10.20944/preprints202307.1233.v1

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Computing the Sound-Sense Harmony-in the poetic works by William Shakespeare and Francis Webb

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Abstract: We assume that poetic devices have an implicit goal: producing an overall sound scheme that will induce the reader to associate intended and expressed meaning to the sound of the poem. Sounds may be organized into categories and assigned presumed meaning as suggested by traditional literary studies. In my work, I have extracted automatically the sound grids of all the sonnets by William Shakespeare and have combined them with the themes expressed by their contents. In a first experiment I have computed lexically and semantically based sentiment analysis obtaining an 80% of agreement. In a second experiment sentiment analysis has been substituted by Appraisal Theory thus obtaining a more fine-grained interpretation which in some cases contradicts the first one. The computation for the second poet - regarded by many critics the best of last century - includes both vowels and consonants. In addition, it combines automatic semantically and lexically based sentiment analysis with sound grids. The results produce visual maps that clearly separate poems into three clusters: negative harmony, positive harmony and disharmony where the latter instantiates the need by the poet to encompass the opposites in a desperate attempt to reconcile them.

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1. Introduction

The main tenet of this paper is the existence of a hidden and systematic plan by important poets like Shakespeare and Webb to organize rhyming structures in accordance with a principle of overall "Sound-Sense Harmony". What is meant here by "Sound-Sense Harmony" is the presence of rhymes whose sound – the stressed vowel is dominant – belongs to the four sound classes that may comprise all vowel sounds, phonologically speaking, i.e. Low, Mid, High-Front, High-Back, or part of them. In addition, the choice of sounds reflects the contents of the poem, as it may be represented by main topics, intended meaning and overall sentiment. The same argument is presented for the presence of the three main classes of consonants, i.e. Continuants, Sonorants, Obstruents and their partition into Voiced vs Unvoiced. The choice to favour the presence of one class vs another is to be interpreted as a way to highlight Sense-related choices of words that will either accompany or contrast with Sounds. In particular, we associate different mood – following traditional judgements - to vowels and consonants according to their class, as follows:

1. Low and Mid vowels evoke a sense of brightness, peace and serenity
2. High, Front and Back vowels evoke a sense of surprise, seriousness, rigour and gravity
3. Obstruent and Unvoiced consonants evoke a sense of harshness and severity
4. Sonorant and Continuant consonants evoke a sense of pleasure, softness and lightness

Classes 1 and 4 will be regarded in the same area of positive thinking, while classes 2 and 3 will more naturally be accompanied by negative sentiment. Of course, it may be the case that crossed matches with classes belonging to opposite types will take place more or less frequently indicating

 doi:10.20944/preprints202307.1233.v1

the need to reconcile opposite feelings in the same poem. This is what happens both in Shakespeare and in Webb work, as will be shown in the sections below.

It is important to remind the role of sounds in poetry, which is paramount for the creation of poetic and rhetoric devices. Rhyme, alliterations, assonances and consonances may contribute secondary and in some cases primary additional meaning by allowing words which are not otherwise syntactically or semantically related to share part if not all of their meaning by means of metaphors and other similar devices. Thus, most of the difficult work of every poet is devoted to the choice of the appropriate word to use for rhyming purposes mainly but also for the other important devices mentioned above.

In the case of Shakespeare, for the majority of the sonnets, he took care of choosing words for the rhymes contributing sounds to the four varieties thus producing a highly varied sound harmony. We will discuss this in the sections below paying attention to associate choice of one class vs another, with choice of specific themes or words. This important feature of the sonnets has never been noticed by literary critics in the past. Reasons for this apparent lack of attention may be imputed to the existence of two seemingly hindering factors: a former factor is the use of words which had a double pronunciation at the time, as for instance LOVE which could be pronounced as MOVE besides its current pronunciation. The latter factor regards the existence of a high – in comparison with other poets of the same Elizabethan period - percentage of a variable we call Rhyme Repetition Rate (TripleR), which indicates the use of the same "head" word – i.e. the rhyming word that precedes the alternate rhyme scheme – or sometimes the same couple of words.

Current DNNs are unable to cope with this task which is highly complex. It requires a sequence of carefully wrought processes in order to produce a final evaluation: in particular, the first task that is problematic for AI systems like ChatGPT is as faithful as possible phonetic transcription of each poem. When asked to produce one such transcription, ChatGPT replied that it was unable to do it and that I had to do it myself. The reason for this refusal is very simple: dictionaries for DNN models number over one million distinct word forms and there is no resource available which counts more than 200,000 fully transcribed entries. The solution is to provide rule-based algorithms but we know that DNNs are just the opposite. They are unable to generalize what they might have learnt from a dictionary to new unseen word forms[1]. And phonetic transcription is just the first step in the pipeline of modules which are responsible for the final evaluation, as the following section will clarify.

The Result section of the paper has a first rather lengthy subsection dedicated to the problem of rhyming structure which in the Sonnets constitutes the basic framework onto which all the subsequent reasoning is founded. Another subsection is dedicated to associating rhyming schemes with different themes as they have evolved in time. We dedicate a subsection to explaining the importance of the lexical approach in organizing the rules for the system SPARSAR which derives the final vowel and consonant grids that allow us to make the first comparison. The lexical and semantic approach to deriving the sentiment of each sonnet operates a first subdivision of harmonic and dis-harmonic sonnets into negatively vs positively marked sonnets. Measuring correlations reveals a constant contrasting attitude induced by the sound-sense agreement, which we interpret as an underlying hidden intention to produce some form of ironic mood.

Detecting irony requires a much deeper and accurate analysis of the semantic and the pragmatics of the sonnets, and for that reason a sound semantic theory is also needed. We proceed into two separate but conjoined ways: producing a gold standard of the sonnets and then manually annotating each sonnet using the highly sophisticated labeling system proposed by the Appraisal Theory Framework, ATF that we introduce briefly in the section below. Matching the empirical approach and the automatic analysis confirms the overall underlying hypothesis: the sound-sense disharmony has a fundamental task, that of suggesting an underlying ironic attitude which is at the heart of all the sonnets. The results show the weakness of the Sentiment-based analysis and makes available a more fine-grained approach which takes non-literal language into due account.

2. Materials and Methods

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In this section I will present the system SPARSAR and the pipeline of modules that allow it to carry out the complex analysis reported above.

2.1. SPARSAR - a System for Poetry Analysis and Reading

SPARSAR [2] produces a deep analysis of each poem at different levels: it works at sentence level at first, then at verse level and finally at stanza level (see Figure 1 below). The structure of the system is organized as follows: the input text is processed at first at syntactic and semantic level and grammatical functions are evaluated. Then the poem is translated into a phonetic form preserving its visual structure and its subdivision into verses and stanzas. Phonetically translated words are computed together for a verse representation into metrical structure. Another important component of the analysis of rhythm is the evaluation of rhyme schemes at stanza level and then the overall rhyming structure at poem level. In addition, the system has access to a restricted list of typical pragmatically marked phrases and expressions that are used to convey specific discourse function and speech acts and need specialized intonational contours.

We use the word "expressivity" in a specific general manner which includes sensible and sensitive reading that can only be achieved once a complete syntactic and semantic analysis has been provided to the TTS manager [3,4]. Levels of intervention of syntactic-semantic and pragmatic knowledge include:

- syntactic heads which are quantified expressions
- syntactic heads which are preverbal SUBJects
- syntactic constituents that starts and ends an interrogative or an exclamative sentence
- distinguish realis from irrealis mood;
- distinguish deontic modality including imperative, hortative, optative, deliberative, jussive, precative, prohibitive, propositive, volitive, desiderative, imprecative, directive and necessitative etc.
- distinguish epistemic modality including assumptive, deductive, dubitative, alethic, inferential, speculative etc.
- any sentence or phrase which is recognized as a formulaic or frozen expression with specific pragmatic content
- subordinate clauses with inverted linear order; distinguishing causal from hypotheticals and purpose complex sentences
- distinguishing parentheticals from appositives and unrestricted relatives
- Discourse Structure to tell satellite and dependent clauses from main
- Discourse Structure to check for Discourse Moves - Up, Down and Parallel
- Discourse Relations to tell Foreground Relations from Backgrounds
- Topic structure to tell the introduction of a new Topic or simply a Change at relational level.

Current TTS are characterized by a total lack of expressivity. They only take into account information coming from punctuation and in some cases, from tagging. This hampers the possibility to capture the great majority of structures listed above. In particular, comma is a highly ambiguous punctuation mark with a whole set of different functions which are associated with specific intonational contours, and require semantic and discourse level knowledge to disentangle ambiguity. In general, question and exclamative marks are always used to modify the prosody of the previous word, which is clearly insufficient to reproduce such pragmatically marked utterances.

2.2. The Modules for Syntax and Semantics

The system uses a modified version of *VENSES*, a semantically oriented NLP pipeline [5]. It is accompanied by a module that works at sentence level and produces a whole set of analysis both at quantitative, syntactic and semantic level. In order to compute syntactic structure, the system makes available chunks and dependency structures. This representation is used for the level of semantics both in the version of a classifier and by isolating verbal complex in order to verify propositional properties, like presence of negation, to compute factuality from a crosscheck with modality, aspectuality – that is derived from the lexica – and tense. The classifier has two different tasks: separating concrete from abstract nouns, identifying highly ambiguous from singleton concepts

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(from number of possible meanings from WordNet and other similar repositories). Eventually, the system carries out a sentiment analysis of the poem, thus contributing a three-way classification: neutral, negative, positive that has been used in the experiments described in this paper for prosodically related purposes, i.e. reading the sound-sense harmony.

Semantics in our case not only refers to predicate-argument structure, negation scope, quantified structures, anaphora resolution and other similar items. It is referred essentially to a propositional level analysis, which is the basis for discourse structure and discourse semantics contained in discourse relations. It also paves the way for a deep sentiment or affective analysis of every utterance, which alone can take into account the various contributions that may come from syntactic structures like NPs and APs where affectively marked words may be contained. Their contribution needs to be computed in a strictly compositional manner with respect to the meaning associated to the main verb, where negation may be lexically expressed or simply lexically incorporated in the verb meaning itself.

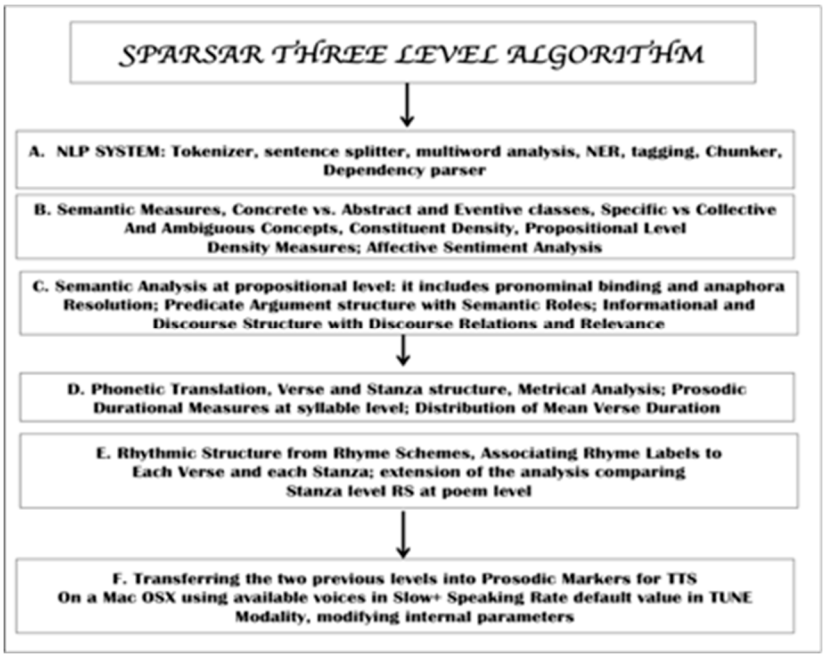

Figure 1. Architecture of *SPARSAR* with main pipeline organized into three levels.

In Figure 1 above we show the architecture of the deep system for semantic and pragmatic processing, in which phonetics, prosodics and NLP are deeply interwoven. As already described above, the system does low level analyses before semantic modules are activated, that is tokenization, sentence splitting, multiword creation from a large lexical database. Then chunking and syntactic constituency parsing which is done using a rule-based recursive transition network: the parser works in a cascaded recursive way to include higher syntactic structures up to sentence and complex sentence level. These structures are then passed to the first semantic mapping algorithm that looks for subcategorization frames in the lexica freely made available for English, including a proprietor lexicon of some 10K entries, with most frequent verbs, adjectives and nouns, containing also a detailed classification of all grammatical or function words. This mapping is done following LFG principles [6,7], where c-structure is mapped onto f-structure thus obeying uniqueness, completeness and coherence. The output of this mapping is a rich dependency structure, which contains information related also to implicit arguments, i.e. subjects of infinitivals, participials and gerundives. LFG representation also has a semantic role associated to each grammatical function, which is used to identify the syntactic head lemma uniquely in the sentence. When fully coherent and complete predicate argument structures have been built, pronominal binding and anaphora resolution algorithms are fired. Coreferential processed are activated at the semantic level. Discourse Level computation is done at propositional level by building a vector of features associated to the main verb of each clause. They include information about tense, aspect, negation, adverbial modifiers,

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modality. These features are then filtered through a set of rules which have the task to classify a proposition as either objective/subjective, factual/nonfactual, foreground/background. In addition, every lexical predicate is evaluated with respect to a class of discourse relations. Eventually, discourse structure is built, according to criteria of clause dependency where a clause can be classified either as coordinate or subordinate.

2.3. The Modules for Phonetic and Prosodic Analysis

The second set of modules is a rule-based system that converts graphemes of each poem into phonetic characters, it divides words into stressed/unstressed syllables and computes rhyming schemes at line and stanza level. To this end it uses grapheme to phoneme translations made available by different sources, amounting to some 500K entries, and include CMU dictionary [1], MRC Psycholinguistic Database[2], Celex Database [8], plus a proprietor database made of some 20,000 entries. Out of vocabulary words are computed by means of a prosodic parser implemented in a previous project [9] containing a big pronunciation dictionary which covers 170,000 entries approximately. Besides the need to cover the majority of grapheme to phoneme conversions by the use of appropriate dictionaries, remaining problems to be solved are related to ambiguous homographs like "import" (verb) and "import" (noun) and are treated on the basis of their lexical category derived from previous tagging. Eventually there is always a certain number of Out Of Vocabulary Words (OOVW). The simplest case is constituted by differences in spelling determined by British vs. American pronunciation. This is taken care of by a dictionary of graphemic correspondances. However, whenever the word is not found the system proceeds by morphological decomposition, splitting at first the word from its prefix and if that still does not work, its derivational suffix. As a last resource, an orthographically based version of the same dictionary is used to try and match the longest possible string in coincidence with current OOVW. Then the remaining portion of word is dealt with by guessing its morphological nature, and if that fails a grapheme-to-phoneme parser is used. Here below are some of the OOVWs that have been reconstructed by means of the recovery strategy explained above: we indicated each example by showing the input word rejected by the dictionary lookup, then the word found by subtraction and the final output obtained by recomposition:

% wayfarer [wayfare-[w_ey1f_eh1_r_r]]

% gangrened [gangrene-[g_ae1_nr_ah0_n_d]]

% krog [krog-g_r_aa1_g]

% copperplate [copper-k_aa1_p_er_p_l_ey1_t]

% splendor [splendour-[s_p_l_eh1_n_d_er]]

% filmy [film-f_ih1_l_miy]

% seraphic seraphine--> [s_e_r_a_ph_iy1_k]

% unstarred [starred-[ah_n_s_t_aa1_r_d]]

Other words we had to reconstruct are: shrive, slipstream, fossicking, unplotted, corpuscle, thither, wraiths, etc. In some cases, the problem that made the system fail was the presence of a syllable which was not available in our database of syllable durations, *VESD* [9]. This problem has been coped with by manually inserting the missing syllable and by computing its duration from the component phonemes, or from the closest similar syllable available in the database. We only had to add 12 new syllables for a set of approximately 1000 poems that the system computed.

The system has no limitation on type of poetic and rhetoric devices, however it is dependent on language: Italian line verse requires a certain number of beats and metric accents which are different from the ones contained in an English iambic pentameter. Rules implemented can demote or promote

[1] Freely downloadable from http://www.speech.cs.cmu.edu/cgi-bin/cmudict

[2] Freely downloadable from https://websites.psychology.uwa.edu.au/school/mrcdatabase/uwa_mrc.htm

 doi:10.20944/preprints202307.1233.v1

word-stress on a certain syllable depending on selected language, line-level syllable length and contextual information. This includes knowledge about a word being part of a dependency structure either as dependent or as head.

As R.Tsur[10] comments in his introduction to his book, iambic pentameter has to be treated as an abstract pattern and no strict boundary can be established. The majority of famous English poets of the past, while using iambic pentameter have introduced violations, which in some cases – as for Milton's Paradise Lost – constitute the majority of verse patterns. Instead, the prosodic nature of the English language needs to be addressed, at first. English is a stress-timed language as opposed to Spanish or Italian which are syllable-timed languages. As a consequence, what really matters in the evaluation of iambic pentameters is the existence of a certain number of beats – 5 in normal cases, but also 4 in deviant ones. Unstressed syllables can number higher, as for instance in the case of exceptional feminine rhyme or double rhyme, which consists of a foot made of a stressed and an unstressed syllable (very common in Italian), ending the line - this is also used by Greene et al.[11] to loosen the strict iambic model. These variations are made to derive from elementary two-syllable feet, the iamb, the trochee, the spondee, the pyrrich. According to the author, these variations are not casual, they are all motivated by the higher syntactic-semantic structure of the phrase. So there can be variations as long as they are constrained by a meaningful phrase structure.

In our system, in order to allow for variations in the metrical structure of any line, we operate on the basis of syntactic dependency and have a stress demotion rule to decide whether to demote stress on the basis of contextual information. The rule states that word stress can be demoted in dependents in adjacency with their head, in case they are monosyllabic words. In addition, we also have a promotion rule that promotes function words which require word stress. This applies typically to ambiguously tagged words, like "there", which can be used as expletive pronoun in preverbal position, and be unstressed; but it can also be used as locative adverb, in that case in postverbal position, and be stressed. For all these ambiguous cases, but also for homographs not homophones, tagging and syntactic information is paramount.

Our rule system tries to avoid stress clashes and prohibits sequences of three stressed/three unstressed syllables, unless the line syntactic-semantic structure allow it to be interpreted otherwise. Generally speaking, prepositions and auxiliary verbs may be promoted; articles and pronouns never. An important feature of English vs. Italian is length of words in terms of syllables. As may be easily gathered, English words have a high percentage of one-syllable words when compared to Italian which on the contrary has a high percentage of 3/4-syllable words.

2.4. Computing Metrical Structure and Rhyming Scheme

Any poem can be characterized by its rhythm which is also revealing of the poet's peculiar style. In turn, the poem's rhythm is based mainly on two elements: meter, that is distribution of stressed and unstressed syllables in the verse, presence of rhyming and other poetic devices like alliteration, assonance, consonance, enjambments, etc. which contribute to poetic form at stanza level. This level is combined then with syntax and semantics to produce the adequate breath-groups and consequent subdivision: these will usually coincide with line stop words, but they may continue to the following line by means of enjambments.

As discussed above - see Figure 1, the analysis starts by translating every poem into its phonetic form. After processing the whole poem on a line by line basis and having produced all phonemic transcription, the system looks for poetic devices. Here assonances, consonances, alliterations and rhymes are analysed and then evaluated. Here metrical structure is computed, that is the alternation of beats: this is done by considering all function or grammatical words which are monosyllabic as unstressed. In particular, "0" is associated to all unstressed syllables, and a value of "1" to all stressed syllables, thus including both primary and secondary stressed syllables. Syllable building is a discovery process starting from longest possible phone sequences to shortest one. This is done heuristically trying to match pseudo syllables with the syllable list. Matching may fail and will then result in a new syllable which has not been previously met. The assumption is that any syllable inventory will be deficient, and will never be sufficient to cover the whole spectrum of syllables

available in the English language. For this reason, a certain number of phonological rules has been introduced in order to account for any new syllable that may appear. Also syntactic information is taken advantage of, which computed separately to highlight chunks' heads as produced by bottomup parser. In that case, stressed syllables take maximum duration values. Dependent words on the contrary are "demoted" and take minimum duration values.

Metrical structure is used to evaluate its distribution in the poem by means of statistical measures. As a final consideration, we discovered that even in the same poem it is not always possible to find that all lines have identical number of syllables, identical number of metrical feet and identical metrical verse structure. If we consider the sequence "01" as representing the typical iambic foot, and the iambic pentameter as the typical verse metre of English poetry, there is no poem strictly respecting it in our analyses. On the contrary we found trochees, "10", dactyls, "100", anapests, "001"and spondees, "11". At the end of the computation, the system is used to measure two important indices: "mean verse length" and "mean verse length in no. of feet" that is mean metrical structure.

Additional measures that we are able to produce are related to rhyming devices. Since we consider important taking into account structural internal rhyming schemes and their persistence in the poem the algorithm makes available additional data derived from two additional components: word repetition and rhyme repetition at stanza level. Sometimes also "refrain" may apply, that is the repetition of an entire line of verse. Rhyming schemes together with metrical length, are the strongest parameters to consider when assessing similarity between two poems.

Eventually the internal structure of metrical devices used by the poet can be reconstructed: in some cases, also stanza repetition at poem level may apply. To create the rhyming scheme couples of rhyming lines are searched by trying a match recursively of each final phonetic word with the following ones, starting from the closest to the one that is further apart. Each time both rhyming words and their distance are registered. In the following pass, the actual final line numbers are reconstructed and then an indexed list of couples, Line Number-Rhyming Line for all the lines is produced, including stanza boundaries. Eventually, alphabetic labels to the each rhyming verse starting from A to Z. A simple alphabetic incremental mechanism updates the rhyme label. This may go beyond the limits of the alphabet itself and in that case, double letters are used.

2.5. From Sentiment Analysis to the Deep Pragmatic Approach by ATF

We based a first approach to detecting sound-sense harmony on sentiment analysis, which in our case encompasses both a lexical and a semantic analysis at propositional level. More generally speaking, computational research on sentiment analysis has been based on the use of shallow features with a binary choice to train statistical model [12] that, when optimized for a particular task, will produce acceptable performance. However generalizing the model to new texts is a hard task and, in addition, the sonnets contain a lot of nonliteral language. The other common approach used to detect irony, in the majority of the cases, is based on polarity detection. Sentiment Analysis [13,14] is in fact an indiscriminate labeling of texts either on a lexicon basis or on a supervised feature basis where in both cases, it is just a binary - ternary or graded - decision that has to be taken. This is certainly not explanatory of the phenomenon and will not help in understanding what it is that causes humorous reactions to the reading of an ironic piece of text. It certainly is of no help in deciding which phrases, clauses or just multiwords or simply words, contribute to create the ironic meaning (see [15]).

Shakespeare's Sonnets are renowned for being full of ironic content [16,17] and for their ambiguity thus sometimes reverting the overall interpretation of the sonnet. Lexical ambiguity, i.e. a word with several meanings, emanates from the way in which the author uses words that can be interpreted in more ways not only because inherently polysemous, but because sometimes the additional meaning meaning they evoke can sometimes be derived on the basis of the sound, i.e. homophone (see "eye", "I" in sonnet 152). The sonnets are also full of metaphors which many times requires contextualising the content to the historical Elizabethan life and society. Furthermore, there is an abundance of words related to specific language domains in the sonnets. For instance, there are words related to the language of economy, war, nature and to the discoveries of the modern age, and

each of these words may be used as a metaphor of love. Many of the sonnets are organized around a conceptual contrast, an opposition that runs parallel and then diverges, sometimes with the use of the rhetorical figure of the chiasmus. It is just this contrast that generates irony, sometimes satire, sarcasm, and even parody. Irony may be considered in turn as: what one means using language that normally signifies the opposite, typically for humorous or emphatic effect; a state of affairs or an event that seems contrary to what one expects and is amusing as a result. As to sarcasm this may be regarded the use of irony to mock or convey contempt. Parody is obtained by using the words or thoughts of a person but adapting them to a ridiculously inappropriate subject. There are several types of irony, though we select verbal irony which, in the strict sense, is saying the opposite of what you mean for outcome, and it depends on the extra-linguistics context[18]. As a result, Satire and Irony are slightly overlapping but constitute two separate techniques; eventually Sarcasm can be regarded as a specialization or a subset of Irony. It is important to remark that in many cases, these linguistic structures may require the use of non-literal or figurative language, i.e. the use of metaphors.

Joining sentiment, irony and sound as it could have been heard by Elizabethan audiences is what makes the Sonnets so special even today, and our paper succeeds in clarifying the at the same time deep and shallow combination of factors intertwined to produce the final glamorous result that every sonnet does also today.

3. Results

This section will present results of the analysis of Shakespeare's sonnets at first and then of Webb's poems highlighting all cases of harmony and disharmony with relation to theme and meaning intended in the poem.

3.1. Sound Harmony in the Sonnets

We postulate the existence of a hidden plan in Shakespeare's poetic approach, to abide to a harmonic principle that requires all varieties of sound classes to be present and to relate by virtue of a sound-meaning correspondance, to thematic and meaning development in the sonnet. To discover such plan, we analysed the phonetic representation of the rhyming words of all sonnets using SPARSAR – the system that analyzes automatically any poem, see below -, and then organized the results of all vowel sounds into the four classes mentioned above. We did the same with consonants and consonant clusters in order to get a complete and as much complex as possible of the overall sound grid of each poem and compare it with sense-related analyses.

However in order to produce such a result, almost 500 phonologically ambiguous rhyming words had to be checked and transformed into the pronunciation current in the XVIth century when Early Modern English was still existent. This will be explained in a section below. It is also important to remind that the sonnets contain some 800 contractions and some 50 metrical adjustments which require the addition of an end of word syllable. After all these corrections we obtained a sound map which clearly testifies to the intention of preserving a sound-sense harmony in the overall poetic scheme of the sonnets.

We may state as a general principle, that the sound-sense harmony is respected whenever there is a full agreement between the sound grid and the mood associated with the meaning of the words. We assume then that there exists a sound-meaning correspondance by which different emotions or sentiments may be associated to each class. And of course different results will be obtained by subtracting one class from the set, as we will comment below.

3.1.1. Periods and Themes in the Sonnets

The sonnets have been written in the short period that goes from 1592 to 1608, but we don't know precisely when. The majority of critics have divided them up into two main subperiods: a first one from 1592 to 1597 encompassing Sonnets from 1 to 126 and a second subperiod from 1598 to 1608 that includes Sonnets 127 to 154 (see Melchiori [19]). In addition, the sonnets have been traditionally

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subdivided into 5 main cycles or themes (Melchiori: Introduction): from 1 to 17, the reproduction sonnets, progeny, in which the poet spurs the young man to marry; from 18 to 51, immortality of poetry, the temptation of the friend by the lady, friend is guilty, and the absence of the loved one; from 52 to 96, poetry and memory, beauty and poetic rivalry; from 97 to 126, memory, the mistakes of the poet; and the last one from 127 to 152, the theme of the dark lady and unfaithfulness.

In Michael Schoenfeldt's Introduction to his edited book[20], we find a similar subdivision where he comments that Sonnets 1–126 are written to a beautiful young man, while Sonnets 127–152 are written to a dark lady, and there are many other thematic and narrative sequences like 1–17 mentioned above (ibid. iii).

In the study of inversion made by Ingham and Ingham[21] on all of Shakespeare's plays, the authors reported three separate historical periods characterized by different frequencies in the use of subject inversion (VS) compared with canonical order (SV) on a total number of 951 clause structures:

1. A first period that goes from 1592 to 1597 where we have the majority of the cases of VS (214 over 421 total cases).
2. A second period that goes from 1598 to 1603 where the number of cases is reduced by half, but the proportion remains the same (109 over 213 total cases). A third period that goes from 1604 to 1608 where the proportion of cases is reverted (95 over 317 total cases) and VS cases are the minority.

Main themes of the sonnets are well-known: from 1 to 126 they are stories about a handsome young man, or rival poet; from 127 to 152 the sonnets concern a mysterious "dark" lady the poet and his companion love. The last two poems are adaptations from classical Greek poems. In the first sequence the poet tries to convince his companion to marry and have children who will ensure immortality. Else love, the poem and poetry will "defeat" death. In the second sequence, both the poet and his companion have become obsessed with the dark lady, the lexicon used is sensual and the tone distressing. These themes are at their highest in the best sonnets indicated above. So we would expect these sonnets to exhibit properties related to popularity that set them apart from the rest.

We decided to look into the "themes" matter more deeply and discovered that the Immortality theme is in fact present through the lexical field constituted by the keyword DEATH. We thus collected all words related to this main keyword and they are the following ones, omitting all derivations, i.e. plurals for nouns, third person, past tense and gerundive forms for verbs:

BURY, DEAD, DEATH, DECEASE, DECAY, DIE, DISGRACE, DOOM, ENTOMBED, GRAVE, GRIEF, GRIEV ANCE, GRIEVE, SCYTHE, SEPULCHRE, TOMB, WASTE

Which we connected to SAD, SADNESS, UNHAPPYNESS, WRINKLE. We ended up by counting 64 sonnets containing this lexical field which can be safely regarded as the most frequent theme of all. We then looked for the opposite meanings, the ones related to LIFE, HAPPY, HAPPYNESS, PLEASURE, PLEASE, MEMORY, POSTERITY, ETERNITY. In this case, 28 sonnets are the ones mentioning these themes. So, overall, we individuated 92 sonnets addressing emotionally related strong themes. When we combine the two contrasting themes, Death/Eternity, Sadness/Memory, we come up with the following 19 sonnets:

1, 3, 6, 8, 15, 16, 25, 28, 32, 43, 48, 55, 63, 77, 81, 92, 97, 128, 147

3.1.2. Measuring all vowel classes

We show in the table below general statistics of the distribution of stressed vowel sounds in rhyming words of all the sonnets. We included also diphthongs, considering the stressed portion as the relevant sound. The expected result is that the phonological class of High-Back is the one less present in the sonnets, followed by High-Front and Low. Rhyming words with Middle stressed vowel are the ones with highest frequency.

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Table 1. Distribution of sounds of end-of-line rhyming words divided into four phonological classes.

Phon.Class	High-Front	Mid	Low	High-Back	Total
No.Class	119	159	142	111	531
StrVowDiph	493	861	587	314	2155

Here below some examples of the classification of stressed vowels of rhyming words in the first three sonnets:

Sonnet 1: FRONT - increase, decease, spring, niggarding, be, thee

BACK - fuel, cruel

LOW - die, memory, eyes, lies,

MIDDLE - ornament, content

Sonnet 2: BACK - use, excuse, old, cold

MIDDLE - field, held, days, praise

LOW - lies,eyes, mine, thine, brow, now

Sonnet 3: HIGH - thee, see, husbandry, posterity, be, thee

BACK - womb, tomb, viewest, renewest,

LOW - another, mother, prime, time,

In Table 2 we show the presence of the four classes in each sonnet, confirming our starting hypothesis about the intention to maintain a sound harmony in each sonnet: As can be easily gathered, 140 sonnets over 154 have rhymes with sounds belonging to more than 2 classes.

Table 2. Subdivision of the sonnets by number of classes.

No.Classes	4-class	3-class	2-class	1-class	total
No.Sonnets	77	64	12	1	154

There is 1 sonnet with only one class and is sonnet 146; then there are 13 sonnets with 2 classes of sounds: 8, 9, 64, 71, 79, 81, 87, 90, 92, 96, 124, 149. These sonnets contain rhyming pairs with low and middle sounds, except for there sonnets: sonnet 71 which contains high-back and middle sounds; sonnet 9 which contains high-front and low sounds; and sonnet 96 containing high-front and middle sounds. The themes developed in these sonnets fit perfectly into the rhyming sound class chosen. Let's consider sonnet VIII which is all devoted to music and string instruments which require more than one string to produce their sound, thus suggesting the need to find a companion and get married. Consider the line "the true concord of well tunèd sounds," where hints to the need that sounds should be "well" tuned. Sonnet LXXXI celebrates the poet and his verse which shall survive when death will come. Sonnet XCII is in fact pessimistic in the possibility that love will last "for the term of life" and no betrayal will ensue. As to sonnet CXLVI it is a mixture of two seemingly different themes: a criticism of extravagant display or rich clothing of wealth by writers of the time, or perhaps his mistress and trying to convince her to change her ways for eternal salvation. Some critics regard this as the most profoundly religious or meditative sonnet. But the feeling of the lover renouncing something brings back his mistress and the feeling of being powerless against her chastity, so that religious life becomes a desirable aim. In this sense, death can also be depicted as desirable.

It is important to notice the overall strategy of choice of sound in relation to meaning, in rhyming devices used for instance, in sonnet 147:

my reason, the physician to my love,

angry that his prescriptions are not kept,

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hath left me, and i desperate now approve
desire is death, which physic did except.

The interesting fact in this case is that the appearance of a back high sound like |U| would match with the appearance of the saddest word, DEATH in the same stanza. In other words, the magistral use of rhyming sounds goes hand in hand with the themes and meaning developed in the sonnet.

Interesting to note how the rhyming sound evolve in the Sonnets taking sonnet 107 as an example: from SAD sounds (back and high), to MID and CLOSE to LOW and OPEN in the third stanza, to end with a repetition of MID sounds in the couplet:

not mine own fears, nor the prophetic soul
of the wide world dreaming on things to come,
can yet the lease of my true love control,
supposed as forfeit to a confin'd doom.
the mortal moon hath her eclipse endur'd,
and the sad augurs mock their own presage;
incertainties now crown themselves assur'd,
and peace proclaims olives of endless age.
now with the drops of this most balmy time,
my love looks fresh, and death to me subscribes,
since, spite of him, i'll live in this poor rime,
while he insults o'er dull and speechless tribes:
and thou in this shalt find thy monument,
when tyrants' crests and tombs of brass are spent.

In Sonnet 145 the overall feeling of sadness is transferred in the rhyming sounds: in the first stanza the correct EME pronunciation requires |come| to be pronounced as |doom|, CUM/DUM a High-Back sound which is then be repeated in the final couplet where “sav’d my life” appears. Here important echoes of the |U| sound appear in the couplet with end-of-line words THREW and YOU.

……
straight in her heart did mercy come,
chiding that tongue that ever sweet
was us'd in giving gentle doom;
…….
from heaven to hell is flown away.
'i hate', from hate away she threw,
and sav'd my life, saying 'not you'.

We saw above the subdivision into classes: however it does not tell us how the four phonological classes are distributed in the sonnets.

The resulting sound image coming from rhyme repetitions is eventually highlighted by frequency of occurrence of same stressed vowel as shown in the table below. In this table, we separated vowel sounds into three classes, high, middle, low to allow a better overall evaluation.

Table 3. Total count for vowel, final consonants and sonorant sounds organized into classes.

No.	Un/Stress Vow/Con	Following Vowel/ Consonant	Freq Occ	High	Mid dle	Low	Cons onant
1	ay	d, er, f, l, m, n, r, t, v, z	109			109	

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2	ey	d, jh, k, l, m, n, s, t, v, z	81		81		
3	n_	d, iy, jh, s, t, z	80				80
4	r_	ay1, d, ey1, iy, iy1, k, n, ow, ow1, s, t, th, uw1, z	68				68
5	eh	d, jh, k, l, n, r, s, t, th	68		68		
6	ih	d, l, m, n, ng, r, s, t, v	51	51			
7	ao	d, l, n, ng, r, s, t, th, z	40		40		
8	iy	d, f, ih, k, l, m, n, p, s, t, v, z	45	45			
9	s	iy, st, t	38				38
10	uw	d, m, n, s, t, th, v, z	47	47			
11	ah	d, l, n, s, t, z	34			34	
12	ow	k, l, n, p, t, th, z	21	25			
13	t	er, ey1, iy, s, st	21				21
14	ah	d, k, m, n, ng	17			17	
15	aa	n, r, t	16			16	
16	ae	ch, d, k, ng, s, v	14			14	
17	d_z		13				13
18	er	ay1, d, iy, z	11		11		
		Total final sounds	778	168	200	190	220

Eventually we come up with 61 more frequent heads with occurrences up to 4 and a total of 778 repeated vowel and consonant line ending sounds. We now consider the remaining 288 rhyming pairs organized into “head” and “dependent”, i.e. the preceding end of line rhyming word and the one in the corresponding alternate/adjacent end of line.

A direct consequence of the level of rhyming pair repetition rate, is the sound image created in each sonnet. We assume that a high level of repetition will create a sort of echo from one sonnet to the next and a continuation effect, but it will also contribute a sense of familiarity. We decided to verify what would be the overall sound effect created by the total number of rhyming pairs analysed. Thanks to SPARSAR modules for phonetic transcription and poetic devices detection discussed elsewhere [22], we managed to recover all correct rhyming pairs and their phonetic forms. We report results in the Tables below.

The resulting sound image coming from rhyme repetitions is eventually highlighted by frequency of occurrence of same stressed vowel as shown in the two tables below. We separated vowel sounds into three classes, high, middle, low to allow for an easy overall evaluation. If we consider all vowel sounds, there appears to be a highly balanced use of rhyming pairs with stressed low vowels being the more frequent. Not so if we consider diphthongs – we always consider the stressed vowel in both rising and falling diphthongs - where the opposite applies, and low diphthongs scoring highest as can be gathered from Table 5a and b.

3.1.3. Distributing vowel and diphthong classes into thematic periods

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We collected all stressed vowels and diphthongs for the five periods or phases into which the Sonnets collection can be divided up and found interesting variations: Period 1 has only 17 sonnets and 238 stressed rhyming words; Period 2 has 34 sonnets and 476 rhyming words; Period 3 has the majority, 45 sonnets and 630 rhyming words; Period 4 has 30 sonnets and 420 words, and Period 5 has the remaining 28 sonnets and 398 rhyming words.

Table 4. a: Distribution of stressed rhyming vowels in five Phases.

	Low	Middle	High	Total
Period 1	40	42	57	139
Period 2	105	68	102	275
Period 3	111	105	136	352
Period 4	59	79	122	260
Period 5	66	60	99	225
Totals	381	354	516	1251

We computed absolute values for each vowel class distributed in the five period and what can be preliminarily noted is the high number of "high" vowels and the lower number of the two other classes. Now we produced weighted measures in order to take into account differences in number of sonnets considered which as a result will produce a disparity in the total number of occurrences. Frequency values for each vowel class are now a ratio of the number of sonnets per phase, the same with total values.

Table 4. b: Weighted values of the distribution of stressed rhyming vowels in five Phases.

	Low	Middle	High	Total
Period 1	2.3529	2.4706	3.3529	8.1765
Period 2	3.0882	2	3	8.0882
Period 3	2.4667	2.3334	3.0223	7.8223
Period 4	1.9667	2.6334	4.0667	8.6667
Period 5	2.3571	2.1429	3.5357	8,0357
Totals	30.529%	28.365%	41.106%	100%

In this case we can easily see that High vowels are always the class which had the most occurrencies and Period 4 and 5 are the ones with the highest number – which however needs to be divided by two subclasses, front and back. Low vowel class is the one with higher percentage, and in Period 2 Low vowels have their highest value when compared to the other Periods. The opposite takes place in Period 4 where High vowels are at their highest also compared with the other Periods and Low vowels are at their lowest also compared to other Periods. We may note that overall the highest number of stressed vowels belongs to Phase 4, whereas, the lowest number to Phase 3. Overall, the majority of stressed vowels belongs to the phonetic class of High vowels followed by Low and then Middle.

We must now consider diphthongs and verify whether the same picture applies. Diphthongs as annotated in the CMU dictionary, do not contain any high stressed nuclear vowel, because the choice

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was to separate high vowels in all those cases. So we are left with five diphthongs, two low: AW, AY, and three middle: EY, OW, OY.

Table 5. a: Distribution of stressed diphthongs in the sonnets divided in 5 phases.

	Low	Middle	Total
Phase 1	50	46	96
Phase 2	78	103	181
Phase 3	112	154	266
Phase 4	81	72	153
Phase 5	65	85	150
Totals	386	460	846

As can be easily gathered from absolute total values, Middle diphthongs constitute by far the majority. Here below their distribution in the five phases:

Table 5. b: Weighted valued of the distribution of stressed diphthongs in the sonnets in 5 phases .

	Low	Middle	Total
Phase 1	2.9412	2.7059	5.6471
Phase 2	2.2941	3.0294	5.3235
Phase 3	2.4889	3.4223	5.9112
Phase 4	2.7	2.4	5.1
Phase 5	2.3214	3.357	5.3571
Totals	45.626%	54.373%	100%

Both Phase 1 and 4 show a decrease of middle vs low diphthongs, while the remaining three phases behave in the opposite manner: more middle than low diphthongs. Total distribution indicates Phase 3 as the highest number of diphthongs and Phase 4 as the lowest, just the opposite of the previous distribution. General totals shows distribution of Middle vs Low diphthongs which is strongly in favour of Middle ones. This is just the opposite of what we found in previous counts, and in part then compensates with the lack of High diphthongs. Eventually, in table 14, the overall sound image is determined by a strong presence of Middle sounds, followed by Low sounds and eventually High sounds.

Table 6. Sound image of the sonnets.

	Low	Middle	High	Total
Vowels	381	354	567	1312
Diphthongs	386	460		854
Total	767	814	567	2166

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3.2. Rhyming and Rhythm: the Sonnets and Poetic Devices

3.2.1. Contractions vs. Rhyme Schemes

Contractions are present in great number in the sonnets. Computing them requires reconstructing their original complete corresponding word form in order to be able to match it to the lexicon or simply derive the lemma through morphological processing. This is essentially due to the fact that they are not predictable and must be analysed individually. Each type of contraction has a different manner to reconstruct the basis wordform. In order to understand and reconstruct it correctly, each contraction must go through recovering of the lemma. We have found 821 contractions in the collection, where 255 are cases of genitive 's, and 167 are cases of past tense/participle 'd. The remaining cases are organised as follows:

- SUFFIXES attached at word end, for example ['s, 'd, 'n, 'st, 't, (putt'st)]
- PREFIXES elided at word beginning, for example ['fore, 'gainst, 'tis, 'twixt, 'greeing]
- INFIXES made by consonant elision inside the word [o'er, ne'er, bett'ring, whate'er, sland'ring, whoe'er,

o'ercharg'd, 'rous]

Now consider a contracted word like "sland'ring": as said before, at first the complete wordform must be reconstructed in order to use it for recovering the lemma and using the grammatical category for syntax and semantics. However, when computing the metrical structure of each line the phonetic translation should be made on the contracted word, which does not exist in any dictionary neither in the form "slandring" nor in the form "sland-ring". What we do is finding the phonetic transcription if already existent, in the dictionaries, and then subtracting the phoneme that has been omitted, creating in this way a new word. This is ok until we come to the module where metrical counts are made on the basis of the number of syllables. But here again the phonetic form derived from the complete word is not easy to accomodate. There are two possible subdivisions of the phonetic form s_l_ae_n_d_r_ih_ng (in ARPAbet characters): syllable1: s_l_ae_n_d_, syllable2: r_ih_ng. Syllable 1 does not correspond to the subdivision for the complete word which would be s_l_ae_n_|d_eh_|r_ih_ng. Luckily, the syllable exist independently, but this only happens occasionally. In the majority of the cases, the new word form produces syllables which are inexistent and need to be created ad hoc.

3.2.2. Rhythm and Rhyme Violations

In poetry, poetic devices play a fundamental role, in particular in the tradition of the sonnets in Elizabethan times. Sonnets in their Elizabethan variety, had a stringent architecture which required the reciter to organize the presentation according to logical structure in the stanza structure, on the one side – introducing the main theme, expanding and developing the accompanying subthemes, exploring consequences, finding some remedies to solve the dilemma or save the protagonist. On the other side, the line by line structure required the reciter to respect the alternate rhyming patterns which were usually safeguarded by end-stopped lines. Thus, the audience expectations were strongly influenced by any variation related to rhyming and rhythm as represented by the sequence of breath groups and intonational groups. Whenever the rhyming pattern introduced a new unexpected pronunciation – not in other contexts – of a rhyming word, the audience was stunned: say a common word like *love* was pronounced to rhyme with *prove*. The same effect must have been produced with enjambments, whenever lines had to run-on because meaning required the syntactic structure to be reconstructed – as for instance in lines ending in a head noun which had its prepositional-of modifier in the beginning of the following line. Breath groups and intonational groups had to be recast to suit the unexpected variation, but rhyming had to be preserved. We will explore these aspects of the sonnets thoroughly in this section.

In a previous paper [23] we discussed the problem of (pseudo) rhyme violations as it has been presented in the literature on Shakespeare. In particular we referred to the presence of more than 100

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apparent rhyme violations, that is rhyming end of line words which according to current pronunciation do not allow the rhyming scheme of the stanza to succeed, but it did in the uncertain grammar of Early Modern English. For instance, in sonnet 1 we find two lines 2-4, with the stanza rhyme scheme ABAB, ending with the words die-memory. In this case, the second word *memory* should undergo a phonological transformation and be pronounced "memo'ry"[*memoray*] ending in a diphthong at the end and sounding like "die"/[*dye*]. This theme has been discussed and reported in many papers and also on a website - http://originalpronunciation.com/ - by linguist David Crystal. In particular he collects and comments rhyming words whose pronunciation is different from Modern RP English pronunciation listing more than 130 such cases in the Sonnets. However, he does not provide a rigorous proposal to cope with the problem of rhyme violation, and the list of transformations contains many mistakes when compared with the full transcription of the sonnets published in [24]. The solution is lexical as we showed in a number of papers[22,23], i.e. variations should be listed in a specific lexicon of violations and the choice determined by an algorithm. Here below an excerpt of the table, where we indicated the number of the sonnet, the line number, the rhyming word pair, their normal phonetic transcription using ARPAbet and in the last column the adjustment provided by the lexicon as shown here below.

Table 6. Example of lexical treatment of rhyme violation.

Sonnet No.	Line No.	Rhyme violation	Arpabet phoneme	Adjusted phoneme
Sonnet 1	2-4	die-memory	d_ay-m_eh1_m_er_iy	iy ay

Variants are computed by an algorithm that takes as input the rhyming word and its stressed vowel from the first line in a rhyming pair and compares it with the rhyming word and vowel of the alternate line[3]. In case of failure, the lexicon of Elizabethan variants is searched. The same stressed vowel may undergo a number of different transformations so it is the lexicon that drives the change, and it is impossible to establish phonological rules at feature level. Some words may be pronounced in two manners according to rhyming constraints, thus it is the rhyming algorithm that will decide what to do with the lexicon of variants. The lexicon in our case has not been built manually but automatically, by taking into account all rhyming violations and transcribing the pair of word at line end on a file. The algorithm searches couples of words in alternate lines inside the same stanza and in sequence when in the couplet, and whenever the rhyme is not respected it writes the pair in output. Take for instance the pair LOVE/PROVE, in that order in alternate lines within the same stanza: in this case it is the first word that has to be pronounced like the second. The order is decided by the lexicon: LOVE is included in the lexicon with the rule for its transformation, PROVE is not. In some other cases it is the second word that is modified by the first one, as in CRY/JOLLITY, again the criterion for one vs the other choice is determined by the lexicon.

In the table below, we list the total number of violations we found subdividing them by 5 phases as we did before, in order to verify whether the conventions dictated by Early Modern English grammars of the time did eventually impose a standard in the last period, beginning of XVIIth century. After Total we indicate the total number of violations found followed by slash and the number of sonnets. The ratio gives a weighted number that can be used to compare different

[3] Here as in the following pages we will use the phonetic alphabet called ARPAbet which is the one of the phonetic dictionary made available by CMU for computational purposes. The phonetic annotation makes use of American English but includes all vowel phonemes of British English: it has 12 vowels, two semiconsonants. The missing part regards diphthongs: there are 8 diphthongs in the chart, but three of them – descending diphthongs - never appear in the CMU dictionary or are treated as a sequence of a semivowel and a stressed vowel – IA (for CLEAR, _ih_), EA (for DOWNSTAIR CAREFUL, eh_), and UA (for ACTUAL, w_ah)

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occurrences in the five phases. As can be noted, the highest number of violations are to be found in the first two phases. Then there is a decrease from Phase II to Phase IV which is eventually followed by a slight increase in Phase V which however is lower than what we found in previous phases. The first two phases then have numbers well over the average: the decrease in the following phases testifies to a tendency in Shakespeare's work to fix pronunciation rules in the sonnets as more and more grammarians tried to document what constituted the rules for Early Modern English.

Table 7. Number of Rhyme Violations x five Phases.

	Sonnets Interval	No. Rhyme Violations / No. Sonnets	Ratio %
Phase I	1-17	22 / 17	1.2941
Phase II	18-51	40 / 34	1.1765
Phase III	52-96	34 / 45	0.7556
Phase IV	97-126	18 / 30	0.6
Phase V	127-154	23 / 28	0.8214
Total		137 / 154	0.8896

We call these (pseudo) rhyming violations because current reciters available on Youtube don't dare use the old pronunciation required and produce a rhyming violation by using Modern English pronunciation. One of these reciter is the famous actor John Gilgoud, who when reading Sonnet 66 correctly pronounces DESERT with its original meaning, but then in Sonnet 116 produces three violations when rhyming pairs required transformations that were clearly mandatory in Early Modern English, and they are: |love| to be pronounced with the vowel of |remove| in lines 2/4, |come| to be pronunced with the vowel of |doom| in lines 10/12, and |loved| to be pronounced with the vowel of |proved| in the couplet. How do we know that these words should be pronounced in that manner and not in the opposite way – say |remove| as |love|, |doom| as |come| and |proved| as |loved| as is being asserted by Ben Crystal son of David. There are three criteria that determine the way in which words should rhyme: first one is the rhyming constraints which were so stringent at the time owing to the fact that poetry was only recited and not read on books. Ok, then, there are rhyming constraints but how do they work, in which direction? The direction is determined by two factors: the first one is determined by universal phonological principles, as for instance the one the governs phonological variations of vowel sounds – in Vowel Shift of verbs or nouns due to morphological changes - which systematically changed "low" and "mid" features into "high" features and not viceversa[1]. The other factor is simply lexical: i.e. not all words will be subject to a transformation in that period: as a result some words had double pronunciation. This was extensively documented in books and articles published at the time and written by famous poets like Ben Jonson and a great number of grammarians of the XVI and XVII century. All this information are made available by the famous historical phonologist Wilhelm Vietor of the XIX century in a book published at first in 1889[4], by the title "A Shakespeare Phonology" which we have adopted as our reference.

[4] André Mazarin (2020) The developmental progression of English vowel systems, 1500–1800: Evidence from grammarians, in Ampersand 7.

https://reader.elsevier.com/reader/sd/pii/S2215039020300011?token=BCB9A7B6C95F35D354C940E08CBA968ED124CF160B0AC3EF5FE9146C4B3885E825A878104ED06E127685F139918CCEB6

2 (we use 1909 Vol 2. edition that can be freely visualized at)

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Variants are then lexically determined. Some words involved in the transformation are listed below using Arpabet as phonetic alphabet in the excerpt taken from the lexicon. As can be easily noticed, variants are related also to stress position, but also to consonant sounds.

Lexicon 1.

shks(despised,d_ih2_s_p_ay1_s_t,ay1,ay1)

shks(dignity,d_ih2_g_n_ah_t_iy1,iy1,ay1).

shks(gravity,g_r_ae2_v_ah_t_iy1,iy1,ay1).

shks(history,hh_ih2_s_t_er_iy1,iy1,ay1).

shks(injuries,ih2_n_jh_er_iy1_z,iy1,iy1).

shks(jealousy,jh_eh2_l_ah_s_iy1,iy1,ay1).

shks(jollity,jh_aa2_l_t_iy1,iy1,ay1).

shks(majesty,m_ae2_jh_ah_s_t_iy1,iy1,ay1).

shks(memory,m_eh2_m_er_iy1,iy1,ay1).

shks(nothing,n_ah1_t_ih_ng,ah1,ow1).

It is now clear that variants need to interact with information coming from the rhyming algorithm that alone can judge whether the given word, usually at line end - but the word can also be elsewhere -, has to undergo the transformation or not. The lexicon in our case has not been built manually but automatically, by taking into account all rhyming violations and transcribing the pair of word at line end on a file. The algorithm searches couple of words in alternate lines inside the same stanza and whenever the rhyme is not respected it writes the pair in output. Take for instance the pair LOVE/PROVE, in that order in alternate lines within the same stanza: in this case it is the first word that has to be pronounced like the second. The order is decided by the lexicon: LOVE is included in the lexicon with the rule for its transformation, PROVE is not. In some other cases it is the second word that is modified by the first one, as in CRY/JOLLITY, again the criterion for one vs the other choice is determined by the lexicon. Thus the system SPARSAR has a lexicon of possible transformations which are checked by an algorithm that whenever a violation is found, it is searched for the word to be modified and alters the phonetic description. In case both words of the rhyming pair are in the lexicon, the type of variation to be selected is determined by the overall sound map of the sonnet: Shakespeare produced a careful sound harmony in the choice of rhyming pairs including four or at least three sound classes.

3.2.2.1. Commenting on David Crystal's resources

David Crystal makes available on his website the full phonetic transcription of the sonnets. However, as said above, this transcriptions contain many mistakes. There are two vague explanations Crystal finds to support his transcriptions in his OP (Old Pronunciation) and the first is a tautology: the "pronunciation system has changed since the 16th century": this is what he calls "a phonological perspective" (ibid.:298). In section 2. entitled "Phonological rhymes" he writes:

"Far more plausible is to take on board a phonological perspective, recognizing that the reason for rhymes fail to work today is because the pronunciation system has changed since the 16th century. …. a novel and illuminating auditory experience, and introduced audiences to rhymes and puns which modern English totally obscures. The same happens when the sonnets are rendered in OP. In sonnet 154, the vowel of "warmed" echoes that of "disarmed", "remedy" echoes "by", the final syllable of "perpetual" is stressed and rhymes with "thrall", and the vowel of "prove" is short and rhymes with "love".

And further on (ibid:299):

https://books.google.it/books?id=rhEQAwAAQBAJ&printsec=frontcover&hl=it&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

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"Ben Jonson… wrote an "English Grammar" in which he gives details about how letters should be pronounced. How do we know that "prove" rhymed with "love"? This is what he says about letter "O" in Chapter 4: "It naturally soundeth…..In the short time more flat, and akind to "u;" as "cosen", "dosen", "mother", "brother", "love", "prove" ". And in another section, he brings together "love, glove" and "move". This is not to deny, of course, that other pronunciations existed at the time…. "Love" may actually have had a long vowel in some regional dialects, as suggested by John Hard (a Devonshire man) in 1570 (and think of the lengthening we sometimes hear from singers today, who croon "I lurve you"). But the overriding impression from the orthoepists is that the vowel in "love" was short. It is an important point, because this word alone affects the reading of 19 sonnets…."

The second one, is the need to respect puns (ibid. 298) which work in OP but not in modern English; and finally the idiosyncratic spellings in the First Folio and Quarto and the description of contemporary orthoepists, who often give real detail about how pronunciations were in those days. No phonological rules, not even a uniform criterion that underlies the variations. The first reason was expressed as follows at the beginning of the paper: "The pronunciation of certain words has changed between Early Modern English and today, so that these lines (referring to sonnet 154 lines) would have rhymed in Shakespeare's time. The list of pronunciation variations in the Appendix of his paper [25] is messy and confusing but what is more important it also contains many mistakes, and we will comment on the first 10 items below.

First of all, the new rhyming transformation of "loved" is not mentioned in the Appendix where according to Crystal "a complete" list should have appeared (ibid.:299). But the most disturbing fact is the recital performed by Ben Crystal (his son and actor in the Globe Theater), which is corageously made publicly available on Youtube (at https://www.youtube.com/watch?v=gPlpphT7n9s). We are given a reading of Sonnet 116 which is illuminating of the type of OP Crystal is talking about. (see time point 6:12 of total 10:21). The reading in fact does not start there but further on in the last stanza. The first contradictory assertion is just here, in the first stanza where lines B should rhyme and LOVE should be made to rhyme with REMOVE (as it is suggested in the Appendix). The question is that in sonnet 154, the same rhyming pair in the same order LOVE—>REMOVE, is transcribed with the opposite pronunciation. In the same paper he asserts that "the vowel of PROVE is short and rhymes with LOVE" (ibid.:298) referring to the couplet of Sonnet 154 which we assume should be also applied to the B rhyming pair in sonnet 116 and not give us lav/rimav, but rather luv/rimuv. Here an important additional series of alliteration would be fired if we adopt this pronunciation which in fact is the rule all over the Sonnets: TRUE would rhyme with LOVE and REMOVE/R. But also further on as we will see LOVE will rhyme with FOOL and DOOM.

p.296:

Let me not to the marriage of true minds

Admit impediments, love is not love

Which alters when it alteration finds,

Or bends with the remover to remove.

The recital starts in third stanza, continuing with the couplet.

Love's not Time's fool, though rosy lips and cheeks

Within his bending sickle's compass come;

Love alters not with his brief hours and weeks,

But bears it out even to the edge of doom:

If this be error and upon me proved,

I never writ, nor no man ever loved.

In the Appendix, we find another mistake or contradiction, where Crystal wrongly transcribes "doom" to rhyme with "come" (came/dam) rather than the opposite (cum/dum) and "loved" to rhyme with "proved" (pravd/lavd) which again should be the opposite, (pruvd/luvd). Here as

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elsewhere, for instance in Sonnet 55, DOOM rhymes with ROOM in the correct order, ROOM/DOOM, and with the correct sound. Again let's consider Crystal's wrongly reporting in the Appendix the rhyming pair LOVE/APPROVE as rhyming in the opposite manner, i.e. LOVE is being pronounced as APPROVE which is just the contrary in the transcription, APPROVE is being pronounced as LOVE with a short open-mid back sounds[5]. It is important to note that the first element in most cases appears as SECOND rhyming word in the pair, but in some other cases as first word of the pair. But then we find a long list of mistakes if we compare the expected pronunciation encoded in the Appendix with the complete transcription of the sonnets made available by David Crystal in a pdf file in the same website, where results are turned upside down. For instance LOVED = PROVED (116) has been implicitly turned into PROVED = LOVED, that is the transcription of the stressed vowel of "proved" is the same as the one of "loved" and not the opposite. More mistakes in the list can be found where words like TOMB and DOOM are wrongly listed in the opposite manner. In particular DOOM is made to rhyme with the vowel of COME and not the opposite; also TOMB is made to rhyme with COME and DUMB reverting in both cases the order of the rhyming pair and of the transformation. The phonetic transcription file confirms the mistakes: in the related sonnets we find the same short mid-front vowel instead of a short U. dumb/tomb both in sonnet 83 and 101. In all of these cases, the head (the rhyming word of the first line) should be made to rhyme with the dependent (the rhyming word of the second line) as it happens in Sonnet 1 with MEMORY/DIE and in the great majority of cases. So two elements must be taken into account: the order of the two words of the rhyming pair and then the commanding word, i.e. the word that governs the transformation. In the case of MEMORY/DIE, DIE is the head or the commanding word of the transformation, and comes first in the stanza; whereas MEMORY is the dependent word and comes as second line of the rhyming pair. We list below only the wrong cases and comment the type of mistake made: i.e. either as reverted order - the first element of the pair comes before and it should be read as second; reverted order, the first element is in fact the one deciding the type of vowel to be used; else the order is correct, but the pronunciation chosen is wrong. To comment on the wrong pronunciation required by the rhyme we use sometimes the pronunciation indicated by Vietor in his book, and the phonetic transcription of all the sonnets Crystal made in his pdf file[6].

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[5] In Crystal's words:

"There are 19 instances in the sonnets where "love" is made to rhyme with "prove", "move", and their derived forms. And when we look at the whole sequence, we find a remarkable 142 rhyme pairs that clash (13% of all lines). Moreover, these are found in 96 sonnets. In sum: only a third of the sonnets rhyme perfectly in modern English. And in 18 instances, it is the final couples which fails to work, leaving a particularly bad taste in the ear."

This is how he explains the list of the Appendix:

….a complete list is given in the Appendix to this paper. The list indicates a rhyming pair where the first element is the one to be transformed because otherwise violating the rhyme. For instance MEMORY = DIE (1) must be interpreted as follows: pronounce "memory" with the same vowel of "die" in modern RP pronunciation to be found in sonnet 1.

[6] Here are some of the mistakes contained in the Appendix:

anon/alone 75 - should be alone/anon (Vietor:70) both the order and the governor are wrong. It should be: pronounce ALONE as ANON with a short or long /o/

are/care 48 - the order should be care/are, but then the mistake is ARE transcribed like CARE [k€:r]

are/care 112, 147 - the order is correct but the transcription is wrong as before

are/compare 35 - the order should be compare/are, transcription correct

are/prepare 13-the order should be prepare/are, transcription wrong: ARE is pronounced like PREPARE [p€:r]

are/rare 52 - order correct and in transcription ARE is like RARE [r€:r] - but it should be the opposite. RARE should sound like ARE, rare/are even though the line with RARE comes first.

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There are more mistakes in the Appendix as discussed above. We solved the problem by creating a lexicon of phonetic transformations and an algorithm that looked at first for a match in the rhyming word pair positioned in alternate lines if in stanza, and in a sequence if in couplet. In case there was no match, the algorithm looks up the second word in the lexicon, and then the first word and chooses the one that is present. In case both are present in the lexicon, the decision is taken according to position of the rhyming pair in the sonnet with respect to previous rhymes.

3.2.3. Rhyming Constraints and Rhyme Repetition Rate

If on the one side we have rhyme apparent violations using the EME pronunciation to suit the rhyme scheme of the sonnet, on the other side the Sonnets show a high "Repetition Rate" as computed on the basis of rhyming words alone. Due to the requirements imposed by the Elizabethan sonnet rhyme scheme, violations are very frequent, but they are not sufficient to allow the poet with the needed quantity of rhyming words. For this reason it can be surmised Shakespeare was obliged to use a noticeable amount of identical rhyming word pairs. The level of rhyming repetition is in fact fairly high in the sonnets if compared with other poets of the same period, as can be gathered from the tables below. This topic has not gone unnoticed, as for instance in [30], who indicates repetition of rhyming words as occurring in a limited number of consecutive adjacent sonnets, but doesn't give an overall picture of the phenomenon. In fact, as will be clear from the data reported below, the level of rhyming repetition is fairly high and reaches 65% of all rhyming pairs. In [26] we also find an attempt at listing all sonnets violating rhyme schemes which according to him amount to 25. However as can be easily noticed in the list reported in the Appendix, the number of sonnets violating rhyme scheme is much higher than that.

To enumerate rhyming repetitions we collected all end-of-line words with their phonetic transcription and joined them in alternate or sequential order as required by the sonnet rhyme scheme 1-3, 2-4, 5-7, 6-8, 9-11, 10-12, 13-14 – apart from sonnet 126 with only 12 lines and a scheme in couplets aabbccddeeff, and sonnet 99 with 15 lines. Seven rhyming pairs for a total of 1078, i.e. 154 sonnets multiplied by 14 equal 2156 divided by two – less one 2155. In the tables reported as an Appendix[7], we only consider at first pairs with a frequency occurrence higher than 4, and we group together singular and plural of the same noun, and third person present indicative, d/n past with base form for verbs. We list pairs considering first occurrence as the "head" and following line as the "dependent". Rhyme may be sometimes determined by rules for rhyme violations as is the case with "eye". We include under the same heading all morphologically viable word forms as long as word stress is preserved in the same location, as said above, including derivations. We decided to separate highly frequent rhyming heads in order to verify whether less frequent ones really matter in the sense of modifying the overall sound image of the sonnets. For that purpose, we produce a first sound map below, limited to higher frequency rhyming pairs and only in a separate count we consider less frequent ones, i.e. hapax, trislegomena and bislegomena.

In many cases the same pair is repeated in inverted order as for instance "thee/me" and "me/thee", "heart/part" and "part/heart", "love/prove" and "prove/love" but also "love/move" and "love/remove" and "approve/love" and "love/approve", "moan/gone" and "foregone/moan",

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beloved/removed 25 - order correct, but the transcription is wrong: remove is transcribed with the vowel of beloved

brood/blood 19 - the order should be blood/brood: the transcription is also wrong BROOD is transcribed like BLOOD. see Vietor:87, whilst [u] in blood, flood, good, wood s. seems to be the usual Elizabethan sound.

dear/there 110 - correct order but the pronunciation of DEAR is transcribed wrongly as [di:r] while the one of THERE is [th€:re]

doom/come 107,116,145 - correct order but the pronunciation should be governed by DOOM, a short or long [u](Vietor:86): transcription of DOOM is instead with the vowel of COME

[7]The tables related to Rhyming Pair Repetition Rate have been presented in Torino (Delmonte, 2019) at the conference: "La musica della poesia"/The music of poetry, but have not been published elsewhere.

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"alone/gone" and "gone/alone", "counterfeit/set" and "unset/counterfeit", "worth/forth" and "forth/worth", "elsewhere/near" and "near/there", etc. "Thee" is made to rhyme with "me", but also with "melancholy", "posterity", "see". "Eye/s" are made to rhyme with almost identical monosyllabic sounding words like "die", "lie", "cries", "lies", "spies"; but also with "alchemy", "gravity", "history", "majesty", "remedy", which require the conversion of the last syllable into a diphthong /ay/ preceded by the current consonant. Most of the rhyming pairs evoke a semantic or symbolic relation which is asserted or suggested by the context in the surrounding lines of the stanza that contain them. Just consider the pairs listed above where relations are almost explicit. However, as remarked by [26], rhyme repetition inside the same sonnet may have a different goal: linking lines at the beginning of the sonnet to lines at the end as is the case with sonnet 134 and the rhyme pair "free/me" which reappears in the couple in reversed order. Similar results are suggested by repetition of rhyme pair "heart/part" in sonnet 46.

We did the same count with two other famous poets writing poetry in the same century, Sir Philip Sydney and Edmund Spenser. We wanted to verify whether the high level of rhyming pairs repetition might also apply to other poets writing love sonnets. The results show some remarkable differences in the degree of repetitivity. In Table 9 repeated rhyming pairs are compared to unique ones or hapax rhyming pairs in three Elizabethan poets. Percentages reported are a ratio of all occurrences of rhyming pairs. In first column types are considered and Sydney overruns Shakespeare and Spenser. When we come to Token repeating rate - i.e. counting all occurrences of each type and summing them up, we still have the same picture. Eventually unique or unrepeated rhyming pairs are higher in Spenser than in Shakespeare and Sydney.

Table 9. Rhyme Repetition Rates in three Elizabethan poets.

Author / Quanti-ties	Rhyme-Pair Repeat Types	Rhyme-Pair Repeat Token	Hapax or Unique Rhyme-Pairs
Shakespeare	18.02%	65.21%	34.79%
Spenser	17.84%	47.45%	53.55%
Sydney	22.37%	72.08%	27.02%

Now let us consider the distribution of rhyming words into the corpus of the sonnets. As to general frequency data, the Sonnets contain a number of tokens equal to 18,283 with 3085 types; so-called Vocabulary Richness that is used to measure the ability of a writer to use different words in a corpus, corresponds to 16.87%, a high value for that time when compared with other poets (see [27]). Also number of Hapax and Rare Words (indicating the union of Hapax, Dis and TrisLegomena) corresponds to average values for other poets, respectively to 56%, the first type and 79% the second one. If we look at similar data for rhyming words we see that Rare Words cover more than 65% of all as can be gathered from table 9 below:

Table 9. Rhyme Repetition Word Class-Frequency Distribution for Shakespeare's Sonnets.

X Typ	FX Tok	Sum FX	Sum FX+X	% Sum FX+X
28	1	28	28	2.72
17	1	17	45	4.37
14	2	28	73	7.09

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12	2	24	97	9.43
10	1	10	107	10.4
9	5	45	152	14.77
8	3	24	176	17.1
7	1	7	183	17.78
6	6	36	219	21.28
5	10	50	269	26.14
4	29	116	385	37.41
3	37	111	496	48.2
2	87	174	670	65.11
1	359	359	1029	100.0

We report for each word frequency type in column 1 – there is only one head word (*thee*) with frequency 28 -, the corresponding number of tokens in table 9, followed by the sum of tokens, the incremental sum and the corresponding percentage with respect to total corpus. As can be noticed from the last column, where incremental percent of rhyme-pair words corpus coverage is reported, the total of rare words, i.e. type rhyme-pair with frequency of occurrence lower than 4, is 62.59%, a fairly low value if compared to the measure evaluated on simple type/token ratios. If we look at most important English poets as documented in a previous paper [27] we can see that the average value for Rare words is 77.88%. However, we are here dealing with rhyming words and the comparison may not be so relevant.

3.2.4. The Sound-Sense Harmony visualized in charts

As will appear clearly from the charts below, all the data show a contrasting behaviour which will be attested by correlation values. Where sentiment values increase, the corresponding values for vowels and consonants decrease. To allow better perusing of the trends we split the sonnets into separate tables according to whether their sentiment values are positive or negative. The first chart contains the eleven sonnets which received highest positive sentiment values. All the charts are drawn from the tables of data derived from the analysis files in xml format, which will be made available as supplementary data.

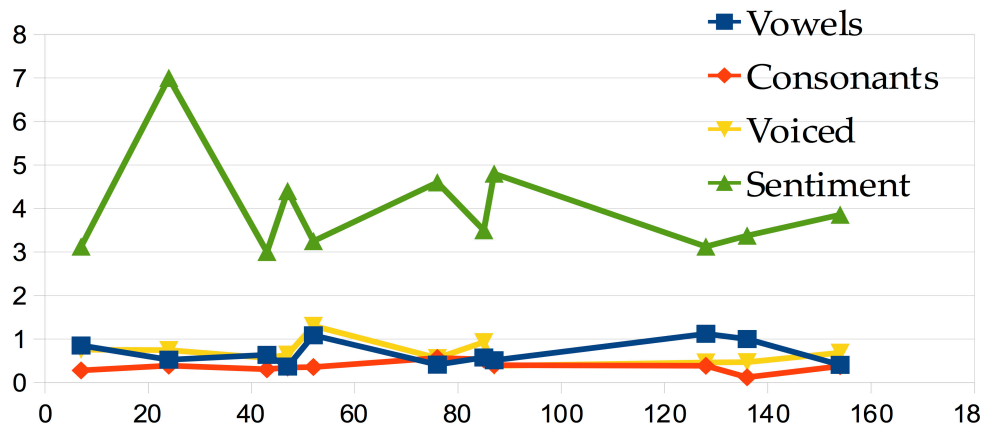

Figure 2. The eleven most positively marked sonnets: 7, 24, 43, 47, 52, 76, 85, 87, 128, 136, 154.

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As can be easily noticed, all sound data seem to agree showing a trend which is very close for the three variables. On the contrary the sentiment variable has strong peaks and its values are set apart from the sound values. However the interval of variability for sound variables does remain below or close to 1, thus indicating an opposite trend. In particular, consonants are all below 1, vowels oscillate in three cases – 52, 128, 136, voiced in two cases – 52, 85 in this case still below 1 but very close 93% in favour of unvoiced.

We interpret consistently contrasting values as a way to convey ironic, sarcastic and sometimes parodistic meaning. More on this interpretation below. Sonnet 136 is the one highly ambiguous and consequently ironic, celebrating the "Will" or simply "will". Sonnet 128 is all devoted to music and playing with a wooden instrument which is the target of the ironic vein and the double meaning of words like "tickle". Finally, sonnet 52 is the celebration of the beloved as a "chest" where the rich keep their treasure, and which must be enjoyed "seldom". Sonnet 85 is a celebration of silent thought, and for this theme it is filled with consonants which are continuants |h,f,th| and are unvoiced, but many words are marked by a sonorant syllable, thus voiced.

We now separate 16 sonnets which have sentiment equal to 1 or slightly lower than 1 but always higher than 92% in favour of positively marked. They are the following: 22, 33, 51, 60, 64, 73, 94, 97, 101, 102, 109, 118, 123, 131, 141, 150.

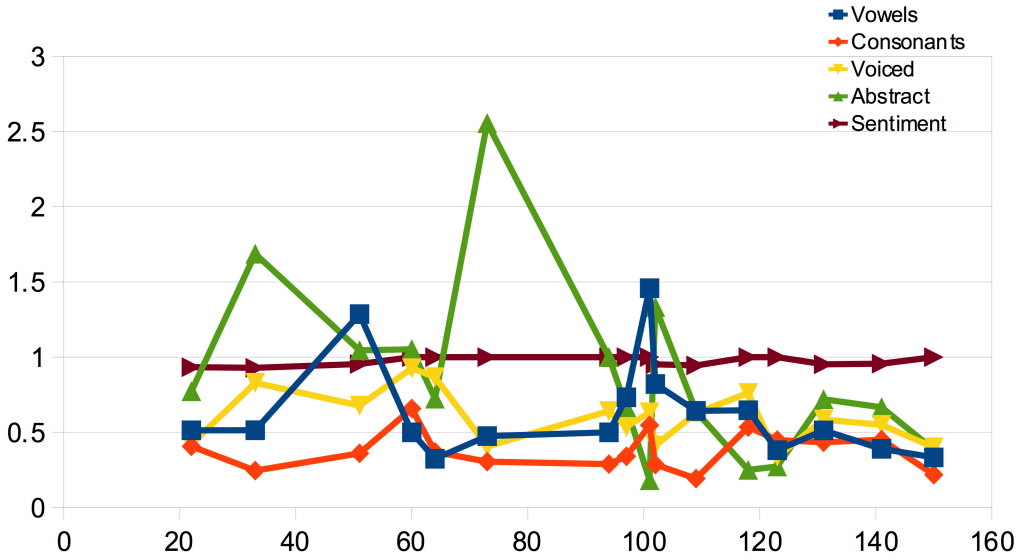

Figure 3. Chart of the 16 borderline sonnets positively marked for sentiment.

In this chart we added the ratio for Abstract/Concrete which shows a peak for sonnet 73. As the chart clearly shows, the line for Sentiment borders 1, as to the remaining variables, Vowels is the one oscillating most after Abstract. Voiced and Consonants are fairly always aligned apart from sonnet 33 and 102. In both sonnets the number of "Obstruents" (|b,d,p,t,k,g|) is very low and real consonants are substituted by "Continuants" (|s,sh,th,f,v,h|) both voiced and unvoiced. In the following analysis for this reason I will only consider Voicing as the relevant variable for consonants and this will show better agreement in the overall data. Now we show charts for all negatively marked sonnets using only three variables.

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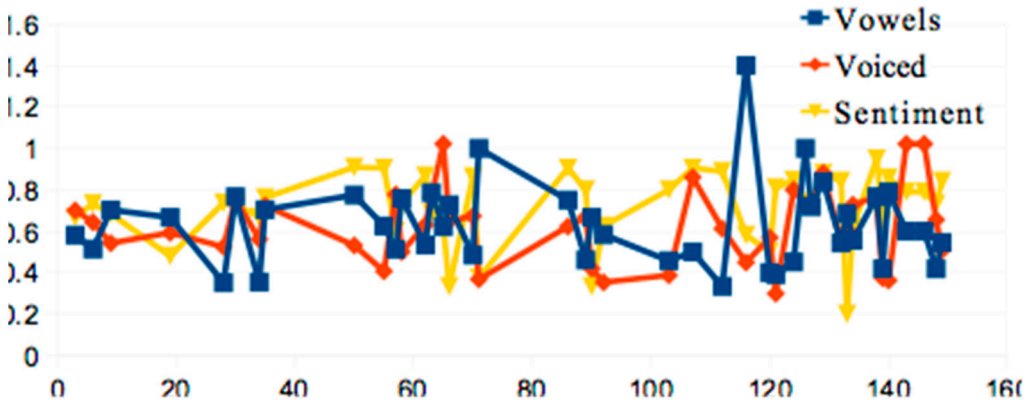

Figure 4. Chart of the 42 negatively marked sonnets: 3, 8, 9, 19, 28, 30, 34, 35, 50, 55, 57, 58, 60, 62, 63, 65, 66, 71, 86, 89, 92, 103, 107, 112, 116, 120, 121, 124, 126, 127, 129, 132, 133, 134, 138, 139, 140, 143, 146, 148, 149.

As can be easily seen, the Sentiment variable is always below 1 but the two remaining variables oscillate up and down, the vowel one oscillating most. In this case, the contrast is even stronger and correlations show a negative trend between Vowels and Sentiment: the one has a decreasing trend while the other has it increasing, apart from a few exceptions, sonnets 30, 35 and 127 which have almost identical values for the three variables. The other correlation between Voicing and Sentiment is positive but very weak, 0.1769. Now we repeat the chart for sonnets positively marked for sentiment and measure the correlation.

Correlation between Vowel and Sentiment is positive but very week; correlation between the Voicing parameter and Sentiment is again negative and very week, -0,0065037. Thus, results for the 42 sonnets negatively marked by sentiment show that we have negative correlation between vowels and voicing, and vowels and sentiment, but positive correlation between voicing and sentiment. So it is just the opposite of what we get with positively marked sonnets. And finally the eleven most positively marked sonnets showing the same contrasting results.

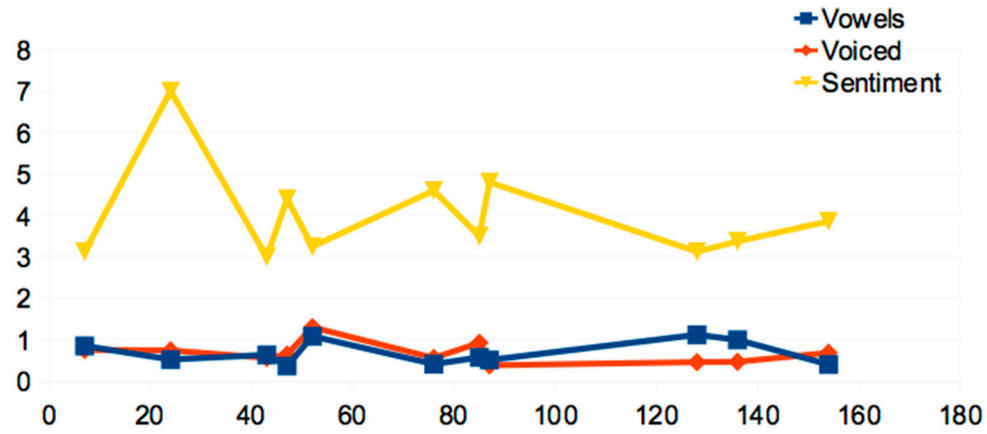

Figure 5. The eleven most positively marked sonnets show the same slightly positive correlation for Vowels-Voicing but very strong negative correlation between Vowels-Sentiment and slightly negative for Voicing/Sentiment, -0.11423482.

The conclusion we may draw is that the sound-sense harmony in Shakespeare's sonnets is represented by a strong extended disharmony: in particular in all the sonnets we have an inverse correlation, that is the two most important variables, Voicing (whether a consonant is a real Obstruent or not) and Sentiment. Voicing includes real obstruents and unvoiced continuants: |p,t,k,s,sh,f,th|. When the pair Voicing/Sentiment assumes a positive correlation value, the other pair

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Vowel/Sentiment shows the opposite and is negative. In particular, in those sonnet which are positively marked for sentiment, the Correlations between Vowel and Sentiment is positive but the correlation between Voicing and Sentiment is negative. Sonnets negatively marked for sentiment have a positive correlation between Voicing and Sentiment, but a negative correlation between Vowel and Sentiment. In other words the behaviour is just reversed: when meaning is positively marked the sound harmony verges towards a negative feeling. On the contrary when the meaning is negatively marked the sound harmony verges, bends towards a positive sound harmony. I assume what Shakespeare intended to produce in this way was a cognitive picture of ironic poetic creation.

3.2.5. From Sentiment to Deep Semantic and Pragmatic Analysis with ATF

The final part of the analysis takes us deep into the hidden meaning that the sonnets in what they communicate, i.e. irony. To do that we need to substitute sentiment analysis with a much more semantically consistent framework that could allow us to enter the more complex system of relational meanings that are governed by pragmatics. In this case, neither a word by word analysis a propositional level one would be sufficient. We need to capture sequences of words which may have a non-literal meaning and associate appropriate labels: this is what Appraisal Theory Framework can be useful for.

We have devised a sequence of steps in order to confirm experimentally our intuitions. The preliminary results obtained using sentiment analysis cannot be regarded as fully satisfactory for the simple reason that both the lexical and the semantic approach based on predicate-argument structures are unable to cope with the use of non-literal language. Poetic language is not only ambiguous but it contains metaphors which require abandoning the usual compositional operations for a more complex restructuring sequence of steps.

This has been carefully taken into account when annotating the sonnets by means of Appraisal Theory Framework (hence ATF). In our approach we have followed the so-called incongruity presumption or incongruity-resolution presumption. Theories connected to the incongruity presumption are mostly cognitive-based and related to concepts highlighted for instance, in [28]. The focus of theorization under this presumption is that in humorous texts, or broadly speaking in any humorous situation, there is an opposition between two alternative dimensions. As a result, we have been looking for contrast in our study of the sonnets, produced by the contents of manual classification. Thus we have used the Appraisal Framework Theory [29] - which can be regarded as the most scientifically viable linguistic theory for this task, as has already been done in the past by other authors (see [30,31] but also [32,33]), showing its usefulness for detecting irony, considering its ambiguity and its elusive traits.

Thus we proceeded like this: we produced a gold standard containing strong hints in its classification in terms of humour, by collecting most important literary critics' reviews of the 154 sonnets (the gold standard will be made available as supplementary material). To show how the classification has been organized we report here below two examples:

• SONNET 8

SEQUENCE: 1-17 Procreation MAIN THEME: One against many ACTION: Young man urged to reproduce METAPHOR: Through progeny the young man will not be alone NEG.EVAL: The young man seems to be disinterested POS.EVAL: Young man positive aesthetic evaluation CONTRAST: Between one and many

• SONNET 21

SEQUENCE: 18-86 Time and Immortality MAIN THEME: Love ACTION: The Young man must understand the sincerity of poet's love METAPHOR: True love is sincere NEG.EVAL: The young man listens the false praise made by others POS.EVAL: Young Man positive aesthetic evaluation CONTRAST: Between true and fictitious love.

 doi:10.20944/preprints202307.1233.v1

As can be seen, the classification is organized using 7 different linguistic components: we indicate SEQUENCE for the thematic sequence into which the sonnet is included; this is followed by MAIN THEME which is the theme the sonnet deals with; ACTION reports the possible action proposed by the poet to the protagonist of the poem; METAPHOR is the main metaphor introduced in the poem sometimes using words from a specialized domain; NEG.EVAL and POS.EVAL stand for Negative Evaluation and Positive Evaluation contained in the poem in relation to the theme and the protagonist(s); finally, CONTRAST is the key to signal presence of opposing concrete or abstract concepts used by Shakespeare to reinforce the arguments purported in the poem. Not all the sonnets were amenable to a pragmatic/linguistic classification. We ended up with 98 sonnets classified over 154, corresponding to a percentage of 63.64%, the rest have been classified as Blank. Many sonnets have received more than one possible pragmatic category. This is due to the difficulty in choosing one category over another. In particular, it has been particular hard to distinguish Irony from Satire, and Irony from Sarcasm. Overall, we ended up with 54 sonnets receiving a double marking over 98. This was also one of the reasons to use ATF: often literary critics were simply hinting at "irony" or "satire", but the annotation gave us a precise measure of the level of contrast present in each of the sonnets regarded generically as "ironic".

The annotation has been organized around only one category, *Attitude*, and its direct subcategories, in order to keep the annotation at a more workable level, and to optimize time and space in the XML annotation. *Attitude* includes different options for expressing positive or negative evaluation, and expresses the author's feelings. The main category is divided into three primary fields with their relative positive or negative polarity, namely:

- *Affect* is every emotional evaluation of things, processes or states of affairs, (e.g. like/dislike), it describes proper feelings and any emotional reaction within the text aimed towards human behaviour/process and phenomena.
- *Judgement* is any kind of ethical evaluation of human behaviour, (e.g. good/bad), and considers the ethical evaluation on people and their behaviours.
- *Appreciation* is every aesthetic or functional evaluation of things, processes and state of affairs (e.g. beautiful/ugly; useful/useless), and represent any aesthetic evaluation of things, both man-made and natural phenomena.

Eventually, we ended up with six different classes: *Affect Positive*, *Affect Negative*, *Judgement Positive*, *Judgement Negative*, *Appreciation Positive*, *Appreciation Negative*. Overall in the annotation there is a total majority of positive polarities with a ratio of 0.511, in comparison to negative annotations with a ratio of 0.488. In short, the whole of the positive poles is 607, and the totality of the negative poles is 579 for a total number of 1186 annotations. *Judgement* is the more interesting category because it allows social moral sanction, which is then split into two subfields, *Social Esteem* and *Social Sanction* - which however we decided not to mark. In particular, whereas the positive polarity annotation of *Judgement* extends to *Admiration* and *Praise*, the negative polarity annotation deals with *Criticism* and *Condemnation* or *Social Esteem* and *Social Sanction* (see [33], p.52). Here below the list of 77 sonnets manually classified with ATF over 98 matching critics' evaluation.

1 2 4 5 6 10 12 14 17 18 19 20 21 27 30 32 33 34 35 37 41 42 47 48 50 56 57 61 65 67 68 69 71 72 74 75 77 78 79 81 82 84 87 92 95 97 98 101 102 104 106 108 109 111 113 114 115 116 123 125 126 127 129 134 136 137 139 142 144 145 146 149 151 152 153 154

List of 77 successfully classified sonnets matching critics' evaluation

As a first result, we may notice a very high convergence existing between critics' opinions and the output of manual annotation by *Appraisal* classes: 77 over 98 correesponds to a percentage of 78%. As to the sonnets' structure, *Judgement* is found mainly in the final couplet of the sonnets.(for more details see [37]). As to interpretation criteria, we assumed that the sonnets with the highest contrast could belong to the category of **Sarcasm**. The reason for this is justified by the fact that a high level of *Negative Judgements* accompanied by *Positive Appreciations* or *Affect* is by itself interpretable as the intention to provoke a sarcastic mood. As a final result, there are 44 sonnets that present the highest

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contrast and are specifically classified according to the six classes above. There is also a group that contains ambiguity sonnets which have been classified with a double class, mainly by **Irony** and **Sarcasm**. As a first remark, in all these sonnets, negative polarity is higher than positive polarity with the exception of sonnet 106. In other words, if we consider this annotation as the one containing the highest levels of *Judgement*, we come to the conclusion that a possible **Sarcasm** reading is mostly associated with presence of *Judgement Negative* and in general with high *Negative* polarity annotations.

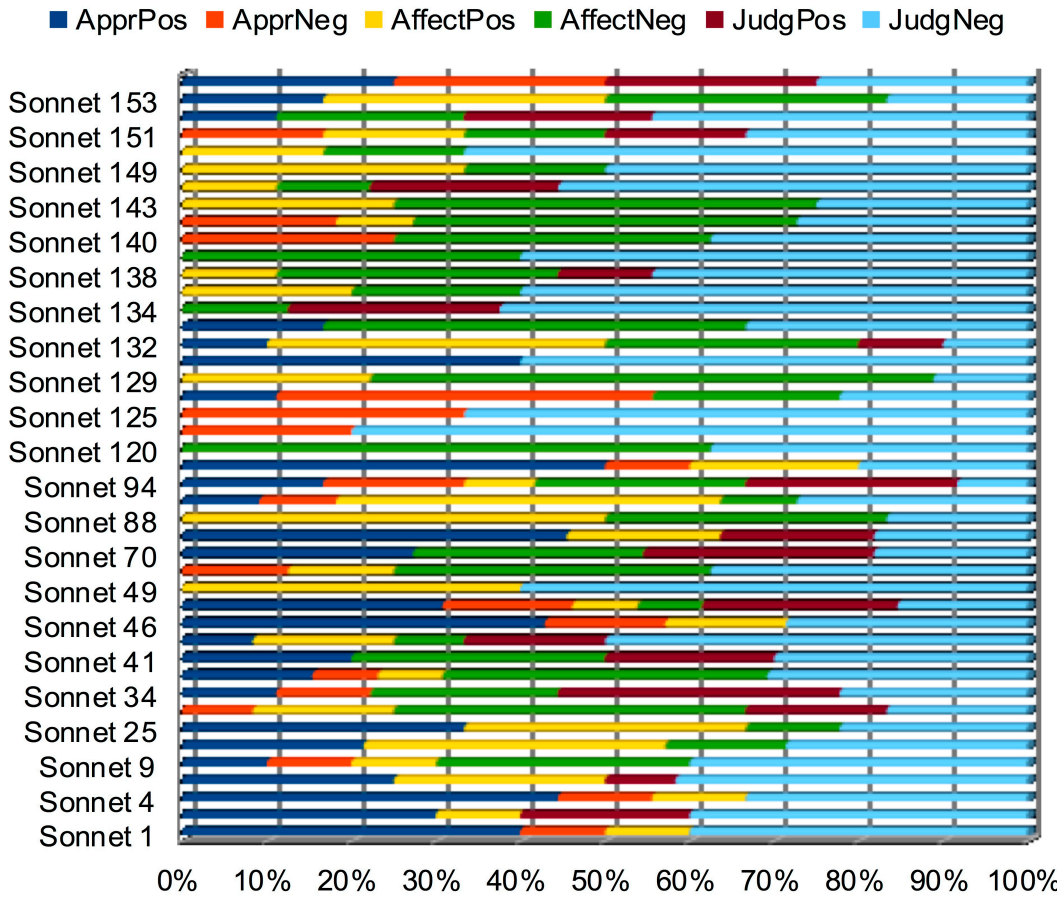

Figure 6. 44 sonnets classified with Sarcasm with the highest level of Judgements.

We associated different colours to make the subdivision into the six classes visually clear. It is possible to note the high number of *Judgements* both *Negative* (in orange) and *Positive* (in pale blue): in case *Judgement Positive* is missing it is substituted by *Affect Positive* (pale green) or by *Appreciation Positive* (blue). This applies to all 44 sonnets apart from sonnets 120 and 121 where *Judgement Negative* is associated to *Affect Negative* and to *Appreciation Negative*. In other words, if we consider this annotation as the one containing the highest levels of *Judgement*, we come to the conclusion that possible **Sarcasm** reading is mostly associated with presence of *Judgement Negative* and in general with high *Negative* polarity annotations. As a first result we may notice a very high correlation existing between critics' opinions as classified by us with the label highest contrast and the output of manual annotation by *Appraisal* classes.

Table 10. Quantitative data for six appraisal classes for sonnets with highest contrast.

	Appr.Pos	Appr.Neg	Affct.Pos	Affct.Neg	Judgm.Pos	Judgm.Neg
Sum	56	25	53	77	32	122
Mean	2.533	1.133	2.4	3.466	1.444	5.466

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St.Dev.	8.199	3.691	7.732	11.202	4.721	17.611

We now show the group of 50 sonnets classified, mainly or exclusively, with **Irony** and check their compliance with *Appraisal* classes.

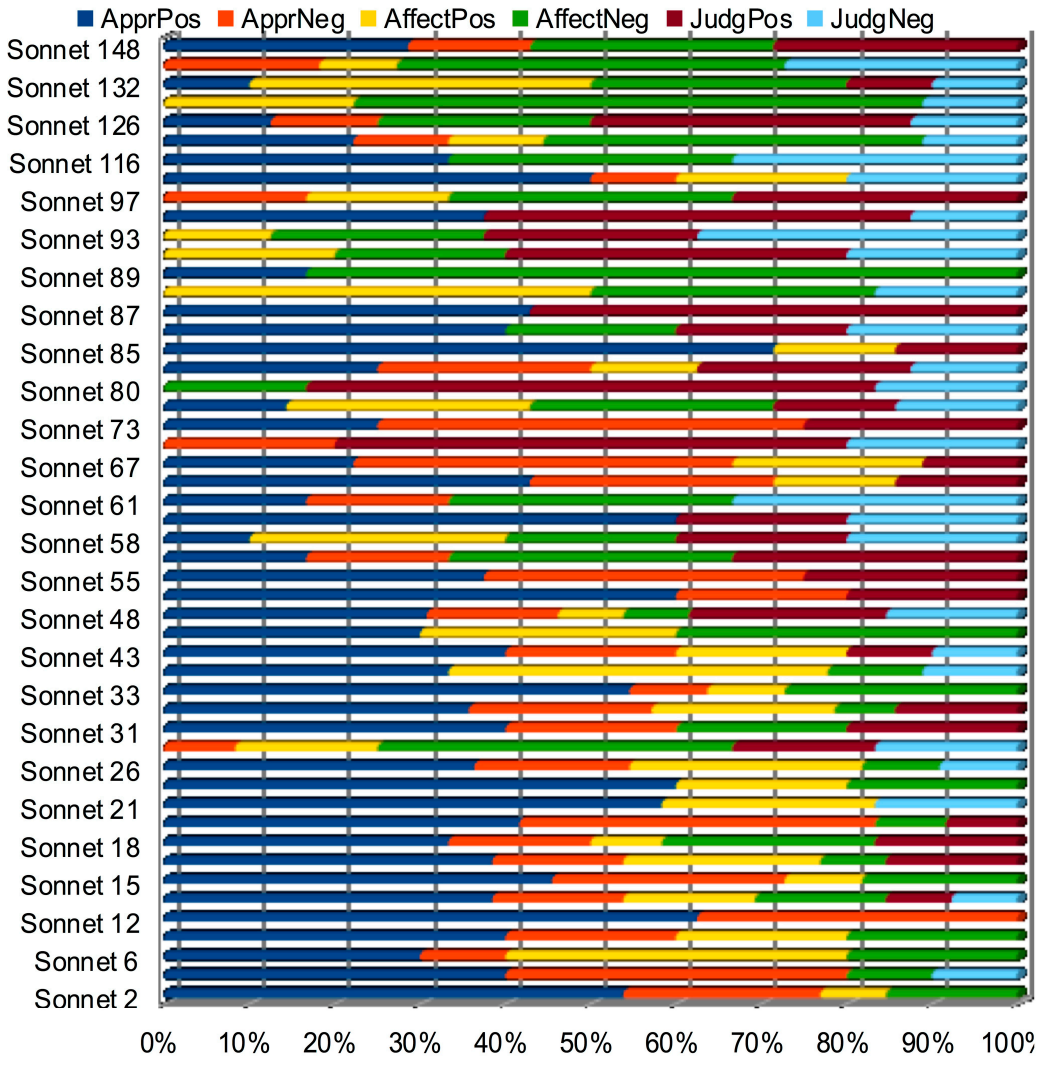

Figure 7. 50 sonnets classified with Irony, with a lower level of Judgement Negative but higher Affect Negative.

As can be easily noticed, the presence of *Judgement Negative* is much lower than in the previous diagram for **Sarcasm**. In fact in only half of them – 25 – has annotation for that class, the remain half introduces two other negative classes: mainly *Affect Negative*, but also *Appreciation Negative*. As to the main *Positive* class, we can see that it is no longer *Judgement Positive*, but *Affect Positive* which is present in 33 sonnets.

Table 11. Quantitative data for six appraisal classes for sonnets with lowest contrast.

	Appr.Neg	Appr.Pos	Affct.Pos	Affct.Neg	Judgm.Pos	Judgm.Neg
Sum	139	65	64	81	59	37
Mean	5.346	2.5	2.461	3.115	2.269	1.423
St.Dev.	18.82	8.843	8.707	11.009	8.029	5.047

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In other words we can now consider that **Sarcasm** is characterized by a majority of negative evaluations 146/224 while **Irony** is characterized by a majority of *Positive* evaluations 262/183 and that the values are sparse and unequally distributed.

The final figure concerns the number of sonnets with blank or neutral evaluation by critics which amount to 60. As a rule, this group of sonnets should look different from the two groups we already analysed.

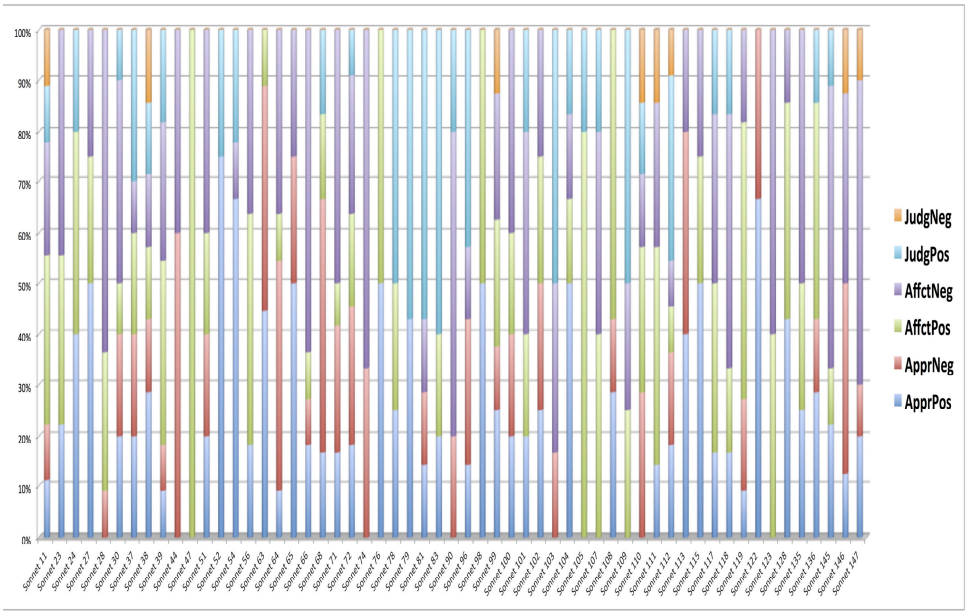

Figure 8. 60 Sonnets classified by critics as neutral.

As expected, this figure looks fairly different from the previous two. The prevailing colour is pale blue i.e. *Judgement Positive*; orange i.e. *Appraisal Negative*, is only occasionally present; green is perhaps the second prominent colour, i.e. *Affect Positive*. In order to know how much is the difference we can judge it from the quantities shown in the table below.

Table 4. Quantitative data for six appraisal classes for sonnets with no contrast.

	Appr.Pos	Appr.Neg	Affct.Pos	Affct.Neg	Judgm.Pos	Judgm.Neg
Sum	88	59	89	109	49	8
Mean	3.034	2.034	3.068	3.758	1.689	0.275
St.Dev.	1.268	7.638	11.482	14.052	6.368	1.079

3.2.6. Matching ATF classes with the Sound-Sense Harmony

The experiment with ATF classes matching critics' evaluation has been fairly successful, but how do these classes gauge with the sound-sense harmony? In order to check this we transferred the data related to vowels and consonants and matched them with ratios of the three main ATF categories: *Appreciation Positive/Negative*, *Affect Positive/Negative*, *Judgement Positive/Negative*. As in previous computation, all data below 1 will be interpreted as a case of superior *Negative Polarity* and the opposite when data are above 1. In order to get a better view of the overall data, we split them into sonnets with contrast a first group, and sonnets with no contrast a second group. This time, however, we used our classification and abandoned the critics' one.

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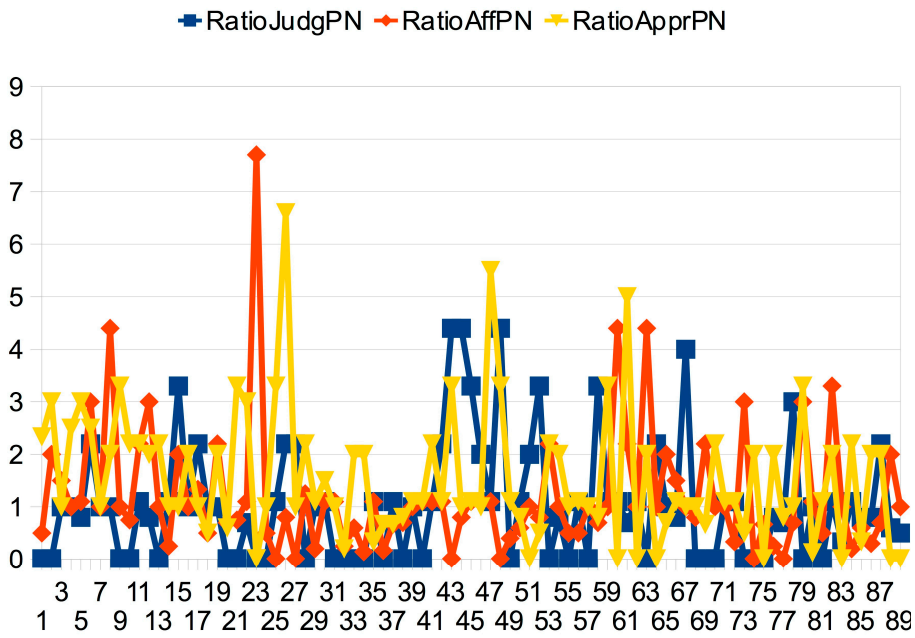

Figure 9. Distribution of 89 sonnets manually classified by ATF with no contrast.

The data in Figure 10 show the distribution of sound-sense variable for the three parameters: we didn't introduce variables for vowels and voicing which are however present in the same table and allow us to evaluate the correlation between ATF and sound, which as can be seen below is negative for both *Judgement* and *Affect*:

1. Correlation between Vowels and *Judgement*: -0.1254
2. Correlation between Voicing and *Judgement*: -0.1468
3. Correlation between Vowels and *Affect*: -0.08859
4. Correlation between Voicing and *Affect*: -0.01346
5. Correlation between Judgement and *Affect*: -0.1376
6. Correlation between *Affect* and *Appraisal*: -0.0351

Correlations of sound data with Appraisal are on the contrary both positive. If we consider now the remaining 65 sonnets which have been classified by ATF with contrast we get a different picture. In this case, we have separated each class and projected them with sound data, Vowels and Voicing in the following three diagrams.

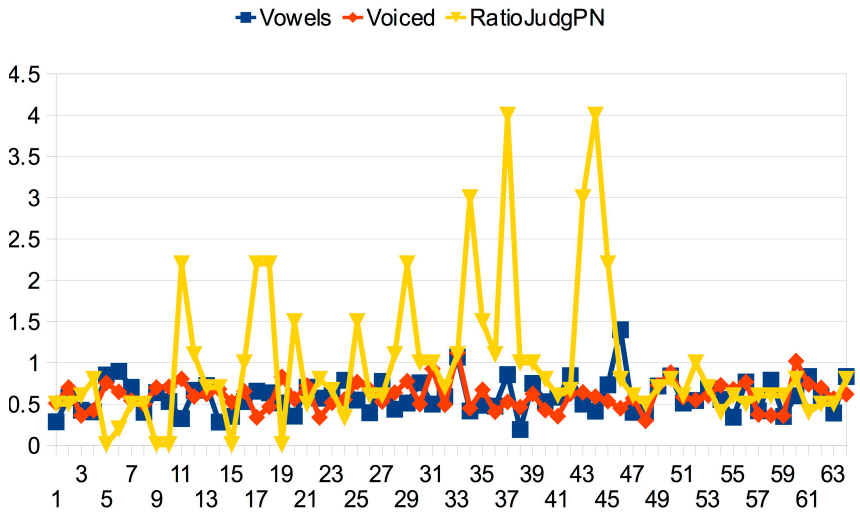

Figure 10. Distribution of 65 sonnets classified as Judgements with contrast and their sound data.

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All correlation measures with *Judgements* are negative:

1. Correlation between Vowels and *Judgements*: -0.0594
2. Correlation between Voicing and *Judgements*: -0.0677
3. Correlation between *Judgement* and *Affect*: -0.0439
4. Correlation between *Judgement* and *Appraisal*: -0.0522

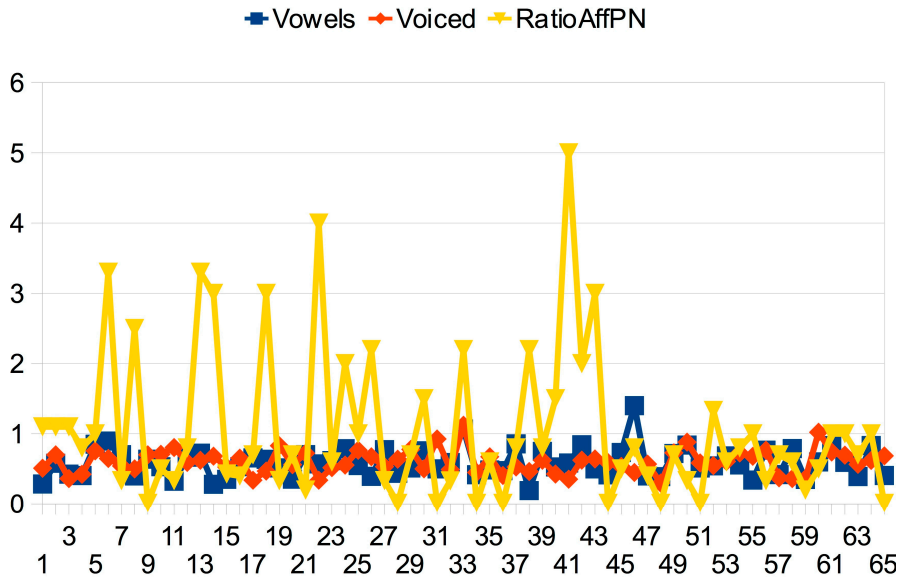

Figure 11. Distribution of 65 sonnets classified by ATF as Affect with contrast and their sound data.

Correlation data for *Affect* are only partly negative:

1. Correlation between Vowels and *Affect*: 0.09
2. Correlation between Voicing and *Affect*: -0.1435
3. Correlation between *Affect* and *Appraisal*: 0.2594

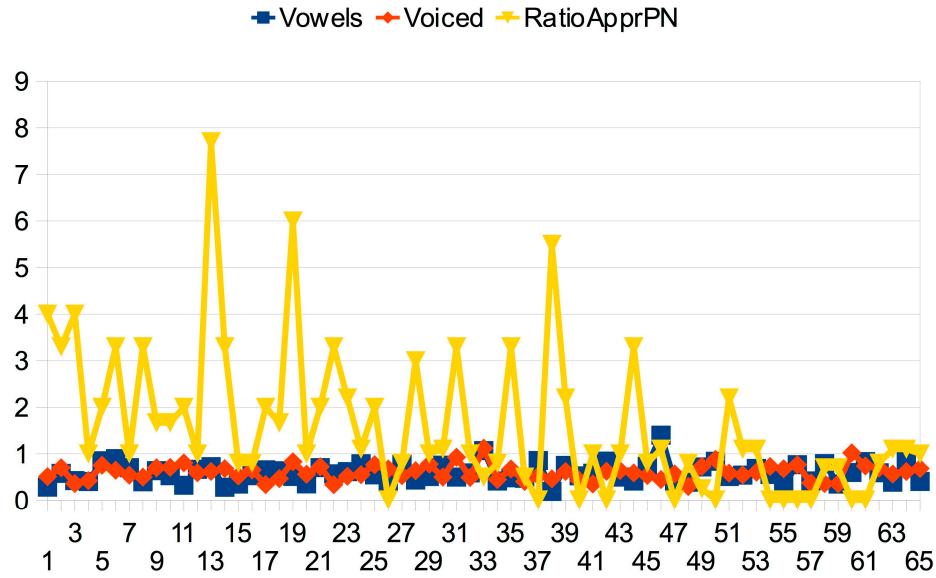

Figure 12. Distribution of 65 sonnets classified by ATF as Appraisal with contrast and their sound data.

Eventually, the correlations for *Appraisal* are also both negative:

1. Correlation between Vowels and *Appraisal*: -0.2068

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2. Correlation between Voicing and *Appraisal*: -0.0103

Now the only positive correlations are the ones shown by *Affect* with Vowels and with *Appraisal*, the remaining correlations are all negative. The subdivision operated now using our manual classification with ATF seems more consistent than the one made before using the critics' evaluation. As a first comment, these data confirm our previous evaluation made on the basis of Sentiment analysis, i.e. the sonnets are all disharmonic due to Shakespeare's intention to produce ironic effects on the audience. Here below the list of the 89 sonnets classified by our manual ATF labeling as having no contrast:

2 6 11 13 14 16 17 20 22 23 24 26 27 30 37 38 39 40 43 44 45 46 47 51 54 56 59 62 63 64 65 66 68 71 72 74 75 76 77 78 79 81 83 84 85 87 89 90 91 96 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 117 118 119 122 123 124 125 126 128 130 135 136 141 145 146 147 148 149 150

List of 89 sonnets manually classified by ATF as having no contrast

1 3 4 5 7 8 9 10 12 15 18 19 21 25 28 29 31 32 33 34 35 36 41 42 48 49 50 53 57 58 60 61 67 69 70 73 80 82 86 88 92 93 94 95 97 116 120 121 127 129 131 132 133 134 137 138 139 140 142 143 144 151 152 153 154

List of 65 sonnets manually classified by ATF as having contrast

Comparing the "contrast" criterion with the sentiment-based classification is not possible however, the "contrast" group of sonnets is included in majority in the "negatively" marked sonnets, with the exception of 16 sonnets which are the following ones:

30 55 60 62 63 66 71 103 107 112 124 126 127 146 148 149

What these sonnets have in common is an identical number of *Appraisal Positive/Negative* feature (28), a high number of *Affect Negative* feature (38) vs *Positve* ones (11), and the relatively lowest number of *Judgement Negative* features (10) vs *Positive* ones (18). In other words, by decomposing *Negative Polarity* items into three classes shows the weakness of Sentiment Analysis, where Negativity is a cover all class.

3.3. Sound and Harmony in the Poetry of Francis Webb

In this section I will presents results obtained from the analysis of the poetry by Francis Webb, who is regarded by many critics among the best English poets of last century – and differently from Shakespeare, never uses ironic attitudes. All the poems I will be using are taken from the Collected Poems edited by Toby Davidson[34].

I will introduce a type of graphical maps highlighting differences using colours associated to sound and sense (see[2]). The use of colours associated to sound in poetry has a long tradition. Rimbaud composed a poem devoted to "Vowels" where colours where specifically associated to each of the main five vowels. Roman Jakobson wrote extensively about sound and colour in a number of papers Jakobson [35,36] lately papers by Mazzeo[37]. As Tsur[38] notes, Fónagy[39] wrote an article in which he connected explicitly the use of certain types of consonant sound associated to certain moods: unvoiced and obstruent consonants are associated with aggressive mood; sonorants with tender moods. Fónagy mentioned the work of M.Macdermott[40] who in her study identified a specific quality associated to "dark" vowels, i.e. back vowels, that of being linked with dark colours, mystic obscurity, hatred and struggle. As a result, we are using darker colours to highlight back and front vowels as opposed to low and middle vowels, the latter with light colours. The same applies to representing unvoiced and obstruent consonants as opposed to voiced and sonorants. But as Tsur (see [38], p.15) notes, this sound-colour association with mood or attitude has no real significance without a link to semantics. In the Semantic Relational View, we are using dark colours for Concrete referents vs Abstract ones with lighter colours; dark colours also for Negatively marked words as opposed to Positively marked ones with lighter colours. The same strategy applies to other poetic

maps: this technique has certainly the good quality of highlighting opposing differences at some level of abstraction[8]. With this experiment I intend to verify the number of poems in Webb's corpus in which it is possible to establish a relationship between semantic content in terms of negative vs positive sense - usually referred to with one word as "the sentiment"[9]- and the sound produced by syllables in particular, stressed ones. I assume that it is possible to regard vowel and consonant sounds as carrier of a sensation inducing a sad rather than a happy feeling in the reader. Thus, I will match negative sentiment expressed by the words' sense with sad sounding rhymes and poetic devices as a whole, and the opposite for positive sentiment by scoring and computing the ratios. I repeat here below the way in which I organized vowel and consonant sounds:

- Low, Middle, High-Front, High-Back

where I identify the two classes Low and Middle as promoting positive feelings, and the two High as inducing negative ones. As to the consonants, I organized the sounds into three main classes and two types:

- *Obstruents* (Plosives, Affricates), *Continuants* (Fricatives), *Sonorants* (Liquids, Vibrants, Approximants)

plus the distinction into

- Voiced vs Unvoiced

In this case the ratios are computed dividing the sum of Continuants and Sonorants by number of Obstruents; and the second parameter will be the ratio obtained by dividing number of Voiced by Unvoiced. So eventually, whenever the value of the ratios are above 1, positive results are obtained, the contrary applies whenever values are below 1. The representation of the proposed Harmony between Sense and Sound will be cast on the usual vector space where I organized the space as follows:

- Class A:

Negatively harmonic poems, mainly negatively marked poems on the left. Either the sounds or the sentiment are in majority negative, or both the sounds and the sentiment are negative;

- Class C.

Positively harmonic poems, mainly positively marked poems on the right. Either the sounds or the sentiment are in majority positive, or both the sounds and the sentiment are positive;

- Class B

Disharmonic ones in the middle. The sounds and the sentiment have opposite values and either one or the other have values below a given threshold.

In addition to the evaluation of positive/negative values we consider the two parameters we already computed related to Metrical Length and Rhyming Scheme that we add together and use for its 10% added value to compensate for poetic relevant features. On the basis of poetic devices analyzed by *SPARSAR*, a list of 15 poems is considered as deviant, and they are the following: *A Sunrise, The Gunner, The Explorer's Wife, For My Grandfather, Idyll, Middle Harbour, Politician, To a Poet, The Captain of the Oberon, Palace of Dreams, The Room, Vancouver by Rail, Henry Lawson, Achilles and the Woman*. We show here below the first map of sense-sound evaluation where the split of the "deviants" poems appears clearly:

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[8] our approach is not comparable to work by Saif Mohammad, where colours are associated to words on the basis of what their mental image may suggest to the mind of annotators hired via Mechanical Turk. The resource only contains word-colour association for some 12,000 entries over the 27K items listed. It is however comparable to a long list of other attempts at depicting phonetic differences in poems as will be discussed further on.

[9] see in particular Brysbaert et al. 2014 that has a database of 40K entries. We are also using a manually annotated lexicon of 10K entries and WordNet supersenses. We are not using MRCDatabase which only has some 8,000 concrete + some 9,000 imagery classified entries because it is difficult to adapt and integrate into our system.

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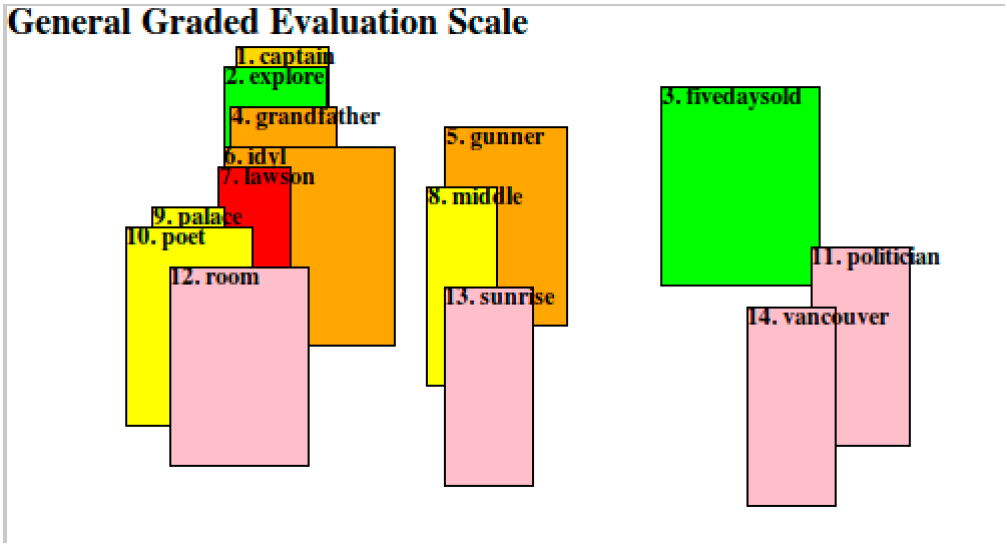

Figure 13. Poems considered as Deviants Evaluated for their degree of Sense/Sound Harmony.

The poem that best represents balanced positive values is *Five Days Old* and this may be deduced by the presence of the largest box positioned on the right hand. Overall, the figure shows which poems achieved harmonic values and positions positives on the right and negative on the left sides, and then in the middle disharmonic ones. As clearly appears, "Five Days Old", "Politician" and "Vancouver by Rail" are the three poems computed as endowed with positive harmony, while the remaining poems are either characterized as strongly negative - "Poet", "Palace of Dreams" and "The Room" - or just negative, "The Captain of the Oberon", The Explorer's Wife", "For My Grandfather", "Idyl", and "Henry Lawson". Finally the last three poems positioned in the centre left are disharmonic, "The Gunner", "Middle Harbour", and "A Sunrise", where disharmonic means that the parameters of Sounds are in opposition to those of Sense. Slight variations in the position are determined by the contribution of parameters computed from poetic devices as said above. Disharmony as will be discussed further on might be regarded as a choice by the poet with the intended aim to reconcile the opposites in the poem.

The choice of these 15 poems includes poetry written at the beginning of the career, i.e. included in the *Early Poems* - A Sunrise, Palace of Dreams, To a Poet, Idyll, Middle Harbour, Vancouver by Rail -; two poems from *A Drum for Ben Boyd*, - Politician, The Captain of the Oberon -; five poems from *Leichhardt in Theatre* - The Room, The Explorer's Wife, For My Grandfather, The Gunner, Henry Lawson-; and finally one poem from *Birthday*, Achilles and the Woman, and one poem from *Socrates*, Five Days Old. In what follows, at first I will show small groups of poems taken from different periods in Webb's poetic production and discuss them separately, rather than conflating them all in a single image. In fact at the end of this section I will show a bigger picture where I analysed together 87 poems thus resulting in two big figures. Back to the second experiment where I collected and analyzed the following poems:

Early Poems - Idyll, The Mountains, Vancouver by Rail, A Tip for Saturday, This Runner

Leichhardt in Theatre - Melville at Woods Hole, For Ethel, On First Hearing a Cuckoo

Poems 1950-52 - The Runner, Nuriootpa

Birthday - Ball's Head Again, The Song of a New Australian

Socrates - The Yellowhammer

The Ghost of the Cock - Ward Two and the Kookaburra

Unfinished Works - Episode, Untitled

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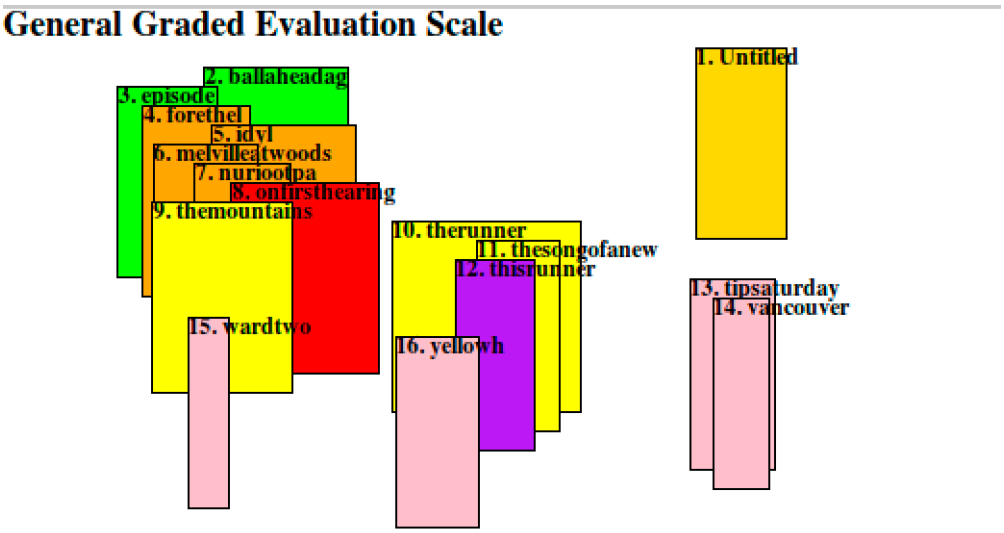

Figure 14. Sixteen poems from different periods of Webb's poetic production computed for their Sense/Sound Harmony.

Here again it is important to notice the majority of the poems positioned on the left hand side thus analyzed as possessing negative harmony; only three poems on the right hand side, one of which is the unfinished "Untitled". And then in the middle a small number of disharmonic poems, or we could call them poems in which there were conflicting forces contributing to the overall meaning intended by the poem. Also take into account the dimension of the box which signal the major or minor contribution of the overall parameters computed as discussed in previous section, of all the linguistic and poetic features contained in the poem, but measured on the basis of their minor or major dispersion using Standard Deviation. In the following group I added more poems from later work, which were computer mainly as positive:

Birthday - Hopkins and Foster's Dam

Socrates - A Death at Winson Green, Eyre All Alone, Bells of St Peter Mancroft

The Ghost of the Cock - Around Costessey, Nessun Dorma

Late Poems 1969-73 - Lament for St Maria Goretti, St Therese and the Child

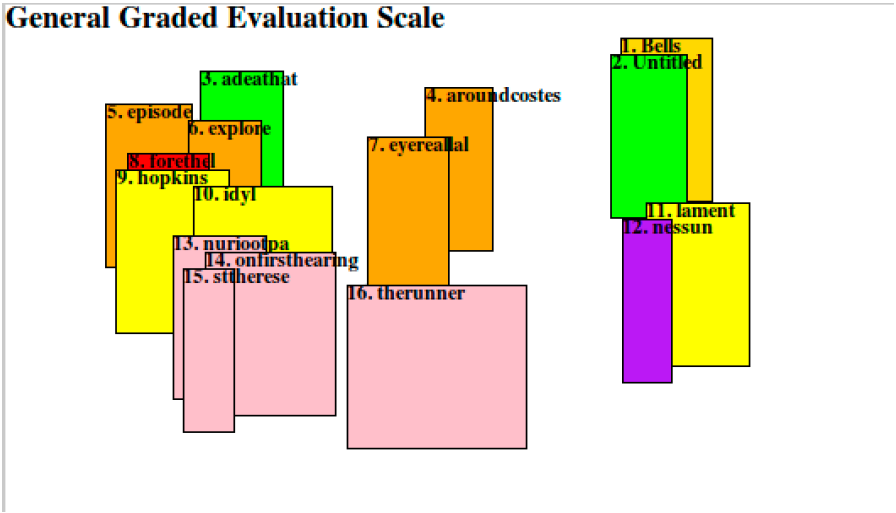

Figure 15. Sixteen poems taken mainly from late poetic production computed for their Sense/Sound Harmony.

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I will now show a bigger picture containing 50 poems, where we can see again the great majority of them being positioned on the left hand side. The positive side is enriched by "Moonlight" from *Early Poems*, and "Song of the Brain" from *Socrates*, and the middle disharmonic list now counts 16 poems.

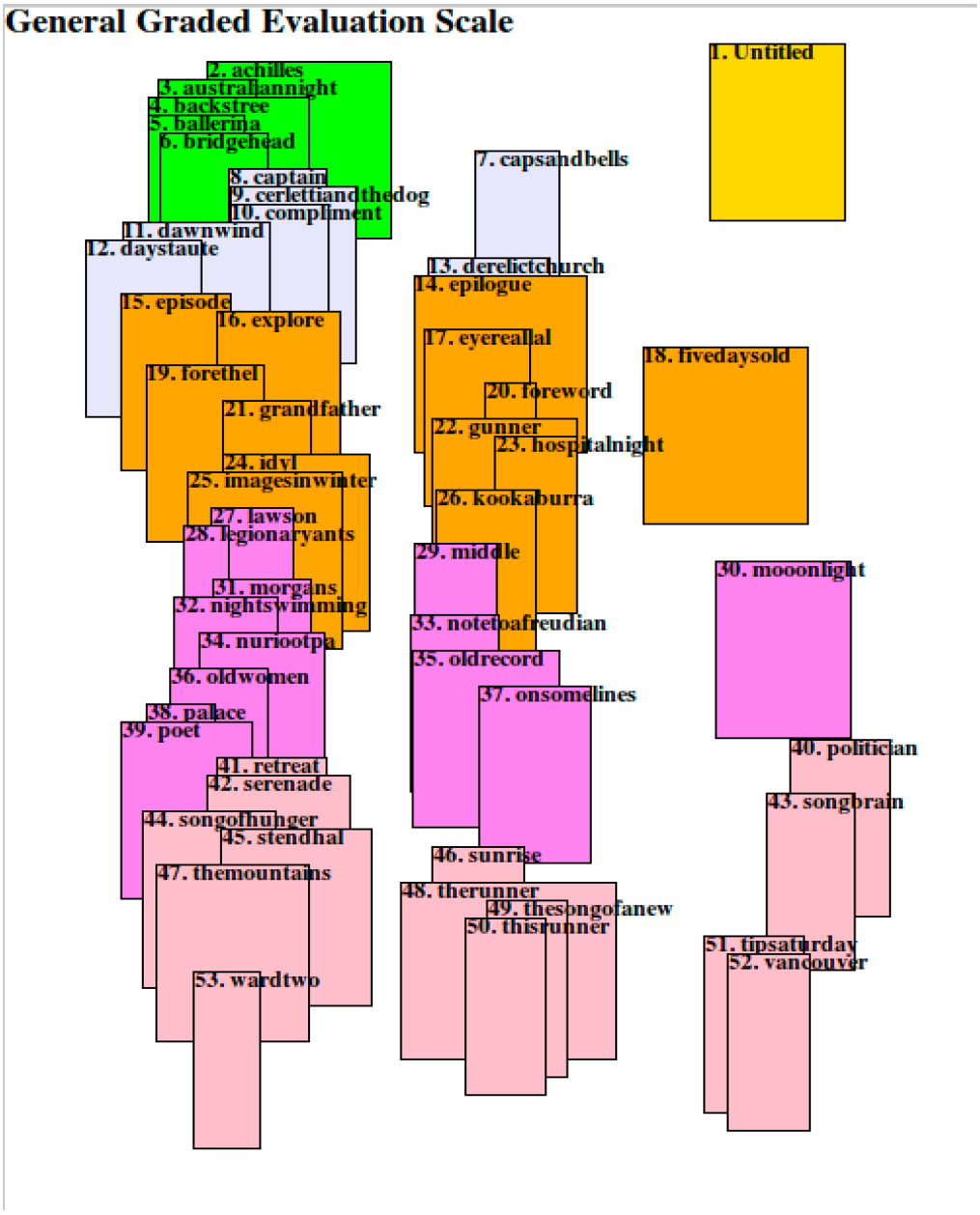

Figure 16. Fifty Poems computed by Sense/Sound Harmony.

So we can safely say that the great majority of Webb's poems contain a negative harmony. This is further confirmed by the following figure which represents the analysis of 87 poems, I decided not to increase the number of poems up to 130 as was done with APSA system simply because otherwise the image becomes too difficult to read and poems' labels will be too cluttered together.

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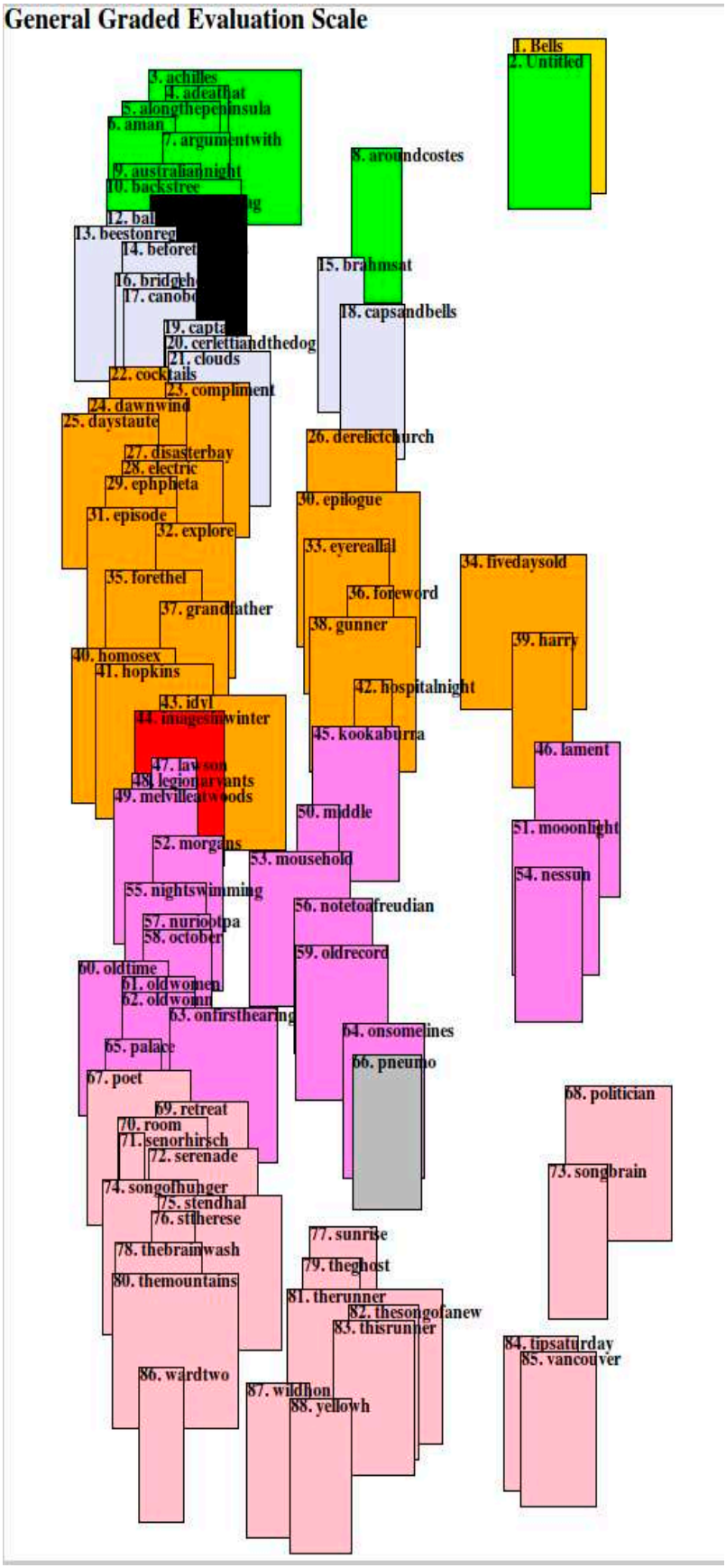

Figure 17. Sound Sense Harmony in Webb's 87 poems.

4. Discussion

As the data presented have extensively shown, sound-sense relation may represent diverse but distinct situations: in case of dis-harmony we may be in presence of ironic/sarcastic expressions, as happens in Shakespeare's sonnets. However, in the case of Webb's poetry, the contrast represents his need to encompass the opposites in life and this is testified by the frequent use of oxymora and by his condition of outcast rejected by society. Data for Webb show a great agreement in negatively marked sound-sense harmony and a much reduced agreement for positively marked data. Webb has lived half of his life in psychiatric hospitals rejected by the people who knew him, and only accepted as a poet.

Data Availability Statement: We make available data of the complete analysis of the 154 sonnets and of 100 Webb's poems used in his section.

Acknowledgments: The ATF classification task has been carried out partly by Nicolò Busetto, co-author of a number of papers describing the work done.

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