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# All the World's a (Hyper)Graph: A Data Drama

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**Corinna Coupette**  
Max Planck Institute  
for Informatics  
Saarbrücken, Germany

**Jilles Vreeken**  
CISPA Helmholtz Center  
for Information Security  
Saarbrücken, Germany

**Bastian Rieck**  
Institute of AI for Health  
Helmholtz Munich  
Munich, Germany

## Abstract

We introduce HYPERBARD, a dataset of diverse relational data representations derived from Shakespeare's plays. Our representations range from simple *graphs* capturing character co-occurrence in single scenes to *hypergraphs* encoding complex communication settings and character contributions as hyperedges with edge-specific node weights. By making multiple intuitive representations readily available for experimentation, we facilitate rigorous *representation robustness checks* in graph learning, graph mining, and network analysis, highlighting the advantages and drawbacks of specific representations. Leveraging the data released in HYPERBARD, we demonstrate that many solutions to popular graph mining problems are highly dependent on the representation choice, thus calling current graph curation practices into question. As an homage to our data source, and asserting that science can also be art, we present all our points in the form of a play.

## DRAMATIS PERSONÆ

AUTHORS.  
REVIEWER, a reader. } Persons in the Induction.  
CREATURE, a curious mind.  
HYPERBARD, a faun, sovereign of spirits.  
GRAPH, a gentle spirit.

PROFESSOR,  
SENIOR RESEARCHER, } Part of the Community.  
COLLEAGUE.  
TUTOR,  
SECRETARY, } Serving the Community.  
DEADLINES.

SCENE.—*Sometimes in the Community; and sometimes in the forest.*

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## INDUCTION.

SCENE I.—*Between submission and decision.*  
*Enter REVIEWER and AUTHORS.*  
1 *Rev.* What is this? Is this not against the rules?  
2 *Auth.* The columns? These are only simple tables.  
3 They serve to help us implement blank verse.  
4 The script-sized numbers count the spoken lines,  
5 They disappear when folks use prose at times.  
6 We introduce a novel dataset,

With full documentation as Appendix. 7  
Raw data stem from all of Shakespeare's plays [13], 8  
We model them as graphs in many ways, 9  
And demonstrate representations matter. 10  
The data readily accessible [5], 11  
All code is publicly available [6]. 12  
What follows, to avoid redundancy, 13  
Conveys our main ideas, as you will see 14  
A tragedy in the Community. 15

ACT I.

SCENE I.—*The Community.* PROFESSOR's office.  
Enter SENIOR RESEARCHER and TUTOR, bearing a barrow. On the barrow, a swooning CREATURE, feeble but breathing.

16 Tut. They must have hit a rock while on our problem.  
17 Sen. R. Did they get hurt? Who are they, anyway?

*They put down the barrow.*

Enter PROFESSOR and SECRETARY.

18 Prof. What is this fuss? Did they get an appointment?  
19 Another rescue? Do they know to code?

20 Tut. Should we employ them?

Prof. What, you mean by contract?

21 Sen. R. It seems that they are really good with graphs.

22 Prof. All right—  
CREATURE moves.

Tut. Be quick, they wake!

Sec. I'll get the forms.

*Exit SECRETARY.*

CREATURE shuffles, sighs, and sits up.

23 Prof. Welcome to the Community!  
*[They smile generously.]*

24 Cre. The what?  
25 Where am I—Why is everything so clean? Wasn't I chasing bugs, out in the woods? Or roaming pastures, playing in the mud? I fail to recollect; I must be dreaming. So is this but a nightmare? Or a prison?

29 Am I a hostage?  
30 Prof. Fellow, you are free!

*Re-enter SECRETARY, handing PROFESSOR the forms.*

31 Prof. Just sign here, will you?  
*They point to a field in the forms. CREATURE signs.*

Prof. and Sen. R. *[in synchrony]* Welcome to your PhD!  
*Exeunt.*

SCENE II.—CREATURE's office.

*Enter CREATURE, closing the door. They pace about the room, then settle before the window.*

32 Cre. So here I stand; and I can do no other? Little do I remember of my roots. Well, elsewhere sure they lie, but must I cut them? How will I learn this play, and play my part?

*Knocking.*

36 Cre. Come in!—*[Aside]* Stay out!  
*Enter COLLEAGUE.*

37 Col. Hello, how are you? You must be the new one!  
38 You work on graphs, or that's what I've been told?  
39 They said you came from outside, from the forest.

40 Well, better not go back—here, we do trees.  
41 Cre. What does that mean?

42 Col. We like to operate with clear-cut questions,  
43 Employing very powerful abstractions.  
44 To be successful, publish many units,  
45 At top-ranked venues, making single points.

46 Evaluate on standard datasets,  
47 And over-promise, then, to hedge your bets.  
48 Cre. So, this is science?

Col. It is how things work.

*Exit COLLEAGUE.*

*Enter PROFESSOR with DEADLINES.*

49 Prof. So let me introduce you to your guardians.  
50 We call them DEADLINES—never mind the name.  
51 They form the circle of scientific life,  
52 And soon will be your greatest motivators.

53 As papers pave your path to graduation,  
54 Your thinking becomes music to their beat.

Cre. But why? 55

First Dea. Why what?

Sec. Dea. It's pressure making diamonds.

Third Dea. We set incentives, we're just here to help! 56

Prof. I'll leave you with them, then, you'll get familiar. 57

And when you're done, make sure to put my name. 58

*Exit. DEADLINES surround CREATURE, who shakes.*

Cre. Fie, get thee off me! 59

FIRST DEADLINE comes closer, breathing down CREATURE's neck. The CREATURE freezes.

Cre. I said no! 60

*They strike at FIRST DEADLINE, then faint in fatigue.*

FIRST DEADLINE staggers and retreats. All other DEADLINES disappear into the distance.

SCENE III.—*The forest, in CREATURE's dream.*

*Enter HYPERBARD, with a lute.*

Hyp. What beauty are these woods! In every tree 61

Lives past enshrined and calling the observant. 62

The devil? Angels lie in all these details. 63

Look at the fragile bark, the fractal branching, 64

The posture, parasites—And see the leaves! 65

Colors, shapes, textures—all varieties. 66

The fauna—beetles, rodents, insects, birds, 67

Thriving together in their interaction. 68

*They strike a chord on their lute.*

Hyp. From all there is, let there be data! 69

As data points, we demarcate these trees 70

And put them into known categories. 71

*They mark the selected trees with leaves of various shapes (Fig. 1).*

Hyp. Each tree is full of life, full of relations, 72

To capture this, we need representations. 73

*They strike another chord. Enter GRAPH.*

Gra. You called me, honor? 74

Hyp. Will you, docile spirit, 75

Transform these trees to yield discoveries? 76

Gra. Your honor, master, mistress, sure I can 77

But there are many different transformations 78

Among the flurry, which one do you choose? 79

Hyp. Why choose but one when there exist so many? 80

How do we even know which one to pick? 81

Gra. Sir, madam, with respect, your speech is madness! 82

Did you not call me to produce your truth? 83

Hyp. What truth? Your transformations are but shadows 84

Of essence vested with complexity 85

Cast on the narrow walls of our perception 86

And varied as you shift and change your light. 87

Gra. I hear your words but struggle with their meaning. 88

Which output do you want me to obtain? 89

Hyp. To every data point associate 90

A set of transformations as its data. 91

Such that in all our future inquiries 92

We treat not only one but many shadows. 93

Each partly blind, together they create 94

A truer truth than commonly considered. 95

Gra. Your honor, as a practicality 96

We can't enumerate exhaustively. 97

Among the myriad possibilities 98

You still will have to choose some transformations. 99

Hyp. Fair spirit, as an overarching goal, 100

All our representations should be faithful. 101

Among the transformations that you see, 102

How do they differ systematically? 103

*Screaming heard. HYPERBARD and GRAPH vanish.*

CREATURE wakes.

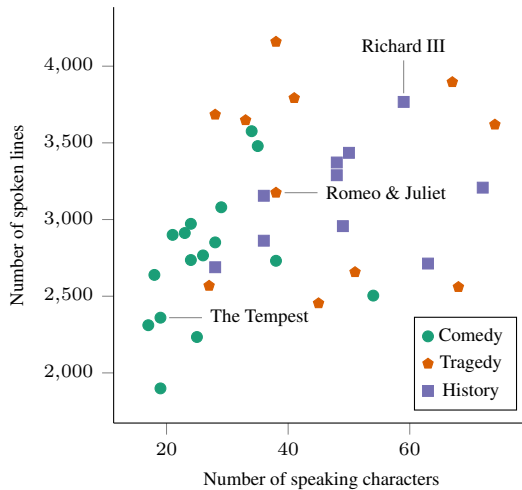


Figure 1: Number of spoken lines vs. number of speaking characters in the 37 plays by William Shakespeare. Each point corresponds to a play for which we provide 18 different (hyper)graph representations.

## ACT II.

SCENE I.—*The Community. In the dining hall.*

PROFESSOR, SENIOR RESEARCHER, and COLLEAGUE seated at a table. Enter CREATURE, carrying a tray.

104 Col. Hey fellow, please come join us, have a seat!  
CREATURE, jolted from their thoughts, obeys with reluctance.

105 Sen. R. They told me you submitted, so, good cheer!

106 Col. Next time, though, try to not scare SECRETARY.

107 Prof. Now fate lies with the review gods, almighty

108 And they select not just for quality.

109 Regardless of their upcoming decision,

110 You'll get this published, well, eventually.

Cre. That's comforting.

111 Col. Well, it is how things go.

112 Prof. My admin work is calling.

Sen. R. And mine, too!

*Exeunt* PROFESSOR and SENIOR RESEARCHER.

*Awkward silence.*

113 Cre. May I ask you something? Here in the Community, how do you get your data? You hardly go outside...

115 Col. What do you mean? We grab it from the shelves. There's shelves for almost every data type.

117 For graphs, e.g., there's OGB [8], and SNAP [11],

118 KONECT [10], and TUD [12], and Netzschleuder [14],

119 And finally, Network Repository [15].

120 Cre. Hold on, you are confusing me. How do the graph shelves get their data, then?

122 Col. You really ask the weirdest things. I guess

123 They send some hunter-gatherers to catch

124 Or pick the graphs they find out in the wild.

125 Cre. You make it sound like graphs exist, for real. But are they not defined by their observers?

127 Col. Who are you? Not the Spanish Inquisition?

128 All graphs have nodes and edges, that's what matters.

129 Sometimes they come with weights or attributes.

130 Semantics—God, who cares?—graphs are abstractions,

131 And abstract data is our working truth.

*Exeunt.*

SCENE II.—CREATURE's office.

*In a corner, on the floor; CREATURE, in contemplation.*

Cre. What canny creatures met my febrile mind. That friendly faun, the gentle spirit, exchanging such profound considerations. I wish I could have stayed a little longer—instead, I'm left to draw my own conclusions. What graph shadows could I create by shining different lights on what there is? It seems the sensible depends on the semantics.

*They close their eyes, following their thoughts.*

Cre. When we transform reality to math, 139

Graphs are but outputs, in—phenomena. 140

The myriad transformations that we see, 141

How do they differ systematically? 142

For now, we shall distinguish three dimensions. 143

First, our *semantic mapping*—Nodes and edges: 144

What types of entities do we assign? 145

Second, our *granularity*—What are 146

Our modeling units for semantic mapping? 147

And third, our *expressivity*: What more 148

Do we attach to all our modeling units? 149

Directions, weights, and multiplicities, 150

Or attributes and cardinalities... 151

What universe! *Haec facta, fiant data.* 152

*Tracing coordinate axes with their fingers, they sigh.*

Cre. All these distinctions, it appears, are known in 153

the Community [18]. And yet, the knowledge seldom

heeded—graph data shelves are filled with all these cap-

tive singular truths. We hardly hold what that free faun

foresaw: For every data point, a set of transformations

as its data. I wonder why.

*Exit.*

SCENE III.—COLLEAGUE's office.

COLLEAGUE, *trimming a bonsai with scissors.*

Col. Alas, they really want documentation? 158

CREATURE *steps into the door frame, unnoticed.*

Col. A datasheet [7]? Well—all the world is data, 159

And all we care for merely data points; 160

They get created, updated, deleted, 161

And every data point plays many parts, 162

Its fate being seven stages. First, *motivation* 163

Defining purpose or specific tasks. 164

Then *composition*, sketching the raw data 165

And telling people where it was obtained, 166

If anything's amiss. And then *collection*, 167

How did we get each single data point, 168

And what else did we check. Then *preprocessing*, 169

Full of strange quirks and idiosyncrasies, 170

But made that it looks principled. Then *uses*, 171

What all things did we do, what could have been, 172

And what should not be done. Then *distribution*, 173

If, when, and how will we make data public, 174

Restrictions by third parties, if imposed, 175

And also all the laws. Last stage of all, 176

That ends this template documentary, 177

Is *maintenance* and hosting and support, 178

Sans updates, sans errata, sans comment. 179

CREATURE *retires, flabbergasted.*

COLLEAGUE *stashes the stunted bonsai into a shelf.*

*Exit.*

SCENE IV.—CREATURE's office.  
*Enter* CREATURE, *restless*.  
 180 *Cre.* This stream of observations leaves me drown-  
 ing in confusion. If *Is* is not what *Ought*, how can *Is*  
 be? What is this thing they call Community? Am I  
 misguided, am I wrong—to doubt that I belong?  
 184 Two souls, alas, are dwelling in my breast,  
 185 And each one seeks to rule without the other.  
 186 The one a falcon, fierce and fighting fetters,  
 187 That's dreaming of faun's forest, flying free,  
 188 The other a caged chary canary,  
 189 That calmly, coyly, cheerfully chants chatters.  
*They open the window and balance on the window sill.*  
 190 *Cre.* Should there be spirits roaming through the air,  
 191 I beg they lift the spell of my despair.  
*They jump.*

SCENE V.—*The forest.*  
 GRAPH *tending to a mat of moss. On the mat, CREA-*  
 TURE, *somnolent. Enter* HYPERBARD.  
 192 *Hyp.* So few return once captured by Its magic!  
 193 *Gra.* Playing that dream was worth it, after all.  
 194 *Cre.* Is this a dream no more? Do you exist?  
 195 *Hyp.* Depends on your philosophy. But see,  
 196 My GRAPH says you have interesting ideas.  
 197 So tell me, how would *you* transform these trees  
 198 To bear the fruit of new discoveries?  
 199 *Cre.* Did you not eavesdrop on my ruminations,  
 200 Distinguishing between those three dimensions?  
 201 Semantic mapping, granularity,  
 202 And expressivity—put abstractly?  
 203 *Hyp.* I heard, but what does it all mean in practice?  
 204 *Cre.* Let's walk through an example. Take this tree:  
 205 The Tragedy of R. and J.—a play.  
 206 When modeled *Les Misérables-y* [9], the nodes  
 207 Are characters, and edges—co-occurrence.  
 208 That's one semantic mapping, hold this fixed.  
 209 Then, as to granularity, we ask  
 210 What unit should determine co-occurrence?  
 211 The first—most common—option is: a scene.  
 212 And here, much modeling ends, unfortunately:  
 213 Max simple graphs, min expressivity.  
 214 *Hyp.* But does this not reveal essential structure?  
 215 *Cre.* It smudges all the details, Fig. 2a!  
 216 Do the play's namesake heroes co-occur  
 217 No more than Montague and Capulet?  
 218 *Hyp.* So should we count-weight edges, Fig. 2b?  
 219 *Cre.* Or introduce edge multiplicity.  
 220 The multigraph perspective would allow us  
 221 To treat—Fig. 2c—co-occurrence weights.  
 222 In our setting, this could, e.g., mean  
 223 The count of spoken lines in every scene.  
 224 But that is basic expressivity—  
 225 We yet have to treat granularity.  
 226 To illustrate, in Fig. 3a, we draw  
 227 The co-occurrence only for Act III.  
 228 The Capulets and Romeo appear  
 229 To interact too much—this sparks suspicion.  
 230 *Hyp.* You mean we're introducing information?  
 231 *Cre.* And hiding what there really is to see!  
 232 The scene is far too coarse a modeling unit,  
 233 Quite often is there movement in between.  
 234 We must keep track of entries and of exits  
 235 To capture interactions faithfully.  
 236 Each part confined by any two such changes,  
 237 A *stage group*, separately defines an edge.

Accounting now for expressivity, 238  
 These edges may be binary or multi, 239  
 Or weighted by lines spoken, Fig. 3b. 240  
 The outcome, evident from Fig. 3c, 241  
 Is far from what we had initially. 242  
 Thus, even for just one semantic mapping, 243  
 And R. and J. as a specific case: 244  
 We see at least six decent transformations, 245  
 Statistics differing tremendously. 246  
*Hyp.* So is this all? 247  
*Cre.* Oh, that is but the start!  
 Thus far, we've had just characters as nodes. 248  
 One possible complaint with this approach 249  
 Is that it gives us artificial cliques. 250  
 Instead, we could in our semantic mapping 251  
 Consider also parts of plays as nodes, 252  
 Transforming plays into bipartite graphs, 253  
 Whose edges signal character occurrence. 254  
 Then granularity, Fig. 4a–b, 255  
 Concerns the nodes, but sometimes also edges. 256  
 In terms of expressivity, we could 257  
 Again attend to weights, and represent 258  
 Directionality, see Fig. 4c, 259  
 With greater ease than in the one-mode case— 260  
 To model single *speech acts*, too, as edges. 261  
*Hyp.* Now, that is quite a lot—so are you finished? 262  
*Cre.* Respectfully, the best is yet to come!  
 Conceptually, all I have just described 264  
 Can be derived from a more general model. 265  
 All graphs, regarding expressivity 266  
 Force '∈ {1, 2}' on cardinality 267  
 Of edges— 268  
*Hyp.* Marvelous mathematically!  
*Cre.* But artificial, thinking critically. 269  
 The interactions in your vivid woods— 270  
 How many of them are bilateral? 271  
 This common cardinality constraint: 272  
 Let's do away with it! 273  
*Hyp.* Then what remains?  
*Cre.* A set system—a *hypergraph*, they say [4], 274  
 We visualize its power in Fig. 6. 275  
 Confusingly: All graphs are hypergraphs 276  
 But not vice versa. 277  
*Hyp.* Do we need this, GRAPH?  
*Gra.* Well, some found hypergraphs to be quite handy 278  
 To capture higher-order interactions [1, 2, 3]. 279  
 They certainly are more intuitive 280  
 Than making cliques of multi-arities, 281  
 Or else treating relations, too, as nodes. 282  
*Cre.* We can go far with *graphs* but don't know yet 283  
 Just how much further we can get with *hyper*. 284  
 Observe the beauty in these hypergraphs: 285  
 They readily entail *all* transformations! 286  
 From their perspective, what first we discussed 287  
 Are *clique expansions*, and our next ideas 288  
 Are known as *star expansions* [17]—see, in sum, 289  
 Fig. 5, and our proposals in Tab. 1. 290  
*Hyp.* Things hyper, in their generality, 291  
 They seem to suit my woods quite naturally. 292  
*Gra.* But sovereign, as a practicality, 293  
 There's hardly any software letting us 294  
 Compute with hypergraphs conveniently! 295  
*Hyp. and Cre. [in synchrony]* Who are you, the 296  
 Community?  
*Gra.* I'm sorry.  
*Exeunt.*

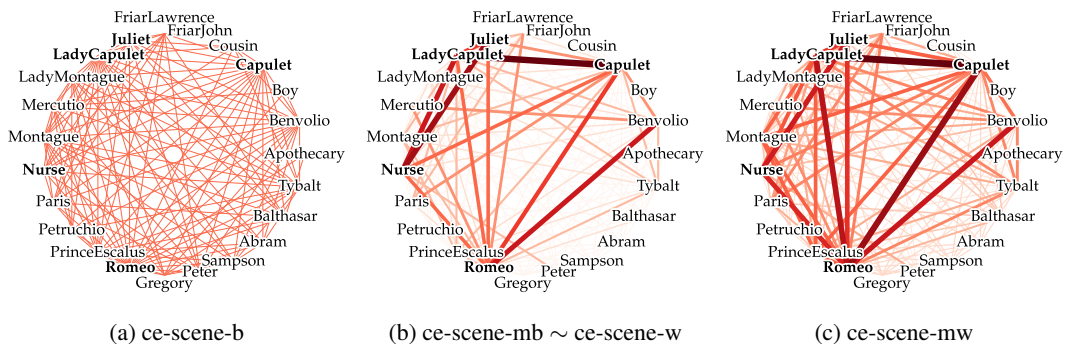


Figure 2: Relationships between the named characters in *Romeo and Juliet* when modeled as binary (a), count-weighted (b), and line-weighted (c) co-occurrence networks, resolved at the scene level, where we highlight the protagonists appearing in Act III, Scene V. The binary representation is a classic hairball, while the count-weighted representation and the line-weighted representation provide more nuance. In (c), the strikingly strong connection between Romeo and Capulet is partly due to Act III, Scene V, where both characters appear but *do not meet* on stage.

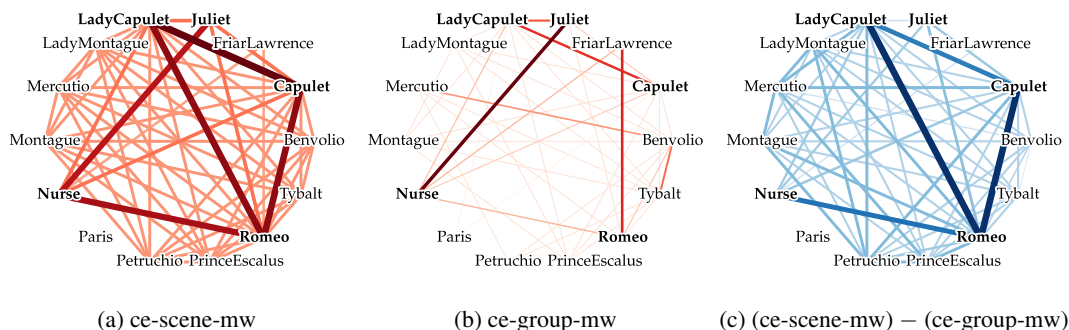


Figure 3: Line-weighted co-occurrence network of the named characters in Act III of *Romeo and Juliet*, resolved at the scene level (a) and at the stage group level (b), as well as the difference network between the two (c), where we highlight the protagonists appearing in Act III, Scene V. The coarse-grained representation overestimates the co-occurrence between Romeo and Juliet’s parents, i.e., Capulet and Lady Capulet (a and c), while the fine-grained representation emphasizes Juliet’s bond with the Nurse and Romeo’s interaction with Friar Lawrence (b).

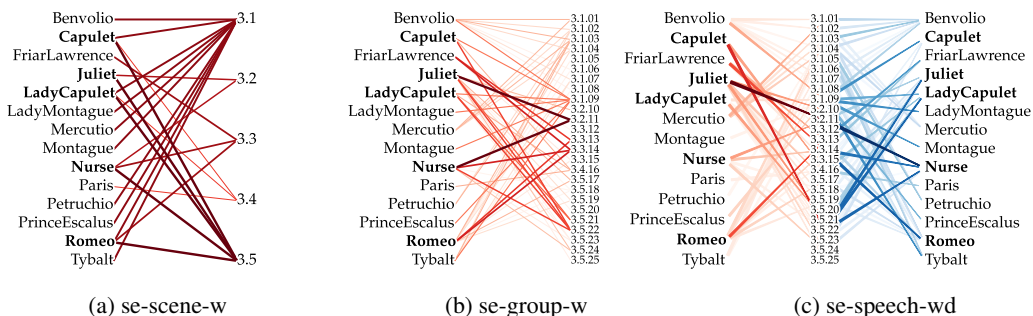


Figure 4: Weighted bipartite graph of named character occurrences in Act III of *Romeo and Juliet*, resolved at the scene level (a) and at the stage group level (b), as well as the directed weighted bipartite graph resolved at the speech act level, with character nodes split up into speakers and listeners for visual clarity (c), where we highlight the protagonists appearing in Act III, Scene V. While the coarse-grained representation overestimates Romeo’s role in Act III, Scene V (a), the finer-grained representation again highlights Juliet’s bond with the Nurse (b), and the directed representation reveals the hierarchical structure of their communication (c).

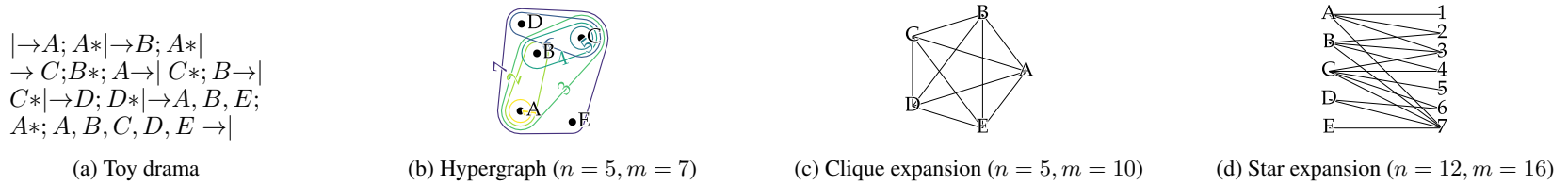


Figure 5: Relationship between hypergraphs, clique expansions, and star expansions, illustrated for a toy drama. In the toy drama, characters are capital letters,  $\rightarrow X$  denotes entry,  $X \rightarrow$  denotes exit,  $*$  denotes speech,  $|$  marks scene boundaries,  $;$  marks activity boundaries, and  $,$  indicates several characters acting together.

Table 1: Overview of relational data representations provided with HYPERBARD for each play attributed to William Shakespeare, based on the TEI simple-encoded XMLs provided by Folger Digital Texts [13]. Unidirectional arrows indicate assignment; bidirectional arrows indicate bijection. We highlight the transformations most commonly used in the literature.

Representation	Semantic Mapping	Granularity	Expressivity
ce-scene-b ce-scene-mb ce-scene-mw ce-group-b ce-group-mb ce-group-mw	$\left. \begin{array}{l} \text{Nodes} \leftarrow \text{Characters} \\ \text{Edges} \leftarrow \text{Co-occurrence} \end{array} \right\}$	$\left. \begin{array}{l} \text{Edges} \leftrightarrow \text{Scenes} \\ \text{Edges} \leftrightarrow \text{Stage groups} \end{array} \right\}$	$\left. \begin{array}{l} \text{—} \\ \text{Edge order} \\ \text{Edge order, edge weights} \\ \text{—} \\ \text{Edge order} \\ \text{Edge order, edge weights} \end{array} \right\}$
se-scene-b se-scene-w se-group-b se-group-w se-speech-wd se-speech-mwd	$\left. \begin{array}{l} \text{Edges} \leftarrow \text{Occurrence} \\ \text{Edges} \leftarrow \text{Information flow} \end{array} \right\}$	$\left. \begin{array}{l} \text{Nodes (2)} \leftrightarrow \text{Scenes} \\ \text{Nodes (2)} \leftrightarrow \text{Stage groups} \\ \text{Nodes (2)} \leftrightarrow \text{Stage groups} \\ \text{Edges} \leftrightarrow \text{Speech acts} \end{array} \right\}$	$\left. \begin{array}{l} \text{Partial node and edge order} \\ \text{Partial node and edge order; edge weights} \\ \text{Partial node and edge order} \\ \text{Partial node and edge order; edge weights} \\ \text{Partial node order; edge weights, edge directions} \\ \text{Partial node and edge order; edge weights, edge directions} \end{array} \right\}$
hg-scene-mb hg-scene-mw hg-group-mb hg-group-mw hg-speech-wd hg-speech-mwd	$\left. \begin{array}{l} \text{Edges} \leftarrow \text{Co-occurrence} \\ \text{Edges} \leftarrow \text{Information flow} \end{array} \right\}$	$\left. \begin{array}{l} \text{Edges} \leftrightarrow \text{Scenes} \\ \text{Edges} \leftrightarrow \text{Stage groups} \\ \text{Edges} \leftrightarrow \text{Speech acts} \end{array} \right\}$	$\left. \begin{array}{l} \text{Edge order} \\ \text{Edge order, edge weights; edge-specific node weights} \\ \text{Edge order} \\ \text{Edge order, edge weights; edge-specific node weights} \\ \text{Edge directions, edge weights} \\ \text{Edge order, edge directions, edge weights} \end{array} \right\}$

Representation abbreviations follow the pattern  $\langle \text{model} \rangle - \langle \text{aggregation} \rangle - \langle \text{properties} \rangle$ , where  $\text{model} \in \{\text{ce: clique expansion, se: star expansion, hg: hypergraph}\}$ ,  $\text{aggregation} \in \{\text{scene: play scene, group: stage group, speech: speech act}\}$ , and  $\text{properties} \subseteq \{\text{b: binary edges, d: directed edges, m: multi-edges allowed, w: weighted edges}\}$ . Binary multigraph representations of clique expansions (ce-\*mb) can be transformed into weighted graph representations of clique expansions without multiedges (ce-\*-w) using edge counts as weights, but only the multigraph representations can retain order information on edges.

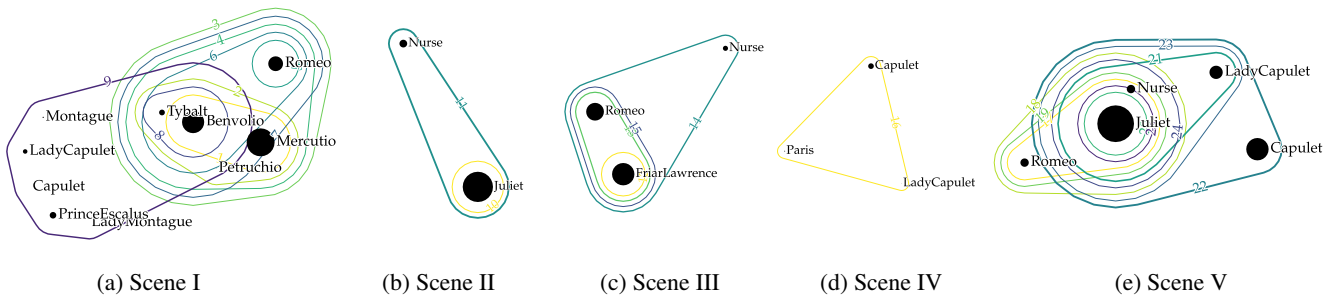


Figure 6: Line-weighted hypergraph resolved at the stage group level, separated by scene and restricted to named characters, for Act III of *Romeo and Juliet*. Edge labels denote stage groups, edge colors indicate edge order, and node sizes and edge widths are proportional to the number of spoken lines. From (e), it is visually clear that Romeo and Juliet’s parents never meet in the balcony scene.

ACT III.  
SCENE I.—*The forest.*

CREATURE, *squatting on a rock, sorting leaves.*  
Enter DEADLINES, *invisible, at a distance.*

297 *First Dea.* I told you! I could see from their submission!

298 *Third Dea.* The poor thing—they adore the real world!

299 *Sec. Dea.* No way that they will make me if we don’t

300 Now intervene. So let us capture them,

301 Surround them, and restore the rhythmic cords,

302 By which we subjugate our sovereigns. Go!  
*They encroach on CREATURE, in silence, settling in a triangle around them.*

FIRST DEADLINE *sings.*

303 Come back to the office lands,

304 Don’t take a chance:

305 Meta fair but be aware

306 In camera, better prepare

307 Fix your figures here and there;

308 And review two the burden bear.

309 *Cre.* Where should this music be? I know the beat.

310 It sounds no more? No, it begins again.

SECOND DEADLINE *sings.*

311 To taller skies your metrics rise;

312 Publish, perish, stars are made;

313 Do not whine, stay in line,

314 Otherwise your glory fade.

315 Dutifully use your wit

316 And then submit.

*Exeunt all but CREATURE.*

317 *Cre.* The ditty does remind me of my paper,

318 And all the future work yet to be done.  
*They rise.*

319 *Cre.* To flee or PhD—that is the question:

320 Whether our destiny lies in the system,

321 To cling onto scientific ladder’s rungs,

322 Or to renounce the reign of rules unwritten

323 And, by opposing, vanish. To flee, to think—

324 To think, perchance discover. Ay, there’s the rub,

325 For once outside the pithy paywalled castles,

326 The giant’s shoulders quickly out of reach,

327 For lack of funding. There’s cautiousness

328 That crafts careers of so long strive,

329 And makes us rather swarm the conference streams

330 Than swim the savage seas so far uncharted.

331 Thus mellow meal the mighty mills of science,

332 And conscience can coerce our compliance.  
*Exit.*

ACT IV.  
SCENE I.—*The Community. CREATURE’s Office.*

Enter GRAPH, *invisible, floating, trailed by CREATURE and HYPERBARD.*

*Gra.* What are we doing here? Did you not exit 333  
Precisely through this window here to flee 334  
From all these straining office-worldly fights 335  
To think, explore, discover, to be free? 336  
*Hyp.* Don’t tease them, spirit! We’ve discussed at length 337  
The ends to which we undertook this trip. 338  
You’ve seen the acts of hunter-gatherers 339  
As they bereave our natural habitat. 340  
If we ignore them, they will seize control, 341  
And colonize our forest with their views 342  
Of graph data as unambiguous truths. 343  
*Cre.* I’m confident we’ll make them understand 344  
The problem once they see our transformations. 345  
That future work in the Community 346  
May operate with more representations! 347  
Enter PROFESSOR.

*Prof.* What’s all this noise? The rules! No visitations! 348  
*Cre.* Let me explain— 349  
*Prof.* Save me your explanations!  
I want you in my office, now! And when 350  
We’re done, this dirty stray thing must be gone! 351  
*Exeunt PROFESSOR and CREATURE.*

*Gra.* Your honor, I foresaw this would be dangerous. 352  
*Hyp.* You see their wielding of authority? 353  
So far up in the hierarchy, so long, 354  
And funeral their only honest feedback. 355  
I’m not afraid, but let us maybe make 356  
Our data case not at the top to start with. 357  
*Gra.* When floating down the hall I think I saw 358  
The perfect target for us to attack. 359  
*Hyp.* What’s with this war rhetoric? 360  
*Gra.* I’ll be back.  
*Exit GRAPH. HYPERBARD settles by the office plant.*

SCENE II.—PROFESSOR’s Office.

Enter PROFESSOR and CREATURE.

*Prof.* The judgment’s in, you have no time to spare: 361  
*They hand CREATURE a sheet of paper.*

*Prof.* Accept, well done, but now in camera’s near. 362  
*Cre.* They’re taking months, and now we’re given days? 363  
Additional experiments? But how? 364  
No space! What should I do about R2? 365  
*Prof.* That’s up to you—it will not change a thing. 366  
*Cre.* [Aside] That’s comforting. 367  
*Exeunt.*

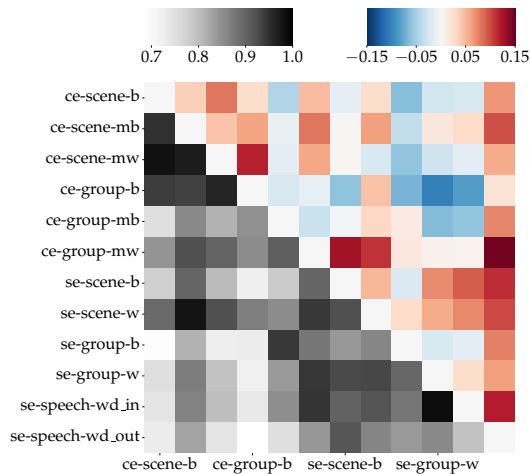


Figure 7: Spearman correlations of degree rankings in the clique and star expansions from Tab. 1 for *Romeo and Juliet* (bottom), and residuals after subtracting the average correlations in the HYPERBARD corpus (top).

SCENE III.—CREATURE’s Office.  
HYPERBARD, *engaging the office plant.*  
368 *Gra.* [Within] Watch out, they’ll be here any minute now!  
*Enter COLLEAGUE.*  
369 *Col.* Congrats on that acceptance—wait! Who’s this?  
370 *Hyp.* What’s in a name? I heard you work with data,  
371 We’re colleagues, in a sense—I do the same  
372 But mostly in the wild.  
*Col.* So you’re a hunter?  
373 *Hyp.* Far off! I roam reality’s realms  
374 In search of structure that persists across  
375 Perspectives.  
*Col.* By perspectives, you mean tools?  
376 *Hyp.* I mean representations, as for each  
377 Phenomenon there’s many paths to data.  
378 I like to call each path a transformation,  
379 And transformation is my tested trade.  
380 *Col.* Can you elaborate? What good is that?  
381 *Hyp.* Let’s take a look at, you would say, *graph data.*  
382 Imagine that you have a tree—say, R. and J.—  
383 *Col.* That famous play?  
*Hyp.* —And that you want to model  
384 The structure of its story as a graph.  
385 *Col.* Well, obviously, each character’s a node  
386 And there’s an edge between two nodes in case  
387 They co-occur in more than zero scenes.  
388 *Hyp.* But this is only one of many options.  
389 And without dwelling on the details here,  
390 Fig. 8 reveals how even simplest things  
391 Such as degree ranks differ with our choices.  
392 The variations vary, too, Fig. 7,  
393 Within a set of trees as data raw.  
394 And—to conclude representation matters—  
395 Less simple transformations may support  
396 More nuanced inquiries as in Fig. 9,  
397 Or exploration over time, Fig. 10.  
398 *Col.* You worry well, but then, so why should I?  
399 What’s in it for my publication record?  
*Enter PROFESSOR.*  
400 *Prof.* What fool is this?  
*Col. and Hyp.* [in synchrony] O that I were a fool!  
*Enter CREATURE.*  
401 *Cre.* Did you discuss the problem with *the data*?

*Hyp.* I laid it out for them, to no avail. 402  
*Col.* You surely got me thinking, but— 403  
*Prof.* Enough!  
My patience is exhausted. Think? Produce! 404  
[To *Col.*] You, give productive treatment to that thinker. 405  
*Exit COLLEAGUE with HYPERBARD.*  
[To *Cre.*] And you, fix these few figures; faugh R2. 406  
*Exeunt.*

ACT V.

SCENE I.—*The Community. COLLEAGUE’s Office.*  
*GRAPH, invisible, floating by the window.*  
*Enter COLLEAGUE, carrying a jar.*  
*Col.* Those fecund thoughts shall find their fertile soil. 407  
*They empty the content of the jar onto the bonsai.*  
*Col.* To ashes, ashes—dust to dust. Not me— 408  
Thus goes the system, let the system be. 409  
*Exit. GRAPH caresses the bonsai.*  
*Gra.* Full many a transformation have I seen 410  
Flatter the flora with their sovereign hand, 411  
And sovereign’s hand in spirit I’ll have been 412  
To help evaluate their promised land. 413  
Community, defined as uninvolved 414  
With hideous beauty born by Mother Earth 415  
Begets solutions without problems solved 416  
And burns the flame of wonder in Its dearth. 417  
When culture counters nature, it prevails, 418  
And builds its truths from rigid rigor bricks, 419  
As myriad feeble fledglings it derails 420  
Into the cave of engineering tricks. 421  
For in the trenches of discovery, 422  
To shatter shadows, meet obscurity. 423  
*Exit.*  
SCENE II.—CREATURE’s Office.  
*Enter CREATURE.*  
A deadline, and a deadline, and a deadline, 424  
Creeps in this petty pace to publication, 425  
To the last syllable of our defense. 426  
They slew my GRAPH and choked my inspiration, 427  
Our work is but a walking shadow thence. 428  
The curiosity that drew me in 429  
Now lies in dust. The lofty dreams I had 430  
Of mindful monasterial devotion 431  
To just the cause—no more. Out, out, sore studies! 432  
Should I give up that which I know I love—to save 433  
my love for it? And go in silence, not disturbing the  
Machine? Or should I stay to salvage my beloved—to,  
once on top, speak out, let nature in?  
My story, so it seems, a tragedy 437  
In the Community: 438  
*All the world’s a (hyper)graph.* 439  
Thus, I’ll begin. 440  
*They write.*

1. Graph data does not exist, it is defined.
2. Semantic mapping, granularity, and expressivity are key ingredients to define graph representations.
3. Many phenomena permit several graph representations.
4. Graph data context matters for graph representations.
5. Graph data representations matter for graph methods.
6. Hypergraphs are powerful.
7. HYPERBARD is free.



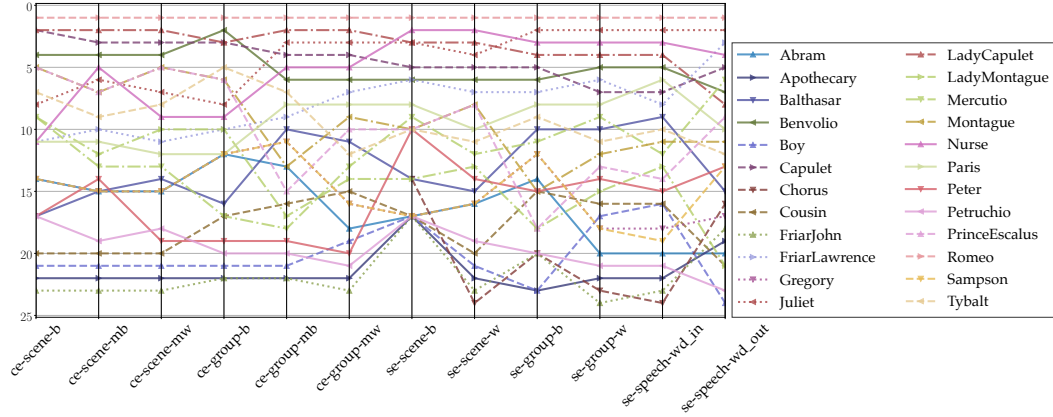


Figure 8: Named characters in *Romeo and Juliet*, ranked by their degree in the clique expansion (ce) and star expansion (se) representations from Tab. 1. We omit the se-speech-mwd representation because its ranking is equivalent to that of the se-speech-wd representation by construction. While Romeo is ranked first under all representations, the rankings differ, inter alia, in the prominence assessment of side characters, such as the Nurse or Friar Lawrence.

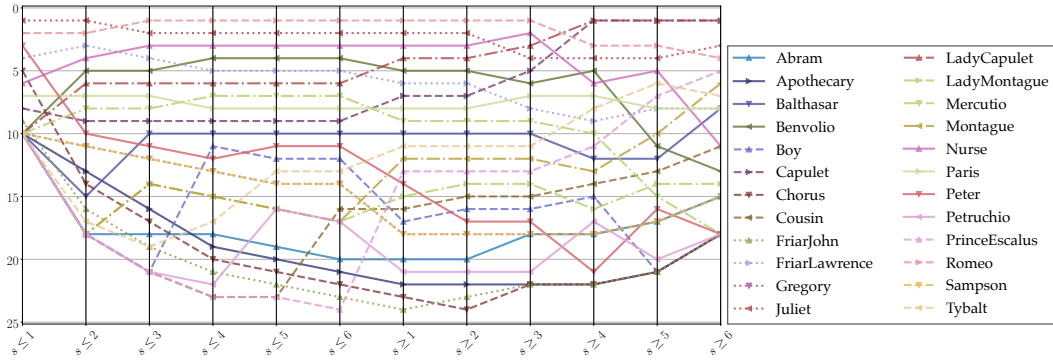


Figure 9: Named characters in *Romeo and Juliet*, ranked by their degree in the weighted hypergraph representation aggregated at the stage group level (hg-group-mw) when considering only hyperedges of cardinality at most  $s$  or at least  $s$ , for  $s \in \{1, 2, 3, 4, 5, 6\}$ . Hyperedges of cardinality at most 1 correspond to monologues. While Romeo and Juliet rank highest when including hyperedges of low cardinality, Capulet and Lady Capulet dominate when considering only less private settings.

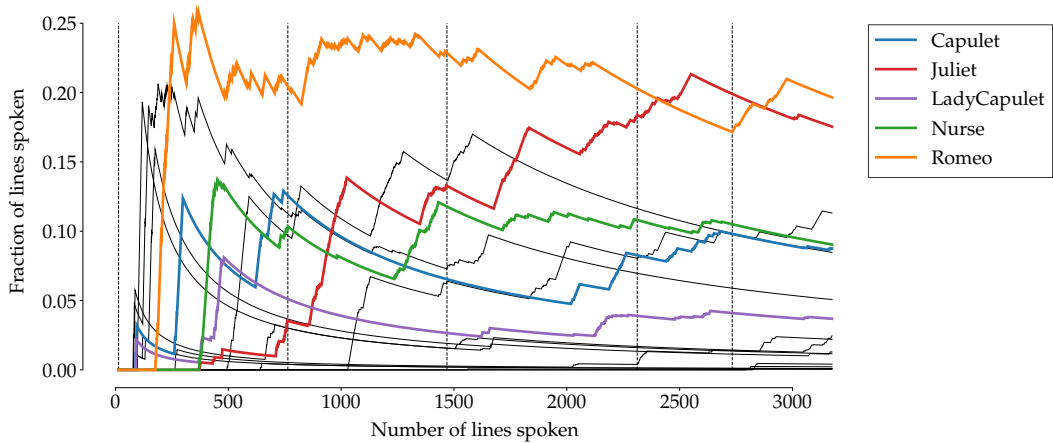


Figure 10: Prominence of named characters in *Romeo and Juliet* over time (excluding named servants), as measured by their fraction of spoken lines, derived from the hypergraph representation resolved at the speech act level (hg-speech-mwd). Dashed vertical lines mark the beginning of each act, and colored lines indicate protagonists of Act III, Scene V. From this perspective, Romeo is most prominent for most of the play, temporarily replaced only by Juliet for a period in Act IV and V.

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## A Data Documentation

All accessibility, hosting, and licensing information for HYPERBARD is summarized in Table 2.

Table 2: Accessibility, hosting, and licensing information for HYPERBARD.

Dataset Hosting Platform	Zenodo
Dataset Homepage	<a href="https://hyperbard.net">https://hyperbard.net</a>
Dataset Tutorials	<a href="https://github.com/hyperbard/tutorials">https://github.com/hyperbard/tutorials</a>
Dataset DOI (original version)	10.5281/zenodo.6627159
Dataset DOI (latest version)	10.5281/zenodo.6627158
Dataset License	CC BY-NC 4.0
Code Hosting Platform	GitHub (maintenance), Zenodo (releases)
Code Repository	<a href="https://github.com/hyperbard/hyperbard">https://github.com/hyperbard/hyperbard</a>
Code Documentation	<a href="https://hyperbard.readthedocs.io/en/latest/">https://hyperbard.readthedocs.io/en/latest/</a>
Code DOI (original release)	10.5281/zenodo.6627161
Code DOI (latest release)	10.5281/zenodo.6627160
Code License	BSD 3-Clause

### A.1 Datasheet

Our documentation follows the *Datasheets for Datasets* framework [7], omitting the questions referring specifically to data related to people.<sup>1</sup> For conciseness, unless otherwise indicated, the term *graph* refers to both *graphs* and *hypergraphs*.

#### A.1.1 Motivation

**For what purpose was the dataset created?** *Was there a specific task in mind? Was there a specific gap that needed to be filled? Please provide a description.*

HYPERBARD was created to study the effects of modeling choices in the graph data curation process on the outputs produced by graph learning, graph mining, and network analysis algorithms.

There was no specific task in mind; rather, all classic graph learning, graph mining, and network analysis tasks were considered to be in scope. These tasks include, e.g., centrality ranking, outlier detection, clustering, similarity assessment, and standard statistical summarization, each for nodes, edges, and graphs, as well as variants of node classification, link prediction, or graph classification.

HYPERBARD was designed to fill a specific gap: Although there were myriad freely available graph datasets, to the best of our knowledge, none of them contained

- several different relational data representations,
- of the *same* underlying raw data,
- derived in a principled and well-documented manner,
- from each of several raw data instances belonging to a natural collection,
- where the raw data is intuitive and interpretable.

**Who created the dataset (e.g., which team, research group) and on behalf of which entity (e.g., company, institution, organization)?**

Corinna Coupette and Bastian Rieck created the dataset as part of their research.

<sup>1</sup>When construed broadly (as suggested by Gebru et al.), our raw data relates to people because the plays were written by William Shakespeare. The people-specific datasheet questions, however, are ill-suited for our scenario, in which the raw data consists of literary works conceived by someone who died several centuries ago.

**Who funded the creation of the dataset?** *If there is an associated grant, please provide the name of the grantor and the grant name and number.*

The creation of the dataset was indirectly funded by the institutions employing the dataset authors, i.e., the Max Planck Institute for Informatics (Corinna Coupette) and the Institute of AI for Health, Helmholtz Munich. There are no associated grants.

**Any other comments?**

None.

### A.1.2 Composition

**What do the instances that comprise the dataset represent (e.g., documents, photos, people, countries)?** *Are there multiple types of instances (e.g., movies, users, and ratings; people and interactions between them; nodes and edges)? Please provide a description.*

Each instance represents a play attributed to William Shakespeare as a graph, and there are multiple different graph representations per play. In some graphs (i.e., hypergraphs and graphs derived from clique expansions of hypergraphs), nodes represent characters, and (hyper)edges represent that characters were on stage at the same time in some part of the play. In other graphs (i.e., graphs derived from star expansions of hypergraphs), nodes represent characters or parts of a play, and an edge indicates that a character was on stage in that part of the play. The representations provided differ not only in their semantic mapping (what are the nodes and edges) but also in their granularity (what parts of the play are modeled as edges resp. nodes) and in their expressivity (what additional information is associated with nodes and edges); see Table 1 in the HYPERBARD paper.

**How many instances are there in total (of each type, if appropriate)?**

There are 37 plays in the raw data; 17 comedies, 10 historical plays, and 10 tragedies. Each play is represented as a graph in (at least) 18 different ways, for a total of 666 graph representations.

**Does the dataset contain all possible instances or is it a sample (not necessarily random) of instances from a larger set?** *If the dataset is a sample, then what is the larger set? Is the sample representative of the larger set (e.g., geographic coverage)? If so, please describe how this representativeness was validated/verified. If it is not representative of the larger set, please describe why not (e.g., to cover a more diverse range of instances, because instances were withheld or unavailable).*

The dataset contains graph representations of all plays attributed to William Shakespeare by the Folger Shakespeare Library (see [https://folgerpedia.folger.edu/William\\_Shakespeare%27s\\_plays](https://folgerpedia.folger.edu/William_Shakespeare%27s_plays)), with the exception of lost plays and the comedy *The Two Noble Kingsmen*—a collaboration between Shakespeare and John Fletcher that is not currently provided in the TEI simple format by Folger Digital Texts.

**What data does each instance consist of?** *“Raw” data (e.g., unprocessed text or images) or features? In either case, please provide a description.*

Each instance, i.e., each of Shakespeare’s plays, is represented by a set of files: one raw data file containing the text of the play as an XML encoded using the TEI Simple format, taken from Folger Digital Texts without modification, three CSV files containing preprocessed data, and 19 CSV files containing node lists and edge lists to construct different graph representations.

Consequently, dataset is distributed using the following folder structure:

- rawdata: contains 37 raw data XML files encoded in TEI simple.
- data: contains 3·37 preprocessed data files derived from files in rawdata.
- graphdata: contains 19·37 node and edge lists to construct graph representations from the files in data.
- metadata: contains playtypes.csv, mapping play identifiers to play types (comedy, history, or tragedy).

Python code to reproduce all graph representations and load them as *networkx* or *hypernetx* graphs is maintained in a GitHub repository (<https://github.com/hyperbard/hyperbard>), and code releases are archived via Zenodo (10.5281/zenodo.6627160).

**Is there a label or target associated with each instance?** *If so, please provide a description.*

There are labels corresponding to the type of play (one of {comedy, history, tragedy}), which could be used to partition the data for exploration, or as targets in classification tasks.

**Is any information missing from individual instances?** *If so, please provide a description, explaining why this information is missing (e.g., because it was unavailable). This does not include intentionally removed information, but might include, e.g., redacted text.*

There is no missing information.

**Are relationships between individual instances made explicit (e.g., users' movie ratings, social network links)?** *If so, please describe how these relationships are made explicit.*

When considering plays as instances, no relationships between individual instances are made explicit. When considering characters or parts of plays as instances, however, relationships between characters, or between characters and parts of plays are made explicit in the graph representations, exploiting the TEI Simple encoding of that data and the annotations provided in the XML attributes.

**Are there recommended data splits (e.g., training, development/validation, testing)?** *If so, please provide a description of these splits, explaining the rationale behind them.*

There are no recommended data splits for the current release.

**Are there any errors, sources of noise, or redundancies in the dataset?** *If so, please provide a description.*

The raw data contain some errors and redundancies in the XML encoding. Errors include redundant XML tags (e.g., doubly-wrapped `<div>` tags), but also character entries or exits not explicitly annotated. Redundancies result from the choice, made by the creators of Folger Digital Texts, to encode some information conveyed in the raw text also as attributes or separate XML tags (e.g., a character who speaks is encoded both as an attribute of the tag wrapping the speech and as an XML tag wrapping the name of the speaker).

There are two notable sources of noise affecting the preprocessed data and the graph data, both of which relate to our handling of stage directions—i.e., our processing of the XML attributes of `<stage>` tags in the raw data.

First, to determine which characters are on stage when a word is spoken, we primarily rely on the contents of `who` attributes in the `<stage>` tags of the raw data marked with `type="entry"` resp. `type="exit"`. The `who` attributes, however, are sometimes *semantically* incomplete, i.e., they may reflect Shakespeare's original stage directions accurately, but the original stage directions do not mention implied character movements (such as the exit of a side character or the exit of characters that died or fell unconscious at the end of a scene). To limit the impact of this noise source on our graph representations, we “flush” characters when a new scene starts (to handle missing exits) and ensure that the speaker is always on stage (to handle missing entries, some of which are also introduced by our character flushing policy).

Second, in our directed graph representations, where edges encode speaking and being spoken to, we equate being on stage while a word is spoken with hearing the word. Thus, we do not account for the impact of some stage directions concerning delivery, e.g., stage directions indicating that speech is inaudible for some or all other characters on stage, on the information flow our directed graph representations purport to capture. In the TEI simple encoding of our raw data, such stage directions are annotated with `type="delivery"`, but there is no indication of who can hear the words so delivered in the XML annotations. There are 2 200 XML tags annotated with `type="delivery"` (i.e., 60 delivery modifications per play on average). As modifications to delivery are sometimes crucial to drive the plot (e.g., by setting up misunderstandings), the impact of this noise source should not be underestimated, but it affects only our directed graph representations, which might be cautiously interpreted as “upper bounds” on the information flow between the characters on stage.

These sources of noise detailed above could likely be eliminated, to a large extent, by a more sophisticated parsing of the stage directions. This parsing could leverage, e.g., natural language processing methods to supplement the XML annotations. We plan to implement this improvement for a future dataset release.

**Is the dataset self-contained, or does it link to or otherwise rely on external resources (e.g., websites, tweets, other datasets)?** *If it links to or relies on external resources, a) are there guarantees that they will exist, and remain constant, over time; b) are there official archival versions of the complete dataset (i.e., including the external resources as they existed at the time the dataset was created); c) are there any restrictions (e.g., licenses, fees) associated with any of the external resources that might apply to a dataset consumer? Please provide descriptions of all external resources and any restrictions associated with them, as well as links or other access points, as appropriate.*

The dataset is self-contained. The raw data stem from Folger Digital Texts, maintained by the Folger Shakespeare Library and released under the CC BY-NC 3.0 Unported license, and they are redistributed without modifications as part of the HYPERBARD dataset. All other data are derived from the raw data, and the CC BY-NC 3.0 Unported license does not impose any additional restrictions. As part of our dataset maintenance (see below), we will regularly check Folger Digital Texts for modifications, and we will recompute and redistribute an updated HYPERBARD dataset under a versioned DOI whenever we detect changes.

**Does the dataset contain data that might be considered confidential (e.g., data that is protected by legal privilege or by doctor-patient confidentiality, data that includes the content of individuals' non-public communications)?** *If so, please provide a description.*

The dataset does not contain data that might be considered confidential.

**Does the dataset contain data that, if viewed directly, might be offensive, insulting, threatening, or might otherwise cause anxiety?** *If so, please describe why.*

The raw data, i.e., Shakespeare's plays, contain scenes that might be considered offensive, insulting, threatening, or otherwise anxiety-inducing from a contemporary perspective. For example, there is considerable controversy in the humanities around whether *The Taming of the Shrew* is misogynistic, and the main female protagonist's final speech on female submissiveness (Act V, Scene 2, ll. 136–179) might cause discomfort to modern readers. Moreover, the corpus uses words that might be considered derogatory or offensive from a contemporary perspective. The preprocessed data, however, disassembles the original text, such that (offensive) play content is no longer immediately apparent when the data is viewed directly.

**Any other comments?**

The entire dataset takes up roughly 365 MB when uncompressed, and 30 MB when compressed.

### A.1.3 Collection Process

**How was the data associated with each instance acquired?** *Was the data directly observable (e.g., raw text, movie ratings), reported by subjects (e.g., survey responses), or indirectly inferred/derived from other data (e.g., part-of-speech tags, model-based guesses for age or language)?*

The raw data associated with each instance was acquired from Folger Digital Texts as XML files encoded in TEI Simple format. This format contains both raw text and structural, linguistic, and semantic annotations embedded in XML tags or XML attributes. Hence, it was partially directly observable (e.g., the raw text and its structure) and partially derived from other data (e.g., the XML tags and their attributes). The preprocessed data and the graph data were derived from the raw data.

**If the data was reported by subjects or indirectly inferred/derived from other data, was the data validated/verified?** *If so, please describe how.*

To the extent that the raw data were indirectly inferred or derived from other data, validation was performed by the specialists from Folger Digital Texts. The preprocessed data and the graph data were validated by unit tests and manual inspection aided by visualizations (which also led us to discover the noise sources detailed above).

**What mechanisms or procedures were used to collect the data (e.g., hardware apparatuses or sensors, manual human curation, software programs, software APIs)?** *How were these mechanisms or procedures validated?*

The raw data was bulk downloaded in TEI Simple format as a ZIP archive from the Folger Digital Texts downloads section, and Folger Digital Texts compiled the raw data through computer-assisted manual curation. The bulk download was checked manually to ensure that the extracted archive contained one XML file per play, as expected. The code creating the preprocessed data from the raw data and the graph representations from the preprocessed data is almost completely unit tested.

**If the dataset is a sample from a larger set, what was the sampling strategy (e.g., deterministic, probabilistic with specific sampling probabilities)?**

The data is not a sample from a larger set.

**Who was involved in the data collection process (e.g., students, crowdworkers, contractors) and how were they compensated (e.g., how much were crowdworkers paid)?**

Only Corinna Coupette and Bastian Rieck, the dataset authors, were involved in the data collection process.

**Over what timeframe was the data collected?** *Does this timeframe match the creation timeframe of the data associated with the instances (e.g., recent crawl of old news articles)? If not, please describe the timeframe in which the data associated with the instances was created.*

The raw data was collected through one download call to [https://shakespeare.folger.edu/downloads/teisimple/shakespeares-works\\_TEIsimple\\_FolgerShakespeare.zip](https://shakespeare.folger.edu/downloads/teisimple/shakespeares-works_TEIsimple_FolgerShakespeare.zip) in June 2022, and the preprocessed data and the graph data were derived from the raw data by running a code pipeline, also in June 2022. This timeframe does not match the creation timeframe of the raw data, which, though internal to the Folger Shakespeare Library, spans at least several months in 2020. It also does not match the creation timeframe of Shakespeare's plays, which spans several decades in the 16th and 17th centuries.

**Were any ethical review processes conducted (e.g., by an institutional review board)?** *If so, please provide a description of these review processes, including the outcomes, as well as a link or other access point to any supporting documentation.*

No ethical review processes were conducted.

**Any other comments?**

None.

#### **A.1.4 Preprocessing/Cleaning/Labeling**

**Was any preprocessing/cleaning/labeling of the data done (e.g., discretization or bucketing, tokenization, part-of-speech tagging, SIFT feature extraction, removal of instances, processing of missing values)?** *If so, please provide a description. If not, you may skip the remaining questions in this section.*

Our data preprocessing consists of two steps.

1. Transform raw XML data into preprocessed CSV data (rawdata→data).  
Script: `run_preprocessing.py`
  - (a) Extract the cast list from the TEI Simple XML and store it as a CSV. (This is technically unnecessary to generate our graph representations, but it gives a convenient overview of the characters occurring in the play.)  
Function: `get_cast_df`  
Artifact: `data/{play}.cast.csv`
  - (b) Parse the TEI Simple XML into a table containing one row per descendant of the TEI Simple `<body>` tag, and the tag names and XML attributes of all XML tags of interest (eliminating redundant XML elements), plus the text content of all XML tags that are

leaves, as columns. Annotate the result with information on the act and scene in which the tag occurs, the characters on stage when the tag occurs, and the speaker(s), if any.  
Function `get_raw_xml_df`

Artifact: `data/{play}.raw.csv`

- (c) Transform the artifact from the previous step into a table with one row per setting on stage, where a setting is a stretch of the play without changes to the speaker or to the group of characters on stage, and information on the setting as well as the number of lines and tokens spoken in that setting as columns.

Artifact: `data/{play}.agg.csv`

2. Transform preprocessed CSV data into node and edge CSV files for graph construction (`data`→`graphdata`).

The artifacts resulting from this step are generally labeled `{play}_{semantic mapping}_{granularity}_{expressivity}.{list type}.csv`, omitting the expressivity (and granularity) components in node lists if all different graph representations with a given semantic mapping (and granularity) use the same set of nodes.

- (a) Create node lists and edge lists for different graph representations in CSV format from `data/{play}.agg.csv` artifacts.

Script: `create_graph_representations.py`

Artifacts:

- `graphdata/{play}_ce-group-mw.edges.csv`
- `graphdata/{play}_ce-group-w.edges.csv`
- `graphdata/{play}_ce-scene-mw.edges.csv`
- `graphdata/{play}_ce-scene-w.edges.csv`
- `graphdata/{play}_ce.nodes.csv`
- `graphdata/{play}_se-group-w.edges.csv`
- `graphdata/{play}_se-group.nodes.csv`
- `graphdata/{play}_se-scene-w.edges.csv`
- `graphdata/{play}_se-scene.nodes.csv`
- `graphdata/{play}_se-speech-mwd.edges.csv`
- `graphdata/{play}_se-speech-wd.edges.csv`
- `graphdata/{play}_se-speech.nodes.csv`

- (b) Create node lists and edge lists for different hypergraph representations in CSV format from `data/{play}.agg.csv` artifacts.

Script: `create_hypergraph_representations.py`

Artifacts:

- `graphdata/{play}_hg-group-mw.edges.csv`
- `graphdata/{play}_hg-group-mw.node-weights.csv`
- `graphdata/{play}_hg-scene-mw.edges.csv`
- `graphdata/{play}_hg-scene-mw.node-weights.csv`
- `graphdata/{play}_hg-speech-mwd.edges.csv`
- `graphdata/{play}_hg-speech-wd.edges.csv`
- `graphdata/{play}_hg.nodes.csv`

**Was the “raw” data saved in addition to the preprocessed/cleaned/labeled data (e.g., to support unanticipated future uses)?** *If so, please provide a link or other access point to the “raw” data.*

The raw data was saved, and it is distributed along with the preprocessed data in the dataset available from Zenodo under a versioned DOI: 10.5281/zenodo.6627158.

**Is the software that was used to preprocess/clean/label the data available?** *If so, please provide a link or other access point.*

The software used to transform the raw data into the preprocessed data, and the preprocessed data into the graph data representations, is available on GitHub in the following repository: <https://github.com/hyperbard/hyperbard>.

All code releases are also available on Zenodo under a versioned DOI: 10.5281/zenodo.6627160.



### **Any other comments?**

All data preprocessing can be completed in a couple of minutes even on older commodity hardware. We used a 2016 MacBook Pro with a 2.9 GHz Quad-Core Intel Core i7 processor and 16 GB RAM.

### **A.1.5 Uses**

**Has the dataset been used for any tasks already?** *If so, please provide a description.*

In the paper introducing HYPERBARD, the dataset has been used to demonstrate the differences between rankings of characters by degree that result from different modeling choices made when transforming raw data into graphs.

**Is there a repository that links to any or all papers or systems that use the dataset?** *If so, please provide a link or other access point.*

Papers or systems known to use dataset will be collected on <https://hyperbard.net> and on GitHub.

**What (other) tasks could the dataset be used for?**

HYPERBARD was designed for inquiries into the stability of algorithmic results under different reasonable representations of the underlying raw data, i.e., to enable *representation robustness checks* for graph learning, graph mining, and network analysis methods. In this role, it could generally be used for all graph learning, graph mining, and network analysis tasks identified as *in scope* in the motivation section.

**Is there anything about the composition of the dataset or the way it was collected and pre-processed/cleaned/labeled that might impact future uses?** *For example, is there anything that a dataset consumer might need to know to avoid uses that could result in unfair treatment of individuals or groups (e.g., stereotyping, quality of service issues) or other risks or harms (e.g., legal risks, financial harms)? If so, please provide a description. Is there anything a dataset consumer could do to mitigate these risks or harms?*

The quality and expressivity of the dataset is limited by the quality and expressivity of Folger Digital Texts encoded using the TEI Simple format, which could restrict usage in the digital humanities, e.g., when they are interested in the minute details of character interactions described in stage directions.

HYPERBARD contains relational data representations of Shakespeare's plays, which were written more than four centuries ago. Hence, there are no risks or harms associated with the dataset beyond the risks or harms also associated with the ongoing study of Shakespeare's works in the humanities, and the risks or harms associated with the decontextualization or overinterpretation of any dataset.

At <https://hyperbard.net> and on GitHub, we keep a continuously-updated list of all known dataset limitations for dataset consumers to review when deciding whether HYPERBARD is appropriate for their use case.

**Are there tasks for which the dataset should not be used?** *If so, please provide a description.*

Outside *representation robustness checks*, HYPERBARD should not be used in tasks that have no reasonable semantic interpretation in the domain of the raw data.

**Any other comments?**

None.

### **A.1.6 Distribution**

**Will the dataset be distributed to third parties outside of the entity (e.g., company, institution, organization) on behalf of which the dataset was created?** *If so, please provide a description.*

The dataset was not created on behalf of any entity, and it will be distributed freely.

**How will the dataset will be distributed (e.g., tarball on website, API, GitHub)?** *Does the dataset have a digital object identifier (DOI)?*

The dataset will be distributed as a ZIP archive via Zenodo, based on code hosted on GitHub. Each dataset version and each code release will have a versioned DOI, generated automatically by Zenodo. See also Table 2.

**When will the dataset be distributed?**

The dataset will be distributed when the paper introducing it is submitted.

**Will the dataset be distributed under a copyright or other intellectual property (IP) license, and/or under applicable terms of use (ToU)?** *If so, please describe this license and/or ToU, and provide a link or other access point to, or otherwise reproduce, any relevant licensing terms or ToU, as well as any fees associated with these restrictions.*

The dataset will be distributed under a CC BY-NC 4.0 license, according to which others are free to

- *share*, i.e., copy and redistribute, and
- *adapt*, i.e., remix, transform, and build on the material,

provided they

- *give attribution*, i.e., give appropriate credit, provide a link to the license, and indicate if changes were made,
- *do not* use the material for *commercial purposes*, and
- *add no restrictions* limiting others in doing anything the license permits.

The code constructing the dataset will be distributed under a permissive BSD 3-Clause license.

**Have any third parties imposed IP-based or other restrictions on the data associated with the instances?** *If so, please describe these restrictions, and provide a link or other access point to, or otherwise reproduce, any relevant licensing terms, as well as any fees associated with these restrictions.*

The Folger Shakespeare Library has released the source of our raw data, Folger Digital Texts, under the CC BY-NC 3.0 Unported license, which has essentially the same usage conditions as our CC BY-NC 4.0 license.

**Do any export controls or other regulatory restrictions apply to the dataset or to individual instances?** *If so, please describe these restrictions, and provide a link or other access point to, or otherwise reproduce, any supporting documentation.*

No export controls or other regulatory restrictions apply.

**Any other comments?**

None.

**A.1.7 Maintenance**

**Who will be supporting/hosting/maintaining the dataset?**

Corinna Coupette and Bastian Rieck will be supporting, hosting, and maintaining the dataset.

**How can the owner/curator/manager of the dataset be contacted (e.g., email address)?**

In the interest of transparency, the preferred method to contact the dataset maintainers is by opening GitHub issues at <https://github.com/hyperbard/hyperbard>. Alternatively, the dataset maintainers can be reached by email to [info@hyperbard.net](mailto:info@hyperbard.net)

**Is there an erratum?** *If so, please provide a link or other access point.*

Errata will be documented at <https://hyperbard.net> and on GitHub.

**Will the dataset be updated (e.g., to correct labeling errors, add new instances, delete instances)?** *If so, please describe how often, by whom, and how updates will be communicated to dataset consumers (e.g., mailing list, GitHub)?*

The dataset will be updated as needed, and updates will be labeled using *semantic versioning*.

- A *patch version* (e.g., 0.0.1 → 0.0.2) is a recomputation of the latest dataset version following a non-breaking change in the underlying raw data.
- A *minor version* (e.g., 0.0.1 → 0.2.0) is an update of the latest dataset version that increases the expressivity of existing representations while maintaining all of their previously present features.
- Any other update is a *major version* (e.g., 0.0.1 → 1.0.0). This includes, e.g., responses to breaking changes in the underlying source data, additions of new representations, and changes to existing representations that might break dataset consumer code.

Patch versions will be created automatically using GitHub actions. Minor versions and major versions will be created by the dataset maintainers, potentially accepting pull requests or implementing feature requests filed via at <https://github.com/hyperbard/hyperbard>.

New releases will be communicated at <https://hyperbard.net> and on GitHub, and they will be available for download under a versioned DOI on Zenodo, with 10.5281/zenodo.6627158 always resolving to the latest release.

**If the dataset relates to people, are there applicable limits on the retention of the data associated with the instances (e.g., were the individuals in question told that their data would be retained for a fixed period of time and then deleted)?** *If so, please describe these limits and explain how they will be enforced.*

There are no data retention limits.

**Will older versions of the dataset continue to be supported/hosted/maintained?** *If so, please describe how. If not, please describe how its obsolescence will be communicated to dataset consumers.*

Older versions of the dataset will remain hosted on Zenodo, with the relevant version of the code needed to reproduce them available in an associated GitHub release, also archived on Zenodo.

There will be basic support for older versions of the dataset, and as HYPERBARD is derived from century-old literary works, dataset maintenance amounts to dataset updates (see the paragraph on dataset updates).

**If others want to extend/augment/build on/contribute to the dataset, is there a mechanism for them to do so?** *If so, please provide a description. Will these contributions be validated/verified? If so, please describe how. If not, why not? Is there a process for communicating/distributing these contributions to dataset consumers? If so, please provide a description.*

Others can extend, augment, build on, and contribute to the dataset through the engagement mechanisms provided by GitHub.

See also <https://github.com/hyperbard/hyperbard/blob/main/CONTRIBUTING.md>.

Extensions, augmentations, and contributions provided via pull requests will be validated and verified by the dataset maintainers in a regular code and data review process, while changes made in independent forks will not be checked.

Contributions integrated with the HYPERBARD code repository will be visible on GitHub, and they trigger new dataset releases, in which contributors will be specifically acknowledged.

**Any other comments?**

None.

## **A.2 Hosting, License, and Maintenance Plan**

For hosting and licensing information, see Table 2 and Section A.1.6. For the maintenance plan, see Section A.1.7.

## **A.3 Author Responsibility Statement**

The dataset authors, Corinna Coupette and Bastian Rieck, bear all responsibility in case of violation of rights, etc., and they confirm that the data is released under the CC BY-NC 4.0 license, and that the code is released under the BSD 3-Clause license.

## B Usage Documentation

The HYPERBARD dataset is distributed in four folders: `rawdata`, `data`, `graphdata`, and `metadata`. See Section A.1.2 for more details on the composition of the dataset. The dataset can be reproduced by cloning the GitHub repository and running `make` (this will also generate most figures included in the HYPERBARD paper).

In addition to the written documentation, we provide Jupyter notebook tutorials for interactive data exploration. The tutorials are hosted on GitHub at <https://github.com/hyperbard/tutorials>, and they can be run both locally and in a Binder, i.e., a fully configured remote environment accessible through the browser without any local setup. Launching the Binder usually takes around thirty seconds.

In the following, we explain the structure of the files in HYPERBARD's folders and detail how these files can be read. All file examples are taken from *Romeo and Juliet*, and for CSV files, all columns are described in alphabetical order.

### B.1 rawdata

This folder contains XML files encoded in TEI Simple as provided by Folger Digital Texts. These files can be read with any XML parser, such as the parser from the `beautifulsoup4` library in Python. All file names follow the pattern `{play}_TEIsimple_FolgerShakespeare.xml`.

The XML encoding is designed to meet the needs of the (digital) humanities, and hence, it is very detailed and fine-grained. For example, every word, whitespace character, and punctuation mark is contained in its own tag.

The encoding practices followed by Folger Digital Texts are described in the `<encodingDesc>` tag of each text. To summarize:

- The major goal of the TEI Simple encoding is to achieve interoperability with a large corpus of early modern texts derived from the Early English Books Text Creation Partnership transcriptions (i.e., it is different from *our* goal).
- The encoding is completely faithful to the readings, orthography, and punctuation of the source texts (i.e., the Shakespeare texts edited by Barbara Mowat and Paul Werstine at Folger Shakespeare Library).
- All `xml:ids` are corpuswide identifiers (i.e., they are unique across all our plays, too).
- Words, spaces, and punctuation characters are numbered sequentially within each play, incremented by 10 (XML attribute: `n`).
- Most other elements begin with an element-specific prefix, followed by a reference to the Folger Through Line Number, a sequential numbering of the numbered lines in the text. (Details omitted.)
- Spoken words are linguistically annotated with a lemma and POS tag.

Running the script `compute_rawdata_xml_statistics.py` in the HYPERBARD GitHub repository, which computes basic XML tag, path, and attribute statistics for the entire corpus and writes the results to the `metadata` folder as CSV files, provides some intuition regarding the structure of the raw data. This script also pulls the descriptions of all tags from the current TEI specification. For more information on the TEI Simple format, which has been integrated with the main TEI specification, see <https://github.com/TEIC/TEI-Simple>.

Example:

```
...
<sp xml:id="sp-0015" who="#SERVANTS.CAPULET.Sampson_Rom">
<speaker xml:id="spk-0015">
<w xml:id="fs-rom-0002610">SAMPSON</w>
</speaker>
<p xml:id="p-0015">
<lb xml:id="ftln-0015" n="1.1.1"/>
<w xml:id="fs-rom-0002620" n="1.1.1" lemma="Gregory" ana="#n1-nn">Gregory</w>
```

```

<pc xml:id="fs-rom-0002630" n="1.1.1">,</pc>
<c> </c>
<w xml:id="fs-rom-0002650" n="1.1.1" lemma="on" ana="#acp-p">on</w>
<c> </c>
<w xml:id="fs-rom-0002670" n="1.1.1" lemma="my" ana="#po">my</w>
<c> </c>
<w xml:id="fs-rom-0002690" n="1.1.1" lemma="word" ana="#n1">word</w>
<c> </c>
<w xml:id="fs-rom-0002710" n="1.1.1" lemma="we|will" ana="#pns|vmb">we'll</w>
<c> </c>
<w xml:id="fs-rom-0002730" n="1.1.1" lemma="not" ana="#xx">not</w>
<c> </c>
<w xml:id="fs-rom-0002750" n="1.1.1" lemma="carry" ana="#vvi">carry</w>
<c> </c>
<w xml:id="fs-rom-0002770" n="1.1.1" lemma="coal" ana="#n2">coals</w>
<pc xml:id="fs-rom-0002780" n="1.1.1">.</pc>
</p>
</sp>
...

```

## B.2 data

This folder contains CSV files, which can be read with any CSV parser, such as the parser from the pandas library in Python.

There are three types of files:

{play}.cast.csv files, {play}.raw.csv files, and {play}.agg.csv files.

### B.2.1 {play}.cast.csv

A {play}.cast.csv file contains the XML identifiers and attributes of all <castItem> tags found in a {play}\_TEIsimple\_FolgerShakespeare.xml file. It gives an overview of the characters occurring in a play, and it can be used to count the number of characters (including characters that do not speak) or to build a hierarchy of characters and character groups.

Rows correspond to characters or character groups.

Columns in alphabetical order:

- `corresp`: group (i.e., another cast item) to which a given cast item belongs, if any (XML attribute abbreviating “corresponds”).  
Type: String or NaN (if the cast item does not belong to any other cast item).
- `xml:id`: unique identifier of the cast member.  
Type: String.

Note that the data in each of these columns does *not* start with a # sign. This contrasts with *references* to the `xml:ids` in the attributes of other XML tags in the raw data XML files, which *do* start with a # sign (to indicate the referencing).

Example:

```

xml:id,corresp
ATTENDANTS.PRINCE_Rom,ATTENDANTS_Rom
ATTENDANTS_Rom,
Apothecary_Rom,
Benvolio_Rom,
Boy_Rom,
...

```

## B.2.2 {play}.raw.csv

A {play}.raw.csv file contains the descendants of the <body> tag found in a {play}\_TEIsimple\_FolgerShakespeare.xml file, with redundancies resulting from the encoding format eliminated, and additional information to build graph representations annotated. It provides a *disaggregated* tabular overview of the information underlying our graph representations, and it serves as the basis of its corresponding {play}.agg.csv file.

Rows correspond to instances of XML tags.

Columns in alphabetical order:

- **act**: Derived attribute. The number of the act in which the tag occurs. An integer in [5] for all tags in the main part of the play. 0 for tags occurring before the first act (e.g., in a prologue or an induction), 6 for tags occurring after the fifth act (e.g., in an epilogue).  
Type: Non-negative integer.
- **ana**: Original attribute. If the tag wraps a spoken word, the POS tag of that word (XML attribute abbreviating “analysis”).  
Type: String or NaN (if the tag does not wrap a spoken word).
- **lemma**: Original attribute. If the tag wraps a spoken word, the lemma of that word.  
Type: String or NaN (if the tag does not wrap a spoken word).
- **n**: Original attribute. A label for the element, not necessarily unique.  
Type: String, positive integer (for <div> tags representing acts or scenes), or NaN (e.g., for <c> tags wrapping whitespace characters).
- **onstage**: Derived attribute. Whitespace-separated list of characters on stage when the tag occurs.  
Type: String or NaN.
- **part**: Original attribute. Rare and not of interest for graph building.  
Type: String or NaN.
- **prev**: Original attribute. Rare and not of interest for graph building.  
Type: String or NaN.
- **rendition**: Original attribute. Rare and not of interest for graph building.  
Type: String or NaN.
- **scene**: Derived attribute. The number of the scene in which the tag occurs. 0 if the tag does not occur in a scene.  
Type: Non-negative integer.
- **speaker**: Derived attribute. Whitespace-separated list of characters who are speaking when a tag occurs. Note that several characters can speak at the same time, although the overwhelming majority of speech in the corpus is uttered by only one speaker.  
Type: String or NaN.
- **stagegroup\_raw**: Derived attribute. Number stating how many changes in the set of characters on stage we have already witnessed when a tag occurs (i.e., the same set of characters can occur in different stage groups). Relevant for sorting and aggregation.  
Type: Non-negative integer.
- **tag**: Original entity. The name of the XML tag to which the row corresponds.  
Type: String.
- **text**: Original text content.  
Type: String or NaN (if a tag is not a leaf in the XML tree).
- **type**: Original attribute. Used to give details on <div> and <stage> tags, e.g., distinguish between acts and scenes, and mark stage directions as, e.g., character entry or exit.  
Type: String or NaN.
- **who**: Original attribute giving information on characters who act, transformed into a set. Will become whitespace-separated list in future releases.  
Type: Set of strings or NaN.

- `xml:id`: Original XML identifier. Note that instances of some XML tags, including `<div>` and `<c>` tags, do not have XML identifiers.  
Type: String or NaN.

Example:

```
tag,type,n,text,xml:id,who,lemma,ana,part,rendition,prev,act,scene,
  onstage,stagegroup_raw,speaker
...
sp,,,sp-0015,{'#SERVANTS.CAPULET.Sampson_Rom'},,,,,1,1,#SERVANTS.
  CAPULET.Gregory_Rom #SERVANTS.CAPULET.Sampson_Rom,3,#SERVANTS.
  CAPULET.Sampson_Rom
p,,,p-0015,,,,,1,1,#SERVANTS.CAPULET.Gregory_Rom #SERVANTS.
  CAPULET.Sampson_Rom,3,
lb,,1.1.1,,ftln-0015,,,,,1,1,#SERVANTS.CAPULET.Gregory_Rom #
  SERVANTS.CAPULET.Sampson_Rom,3,#SERVANTS.CAPULET.Sampson_Rom
w,,1.1.1, Gregory,fs-rom-0002620,,Gregory,#n1-nn,,,,1,1,#SERVANTS.
  CAPULET.Gregory_Rom #SERVANTS.CAPULET.Sampson_Rom,3,#SERVANTS.
  CAPULET.Sampson_Rom
pc,,1.1.1,"",fs-rom-0002630,,,,,1,1,#SERVANTS.CAPULET.Gregory_Rom
  #SERVANTS.CAPULET.Sampson_Rom,3,#SERVANTS.CAPULET.Sampson_Rom
c,,, ,,,,,,1,1,#SERVANTS.CAPULET.Gregory_Rom #SERVANTS.CAPULET.
  Sampson_Rom,3,
w,,1.1.1,on,fs-rom-0002650,,on,#acp-p,,,,1,1,#SERVANTS.CAPULET.
  Gregory_Rom #SERVANTS.CAPULET.Sampson_Rom,3,#SERVANTS.CAPULET.
  Sampson_Rom
c,,, ,,,,,,1,1,#SERVANTS.CAPULET.Gregory_Rom #SERVANTS.CAPULET.
  Sampson_Rom,3,
...
```

### B.2.3 {play}.agg.csv

A {play}.agg.csv file contains a condensed and filtered view of its corresponding {play}.raw.csv file, focusing only on spoken words. It provides an *aggregated* tabular overview of the information underlying our graph representations, and it serves as the basis of all files in the graphdata folder. In contrast to the {play}.raw.csv file, which contains some original attributes, {play}.agg.csv contains only derived attributes.

Rows correspond to *settings* (or *speech acts*), i.e., maximal sequences of words in which neither the speaker(s) nor the group of characters on stage change.

Columns in alphabetical order:

- `act`: The same as `act` in {play}.raw.csv.
- `n_lines`: The number of lines spoken in a setting.  
Type: Positive integer.
- `n_tokens`: The number of tokens spoken in a setting.  
Type: Positive integer.
- `onstage`: The same as `onstage` in {play}.raw.csv.
- `scene`: The same as `scene` in {play}.raw.csv.
- `setting`: Number stating how many changes in the tuple (set of characters on stage, speaker) we have seen when the words summarized in this row occur, plus 1 (for consistency with the numbering in `stagegroup`).  
Type: Positive integer.
- `speaker`: The same as `speaker` in {play}.raw.csv.
- `stagegroup`: The contents of the `stagegroup_raw` column, renumbered to be consecutive in {play}.agg.csv, starting with 1.  
Type: Positive integer.



- stagegroup\_raw: The same as stagegroup\_raw in {play}.raw.csv.

Example:

```
act,scene,stagegroup,stagegroup_raw,setting,onstage,speaker,n_lines,
n_tokens
0,0,1,1,1,#Chorus_Rom,#Chorus_Rom,14,106
1,1,2,3,2,#SERVANTS.CAPULET.Gregory_Rom #SERVANTS.CAPULET.
Sampson_Rom,#SERVANTS.CAPULET.Sampson_Rom,1,8
1,1,2,3,3,#SERVANTS.CAPULET.Gregory_Rom #SERVANTS.CAPULET.
Sampson_Rom,#SERVANTS.CAPULET.Gregory_Rom,1,7
1,1,2,3,4,#SERVANTS.CAPULET.Gregory_Rom #SERVANTS.CAPULET.
Sampson_Rom,#SERVANTS.CAPULET.Sampson_Rom,1,9
1,1,2,3,5,#SERVANTS.CAPULET.Gregory_Rom #SERVANTS.CAPULET.
Sampson_Rom,#SERVANTS.CAPULET.Gregory_Rom,2,10
```

### B.3 graphdata

This folder contains CSV files, which can be read with any CSV parser, such as the parser from the pandas library in Python.

For each play, the folder holds all files needed to generate the representations listed in Table 1, i.e.:

- Files to construct *clique expansions* (ce, i.e., character co-occurrence networks):
  - {play}\_ce-group-mw.edges.csv:
    - Weighted multi-edges for clique expansions aggregated at the stage group level.
    - Use to generate ce-group-{mb,mw} representations.
  - {play}\_ce-group-w.edges.csv:
    - Count-weighted edges for clique expansions aggregated at the stage group level.
    - Use to generate ce-group-b representations (or ce-group-w representations for easier plotting of ce-group-mb representations if the edge order does not matter).
  - {play}\_ce-scene-mw.edges.csv:
    - Weighted multi-edges for clique expansions aggregated at the scene level.
    - Use to generate ce-scene-{mb,mw} representations.
  - {play}\_ce-scene-w.edges.csv:
    - Count-weighted edges for clique expansions aggregated at the scene level.
    - Use to generate ce-scene-b representations (or ce-scene-w representations for easier plotting of ce-scene-mb representations if the edge order does not matter).
  - {play}\_ce.nodes.csv:
    - Nodes for all clique expansions.
    - Use to generate all ce-\* representations.
- Files to construct *star expansions* (se, i.e., bipartite graphs with characters and text units as node sets):
  - {play}\_se-group-w.edges.csv:
    - Edges for star expansions aggregated at the stage group level.
    - Use to generate se-group-{b,w} representations.
  - {play}\_se-group.nodes.csv:
    - Nodes for star expansions aggregated at the stage group level.
    - Use to generate se-group-{b,w} representations.
  - {play}\_se-scene-w.edges.csv:
    - Edges for star expansions aggregated at the scene level.
    - Use to generate se-scene-{b,w} representations.
  - {play}\_se-scene.nodes.csv:
    - Nodes for star expansions aggregated at the scene level. The character nodes are the same as for {play}\_se-group.nodes.csv, but the text unit nodes differ.
    - Use to generate se-scene-{b,w} representations.
  - {play}\_se-speech-mwd.edges.csv:
    - Directed multi-edges for star expansions aggregated at the speech act level. Multi-edges

can occur because there exists one edge per speech act, but text unit nodes are resolved at the stage group level, and one stage group can contain several speech acts.

Use to generate the `se-speech-mwd` representation.

- `{play}_se-speech-wd.edges.csv`:  
Directed edges for star expansions aggregated at the speech act level, with multi-edges aggregated into edge weights.  
Use to generate the `se-speech-wd` representation.
- `{play}_se-speech.nodes.csv`:  
Nodes for star expansions aggregated at the speech act level. The same as `{play}_se-group.nodes.csv`; provided separately to facilitate the matching between node and edge files.  
Use to generate `se-speech-{wd,mwd}` representations.
- Files to construct *hypergraphs* (hg, i.e., generalized graph representations allowing edges with cardinalities in  $\mathbb{N}$ ):
  - `{play}_hg-group-mw.edges.csv`:  
Edges for hypergraph representations resolved at the stage group level.  
Use to generate `hg-group-{mb,mw}` representations.
  - `{play}_hg-group-mw.node-weights.csv`:  
Edge-specific node weights for hypergraph representations resolved at the stage group level.  
Use to generate `hg-group-{mb,mw}` representations with edge-specific node weights.
  - `{play}_hg-scene-mw.edges.csv`:  
Edges for hypergraph representations resolved at the scene level.  
Use to generate `hg-scene-{mb,mw}` representations.
  - `{play}_hg-scene-mw.node-weights.csv`:  
Edge-specific node weights for hypergraph representations resolved at the scene level.  
Use to generate `hg-scene-{mb,mw}` representations with edge-specific node weights.
  - `{play}_hg-speech-mwd.edges.csv`:  
Directed, weighted multi-edges for hypergraph representations resolved at the speech act level, where both the source and the target can contain multiple nodes.  
Use to generate the `hg-speech-mwd` representation.
  - `{play}_hg-speech-wd.edges.csv`:  
Directed, weighted edges for hypergraph representations resolved at the speech act level, where both the source and the target can contain multiple nodes, with multi-edges aggregated into edge weights  
Use to generate the `hg-speech-wd` representation.
  - `{play}_hg.nodes.csv`:  
Nodes for all hypergraph representations. Technically redundant because hyperedges can have cardinality 1, too, such that all nodes can be derived from the edge lists. Provided with global node weights for convenience.  
Use to generate all `hg-*` representations.

The rows in each file represent either nodes or edges.

The columns in the individual files differ depending on the *semantic mapping*, the *granularity*, and the *expressivity* of the file contents, all of which are expressed in the file name (cf. Table 1), but the column semantics should be intuitive in light of the details on the `{play}.agg.csv` file columns given above. Note the following conventions for column names in edge lists:

- For clique and star expansions, if the graph is undirected, the nodes are called `node1` and `node2`, and if the graph is directed, the nodes are called `source` and `target`.
- If edges are count-weighted, the weight column is called `count`, otherwise, the columns `n_tokens` and `n_lines` can both serve as edge weights.
- For multi-edges in clique and star expansions, the column `edge_index` ensures that there are no duplicate rows. In hypergraphs, this is ensured by the `setting` column.

Finally, when working with the edge lists, please refer to the *expressivity* column in Table 1 to check whether the edge ordering in any particular file is intrinsically meaningful.

Examples:

- Nodes for clique expansions:

```
node
#ATTENDANTS.PRINCE_Rom
#ATTENDANTS_Rom
#Apothecary_Rom
#Benvolio_Rom
#Boy_Rom
...
```

- Edges for clique expansions (here: ce-group-mw):

```
node1,node2,key,act,scene,stagegroup,n_tokens,n_lines,edge_index
#SERVANTS.CAPULET.Gregory_Rom,#SERVANTS.CAPULET.Sampson_Rom,0,1,1,2,254,33,2
#SERVANTS.CAPULET.Gregory_Rom,#SERVANTS.CAPULET.Sampson_Rom,1,1,1,3,149,25,3
#SERVANTS.CAPULET.Gregory_Rom,#SERVANTS.MONTAGUE.1_Rom,0,1,1,3,149,25,3
#SERVANTS.CAPULET.Gregory_Rom,#SERVANTS.MONTAGUE.Abram_Rom,0,1,1,3,149,25,3
#SERVANTS.CAPULET.Sampson_Rom,#SERVANTS.MONTAGUE.1_Rom,0,1,1,3,149,25,3
...
```

- Nodes for star expansions (here: se-group):

```
node,node_type
#ATTENDANTS.PRINCE_Rom,character
#ATTENDANTS_Rom,character
#Apothecary_Rom,character
...
0.00.0001,text_unit
1.01.0002,text_unit
1.01.0003,text_unit
...
```

- Edges for star expansions (here: se-speech-mwd):

```
source,target,key,n_lines,n_tokens,edge_index,edge_type
#Chorus_Rom,0.00.0001,0,14,106,1,active
#SERVANTS.CAPULET.Sampson_Rom,1.01.0002,0,1,8,2,active
1.01.0002,#SERVANTS.CAPULET.Gregory_Rom,0,1,8,2,passive
#SERVANTS.CAPULET.Gregory_Rom,1.01.0002,0,1,7,3,active
1.01.0002,#SERVANTS.CAPULET.Sampson_Rom,0,1,7,3,passive
...
```

- Nodes for hypergraphs:

```
node,n_tokens_onstage,n_tokens_speaker,n_lines_onstage,n_lines_speaker
#ATTENDANTS.PRINCE_Rom,1147,0,150,0
#ATTENDANTS_Rom,905,0,121,0
#Apothecary_Rom,224,53,29,7
#Benvolio_Rom,5671,1160,771,161
#Boy_Rom,905,0,121,0
...
```

- Edge-specific node weights for hypergraphs (here: hg-scene-mw):

```
act,scene,node,n_tokens_speaker,n_lines_speaker,n_tokens_onstage,n_lines_onstage
0,0,#Chorus_Rom,106,14,106,14
1,1,#Benvolio_Rom,376,52,1403,189
1,1,#CITIZENS_Rom,16,2,237,32
1,1,#Capulet_Rom,26,3,221,30
1,1,#LadyCapulet_Rom,10,2,221,30
...
```

- Edges for hypergraphs (here: hg-speech-mwd):

```
act,scene,stagegroup,setting,speaker,onstage,n_tokens,n_lines
0,0,1,1,#Chorus_Rom,#Chorus_Rom,106,14
1,1,2,2,#SERVANTS.CAPULET.Sampson_Rom,#SERVANTS.CAPULET.Gregory_Rom
#SERVANTS.CAPULET.Sampson_Rom,8,1
1,1,2,3,#SERVANTS.CAPULET.Gregory_Rom,#SERVANTS.CAPULET.Gregory_Rom
#SERVANTS.CAPULET.Sampson_Rom,7,1
1,1,2,4,#SERVANTS.CAPULET.Sampson_Rom,#SERVANTS.CAPULET.Gregory_Rom
#SERVANTS.CAPULET.Sampson_Rom,9,1
...
```

#### **B.4** metadata

This folder currently contains exactly one CSV file, which maps play identifiers to play types. The file can be read with any CSV parser, such as the parser from the pandas library in Python, but since its provenance is documented as a comment at the start of the file, the # character needs to be passed to the parser as a comment character.

Rows correspond to plays.

Columns in alphabetical order:

- `play_name`: The name of the play, as used to fill the {play} placeholder in all play-specific file names.  
Type: String.
- `play_type`: The type of the play. One of {comedy, history, tragedy}.  
Type: String.

## C Play Documentation

### C.1 Inspirations

The play deliberately adopts and adapts ideas and text fragments from Shakespeare’s works and other popular texts. These are:

- Dramatis Personæ: Three deadlines ~ three witches from Shakespeare’s *Macbeth*
- Induction: Framing device used in Shakespeare’s *The Taming of the Shrew*
- Act I, Scene II, l. 32: A phrase famously *attributed* to Martin Luther
- Act II, Scene I, l. 127: Allusion to a series of sketches from Monty Python’s Flying Circus
- Act II, Scene III, ll. 159–179: Jon’s speech from Shakespeare’s *As You Like It*
- Act II, Scene IV, ll. 184–191: Faust’s speech from Goethe’s *Faust I*
- Act III, Scene I, ll. 303–316: Ariel’s Song from Shakespeare’s *The Tempest*
- Act III, Scene I, ll. 319–332: Hamlet’s monologue from Shakespeare’s *Hamlet*
- Act IV, Scene III, l. 370: Juliet addressing Romeo in Shakespeare’s *Romeo and Juliet*
- Act IV, Scene III, ll. 401–402: Pieces from Jon’s interactions in Shakespeare’s *As You Like It*
- Act V, Scene I, ll. 416–429: Shakespeare’s *Full Many a Glorious Morning Have I Seen* (Sonnet 33)
- Act V, Scene II, ll. 424–432: Macbeth’s monologue from Shakespeare’s *Macbeth*

### C.2 Style

Our layout follows the Oxford Shakespeare from 1916 [16] (whose text sometimes differs from the Folger Shakespeare underlying our data [13], especially in the stage directions). We adopt the basic language patterns characteristic of Shakespeare’s plays, using primarily blank verse, i.e., non-rhyming verse in iambic pentameter with feminine endings allowed, but also prose and rhyming verse. Our main character switches between blank verse and prose depending on their internal state. Longer passages of rhyming verse occur in song and sonnet adaptations (see Section C.1); shorter passages of rhyming verse are scattered throughout the play. We generally use Modern American English, sprinkled with brief interludes of Old British English.