

# The Readers Project: Procedural Agents and Literary Vectors

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## ABSTRACT

*The Readers Project* is an aesthetically oriented system of software entities designed to explore the culture of human reading. These entities, or “readers,” navigate texts according to specific reading strategies based upon linguistic feature analysis and real-time probability models harvested from search engines. As such, they function as autonomous text generators, writing machines that become visible within and beyond the typographic dimension of the texts on which they operate. Thus far the authors have deployed the system in a number of interactive art installations at which audience members can view the aggregate behavior of the readers on a large screen display and also subscribe, via mobile device, to individual reader outputs. As the structures on which these readers operate are culturally and aesthetically implicated, they shed critical light on a range of institutional practices – particularly those of reading and writing – and explore what it means to engage with the literary in digital media.

## Introduction

*The Readers Project* was begun in 2009 in response to the question, “How might cellular automata play out a ‘game of life’ – or rather a ‘game of reading’ – on the (complex) surface of a text?” [1] In the best-known form of the game of life [2], the grid on which the cellular automata live and die maps out generations of binary distinctions. (Figure 1) This grid and the automata’s behaviors are one and the same. By contrast, a textual grid is inherently complex, bearing all the structure of natural language, despite remaining – as graphic representation – unambiguously two-dimensional and, indeed, both grid-like and cellular [3]. While certain 2D characteristics of visible language may have inspired us to ask our question about reading and cellular automata (CAs), we do not claim any regular or formal relationship between CAs and our expressive natural language processing [4]. In fact, while cellular automata have proven a productive formalism in a range of art contexts [5], there has been surprisingly little experimentation with CAs in the domain of literary art. *The Readers Project* thus represents an initial foray into this interesting and problematic space.

## The Framework

Because of the layered and discrete structures of natural language, it is possible to implement cell-based procedural readers at any number of levels. A “cell” might correspond to a letter, a word, a phrase, a sentence, and so on, each an atomic unit of a particular structural layer [6]. We chose the typographic word as our cellular unit. We define the current word – or word being read – as a “live” cell [7]. If a traditional Western linear reading is expressed in terms of cellular rules, then we might say that a live word-cell will, in each generation, bring to life the cell directly to its *right* while, itself, dying. A *simple reader*, defined in this way, could be arbitrarily placed on a textual grid and, generation by generation, would seem to move from left to right through the text. But what happens when such a reader reaches the rightmost word in a line of type on the grid?



We may seem to be over-articulating the most simple of operations, but even here we discover an interesting and problematic encounter between natural language and the formalized vectors of reading [8]. The rules of our simplest automata are determined by a left-to-right culture of reading. However, the definition of “to the right” must be further formalized such that when a live cell is at the end of a line, the cell to its right will be the first word of the next line of text – far to its graphical, if not its “literal” left. In prose, the notion of “end of a line” is determined by *typography*, not by grammar or any other aspect of linguistic structure. In poetry, the composition of the line and thus the choice of a final word is generally deliberate, representing a correspondence between some aspect of poetics (minimally: lineation) and typography. On an arbitrary prose grid however, even our simple automaton must be taught to behave in a manner that implies no less than a poetics of prose reading, a poetics that allows it (and ourselves) to move from line to line without breaking the process of reading itself [9].

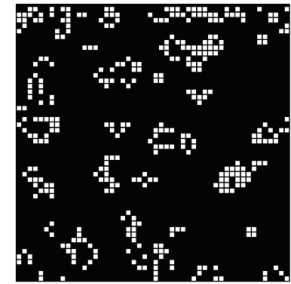


Figure 1. Created by Daniel C. Howe using Conway's Game of Life. © 2010 Daniel C. Howe.

### The Typographic Dimension

As the project has progressed, considerations such as these have suggested a distinction between those aspects of typography that are properly the concern of graphic design and what we will characterize as the *typographic dimension*. The latter might be thought of as the typographically embodied space – necessarily shaped and structured – within which reading occurs. Another way to recognize this proposed distinction might be to consider typography in the graphic design sense as guaranteeing the visual legibility (or visual aestheticization) of linguistic elements, whereas the typographic dimension constitutes the space for reading formed from the gathering together of all those typographic elements required by a particular piece of written language. Design in the service of legibility drives typography as is it usually addressed in graphic design, whereas language-as-writing gives rise to a dimension of reading that is necessarily typographic [10].

These considerations impressed themselves upon us as we implemented a formal definition of *typographic neighborhood*. In order for procedural readers to navigate, they need to be formally aware of the space within which they read. Precisely which words nearby a current live word-cell should be treated as its formal neighbors? In answer to this question, we identified, as in the game of life, eight potential neighbors for each live word-cell, four of which may be null [11]. We say that this definition is an aspect of the text's *typographic dimension*. It is set out in terms of graphic proximities that are dependent on typographic design, but the procedural consequences of the definition are inflections of reading, not graphics.

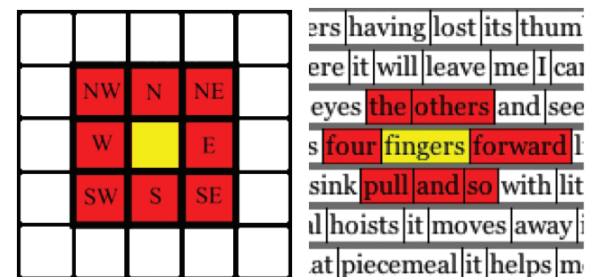


Figure 2: The layout (a) of the traditional Moore neighborhood [12] as generally employed in “the game of life,” contrasted with the typographic neighborhood (b) for a textual grid. Note that neither “eyes” nor “and” are included in the neighborhood due to their lack, in this example, of vertical overlap with the selected word below. The word “others” is considered to occupy the NE neighbor position, while the NW position is null. © 2010 Daniel C. Howe.

### Vectors of Reading

The first major gesture of *The Readers Project* is a re-conception of typography as a dimension for a cellular automata-like “game of reading.” The project’s second significant move is the elaboration

tion of forces that drive the various *vectors* of reading for its automata. A majority of these forces are derived from the engines of relatively straightforward text analysis and generation, e.g., Markov-chains [13], context-free grammars, feature analysis, etc. Effectively, we are re-placing and re-contextualizing such engines *within*, rather than *apart from*, the structures of their own supply texts. This requires our processes to remain responsive to conventional reading and writing even as they disrupt it, since the structures within which they operate are culturally and aesthetically implicated.

To date, apart from the *simple reader*, five readers with distinct behaviors have been coded and implemented for public installations of the *Project*, with a number of others currently in development [14]. Here we will introduce only the Perigram Reader in detail. Nonetheless, this reader highlights both the *Project's* exploration of generative reading in terms of the typographic dimension of visible language, and also the use of live or near-live natural language data-mining to animate and direct its vectors of reading.

The Perigram Reader is a left-to-right reader that also pays attention to its northeast and southeast neighbors, in addition to its immediate neighbor to the “right.” It was designed to be a reader that would progress through a text with a broadly traditional trajectory but that might, on occasion, be deflected from a simple linear path. It looks in particular at the neighbors (NE and SE) that are ahead of it but on the lines above or below. Thus, overall, it maintains a “forwards” reading impetus. As its “game of reading” unfolds, should either of its non-null neighbors (NE or SE) complete a phrase that is what we call a *perigram*, then that word-cell may be selected, instead of the word to the right. We have defined a perigram as a special variety of word-based n-gram (or Markov chain). In a standard word-based n-gram, all possible word combinations in the text may be considered and ranked for frequency. Here we define the perigrams for a given text to be a subset of these phrases that take typographic neighborhood into account. Our current algorithm collects only those combinations of n-words that can be found within a variable reading window, generally around 20 words, around the selected word. This definition is intended to include the selected word and all words that might possibly be set adjacently, according to standard typographic practice [15]. An n-gram sequence composed of perigrams will contain probabilistically assembled phrases with a vocabulary constrained by the typographic neighborhood, as defined above. It will, thus, contain language tending to be more sensitive to the context of the particular passage from which it is assembled.

As the Perigram Reader moves through a text, it remembers each previously read word and checks its NE and SE neighbors as potential next words. (Figure 3) If it finds that a combination of these three words (previous, current, and potential next, in order) constitutes a phrase with a frequency above a certain threshold (i.e., it has been used previously in natural language to some

Having placed my first, its first, their first word —  
Placed? Written. Having written: having — and so  
having instantly obliterated that unempty vertiginous  
emptiness in which it was once possible not to read,  
I've instantly begun to make the worlds and spaces  
through which they, you, I, may read. I wanted to  
give them nothing new. I wanted them to read some  
piece of what was already, virtually there if not there  
yet, if only a matter of transcription or, these days:  
collage, paste, grab, feed. In another place we may  
feed you and feed them and feed them for you:  
Mallarmé, Pound, Beckett, Stein, Coover, whoever,  
whatever was already virtually there because now  
(then) it could already have been found to have been  
there (here). While here and now instead I explain or  
misdirect by filling and composing this surface with  
what my own readers read — between my ears, in  
the echoing space of an orature and aurature as vast  
and formless and surfaceless as what was here before  
having written having — as I write this in a manner  
or manners and with a method or methods through

Having placed my Having written: having - vertiginous emptiness  
in which it was once the worlds I wanted some piece of only a  
what was already, virtually there if these days: feed you and  
feed them and feed them for you: Mallarmé, Pound, Beckett,  
Stein, Coover, whoever, whatever was already virtually there  
because now (then) it could already have been found instead I  
explain or misdirect by filling and composing this surface with  
the echoing space of an orature and aurature as vast and having  
written and with a method or methods process or system and  
composed and herewith propose as, in no need of prose, poetry,  
prose, word, having begun to read: having as your or anyone's or  
any whatever in some these circumstances it is here or anywhere  
at all - proceed along the line of the syntagm, of the diegesis,  
of the world they break with every, even the least  
distinguishable, instance of language. arbitrarily and  
infinitely fine and various, nonetheless, you will proceed. And  
they will and I, reading as I and in all we did this. Making a  
little formed by formed by having formed by the first and then  
proceeded in convention, in our own field of writing written, by  
cultural practice, this? A the right, own field Having written,  
by cultural practice, this? A frequent periodic, instantaneous  
teleportation of reader attention periodic, instantaneous  
teleportation of reader attention having there set in me, next  
world-breaking instance of orature for and in me, you critics.  
Clearly anything can have permission to make since what are that  
is, readers as having written? Having placed my first, its

**Figure 3: A Perigram Reader moving (a) through Poetic Caption, a text written as a “caption” for the project. Sample output (b) from the reader moving through this same text. As even 2D cellular automata generally have simple visual characteristics, our readers are coded with a variety of configurable visual behaviors that have become an important aspect of the *Project's* aesthetics. For the Perigram Reader (a), we highlight its divergent path through the text in a distinct color and shading, with a gradual return to full color and opacity over time. © 2010 John Cayley.**



Figure 4: *Read for us*, an installation from *The Readers Project* at the David Winton Bell Gallery, Brown University, December 2010.  
© 2010 Danny Cannizzaro.

extent) then its reading path may diverge, effectively also generating an alternative text that is, as it were, perigrammatic (See Figure 2b). As currently implemented, the Perigram Reader is probabilistically weighted to tend *rightwards* and to proceed steadily through a text, although it does so more quickly than a simple reader would (since it tends to jump down to the line below more frequently than it jumps up to the line above).

Rather than deriving perigrammatic frequency information solely from the domain of the supply text, for existing *Readers Project* works, we have collected “counts” from Google and other search engines [16]. This gives us a loose but near real-time relative frequency for the phrase, or else an indication, in cases where there are no hits, that the phrase searched is not yet within the domain of natural language as currently indexed on the Internet [17]. Further, it enables reader behavior to change over time (from installation to installation), reflecting continuous changes to the corpus as updated by search engine crawlers [18].

#### Reader Networks

Finally, we have developed a mechanism for distributing the “readings” of each reader. Often, when a text has more than one or two readers moving through it, following a particular reader’s path can become quite difficult for human observers. To address this, each of the words selected by a reader can be sent to a server process listening on a local or remote network port. Browsers and other custom web clients may then

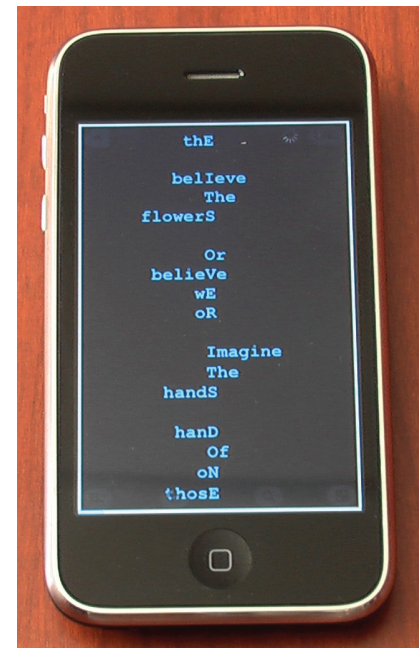


Figure 5: A networked Mesostic Reader's output displayed on an iPhone. This reader is reading through a text, looking beyond its neighborhood in order to find words from the text that spell out, mesostically, the phrase “It’s over, it’s done, [in aligned capitalized letters] I’ve had the image.”  
© 2010 John Cayley.



subscribe to particular readers and receive a relatively straightforward, linear presentation of their chosen reader on the device they used to subscribe.

In this context, any of the project's readers can manifest as a relatively straightforward text generator. For human readers present at an installation, subscribing to a reader allows them to clarify and focus the reader's generated text stream, and to compare this distinct text with the reader's traversal of the original text as visible in the main display.

The features described above were realized for an installation in the fall of 2010. As illustrated in Figures 4 and 5, a large screen with the text laid out in book-like opening displayed up to four distinct readers traversing the text. The viewer was provided with an interactive console which allowed them to select a specific reader for "focus," ensuring its presence on the display, even as it traversed remote sections of the text. Additionally, at each time-step, all readers sent their current words to the server. Audience members with web-enabled devices could then subscribe to any of the four available streams. At the installation site, these four streams were shown on four wall-mounted iPad displays, as seen in Figures 6 and 7.

Further developing the project's relationship to cellular automata, we have also experimented with what we call *Spawning Readers*. A Spawning Reader is a reader that, in addition to the capabilities described above, can spawn other readers in its neighborhood. Whether it spawns or not can depend on any number of criteria. For example, we have implemented a reader that spawns when individual words in its neighborhood complete a perigram. This may happen in any direction except the direction in which the spawning reader is itself moving. So far we have implemented a Simple Spawning Reader, one that moves through the text like the Simple Reader described above. In principle, readers of any type might be generated by a Spawning Reader, and its spawned readers, in turn, might be fertile, that is, capable themselves of spawning. (Figure 8) This would quickly produce a highly complex visual display. Thus, spawned readers may be configured to live only for a limited number of time-steps before "dying." For example, our current Simple Spawning Reader produces infertile Perigram Readers that are constrained to move in the direction in which they were spawned. They can only continue to exist if they find further perigrams in this direction. In the typographic space of conventional prose this means that they will usually die within three generations or less.

### Discussion

The attempt to apply a formal construct like "cellular automata" to the act of reading has forced us to rethink the nature and complexities of the inscribed surface. The requirement to map this surface onto a cellular grid has led us to the perhaps surprising realization that it is structured, in the first instance, typographically – not stylistically, and not grammatically. Further, our



Figure 6: Main display, console, and iPad displays at the installation from *The Readers Project* at Pixilerations [v.7], Providence, Rhode Island, October 2010. © 2010 John Cayley.

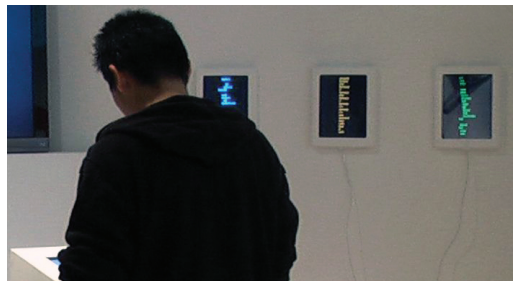


Figure 7: The output of three separate Readers, presented on networked iPad displays. © 2010 John Cayley.

articulation of the behaviors for our readers, even simple readers, has forced us to recall that the typographic dimension of inscribed language is structured by its material cultural history, leading us to derive somewhat counter-intuitive notions of properties such as proximity and neighborhood, when speaking of typeset words. It appears that the possibility of playing off typographic relations between words and their other linguistic, stylistic, and poetic relations offers much in the way of literary aesthetic potential. For example, consider the relationship between linguistic collocation and typographic neighborhood. Collocation and “simple reading” not only correspond in typography; typography is, precisely, one of the primary mechanisms wherein the collocations of conventional written text are constituted. If readers look for alternative collocations in the typographic neighborhood of a word, the conventional correspondences will be challenged and new sequences – with collocational, and perhaps even literary, momentum – are proposed. Even the slight divergences of the Perigram Reader generate tensions and literary potentials between the collocations of simple reading and the alternates that it discovers.

The *Project*’s readers can, and do, look for other relations between words – alliteration, assonance, rhyme, grammatical or semantic features, shared letters, indeed any stylistic feature or linguistic property – that are within a word-cell’s “visible range,” allowing each reader to discern a vast number of potential reading paths through the typographic space of the text. This process amounts to no less than a dynamic visualization of poetics [19].

### Conclusions

*The Readers Project* is explicit in its address to the institution of reading. By visualizing alternative vectors for reading, it both celebrates and critiques this institution. As described above, it also reveals and articulates a relatively neglected but vital aspect of this institution, the typographic dimension. The project focuses on typography as a space for reading and writing rather than on what it usually signifies: those far less neglected niceties surrounding the graphical representation of linguistic substance; that is to say, typographic design. *The Readers Project* asserts the importance of typography in the practices of reading and writing, rather than simply illustrating how the traces of these practices are manifest in the world. Less explicitly, the *Project* also concerns itself with the institution and practices of writing, both presenting an alternative vision of text generation and reflecting on writing that may be discovered within or as emergent from prior writing – that is, with writing as performative reading.

Having placed my first, its first, their first word —  
Placed? Written. Having written: having — and so  
having instantly obliterated that unempty vertiginous  
emptiness in which it was once possible not to read, I’ve  
instantly begun to make the worlds and spaces through  
which they, you, I, may read. I wanted to give them  
nothing new. I wanted them to read some piece of what  
was already, virtually there if not there yet, if only a  
matter of transcription or, these days: collage, paste,  
grab, feed. In another place we may feed you and feed  
them and feed them for you: Mallarmé, Pound, Beckett,  
Stein, Coover, whoever, whatever was already virtually  
there because now (then) it could already have been  
found to have been there (here). While here and now  
instead I explain or misdirect by filling and composing  
this surface with what my own readers read — between  
my ears, in the echoing space of an orature and  
aurature as vast and formless and surfaceless as what  
was here before having written having — as I write this  
in a manner or manners and with a method or methods  
through which I pretend to poeticize a process or system

**Figure 8: Poetic Caption (see Figure 2) with a Perigram Reader (white) moving through it and a fertile Simple Reader (ochre) that is spawning infertile Directional Perigram Readers (gray) in all neighboring directions, except west and east (the Simple Reader’s preceding and following) words. © 2010 Daniel C. Howe.**

## References and Notes

1. This paper is largely concerned with the details of our project's analytical and computational methods. However these are pursued as integral to a practice of digital literary art, fully within the context of long-standing discussions concerning the interrelation of digital media and "the literary." There is an extensive critical literature on this subject, recently summarized and extended, although from a relatively theoretical perspective, in N. Katherine Hayles, *Electronic Literature: New Horizons for the Literary* (Notre Dame: University of Notre Dame, 2008).
2. M. Gardner, "The Fantastic Combinations of John Conway's New Solitaire Game of 'Life'," *Scientific American*, 223, 120–123 (1970).
3. In fact, this is historically/culturally determined, a function of the fact that the z-dimension happens to have had little or no significance for the graphic representation of language, or at best only marginal significance, for reasons associated with the media-support for graphic language that have been available to date. This situation could change and, arguably, is now changing as it becomes ever easier to make the z-dimension perceptible within devices that represent graphic language. Note also that in sign language the z-dimension is significant, "phonologically" in the technical linguistic sense, and in other grammatical ways as well.
4. This phrase is intended to invoke both the natural language processing research that underlies our project and also the concept of "expressive processing" as vital aspects of much contemporary aesthetic practice, including literary practice, as elaborated by Noah Wardrip-Fruin, *Expressive Processing: Digital Fictions, Computer Games, and Software Studies* (Cambridge: MIT Press, 2009).
5. See D. Ashlock and J. Tsang, "Evolved Art Via Control of Cellular Automata," *Proceedings of the Eleventh Conference on Congress on Evolutionary Computation* (Piscataway, NJ: IEEE Press, 2009) 3338–3344; D. Burraston and E. Edmonds, *Cellular Automata in Generative Electronic Music and Sonic Art: Historical and Technical Review* (Sydney: Creativity and Cognition Studios, Faculty of Information Technology, University of Technology, 2005); Kenneth E. Perry, "Abstract Mathematical Art," *Byte*, December 1986, 181–190 (1986); and Mitchell Whitelaw, *Metacreation: Art and Artificial Life* (Cambridge: MIT Press, 2004).
6. One might also pre-process texts so as to be able to extract other cellular properties that are not regularly represented in traditional orthography, such as phonemes, morphemes, syllables, etc. As will be clear from our description, while the identity of cells is based on traditional orthographic and typographic distinctions, the strategies and behaviors of particular readers are often based on features extracted by computational analysis of the supply texts. Rhyme, which is based on phonemic analysis, represents one of many such examples.
7. Although we would appreciate connecting our aesthetic research more rigorously with, for example, studies of reading in cognitive science, such relations are only loosely suggested here. The authors are nonetheless involved with UK ARHC-funded research network Poetry Beyond Text, based at the Universities of Dundee and Kent, in which both cognitive scientists concerned with reading and even cognitive aestheticians have a role. See: [projects.beyondtext.ac.uk/poetrybeyondtext/](http://projects.beyondtext.ac.uk/poetrybeyondtext/).
8. We use "vector" in a figurative sense, related to its definition as: a quantity (e.g., of directed force or attention) that can be resolved into components. "Vector" also provides us with a noun that can refer to what is really, in this case, a potential direction for the choice of a next word to be read.
9. The term "poetics" is used here to encompass any property or method of language that may be composed for rhetorical or aesthetic effect.
10. We are aware that there is much sophisticated discussion of the interrelation between typography and semantics, typography and literary aesthetics, and so on. Johanna Drucker's work is exemplary in this regard. Nonetheless, we believe that the distinction proposed here is both novel and critically generative. J. Drucker, *The Visible Word: Experimental Typography and Modern Art, 1909–1923* (Chicago: University of Chicago Press, 1994).

11. For precise details of the current definition, please see: [thereadersproject.org/?p=contents/neighborhood.html](http://thereadersproject.org/?p=contents/neighborhood.html). In our scheme – as a reflection of traditional left-to-right reading in the West – the NE and SE neighbors will not be null where there are lines of type above or below the current word. The NW, N, SW, and S positions may, however, be null, depending on relative word-lengths.
12. E. F. Moore, “Machine Models of Self-Reproduction,” *Proceedings of Symposia in Applied Mathematics*, The American Mathematical Society, Volume 14, 17–33 (1962).
13. A. A. Markov, “Classical Text in Translation: An Example of Statistical Investigation of the Text *Eugene Onegin* Concerning the Connection of Samples in Chains,” trans. David Link, *Science in Context*, 19.4, 591–600 (2006). Online: [journals.cambridge.org/production/action/cjoGetFulltext?fulltextid=637500](http://journals.cambridge.org/production/action/cjoGetFulltext?fulltextid=637500).
14. See [thereadersproject.org/?p=contents/readers.html](http://thereadersproject.org/?p=contents/readers.html). We might also count as implemented a subtle variation of a simple reader, the “writing to be found” reader that was deployed in the *Read for us* installation, described here: [thereadersproject.org/?p=installations/readforus/readforus.html](http://thereadersproject.org/?p=installations/readforus/readforus.html).
15. Note that the preprocessed identification of perigrams for a text is carried out chiefly for reasons of efficiency. Often, depending on network constraints, the frequencies of particular phrases are cached in advance rather than being searched in real-time. The extraction of perigrams means that considerably fewer word combinations need be considered and processed.
16. *The Readers Project* is written, chiefly, in Processing ([processing.org](http://processing.org)) and Java, and makes use of the RiTa natural language processing library ([www.rednoise.org/rita/](http://www.rednoise.org/rita/)) developed by Daniel C. Howe. See D. C. Howe, “RiTa: Creativity Support for Computational Literature,” *C&C '09: Proceeding of the 7th ACM Conference on Creativity and Cognition*, Berkeley, October 26–30, 2009 (New York: ACM, 2009) 205–210, retrieved from [doi.acm.org/10.1145/1640233](http://doi.acm.org/10.1145/1640233). This library also provides objects designed to mine natural language data, in real time, from indexed repositories – those built by certain of the main internet search engines – that represent the most extensive corpus of natural language that has ever been available to language art practitioners. The phrases searched are enclosed in double quotes, providing a rough relative frequency for exact word sequences. There are problems with the way that search engines handle punctuation – whether or not punctuation is considered to break a sequence. (Google, for example, treats punctuation differently in different search portals: all of Google vs. Books.) These problems have been bracketed for the time being.
17. We are also able to constrain our searches to, for example, the indices of Google “books,” thus disregarding much of the commercially or technically implicated Internet text.
18. We believe that the existence of “services” (or pretended cultural vectors) such as those provided by Google, combined with a burgeoning, aesthetically motivated “use” of these services, has profound implications for contemporary artistic practice. Such use also allows artists to engage critically and productively with important socio-economic and political developments in an unprecedented manner. We are unable to address these crucial issues within the scope of this paper, but plan to do so in future contributions.
19. For us, one of the attractions of this approach and these procedures is that they may visualize and perform the workings of protosemantic and sublexical linguistic properties – both traditional poetic properties like rhyme and less-frequently acknowledged properties such as mesostic relations – highlighting their contribution to literary aesthetics. The role of the protosemantic in *The Readers Project* must wait for fuller treatment in the future. See: S. McCaffery, *Prior to Meaning: The Protosemantic and Poetics* (Evanston, IL: Northwestern University Press, 2001).