[Essay submitted to *JITP* on December 1, 2017 for peer review]

Playing with Poetry: Better Reading through Geometry[1]

All figures/images available at Dropbox:
https://www.dropbox.com/sh/78hveuz49khycg5/AACPUHFKFEGTSZ9n4lq5Z6mja?dl=0

The Event

Ten puzzles, forty kids, three rounds—one winning team. It was an event that asked students from the University of Virginia English department's Brit Lit survey to forego their evening social plans to come together and immerse themselves in Shakespeare's artistry, recomposing his sonnets through puzzling play. The puzzles, cut from sheets of acrylic, inspired competition and collaboration. Four-student teams, huddled around tables, were tasked with assembling into the correct sequence fragments of Shakespeare lines etched onto the surfaces of acrylic pieces. Players excitedly glanced over at adjacent tables to compare their progress with that of other contestants, all scrambling to fit the irregularly squared-off pieces into rectangles. In the first round, ten digital timers counted the clock, telling the competitors who would advance to the next round.

The atmosphere of competition focused the attention of the students. Having attuned themselves to meter and the rules of rhyme, they pieced together the complicated Elizabethan verse. Teams that understood the structures that compose a sonnet—sestet, quatrain, iambic pentameter—proved more successful at the games. Hectic and noisy, our contestants argued about the placement of pieces. Multiple hands shuffled the elements of the poem, fitting bits of language together, trying phrases out. Guided by the syntax, they tested piece against piece, composing sense from smaller units. Working collectively, they discovered false solutions, which packed the grid of the sonnet form with grammatically correct, Shakespearean phrases that were never written by Shakespeare. They back-tracked, repositioned the shapes, and arrived finally at

[1] We want to thank Jordan Burke, Jordan Buysse, Andie Waterman, and Worthy Martin for contributing to a discussion of form and formalism that helped shape this essay. Abigail Johnson lent us her photography expertise the night of the Sonnet Games competition. Melissa Goldman has patiently trained many of our puzzle makers. We thank also Elizabeth Fowler for her support of the tournament and the encouragement she gave her students to participate. Finally we must thank U.Va.'s IHGC for providing meeting spaces and financial support and also the Page Barbour and Richards Committee, which has generously funded us to buy materials.

the correct poem, stopping the timer when they were sure that they had reconstructed Shakespeare's word order.

In between the rounds, we listened as teams debriefed and formed new strategies for dividing labor among group members. Performances improved markedly with the second and third puzzles. Solving the puzzles forced our students to think through the themes that make a poem cohesive. After testing out likely phrases, the teams had to return to the beginning of the poem and read it line by line. By the time a team solved their poem puzzle, they had read and reread the language ten or twenty times over in all directions, both vertically and horizontally, alternating between slow, deliberate considerations of small syntactical units and faster, instinctive impressions of the poem as a whole. In short, the puzzles encouraged a kind of multidirectional, multi-tempo reading that helped students understand Shakespeare's sonnets in a way they never had before.

[Figure 1. Movie of competitors at https://drive.google.com/drive/folders/0B3N3jFwzH7adcGdwVkZCLWJ1RWM]

In the months before this November evening, a newly funded interdisciplinary group of MFAs, faculty, graduate and undergraduate students had met to plan the competition and design the puzzles. While students of the Brit Lit survey honed their prosodic chops in preparation for the tournament, the puzzle makers (the authors of this essay among their number) were busy closely reading Shakespeare's sonnets, studying geometry and structuralist theory, and learning to work a laser cutter.[2] In effect, while one set of students were brought into the games, another was invited behind the scenes to create the puzzles.

In what follows we introduce the reader to our pedagogical thinking and offer a guide to the fabrication of the puzzles. After first relating some testimonial responses to the event, we then review the formalist and mathematical contexts in which we are working, and finally detail the know-how required for fabrication. We offer a template for others to cut the same puzzles and stage a tournament in their own departments, and we promote our puzzles as a transmedial engagement with poetry that excites students and brings them into collaborative endeavor. We show how our puzzles can complement a survey course with an

[2] The group, named Puzzle Poesis, was formed to answer the following questions:
1. What poetics is encouraged by collage, remediation, rearrangement, and computation?
2. What are the constraints and affordances of puzzle poetry?
3. What is the relation of mechanism and algorithm to creativity?
4. What current technologies employ constraint as a design principle?

extra-curricular space of play in which students engage haptically with the formal structures introduced in their lectures on lyric poetry.

Elizabeth Fowler, who teaches the main course to which the games were annexed, reports: “The Sonnet Games, with their poetry puzzles, were a surprisingly productive challenge to our students (and me) in our required survey, History of Literatures in English: Beowulf to Jefferson. They created an instant annual tradition; the students are still talking about winning big next year.” She confirms that "a very large number came out for the voluntary competition despite its evening hours," and further affirms that "there wasn’t another situation over the course of the semester that engaged them so intensely. During the competition, the room was galvanized—the challenge of putting phrases together into the scheme of the sonnet, figuring out how many different ways words could work together, brought the poems to them in a new way—they saw them from the inside. The puzzles give us a sense of the poems as alive, as always in the process of being created. Puzzlers participate in their creation. It’s an utterly new and revealing way of engaging with Shakespeare and the other sonneteers."[3]

Undergraduate competitors likewise commented on the way in which the puzzles brought out unnoticed formal features of the sonnet for them. One saw how, “When putting a sonnet together like a puzzle, you realize that there is not only art in what is being said, but also in how the poem is structured."[4] Another student remarked, “The physical dismantling of the sonnets provided me with the opportunity to pay closer attention to each word's role within the poem. Smaller features that might've been lost within the complexity of a more lengthy composition came to light in a fascinating way and exciting way during the game!”[5] A third reported on how the interlocking pieces required her to think about scansion and rhyme: “it really made me consider the way iambic pentameter and rhyme scheme together with meaning join to form the sonnet as a cohesive unit.”[6]

Geometric Formalism

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[3] Elizabeth Fowler, personal communication (November 18, 2017).

[4] Caky Winsett, personal communication (November 8, 2017)

[5] Claudia Murator, personal communication (November 10, 2017)

[6] Katherine Viti, personal communication (November 9, 2017)

The spirit of our project is in many ways related to approaches I.A. Richards pioneered in his lectures in 1925 at Cambridge, and then again at Harvard from 1944-63. Richards' famous "protocols" introduced defamiliarizing and fragmenting pedagogical techniques into the classroom. The longer story involves the spread of twentieth-century active-learning teaching strategies that first “flipped the classroom” and is directly related to the development (and controversies) concerning close reading. While this history is much retold, in short, in the post-war moment, the New Critics converted Richards' explorations into the pedagogical program we have come to call close reading.[7] Richards democratized the reading experience, stripping poems of titles and author names before presenting them to his students. In so doing he forced a direct engagement with the language itself, much as we encourage our students to bring their intelligence to bear on the poem fragments.

In an article by Chanita Goodblatt and Joseph Glickson on I. A. Richards’ pedagogy, the authors discover archival evidence of Richards cutting Samuel Daniel's *Musophilus* and Rudyard Kipling's "Cities and Thrones and Powers" into strips for his students to reassemble, line by line.[8] In contrast, our poems are cut into pentomino shapes: a pentomino is a polygon in the plane made of equal squares, connected edge to edge. There are twelve pentomino shapes, often designated by the letter they resemble (F, I, L, W, X, P, etc.). The full set of free pentominos appears below:

[Figure 2. The Twelve Pentominos.]

Named by Solomon Golomb, the geometry has been explored by mathematicians and popularized by puzzle enthusiasts since Golomb's lecture at the Harvard mathematics club in 1953. Several factors specific to poetry motivated our choice of the pentomino form: the five-syllable unit is a building block of the sonnet structure, which gathers five stressed beats per line (hemistich). The pentomino shape introduces a new geometry that breaks the hemistich**.** The versatility of the pentomino, which extends up and down in two or three contiguous squares, allows us to gather neighboring words from multiple lines on a single piece. In clustering thematically associated words onto a

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[7] Gerald Graff's *Professing Literature: An Institutional History* (U of C Press, 1989) is a standard, much cited account. Joseph North's *Literary Criticism: A Concise Political History* (Harvard University Press, 2017) newly valorizes Richards' efforts as available to a progressive, leftist pedagogy.

[8] Chanita Goodblatt and Joseph Glickson, "Conversations with I.A. Richards: The Renaissance in Cognitive LIterary Studies," *Poetics Today* 31:3 (Fall 2010): 387-432. See especially the image of Richards's teaching materials included at p. 392.

pentomino piece, we throw the interlinear cohesion of the poem into relief. The pieces defamiliarize the sonnet and bring out thematically connected units of diction so that the puzzle solver is teased by these blocks of language but must resist reading the piece in isolation if she is to reproduce the original sequence of words and reconstruct the poem line by line.

[Figure 3: "A mightier tyrant”]

The puzzles allow the solver to enter into a structuralist poetic mode in which selection and combination are both manifest. The student is both reading and composing. In every moment that two pieces are joined, there's a spark of apprehension. A puzzle solver will glimpse a line or half line of verse that might have been written, but wasn't. Creatively juxtaposed pieces escape the original Shakespearean word sequence and invent new verses (in the vignette below we see "the lines unset”).

[Figure 4: “The lines unset”]

On each piece, the diction and its selected terms become visible as cohesive units. The individual pieces relay the poet's vocabulary, which was drawn from a historically conditioned set of possibilities. An unassembled puzzle reproduces the scene of selection and combination but reduces it to the given language of a specific poem thus focusing the attention of the puzzle solver. Provided with a vocabulary, the solver must reconstruct the sonnet from which the words have been drawn by thinking through a limited, although large, number of combinations. Assembling potential lines and reading across each, the solver searches for the original logic of contiguity—that is, the line that Shakespeare authored. We are interested in the gestalt shifts the puzzle facilitates, the way a puzzle solver wrestles with both aspects of composition.[9] The pentomino puzzle form privileges neither the metaphoric or metonymic axes of composition. Each time the pieces move, the puzzle solver grapples with both dimensions simultaneously—alternately reading and making (*poiesis*) poems, but in a way that’s limited and analytically useful.

In preparing our puzzles, we abstract from the sonnet form to a 10x14 grid of syllable squares, a coordinate field of positions. Viewing the sonnet in this way is

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[9] The original, historical scene of composition is one in which a poet draws his poems (an instance of *parôle*, in the terms of structuralism) from the system of language (*langue*). See Roman Jakobson, "Linguistics and Poetics," *Language in Literature*, eds. Krystyna Pomorska and Stephen Rudy (Harvard UP): 62-94, 85.

not entirely divorced from traditional formalist accounts; and in several of our puzzle designs, we have attempted to divide the octave (the first eight lines of a sonnet) from the sestet (the last six lines of a sonnet).[10] These two rectangles can then be packed separately with pentominos. A 6x10 sestet—a section of the poem traditionally associated with the "answer" given to a "question" posed in the octave—can be neatly packed with the twelve unique, free pentominos. In fact, there are (only!) 2,339 ways to pack the twelve unique pentominos into a sestet.

We are exploring the geometry of the sonnet in an experimental, interdisciplinary, collaborative spirit—our bent may even be described as somewhat perverse—if not hyper-formalist then sub-formalist. We aim at a layer beneath prosody, at what I. A. Richards often describes as mere sound, as distinguished from rhythm, a "skeleton" on which a reader "casts flesh and clothing" of sense and feeling.[11] While Richards in his protocol exercises is interested in his students' ability to describe the interdependence of sound, rhythm and meaning, he also goes some way in his discussion of "Poetic Form" in *Practical Criticism* towards showing how the sound aspect of a poem can be isolated. In one thought experiment he rewrites a stanza of John Milton's *On the Morning of Christ's Nativity* in nonsense syllables (See below: "Yintomen I adaits afurf I gallas Ball" = "Will open wide the Gates of her high Palace Hall.")

J. Drootan-Sussting Benn
Mill-down Leduren N.
    Telambra-tras oderwainto weiring
Awersey zet bidreen
Ownd istellester sween
    Lithabian tweet ablissood odswown stiering
    Apleven asweten sestinal
    Yintomen I adaits afurf I gallas Ball.

Yea Truth, and Justice then
Will down return to men,
Th' enameld Arras of the Rainbow wearing,
And Mercy set between,
Thron'd in Celestiall sheen,

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[10] See Paul Fussell's discussion of the "Structural Principles" of the sonnet form in *Poetic Meter and Poetic Form*, rev. ed. (McGraw-Hill, 1979), 109-126.

[11] I.A. Richards, *Practical Criticism: A Study of Literary Judgment* (Harcourt and Brace, 1929), 218.

With radiant feet the tissued clouds down stearing,
And Heav'n as at som festivall,
Will open wide the Gates of her high Palace Hall.

What Richards calls the "skeleton" or "purified dummy" corresponds to the syllabification that we attend to in our puzzle cutting, but we go even farther than Richards, stripping away phonemes in order to count barest syllables. Both Richards's purified dummy and our syllable grids offer ways of identifying an underlying structure upon which the reader imposes her reading. But we hope to dwell at the level of the bare shape, which is where the piece-ification—the drawing of pentomino boundaries around words—takes place. When we do look beyond the syllable counts, the dummy structure encourages us to discover poems that share a common sound shape of the sort Richards tried to isolate in the nonsense lines shown above.

Below is represented the first sonnet of Shakespeare's *Sonnets* (1609), where a free circle corresponds to a monosyllabic word and connected circles correspond to multisyllabic words:

o o–o o–o o o–o o–o
o o–o o–o o o o–o o
o o o o–o o o o o–o
o o–o o o o o o–o–o
o o o–o–o o o o o o
o o o o o o o–o–o o
o–o o o–o o o–o–o o
o–o o o o o o o o o
o o o o o o o o–o–o
o o–o o–o o o o–o o
o–o o o o o–o o o–o
o o–o o o o o o–o–o
o–o o o o o o o–o o
o o o o o o o o o o

The main difference between our approach and Richards' is that our skeleton doesn't require an interpreting reader in the same way that his does, where an imagined vocal or subvocal performance must activate the rhythm of the poem. Our syllable grids, by contrast, present a kind degree zero of poetic composition.

As we pared away poetic language from our sonnets, we developed a jargon—some vocabulary to clarify our concepts. For example, we distinguish between *false solutions* and *multiple solutions*. In the former case, it's all about how Shakespeare's words go together, where the goal is to get the words in the correct order. We've found that when handing a pile of pieces to a student they often put them together in a rectangular shape, in some cases constructing lines of verse that are plausibly Shakespearean but don't belong to the original poem. We call these "false solutions." In the latter case, it's about geometry: we know that there are sonnets that might be divided up differently, that contain other pentomino designs. For instance, two different pentomino designs, either generated by a reader or an algorithm, might piece-ify the same Shakespeare sonnet, with the edges of the pentomino pieces following *different* word boundaries, resulting in different puzzles.

In Solomon W. Golomb's seminal study of *Polyominoes*, he makes a distinction between data and pattern that we find illuminating: "There is a lesson in plausible reasoning to be learned from the pentominoes. Given certain basic data, one labors long and hard to fit them into a pattern. Having succeeded, one then believes the pattern to be the *only* one that 'fits the facts,' indeed, that the data are merely manifestations of the beautiful, comprehensive whole constructed from them."[12] (10). For a player solving a puzzle this means that two or more likely pieces may seem to lock in a solution. We have watched many players convince themselves that they have uncovered a syntactical pattern when they have, in fact, imposed it upon the pieces. However, if it's not solutions that are desired but new arrangements of the constituent pieces, then the "pentominoes illustrate that many different patterns may be constructed from the same data, all equally valid, and that the nature of the final pattern is determined more by the desired shape than by the information at hand" (Ibid.) Of course, Golomb, a mathematician, is thinking of pure shapes free of syntactical and grammatical constraints, but his fundamental principle holds that many different patterns can be constructed from the same given set of pieces. Once a player is told that she has arrived at a false solution, she must accept the idea that prosody and a set vocabulary support multiple arrangements.

It is from out of this matrix of false and multiple solutions that we imagine generative potential. This is the motivating impulse of our next major project. The group is currently hard at work converting a sequence of Shakespeare's sonnets

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[12] Solomon W. Golomb, *Polyominoes: Puzzles, Patterns, Problems, and Packings*, rev. and expanded 2nd ed. (Princeton University Press, 1996), 10.

into pentomino puzzles. These will be laser cut from wood, acrylic, and other materials, and then assembled as an art object titled *Increase*. The project focuses on the first seventeen of Shakespeare's *Sonnets*, the so-called "procreation" sonnets, which thematize creativity and multiplication. The player will have the opportunity to remix the sonnets by pulling pieces from multiple puzzles. We plan to assemble seventeen puzzle kits and distribute them nationally, mailing them to favored Shakespeare scholars, critics of concrete poetry, and art galleries. A large-scale undertaking, many hands will be involved in designing the puzzles in Adobe Illustrator, cutting them in campus fabrication labs, and packaging the manufactured sonnets and their solutions for distribution. The story of the puzzles and their scattering will be documented on our website, with student contributions recorded in GitHub, and written up collaboratively as an article for a digital humanities journal.

Supercomputers and Laser Cutters

To exploit fully the intersection of *The Sonnets*' prosody and pentomino geometry, we contacted Katherine Holcomb, director of Advanced Research Computing Services (ARCS) at the University of Virginia, who consulted with us on adapting existing pentomino-solving code to our unusual investigation.[13] We brought her a specific problem: is it possible, using an algorithm, to discover all the ways to pack pentomino shapes into our sonnet grids—to uncover Golomb's "many different patterns [that] may be constructed from the same data"? After conferring with Holcomb, we are cleared to solve for multiple solutions on Rivanna, UVa's supercomputing cluster, and we have tasked an undergraduate (Jeremy Little), currently in an upper-level CS course on algorithms, to write bespoke code for his final project (as before, each of the solutions to a sonnet must respect the given word boundaries).[14] In short, by solving the abstract rectangular 10 x 14 shape by means of a walk-back algorithm, we hope to generate a bank of pentomino designs that we can later match to existing sonnets. These designs will comprehend all the piece-ifications available for imposition upon each sonnet. Soon we will be able to enumerate the number of solutions realized by Shakespeare's sonnets, and calculate the ratio between composed sonnets and the remaining unused schemes.

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[13] We are archiving code at github.com: https://github.com/bpasanek/puzzlepoesis

[14] Little is also currently at work on an in-browser web applet, written largely in Javascript, that will allow players to experiment with different pentomino grid schemes.

Because we are visualizing (mere) patterns of syllabification before working back to questions of syntax, we are busy uncovering facts about sonnets, that we like to say, no one has cared to know about. Here is one exemplary fact: we have learned that sonnets 6, 12, and 15 all have sestets into which all twelve free pentomino shapes can be packed. Focusing on related formalist questions, we hope, will yield new esoteric facts about shape and pattern. As a group, we have half-seriously described our activities as an investigation into "pure poetry," but these investigations may well enable finer work in literary history. By mapping patterns of syllabification, a critic could sort and group poems by their syllable grids, and therefore be in a position to extrapolate from these schematics to an individual poet's preferred methods of composition, or even to the general tendencies that characterize a historical period.

Meanwhile a team of undergraduate CS/English double majors has been building a website to show off our efforts and we have, as a group, been brainstorming puzzle projects. These include the work of U.Va. M.F.A. students (for example, Mary Szybist's abecedarian poem, "Girls Overheard Assembling a Puzzle"), a puzzle based on James Merrill's "Lost in Translation" (an idea forwarded by Julianne McCobin), and another on an Old English poem (Lauren Johnson's idea). Other students are taking design and fabrication in new directions. One of our graduate students (Madeline Zehnder) has imagined capturing the poet's process of revision by exploiting layered puzzles, which stack newer pieces (the revisions) on top of other ones (the base text), or use a combination of opaque and clear pieces to model the revision process. Puzzles could be further gamified in a digital interface. Many of these proposed puzzles are distinct from what we've worked up so far—many are longer, imagine new constraints, and will require more collaborative solving strategies.

In closing we describe our process of puzzle design and provide a template. Our earliest puzzles were worked out on engineering graph paper. First we drew a 10 x 14 rectangle. We then copied out the poem in pencil, assigning each syllable to a square. Having distributed the syllables across the grid, we would experiment with outlining pentomino shapes that respected word boundaries—tracing the edges of pieces. In an early meeting three students independently came up with three different patterns for a single sonnet, demonstrating the potential for multiple solutions. Many erasures later, we have built up, by hand, a workable set of pentomino designs in advance of the computationally generated solutions we look forward to producing.

[Figures 5 and 6. Designing in Illustrator]

Moving from paper to pixels, the same routine was repeated in Adobe Illustrator. We found students were quick to pick up the basics of this vector graphics editor, and we were happy to see them equipped with some knowledge of this popular graphic design program. Our syllable grids were created by using Illustrator's snap-to-grid feature, which accelerated the tracing process. The words were then typed out as text objects that could be easily manipulated and centered in each gridded square. Before sending these Illustrator files to the laser cutters, they had to be properly formatted. One layer was devoted to the language of the poem. Decisions had to be made about typeface, kerning, ascenders and descenders to make the verses as legible as possible. A separate layer was used to outline the pentomino shapes, setting the stroke width to .01 to ensure a proper cut.

Operating the laser cutters in the U.Va. Architecture School's Fab Lab required further training for our student volunteers, who met with Melissa Goldman, Fabrication Facilities Manager of the A-School maker spaces, for a two-hour training session. Our students were then given unlimited access to the Fab Lab's impressive resources. Since then our group has spent many hours in the Fab Lab, elbow to elbow with Architecture students, trading tips and tricks.

We've been making most of our puzzles from sheets of colored acrylic, which are placed inside the laser cutters, positioned on the cutting bed underneath a transparent hood. Our puzzles require two passes of the laser, corresponding to the two layers in the original Illustrator file. The text layer is rasterized and then etched on the surface of the material. After the language of the poem has been "printed" in this way, the sheet is cut into puzzles with the settings of the laser adjusted appropriately. We prefer the large X660 model (when it's available). With its 18 x 32 inch laser bed, we were able to cut 11 puzzles (3 full sonnets and 8 sestets) efficiently on one sheet. Working with 1/8"- or 3/16”-inch thick acrylic, we used a power setting of 95% on the 50-watt cutter with a speed of 4%, at 500 ppi (pulses per inch). This was good for cutting in one or two passes, although we are still figuring out best practices and settings to avoid scorched or melted acrylic.

Other instructors interested in starting a Puzzle Poetry group or hosting their own Sonnet Games are encouraged to contact the authors, who are happy to help with planning and organization. We have attached an Illustrator file for the sestet to Shakespeare's Sonnet 12 to use as a puzzle template.