

Haiku and the Brain: An Exploratory Study

ABSTRACT: This paper presents the first results of an interdisciplinary project, bringing together haiku poets and neuro-/cognitive scientists, to investigate the reading of English-language haiku (ELH) as a potentially paradigmatic material for studying the reception of poetic texts. Our pilot study was based on the ‘eye-mind assumption’, that where and for how long we gaze at sections of text reflects processes of information harvesting for meaning construction. The results indicate that the interactive process between the poem and the reader gives rise to characteristic patterns of eye movements (saccades and fixations) across the text from which (i) the position of the cut (after line 1 vs. after line 2) and (ii) the type of haiku (context-action vs. juxtaposition) can be discerned. Finding (i) is of special importance: it provides evidence that the effect intended by the poet can indeed be traced in oculomotor behavior and that, thus, the cut is indeed a potent poetic/stylistic device with a specific effect in the reader. Moreover, readers’ recognition memory was found to be associated with more explicit, conscious-recollective experience of having read a particular haiku if the poem was self-rated to be understood. This suggests that the realization of the haiku’s ‘meaning gestalt’ in the reader’s mind, which may be associated with an ‘aha’ experience, is important for memory consolidation and remembering. Albeit tentative, these findings and conclusions open up interesting lines for future, interdisciplinary research.

by Stella Pierides, Hermann J. Müller, Jim Kacian, Franziska Günther, and Thomas Geyer

Introduction

Haiku poets and readers know and appreciate the values inherent in haiku: the thrill of the unfolding images, the gem-like quality of each nugget of insight, the connection to the present moment, the feeling of containment and time expansion experienced. Usually, we are quite content to stay with this enjoyment. However, at times, we wonder what is it about haiku that makes it so powerful, that gives it such a special password to the readers’ heart and mind. Is it a miraculous power, as has been suggested by some (e.g., Collins, 2013)? Might its shape, juxtaposition of images, play with pacing, rhythm, speed, and other qualities have something to do with the way it is being received by the brain and transformed into gold? Might the poetic form of haiku have unique properties that act on us like “a magical utterance”, a “poetic spell” (Lucas, 2009)? And if so, were we to explore some of the form’s pathways to the brain, might we understand how a given haiku is re-created by the neuro-/cognitive system, as well as discover a baseline of how meaning in general is re-constructed by the mind-brain? Might haiku be the royal road to our understanding of the brain’s making meaning?

Questions such as these were the starting point for our Haiku and Brain project. A detailed account of the initial pilot experiment, with statistical analyses is provided in Geyer et al. (2017) and Müller et al. (2017). Here, we will be describing how we set out to explore these tantalizing questions, and sketching roughly the methods used and our initial findings as starting points for further thinking and research.

A few preliminary notes. The question how haiku is received by the mind-brain is an interdisciplinary one and requires an interdisciplinary approach: our initial team involved two haiku poets, two neuro-/cognitive psychologists, and one cognitive linguist. It involved haiku, eye-movement tracking equipment, participant questionnaires, and hours of eye-watering

statistical analyses.

As with all interdisciplinary endeavors, approaching our subject required a looking over each others' fences, for both poets and scientists, and a lot of goodwill in deciding on the best course of action. For instance: How do you measure eye movements? Does one really keep the head immobile on the chin-rest while reading haiku? What is juxtaposition? How do you get the point of the poem? Is word the primary unit of processing meaning in texts? Put differently, interdisciplinary efforts rely on as well as address the common ground shared by both parties. [Note: *The difficulties as well as rewards associated with such a cross-boundary effort have been well illustrated by Roberts et al. (2013) in their work on "space and pattern in linear and postlinear poetry".*]

Ruth Padel, British poet and writer, writing about the commonalities shared by poetry and science, points out how both "get at a universal insight or law through the particular . . . both arrive at the grand and abstract (when they have to) through precision. Scientists and poets focus on details. Poetry is the opposite of woolly or vague. Vague poetry is bad poetry — which, as Coleridge said, is not poetry at all. Woolly science is not science" (*The Guardian*, 2011). And there is more than precision in symbols and language that is shared by poetry and science: the sense of inquiry and wonder, the vision at the core of both endeavors; the dedication, energy, and passion exhibited by their respective practitioners.

At the same time, while poetry and science go back a long way on shared common ground, there have been organic divergences that have resulted in a need to approach their object of study with differing instruments, aims, languages. Even within science, there has been a proliferation of sub-disciplines developing their own instruments and languages to describe their observations, so that it has become impossible to understand their texts without adequate understanding of terms. While it may arguably be a matter of explication . . . or translation, each scientific study as well as literary communication addresses a specific audience, in a specific journal or with a specific publisher, using the specified language (and submission criteria).

Given this divergence, specialization, and linguistic diversification of Babelesque proportions, we are inevitably, for instance, writing for, and reading certain journals and not others. This is not to ignore the existence of interdisciplinary journals that welcome research on the cognitive, and neuro/cognitive, processing of cultural texts, but to draw attention to the relative scarcity of such venues.

Of course, the starting point of our shared interest, as well as intrigue, is mutual and universal. It is the moment we touch ice, or fire, witness a falling star, follow the moon's waxing and waning, open up to another human being, watch a kitten being born; the moment we perceive the object fully emerge from the surrounding background; the moment we all experience a sense of unity and wholeness, simple as well as revelatory, calming as well as exciting, such as when a wildflower opens up to us with all its completeness and beauty.

Poets and writers attempt to share this experience by recreating it in the mind of the reader. How this may be achieved, what techniques may be best suited to awaken similar processes of (re-)construction and insight in the reader's 'mind-brain', is a question that has concerned them for a long time. Consider the haikuist portrayed sitting for hours by a pond, listening to silence, contemplating the moon, or mapping the ambulance route from the sound of its siren, captivated, and mulling over, sharpening, and storing the words to describe her/his experience; or the reader facing the minimalist form of haiku, and filling the mind's page with associations, memories, cultural reference, fantasy, making the poem her/his own. Or papers written on technique: how to haiku, how to (re-)create the aha experience, the importance of season words, horizontality in haiku and the importance of the vertical axis . . . how to ensure as far as possible, as well as enrich, the smooth transition of the moment's experience, or

indeed its re-creation in the mind of the reader, or, put differently, its route from the poet to the reader's mind-brain.

More recently, these questions have attracted the interest of researchers in the areas of cognitive, and neuro-/cognitive, poetics (henceforth referred to as neuro-/cognitive poetics), the study of mentally processing (receiving, comprehending, appreciating, emotionally responding to) literary texts, especially poetry, using the concepts and methodological approaches of neuro-/cognitive psychology. These methods, when applied to well-constrained literary material, facilitate the drawing of inferences about the underlying neuro-/cognitive mechanisms involved. Short forms of poetry (micropoetry), in particular, have been suggested as providing the most suitable material (Kliegl, communication, 2010).

In our pilot study, we followed this recommendation, studying ELH. Although haiku poems vary widely, in their normative (three- or one-line, variable line-length) format, they share properties that make them eminently suitable for understanding how the mind-brain makes sense and meaning of the poetic text. In particular, one key feature (out of several techniques and devices used by haiku poets) in three-line haiku is the placing of two images in relation to — or juxtaposed with — one another, often in surprising ways, across what is referred to as a gap, pause, or break (a caesura or cut), inviting the reader to construct, or contribute to, the construction of the haiku's meaning (see, e.g., Kacian, 2006, and below). This technique interrupts the flow of reading and introduces a semantic/syntactic fissure we came to see as of crucial importance for the formation of a coherent 'meaning gestalt' (Iser, 1976).

On this background, we set out to investigate the reading of ELH using eye-movement recording, combined with measures of memory for the read material as well as subjective ratings of comprehension difficulty and of the understanding achieved. Although (the pattern of) eye movements during reading and memory measures obtained post-reading are purely behavioral data, they permit inferences to be drawn about some of the underlying neuro-/cognitive processes involved in meaning construction. In brief (see below for details), the succession of eye fixations on a piece of text tells us where the reader's attention is allocated: from where information (from the visual word-encoding stage to semantic processing levels) is extracted over time and integrated in the representation of global meaning (e.g., Engbert et al., 2005; Rayner, 1998). And memory measures can tell us something about the 'depth' of the mental processing the reader engaged in (e.g., Craik, 1972).

Additionally, going further inwards, beyond the retina, the gates to the brain, neuro-/cognitive poetics traces the paths poetry follows into the brain, in order "to compactly demonstrate the complexities with which our brains construct the world in and around us", permitting processes of "thought, language, . . . and images" (cognition) to be brought together with those of "play, pleasure, and emotion" (motivation/emotion) (Jacobs, 2015, 2).

Toward a Neuro-cognitive Understanding of Literary Reading

Jacobs and colleagues synthesized this growing body of work into a tentative model of literary reading. Drawing on the cognitive-poetics literature (e.g., Stockwell, 2002), the model assumes that all literary texts, including even single words in isolation, consist of, and transport, background [BG] and foreground [FG] features, in various mixture ratios.

The FG-BG distinction can be traced back to 'Gestalt' theory (e.g., Wertheimer, 1922, 1923): the notion that (e.g., visual) perception involves lawful processes of organization that integrate basic perceptual elements (e.g., visual features such as lines, curves, color patches, etc.) into coherent wholes, or '*Gestalten*' (figures). The wholes thus created are perceptually foregrounded, in the focus of attention (whereas the ungrouped elements remain in the amorphous background), and have a meaning of their own which is 'different' than the sum of

their parts (and, in fact, alters the interpretation of the elements).

These fundamental notions from, originally, perception theory were later extended to other psychological fields, including problem solving (conceived as a process of mental re-organization; e.g., Duncker, 1935; Köhler, 1921), as well as other domains, including the study of language: cognitive linguistics (see also Croft & Cruse, 2004; Langacker, 1987, 1991; Talmy, 2000; Ungerer, 2006 for an overview) and, importantly, cognitive poetics (e.g., Stockwell, 2002). The central idea here is that, since complex processes of mental organization are invoked in the ‘ception’ (Talmy, 1996, 2000) of literary texts, literary construction and appreciation encourages play with perceptions, conceptions, and expectations; and shifts in the relationship between BG and FG.

In more detail, BG features are the elements of a text that create a feeling of familiarity in the reader: familiar words, phrases, and images; familiar situation models, socio-cultural codes, and affective scripts. As such, BG features facilitate immersive processing, “little disturbed by attention-capturing features and the higher cognitive processes . . . [of] mental-situation model and event-structure building (Kintsch and van Dijk, 1978; . . . Speer et al., 2007)” (Jacobs, 2015, 16). In eye-movement terms, this fluent reading mode is characterized by larger saccades and shorter fixations. In contrast, FG features of a text, such as unusual form elements (including, in poetry, the use of line breaks) and semantic ambiguities, may be brought in a relationship of tension or conflict with the BG elements, interrupting the flow by capturing attention. In such situations, the repertory of standard cognitive and affective schemata no longer suffices to make meaning, “defamiliaris[ing] what the reader thought s/he recognized, leading to a distrust of the expectations aroused and a reconsideration of seemingly straightforward discrepancies that are unwilling to accommodate themselves to these patterns” (Iser, cited in Jacobs, 2015, p. 7). This induces a disfluent — potentially poetic/aesthetic — reading mode, characterized by “evaluative [(self)reflective] processing, . . . not only (automatically) recognizing words, but ‘seeing’, ‘hearing’, or ‘smelling’ them. Eye movement behavior slows down [i.e., movements become smaller and fixations longer], as do thoughts and feelings: they expand . . . ” (Jacobs, 2015, 16). This serves the effortful process of closing ‘meaning gestalts’, that is, discovering or constructing new meanings from the multitude of meaning potentials that the (skillfully crafted) text affords — involving the adaptation of schemata and situation models and processes of integration and synthesis.

Reaching the end of this ‘aesthetic trajectory’ (Fitch, 2009) is rewarding: “after initial moments of familiar recognition, followed by surprise, ambiguity, and tension, the closure of meaning gestalts [releases the tension and is] . . . occasionally supplemented by an ‘aha’ experience . . . or feeling of good fit, ‘rightness’, or harmony . . . ” (Jacobs, 2015, 16).

In the haiku literature, too, ideas of BG and FG abound, often traced to the original Japanese roots of the form, where the poem was presented as an object on an aesthetically enhancing background. It was ‘written’ in ideogrammatic characters, each loaded with references, cultural associations, and layers of meaning. As such, it was primarily viewed rather than read, giving rise to a different mode of experience (Kendall, 2016). While western ELH is predominantly read, several of its elements “reach beyond the bounds of what is normally considered language’s terrain into the realm of pictures and even beyond that: unwritten, non-textual and even at times invisible elements contribute to the haiku’s power” (51). In other words, an additional and important influence on the non-textual effects in haiku is the aspect of what is not written, expressed or directly seen in the written text, which has been considered to invite a viewing mode/add aesthetic value to the poem (Kacian, 2015). As with other literary forms, this may be reinforcing both background as well as foreground modes of reading, potentially generating interesting research data and insights.

Haiku as Paradigmatic Study Material

In the neuro-/cognitive poetics literature, various types of ‘stimulus material’ have been used to examine what happens in the mind-brain when people read literary texts, ranging from extended prose texts to longer forms of poetry (e.g., Hsu et al., 2014; Zeman et al., 2013). These developments have been supported by methodological advances of formally analyzing and characterizing larger (sections of) texts. However, despite such advances, these methods still require relatively well-constrained stimulus material to be optimally applicable, in order to support reliable and valid inferences about the underlying neuro-/cognitive mechanisms.

One important criterion in this regard is repeatability of measurement: a pre-condition for discerning stable patterns, across texts and readers, that can be theoretically interpreted as reflecting well-defined mental processes. In view of this, we propose that short forms of poetry — in particular, the specific form of ELH (i.e., the normative three-line and one-line poems; see, e.g., Kacian, 2015) — may provide particularly suitable material for studying the reading of poetic texts.

Normative ELH fulfill two desiderata: They are (i) compositionally well constrained and similar in structure, while varying in meaning/content, thus allowing for systematic variation and repeated measurement. (ii) They engage a rich set of mental functions with the minimum of linguistic means (using everyday, unadorned language, largely devoid of common stylistic poetic devices), thus offering a potent literary form for investigating processes of meaning construction, including closure: the resolution of surprise induced by the juxtaposed images and other elements. Concerning point (ii), ELH contain an interesting mixture of, and interplay between, background and foreground features, potentially providing a paradigmatic study material for neuro-/cognitive poetics.

Originating in Japan, haiku developed its own identity in the English-speaking West as ELH (e.g., Kacian, Rowland, & Burns, 2013). See Figure 1 for examples. A brief poem, unrhymed, normative haiku unfolds over three lines, in a short-long-short line pattern, with, as a rule, fewer than 17 syllables in total, not necessarily arranged in the earlier 5-7-5 syllable pattern. Furthermore, haiku records a moment of insight into the nature of the world, in an effort to share it with others (e.g., Kacian, 2006). The contemporary haiku poet aims to convey her/his experience of that moment in the present (including recollected as well as imagined moments) in words that render it so concisely and directly (without commenting, explaining, or marveling at the experience) and, at the same time, so suggestively (making the words expand in the reader’s mind into a multitude of images and feelings) that it is possible for the reader to re-create and share that moment and the insight it encapsulates.

This process is aided by the fact that haiku use ordinary, everyday words, images, and concepts, importantly including keywords/phrases (such as “cherry blossom”, “harvest moon”, “snow”, or “New Year’s Eve”) that refer to a season, occasion, or aspect of the environment and have a rich, and long, tradition (especially in the Japanese tradition) known to, and shared by, the poets and their (initiated) readership. While keywords such as “harvest moon” may not be entirely transparent to the uninitiated, 21st-century reader, everyone would develop a fitting set of associations to “New Year’s Eve”. Such keywords thus evoke in the reader’s mind a season of the year and associations, literary connections, and situation models or scripts that ground the poem. That is, they provide BG features that allow for an element of immersion on the part of the reader.

In addition, the development of the haiku is skillfully crafted by the poet, using the stylistic devices of formal, FG elements of pacing and line breaks as well as introducing the element of caesura, referred to as cut: a break point or gap between two (at first glance) often seemingly disparate images, or parts. This is what constitutes the poetic device of juxtaposition: two images (Kacian, 2006) — or, in Reichhold’s terms (Reichhold, no year),

‘fragment’ and ‘phrase’ parts — are juxtaposed side by side in a more or less tense relationship, inviting comparison of the haiku’s constituent elements – inviting the reader to unravel the significance of the moment the poet presents; to reconstruct the experience / construct his/her own meaning.

JUXTA

drowned moth—
the wax hardens
around it

TYPE: context-action CUT: L.1-cut (i.e., fragment: l.1, phrase: ll.2-3)
source: Jim Kacian, *Presents of Minds* (Portland OR: Katsura Press, 1996) (Reprinted with permission)

night border crossing—
the elephant calf holds
his mother’s tail

TYPE: context-action CUT: L.1-cut (i.e., fragment: l.1, phrase: ll.2-3)
source: Sonam Chhoki, *Shamrock 26* (2013) (Reprinted with permission)

picking stones
from the lentils . . .
winter dusk

TYPE: context-action CUT: L.2-cut (i.e., fragment: l.3, phrase: ll.1-2)
source: Mark E. Brager, *The Heron’s Nest XVI.3* (2014) (Reprinted with permission)

bruised apples
he wonders what else
I haven’t told him

TYPE: juxtaposition CUT: L.1-cut (i.e., fragment: l.1, phrase: ll.2-3)
source: Melissa Allen, *Acorn 26* (2011) (Reprinted with permission)

photos of her father
in enemy uniform—
the taste of almonds

TYPE: juxtaposition CUT: L.2-cut (i.e., fragment: l.3, phrase: ll.1-2)
source: Sandra Simpson, *Notes from the Gean 1* (2009) (Reprinted with permission)

As an illustration of the interplay between the BG-FG modes of processing in haiku reading, take, for example, Chhoki’s poem. The fragment “night border crossing” will invoke, in the reader’s mind, a grounding context situation model, setting up expectations as to the range of possibilities to follow depending on personal, cultural, other associations, most likely involving humans/the narrator crossing a border clandestinely, invoking feelings of danger, worry, suspense. The subsequent phrase (following an explicit cut marker) “the elephant calf / holds his mother’s tail” will challenge this situation model, jolting the reader into foreground mode. In this mode, the reader can adapt/change the model from “human” to “animal” agents, though effecting this adaptation/change is compounded by the realization that animals don’t know anything about human-defined borders. The final line then adds an element (that is shared by humans) of touch/ touching/feeling of security/containment, as well as resolution, which is put against the suspense set up in the first line.

Figure 1. Stimulus material. Example haiku from the sample used in the study, for each of the four haiku type x cut position conditions.

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Note that the strength of the juxtaposition varies between different types of haiku, such as between haiku of juxtaposition and context-action haiku (Kacian, 2006; see Figure 1 for examples). In context-

action haiku, “one of the images . . . establishes the setting where the haiku moment is experienced; the other suggests the activity which caught the notice of the poet’s imagination” (Kacian, 2006) — so, for the reader, the gap between the two images is more straightforward to close. In juxtaposition haiku, by contrast, “two images not obviously related by context or action are paired” — with a clear, recognizable pause, break, or gap between the two disparate parts (apart from syntactic construction, ELH poets often use punctuation to indicate and emphasize the cut, though the cut itself would normally be clearly discernible even without such markers (Gilli, 2001)). This engenders both a startling, defamiliarizing, almost uncanny experience and acts as an invitation to reflection and processes of re-appraisal (this is one sense in which haiku may be distinguished from other forms of micropoetry and microtexts). As MacNeil (2000) put it: “. . . it is in the space between [the parts], that space created by the break or cut, that haiku are found.”

To illustrate, in context-action haiku (for an example, see S. Chhoki’s, 2013, haiku in Figure 1), one component (image) of the haiku provides the context (e.g., fragment: “night border crossing”) and the other an action set within this context (phrase: “the elephant calf holds / his mother’ tail”), where both images, although each relatively familiar, are set in a relationship with one another. In juxtaposition haiku, by contrast, there is no straightforward (familiar) context-action relationship, that is, the images juxtaposed are more jarring, in a relationship of tension that needs to be resolved (see, e.g., S. Simpson’s, 2009, haiku in Figure 1: “photos of her father / in enemy uniform — / the taste of almonds”). [*Note that line breaks in the two examples above are denoted by virgules (/).*]

Thus, juxtapositions (especially those in juxtaposition haiku) give rise, at first, to feelings of discrepancy and surprise, activating the play-and-see system and recruiting mental problem-solving processes to reduce the surprise and release the tension. Resolution of the ‘puzzle’, filling-in of the gap, realization of how the juxtaposed images go together, achieving integration/coherence and closure of the meaning gestalt — depending on the reader’s psychological, cultural, educational background — gives rise to what is referred to as haiku moment, which may involve an ‘aha’ experience, aesthetic appreciation, and feelings of reward. This potential has been described as “haiku’s mysterious power to cause in the reader’s consciousness a sudden shift, literally a new way of seeing” (Collins, 2013) and “Haiku as Poetic Spell” (Lucas, 2009). Note, in this context, that haiku is a form of poetry that is interpretationally open, providing ample space for the reader to contribute: by virtue of its minimal length, by what is implied, referred to, specifically left unsaid, the meaning gestalt ultimately formed by the reader may or may not be that intended by the author.

The Present Study

Background and Overview

Thus, as already indicated, the current study used eye-movement recording, combined with post-reading memory and subjective haiku/reader-rating measures (see below), to explore how readers of normative ELH — specifically: three-line haiku — scan the poem to derive sense and meaning.

Superimposed on the text — in our case, the haiku read — the pattern of eye movements describes a scan path (a kind of ‘breadcrumb trail’) which is made up of fixations and saccades. See Figure 3 below for an example. Fixations are relatively brief periods, typically about a quarter of a second in duration, during which the eye stands still at a location, permitting visual (word) information to be taken up and transmitted to the brain. And saccades are rapid movements of the eye from one fixation location to the next. Saccades can

be classified into progressive movements in the reading direction (in English, from the left to the right in the text), and regressive saccades counter the reading direction. Accordingly, we can distinguish pro-fixations (which follow a forward saccade) and re-fixations (which follow a backward saccade). Usually, at the end of a line, the reader makes a return eye sweep to the beginning of the next line (a progressive cross-line saccade), but s/he may also make a regressive movement from a 'lower' line to one already read higher up (a regressive cross-line saccade). During (pro-)fixations, visual information uptake is typically skewed in the reading direction. Thus, when reading English text, we usually take up more letter and global word (i.e., shape and boundary) information to the right of the fixation point than to the left. The letters around the fixation point are represented in the fovea of the eye, where we have the highest visual resolution (central vision); but information further out to the right (peripheral vision) helps the eye to determine where to jump next (in order to maximize information uptake). How long we dwell on a fixation (fixation duration) and how far we jump ahead in the next saccade (saccade size) depends on a number of factors: apart from purely visual factors (e.g., aspects of the type script), for instance, how familiar (or frequent in language) the word is we are currently reading, how predictable the word is from the context of what we have already read, etc. For example, we are more likely to spend fixations, and thus mental processing time, on content words and less on function words (such as 'a', 'the', etc.); the latter tend to be more predictable and carry less (lexical) meaning, and may thus be read by peripheral vision alone. This illustrates that the mind-brain constantly generates and updates predictions (in reading, on multiple levels: orthographic, lexical, syntactic, semantic predictions) of what will be encountered next, and the speed and 'fluidity' with which visual input is taken up (and the extent to which it is thoroughly analyzed) — which is revealed by the eye movement pattern — depends on predictability. This is also evidenced by mis-readings (e.g., when we mistake unfamiliar words for familiar ones that are visually similar in letter composition and word shape), as well as by extended dwell times when our predictions turn out to be wrong — in which case we may have to regress to, that is, re-read a previous section to resolve the discrepancy. [*Note: It may be interesting, though beyond the scope of this pilot study, to explore how haiku arranged in particular, more or less 'organic' visual shapes rely on brain preferences, teasing or unsettling them, in order to facilitate processes leading to insight.*] — Given this, the eye movement patterns recorded while our participants 'scanned' the haiku provide us with a potentially rich source of information about the construction of meaning during reading.

Our reading material, ELH, is written in a variety of approaches (Brooks, 2011) and formats (e.g., from the standard three-line haiku to four, two- and one-line haiku). In our pilot study, we focused on the normative three-line haiku, with a cut either at the end of line 1 or at the end of line 2. Also, we looked into two haiku types distinguished by Kacian (2006; see also above): context-and-action haiku and haiku of juxtaposition (acknowledging that there are other schemes for classifying haiku). Note that the position of the cut is 'orthogonal' to the type of haiku, that is: independently of the type of haiku (context-action vs. juxtaposition), the cut can occur after line 1 or after line 2.

The three-line ELH poems to be read by the participants in our study (and the non-read haiku additionally presented during the memory test; see below) were selected from highly reputed English-language haiku journals and registries (such as *A Hundred Gourds*, *Frogpond*, *Modern Haiku*, The Haiku Foundation, *The Heron's Nest*, among others) by the co-authors. Each 50% of the poems were, in terms of the classification proposed by Kacian (2006), 'context-and-action haiku' and 'haiku of juxtaposition', respectively. See Figure 1 for examples (reprinted with written permission of the authors). Furthermore, all haiku had a clearly discernible cut (agreed by the co-authors), either after line 1 (L.1-cut haiku) or after line 2 (L.2-cut haiku); see illustrations in the figure. This resulted in four sets of haiku or

experimental conditions: context-action L.1-cut and L.2-cut haiku and juxtaposition L.1-cut and L.2-cut haiku. Post-selection analyses ensured that these four sets were largely comparable in terms of a range of linguistic variables, making it unlikely that any of the effects found are attributable to linguistic differences.

Given these experimental conditions, the primary aim of the present, exploratory study was to examine the patterns of eye movements during haiku reading. It was expected that both the type of haiku and the position of the cut would influence this pattern. Overall, context-action haiku were expected to permit a more fluent mode of reading; juxtaposition haiku, by contrast, were expected to be read in a more disfluent mode. Likewise, the position of the cut was expected to influence the scanning pattern, with the fragment line (i.e., line 1 in L.1-cut haiku and, respectively, line 3 in L.2-cut haiku) perhaps receiving the most attention (i.e., processing time).

A secondary aim was to relate memory and subjective rating measures obtained post reading to the eye-movement patterns. To this end, we administered a memory test in the second, post-reading phase of the experiment, and obtained subjective measures of (rated) haiku difficulty and understanding achieved in the third phase.

Note that the memory test was not announced to the participants in advance, so that, during the reading phase, they would not ‘study’ the haiku presented with the aim to perform well at a memory test later on. Consequently, any memory of the haiku read would have been established purely as a result of participants’ reading the poems for their own understanding, that is, as a result of the mental processes engaged to (re-)create the poems’ meaning (rather than employing rehearsal strategies for doing well in the subsequent memory test).

In this — memory test — phase, participants were presented with haiku they had read in the initial reading phase of the experiment (‘old’ haiku), randomly interspersed with an equal number of ‘new’ haiku they had not read before. The task was to make a yes-no recognition response and, in case of a positive response, rate the certainty associated with this decision: “recollect” with certainty versus recognize as “familiar” with lesser degrees of certainty. This scale was meant to cover the spectrum from explicit, self-aware memory to more implicit (vaguer) feelings of knowing that one has encountered a particular poem before (e.g., Dunn, 2004; Gardiner, Ramponi, & Richardson-Klavehn, 1998, 2002).

Memory performance, in particular when it is associated with recollective experience, can be regarded as a measure of the depth of processing and closure of the meaning gestalt achieved. For instance, experiencing an ‘aha’ moment as a result of reading might be experienced as rewarding, leading to better consolidation and accessibility of the memory — including recollection of the experience of reading and understanding the haiku — later on.

Finally, in the third phase, participants rated the haiku they had read for difficulty and understanding achieved.

The aim of these post-reading measures was to relate the memory quality and ratings to the reading modes evidenced in the eye-movement pattern; that is, for instance: could memory quality, or understanding achieved, be predicted from the eye-movement patterns?

Study Design and Procedure

Eleven (international) students at LMU Munich took part in the study. All participants were native English-language speakers, none were experienced haiku readers, or regular readers of poetry, and all were naïve with respect to the precise purposes of the study.

The haiku to be read during the initial reading phase, 48 in total, all consisting of three lines, were presented left-aligned in the center of a computer monitor (see Figure 2 for an example display screen). Prior to the onset of the haiku, participants, resting their head on a chin rest,

fixated a black cross symbol to the left of the first word on line 1 for a few seconds. During reading, participants' eye movements were recorded (using a special, remote SR Research eye-movement tracker system). Recording ended either once the participant indicated (by pressing the cursor-down key on the computer keyboard) that she/he had completed reading or else after the maximum reading time of 12 sec. Following a blank interval of 1 sec, the next trial started automatically with the fixation marker. The next poem was presented only once the eye tracker had established that the participant's eye stood still on the marker (which added a few seconds to each reading trial). — In this phase, participants were instructed to “read each haiku attentively for your own understanding, trying to recreate the images presented in your mind. Your eye movements will be recorded while you read the haiku”.

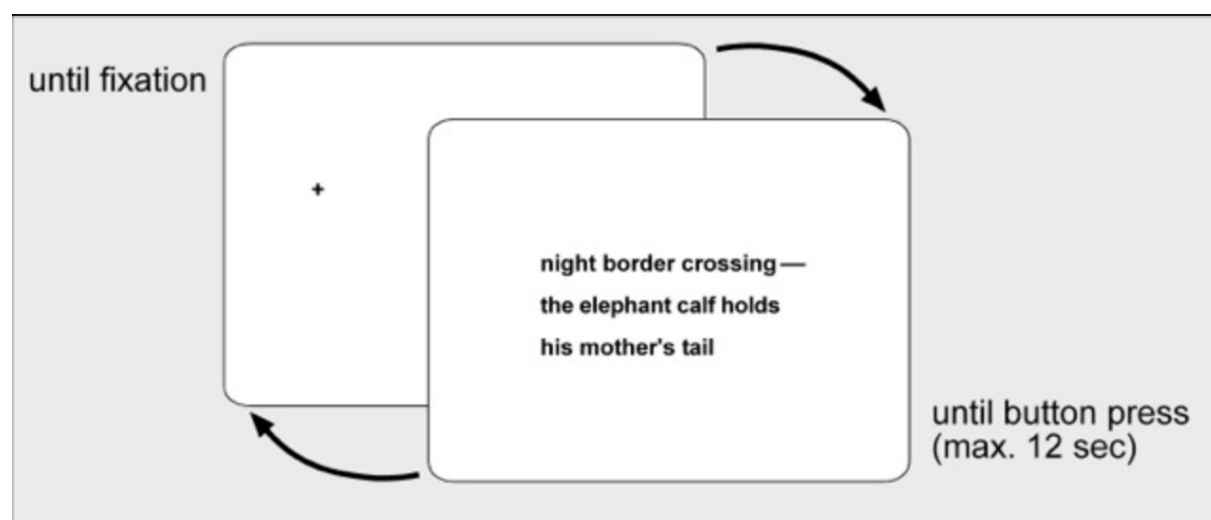


Figure 2. Trial events in the reading phase. Example display screen, with fixation cross. The poem depicted, by Sonam Chhoki (2013; *Shamrock* 26), is reprinted with permission.

At the end of the reading phase (which, including re-calibration of the eye-movement recorder on the initial fixation position, lasted up to 15 minutes in total), participants were given a rest period of 3 minutes (in which they stayed in the experimental room). Next, participants were informed that, in the next phase, they would be presented with haiku they had already read as well as new haiku they had not seen before; the task was to respond “yes” to each haiku they recognized as ‘old’ (and, respectively, to respond “no” to ‘new’ haiku); a yes-response was immediately followed by the question: “How certain are you that you have seen this haiku earlier on? (1 = “I definitely recollect having seen the haiku” and 2–4 = “I feel I have seen the haiku”, with various (degrees of) strengths associated with this “feeling of familiarity”).

The final, subjective-rating phase followed immediately afterwards. In this phase, participants were re-presented — and explicitly told so — only with the haiku they had actually read in the first phase of the experiment and were asked to indicate the following: “how difficult was this haiku to understand?” (scale: 1=very easy – 5=very difficult) and “did you achieve an understanding of this haiku?” (scale: 1=fully understood – 5=completely failed to understand).

At the end of phase three, participants were debriefed: apart from gathering information about whether they were, or were not, familiar with haiku poetry, they were given more information about this form of poetry (including an information sheet with a brief explanation and web-links for further reading) and more details about the purpose of the study. Altogether, these three phases (plus debriefing) took about 50 min to complete.

Summary of results and implications

For understanding eye-movement patterns in neuro-/cognitive research, it is important to note that we are not primarily interested in how a particular reader reads a particular text — however interesting this may be! Instead, we wish to derive conclusions that generalize across readers (who all read with a similar intention) and texts (that are all of a similar description). That is, technically, both the readers and the texts are considered a source of ‘random variation’ that we need to control in order to reveal the underlying pattern (i.e., the systematic variation). One statistical means of controlling random variability is by ‘averaging’: given that a particular sample randomly deviates from the ‘true’ value (sometimes being a bit smaller and sometimes larger), we can estimate the true value by calculating the mean. *[Note: Of course, there may be systematic information in the degree to which measured values differ from the mean, which is an issue ignored here.]* This is the approach we adopted in the analysis of our haiku reading data: we looked at key measures, specifically: the ‘dwell time per word’ in a particular line (where the dwell time is the total time of the fixations falling on a word), dependent on a limited number of key variables characterizing our sample of read haiku: the haiku type: context-action versus juxtaposition; and the cut position: at the end of line 1 (=L.1-cut) versus the end of line 2 (=L.2-cut).

Thus, for instance, we calculated the dwell time per word in line 1, averaged across all participants and haiku, say, an L.1-cut context-action haiku (i.e., dwell time in the fragment line), and compared this to the mean dwell time per word in lines 2 and 3, also averaged across all participants and haiku of this category (i.e., with L.1-cut context-action haiku, the phrase lines), or to the mean dwell time per word in line 1 of an L.1-cut juxtaposition haiku (i.e., the fragment line in a different type of haiku).

In addition to dwell time per word in a given line, we also looked at the total number of saccades (progressive and, respectively, regressive) within lines (again related to the number of words), and the number of progressive and regressive saccades across lines (per line). Note that dwell times and number of intra-line saccades need to be calculated per word, because the number of words per line differs between poems. *[Note: This is a form of normalization, which makes the different lines within a poem and the different poems comparable. It assumes that ‘the word’ is the unit of reading and corrects for the fact that, e.g., typically the middle line is longer (contains more words) than the first and the third line of a standard three-line ELH. So, for instance, finding that readers take longer to scan line 2 than lines 1 and 3 would be trivial (this might simply be owing to the greater number of words to be scanned). By contrast, it would be nontrivial, if readers spend more fixation dwell time to process the words in a particular line, such as the fragment line compared to the phrase lines.]*

Note that the dwell time and fixation data were examined both aggregated across all reading passes, as well as separately for individual (i.e., the first, second, and third) passes. While the overall, aggregated analysis reveals general effects, examination of the individual passes provides more detailed insights into the on-line reading and re-reading dynamics.

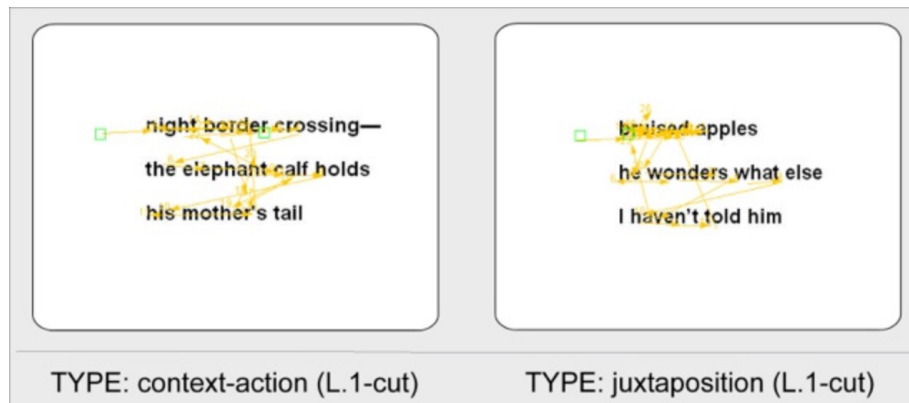


Figure 3. Example scan paths by one participant overlaid on the poems that s/he read. The yellow arrows mark saccadic eye movements (and subsequent fixations at the head of the arrow); numbers denote the order of saccadic eye movements over time. As can be seen, meaning resolution is achieved in qualitatively different ways: relatively frequent back- and renewed forward-tracking across lines in the context-action haiku compared to extended time spent processing the fragment line in the juxtaposition haiku (left and right panel, respectively). The green squares to the left of the haiku indicate the eye position (on the fixation cross) at the beginning of the trial; the right green squares within the haiku mark the position of the eye when the participant executed a button press (to signal the end of reading) or when the maximum trial duration was reached. The poems depicted, by Sonam Chhoki (2013, *Shamrock* 26; left panel) and Melissa Allen (2011, *Acorn* 26; right panel), are reprinted with permission.

Overall, looking at the scan paths of our readers (see Figure 3 for examples), it is clear that reading haiku involves a complex, and non-linear pattern of eye movements: readers go forwards and backwards within lines, and they jump between lines not only in the standard, forward path, but they also go back, for instance from the end to the beginning of the poem. Thus, frequently, a poem is sampled not only once, but twice (probability of entering a line for a second time: 65%) or three (41%) or more times — where re-reading may not involve a ‘straight’ path (e.g., the eye may return to line 1 via line 2 from line 3 and then jump directly to line 3 from line 1), reflecting complex, and non-linear, processes of visual information harvesting and meaning construction. Given the complexity of the scan paths (which differ between individual poems and readers), our approach was to look at general eye-movement patterns that describe whole categories of poems (i.e., haiku type and cut position) in summary terms. Thus, what we outline below are findings based on these summary measures (for more details and more formal statistical analyses, see Geyer et al., 2017, and Müller et al., 2017). Please note that these findings are statistical in nature, that is, while applying to most poems, individual haiku may be found which do not comply with the findings.

The main finding was a *cut effect*: The position of the cut has a major, and general, influence on the eye-movement pattern, that is, on the way readers allocate attention over the poem: statistically, more reading time per word is spent on the fragment line than on (each of) the phrase lines, whatever the type of haiku (context-action or juxtaposition) and wherever the cut is placed (at the end of the first or the second line). This pattern is evident already when we look at the first reading of a line (first-pass reading), as well as when the reader re-enters the line for the first or the second time (second- and third-pass reading). For instance, in first-pass reading, the dwell time per word is 370 milliseconds (more than one third of a second) for the fragment line, as compared to only 250 milliseconds (a quarter second) for the phrase lines. Thus, from the pattern of dwell times, we can deduce where the cut is in the haiku.

Thinking along the lines of background and foreground features, perhaps the extended time spent processing the fragment is due to the reader encountering the cut, which acts as a foregrounding, attention-capturing feature. This puts the reader into a more disfluent reading mode, characterized by an increased number of regressions within, and eye movements from other (phrase) lines to, the fragment line (see below for details). The fragment is thus ‘pivotal’ for global meaning construction: the eye, and attention, tends to dwell on and return to the fragment where the grounding may be provided for the integration of the juxtaposed images.

This general cut effect was modulated by the position of the cut: relatively more time per word was spent on the fragment line when the cut was encountered at the end of line 2 compared to when it was encountered at the end of line 1, and this is the case whatever the type of haiku. For instance, in first-pass reading, the dwell time per word in the fragment line was 460 milliseconds for L.2-cut haiku, but only 290 milliseconds for L.1-cut haiku. This may be taken to indicate that the disorienting, attention-capturing effect of encountering the cut is greater in L.2-cut haiku compared to L.1-cut haiku and therefore engenders a different reading and re-reading dynamics (see below for details).

While the general cut effect, and its modulation by position, is shared by context-action and juxtaposition haiku, there are also differences between the two haiku types. In particular, the cut effect (extended time spent in the fragment line) is somewhat more pronounced for juxtaposition than for context-action haiku, whether the cut follows line 1 or line 2. For instance, in first-pass reading, the average dwell time per word in the fragment line is 350 milliseconds for context-action haiku, but 400 milliseconds for juxtaposition haiku.

In other words, the cut effect is modulated by the strength of the semantic/conceptual distance/discrepancy between the two parts, which is generally greater for juxtaposition than for context-action haiku: the greater the gap between the two images/parts, the more time is spent on working out the meaning implications of the fragment (line).

As outlined above, meaning resolution frequently involves several — an initial reading plus one or more re-reading — attempts, or passes at a haiku. Here, the interplay between forward- and backward-directed eye movements (and subsequent fixations) in the various lines is of interest, where the ratio between the two is indicative of the fluency of reading, that is: reading is more disfluent, reflecting heightened information-seeking and processing activity (Jacobs, 2015), when regressions (i.e. the eye going back to re-read, and the time spent on re-fixations) increase relative to progressions (and the time spent on pro-fixations). Examining the scanning patterns in the separate passes in this way (see Müller et al., 2017, for details) reveals that while the *first-pass* dynamics share similarities among all conditions, differences emerge in the re-reading (i.e., the *second-* and *third-pass*) patterns between L.1-cut and L.2-cut haiku, and among the latter between context-action and juxtaposition haiku.

Specifically, *first-pass* reading is predominantly forward-directed (i.e., relatively fluent) and concentrated on the fragment line in both context-action and juxtaposition haiku. In the former, there is also a focus on the first phrase line (line 2 in L.1-cut haiku and line 1 in L.2-cut haiku) — which opens up the action. Within-line regressions (indicative of more disfluent reading) are significantly increased in the third line, in all conditions. This pattern — of disfluent scanning of line 3 after a relatively swift taking-in of lines 1 and 2 — may reflect a first attempt, towards the end of the first pass, to integrate the haiku’s parts, or to form a (first) hypothesis about the haiku’s global meaning. [*In L.2-cut haiku generally, and especially in L.2-cut juxtaposition haiku, the final-line re-fixations add substantially to the pro-fixations. As already noted, in the data aggregated across pro- and re-fixations, this manifests as a very marked ‘dwell’ on the fragment line — while it is probably best understood as a superposition of attentive re-appraisal over fast initial ‘foraging’ processes.*]

These dynamics change, and become more differentiated, in *second-pass* reading.

In *L.1-cut haiku* (of both the context-action and juxtaposition types), there is extensive re-sampling of the fragment line (line 1), though now in a disfluent mode of reading — suggestive of a secondary attempt (after complete first-pass reading) to tie the phrase (encountered towards the end of the first pass) together with the fragment, or to re-interpret the fragment in light of the phrase. This is followed by relatively fluent re-sampling of the phrase lines (lines 2 and 3), perhaps in order to check, or confirm, this ‘holistic’ re-interpretation.

In *L.2-cut context-action haiku*, re-sampling is concentrated on the first phrase line, in a markedly disfluent reading mode, suggestive of a second resolution attempt (after the extended ‘dwell’ on the fragment at the end of the first pass). There follows another focus on the fragment line (i.e., line 3), which this time is sampled in a more fluent mode, perhaps to confirm some already formed (re-)interpretation. In other words, the extensive revisit to phrase line 1 suggests that the reader attempts to work out the impact of the fragment (providing the grounding context and encountered at the end of the first pass) on the phrase. This involves re-processing of the phrase in the light of the fragment, possibly bringing about a shift in the phrase’s meaning — which is then checked in another (re-)sampling of the fragment line.

In *L.2-cut juxtaposition haiku*, by contrast, second-pass reading involves some relatively swift re-sampling of, predominantly, the second phrase line (line 2). This is followed by a focus on the fragment line (line 3), which is again read in a comparatively disfluent reading mode, suggesting another resolution is attempted in the fragment line. This pattern – focus on the fragment part, with a swift re-take of the phrase part (mainly of the second phrase line) — would imply that the meaning of the phrase part has been relatively worked out in the first pass, and the juxtaposition is resolved mainly by dwelling on the (startling) fragment part.

For all conditions, the *third-pass dynamics* are generally similar to the second pass, but with reading being more fluent overall – perhaps indicative of a ‘confirmatory’ mode of re-reading, that is, of checking the solution (holistic interpretation) worked out in the second pass.

A possible account of the differential re-reading (second and third pass) of the phrase between *L.2-cut context-action haiku* (focus on phrase line 1) and *L.2-cut juxtaposition haiku* (focus on phrase line 2) may be that, in the former, the phrase in *L.2-cut context-action haiku* is often syntactically more regular and integrated (frequently containing a verb in phrase line 1) than in the latter. At present, this is a post-hoc account, based on syntactic properties of the haiku in our sample, which will have to be tested using larger samples of *L.2-cut haiku* (one of the aims of our follow-on study).

There were some further, interesting findings concerning the link between the eye movements during initial reading (see results above) and (i) memory for read haiku, as assessed in the post-reading memory test (i.e., how well, in terms of recollective experience, the haiku was recognized as previously read); and (ii) the link with haiku understanding achieved, as assessed in the final subjective ratings.

Memory performance: Overall, with a recognition success of 86%, memory for read haiku was quite high, and successful recognition was largely associated with (self-stated) explicit, recollective experience rather than just a vague feeling of familiarity. There were no statistically robust effects linking memory with eye-movement measures, that is: from the eye-movement pattern alone, one cannot tell whether a given haiku was later explicitly recognized (i.e., recollected) as read, or just judged as (vaguely) familiar.

In terms of the other subjective ratings, interestingly, participants’ assessment of haiku difficulty was wholly uncorrelated with their recognition performance. But haiku for which participants achieved a better self-rated understanding were more likely recognized with

recollective experience, rather than being experienced as just familiar. Although we cannot tell on what representation (surface or semantic level) our readers based their memory response, the association of comprehension achieved with vivid recollection may suggest that good, explicit memory performance depends on successful construction of the meaning of a read haiku. This would be consistent with views according to which recollective experience may be associated with experiencing an ‘aha’ moment (i.e., actually resolving the haiku’s meaning, rather than just striving to resolve it) and the feelings of reward associated with this.

There are a number of further, general observations worthy of note. Overall, the reading patterns are surprisingly non-linear: the numbers of pro- and regressions (within and, in particular, across lines) appear higher with haiku than with most other texts (e.g., about one third of cross-line regressions as compared to the usual 10–15% reported by Rayner, 1998). Further, in addition to regress-and-progress and regress-and-dwell type of re-reading patterns of eye movements, there were also many instances of regress-and-regress movements, that is, sequences of movements starting from line 3, with one subsequent fixation in line 2 and one in line 1. Overall, this spatially distributed reading pattern might be characteristic of reading haiku (or perhaps of short poetry in general; see also Koops van’t Jagt et al., 2013). In addition, the tendency to skip function words (which has been reported to occur with up to 50% of function words in standard texts; Staub & Rayner, 2007) appears to be particularly strong in the reading patterns for haiku: on many trials, readers started by jumping from content word to content word (i.e., they skipped almost all of the function words) and only took a closer look at the text as a whole on a second or third reading of the same poem. This focus on content words might, to a certain extent, be the result of the partly fragmentary or elliptical syntax in the haiku, as well as of haiku being a “poetry of nouns” (see, e.g., Kacian, 2006), striving for both precision and condensation.

The strong effect of the cut, as well as its modulation by the cut position and the type of haiku, are of particular interest, because they permit us to tell from the eye-movement pattern alone which kind of haiku (in terms of type and cut position) is being read. The haiku poet might consider these effects as ‘known’ and ‘a given’, as the strength of the juxtaposition and the positioning of the cut are essential techniques of ‘foregrounding’, designed to induce in the reader this particular pattern of non-automatic processing and meaning resolution. In the cognitive-poetics literature, however, this result has novelty value: it provides first evidence indicating that the effect intended by the poet can indeed be found in reader behavior and that, thus, the cut is indeed a potent poetic/stylistic device with a relatively specific and clearly definable effect in readers. While some stylistic and form features typical of poetic texts, like the spatial layout of the text on the page (Roberts et al., 2013) or the stylistic device of enjambment (e.g., Carminati et al., 2006; Koops van’t Jagt et al., 2014) have been identified to have specific effects on eye-movements during reading, there have not been other findings of signature eye-movement patterns reflecting the more content-related features of an unexpected sharp thematic or imagistic turn in poetry, as is, for instance, also characteristic of sonnets (Burt & Mikics, 2010). While such turn or volta effects might still be found in other poetry in future research, the fact that we were able to establish such a signature pattern in the present study (even though we used readers that were naïve with regard to the genre of haiku) suggests that haiku — of the particular sort and quality found in leading ELH journals, which we used in the present study — are a particularly potent material for studying processes of literary meaning construction in neuro-/cognitive poetics.

Thus, however limited a measure they may be, we argue that the analysis of eye movements (coupled with other measures) can provide interesting, nontrivial insights into how the reader constructs, out of the constituent parts of a haiku, a coherent ‘meaning gestalt’ that is other than the sum of the poem’s parts.

Limitations and Outlook

As is apparent from the description above, our pilot study already produced a considerable amount of data, analyses (involving the adaptation of standard analytic approaches to the reading of haiku; see Geyer et al., 2017, and Müller et al., 2017), and tentative conclusions. Nevertheless, it scratched only the surface of the subject matter. Apart from replicating some of the more subtle effect patterns revealed, we need to gain a closer understanding of the mental and brain processes involved in haiku reading. This will require a more fine-grained look at the haiku themselves (including extension to other forms of haiku, in particular, monoku), as well as at their readers.

Concerning the haiku, pertinent questions are, for instance: How are the cut effects modulated by the addition of a cut marker? Is the mode of reading a particular haiku modulated by the context of the haiku encountered before (e.g., does reading an L.2-cut haiku engender a ‘strategic’ set in the reader especially suited for resolving L.2.-cut haiku)? How does the degree of syntactic/semantic integratedness of the fragment and phrase parts influence haiku reading? What happens when the experience of the present moment coalesces with a memory, a historical or topographic reference in ever widening circles? In what ways do keywords influence the reception and memorability of the poem? And concerning the reader, questions include, for instance, whether and in which ways the experienced reader approaches the poem differently from the novice.

In more general terms, how do results obtained in a laboratory set-up so constrained as to strike horror in the heart of most poets (e.g., the reader being made to keep her/his head still while reading by placing it on a chin rest, her/his eyes being tracked by an infrared beam) compare with reading haiku in our natural environment? And how about situations where haiku is recited by the poet her-/himself and listened to by the reader: is the poem overall better understood when both read and listened to, compared to only being read or only being listened to? Are auditory cues adding to the poem’s comprehension and, if so, in what way?

Another limitation of our pilot study is that, in terms of our primary measure, it only went as far as the gates to the brain: the sequential sampling of information by the retina. Eye-movement measures are highly informative of mental processes going on while reading haiku, the idea being that higher processes of meaning construction and gestalt formation control where the eye goes. Nevertheless, they are indirect, purely ‘behavioral’ measures, which would need to be augmented by ‘brain’ measures to acquire a more complete, and complementary, ‘neuro-cognitive’ picture of the reading process. And this is what we are currently embarking on: gathering additional EEG — and, in the longer run, functional neuro-imaging (fMRI) — data. Questions here concern, for instance, whether we can find key EEG signatures of the ‘aha’ moment experienced when closing the meaning gestalt, and how the reader re-instates and expands the images just ‘sketched’ in a haiku in terms of the activation of a whole network of brain regions associated with the sensory (e.g., visual, auditory, tactile), emotional, and aesthetic qualities of the haiku.

Conclusions

In summary, the results demonstrate that, out of the elements created by the poet and skillfully placed into a dynamic relationship using such techniques as the juxtaposition of images and the cut, the reader is led to recreate in her/his mind patterns intended by the poet from within the poem’s larger meaning potential. This interactive process between the poem and the reader, which may culminate in the ‘aha’ experience, gives rise to (or is the end result of) a characteristic pattern of eye movements and fixations across the text, indicative of the type of haiku (context-action vs. juxtaposition) and the position of the cut (after L.1 vs. after L.2). Moreover, in a memory test administered after reading, readers reported a more explicit (i.e., conscious) experience of having read a particular haiku if they had been able to understand the poem. This is consistent with the notion that an ‘aha’ experience is important

for memory consolidation and later retrieval. Further work, going beyond eye movement and memory measures (e.g., combining these measures with EEG methodology), is necessary to examine how these processes arise in the reader's brain.

While this is, in essence, fundamental research, it may also have applied implications. By investigating the different ways in which mental and brain processes interact in reading — when the poem and the mind-brain reach for each other like the bee and the flower — we can open up pathways towards understanding how the brain might be helped to strengthen its powers (of rich sensory perception, emotional experience, memory connections, problem solving) and perhaps even heal.

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