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Poet and Psychologist: A Conversation

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ABSTRACT

I consider poetry composition from both the "inside" view of a poet and the "outside" view of a cognitive psychologist. From the perspective of a psychologist, I review behavioral and neural studies of the reception and generation of poetry, with emphasis on metaphor and symbolism. Taking the perspective of a poet, I discuss how the seeds for a poem may arise. Finally, I consider the prospects for future developments in a field of computational neurocognitive poetics.

What might a poet and a psychologist (who cares about metaphor and symbolism) have to say to one another? I am of two minds about it – or really just one, a mind that happens to think sometimes as a poet and other times as a psychologist. As a poet, I would greatly appreciate anything the psychologist could tell me that would help me become a better one; regrettably, I have yet to hear any transformative advice. As a psychologist, I would ask the poet to share their insights into the creative process; the resulting anecdotes are likely to be fascinating, though falling short of a roadmap for the neural circuitry supporting creativity. Of course, the psychologist may happen to appreciate poetry, and the poet is perhaps curious about how the brain creates metaphors. Their conversation may be mutually beneficial, as long as the poet avoids over-intellectualizing the creative flow and the psychologist remembers that scientific truth need not be poetic.

I have long sought connections between ideas from cognitive science and literary criticism (Holyoak, 1982). After many years in which I was separately a psychologist and a poet, I let my "two minds" collaborate in the process of writing a book called *The Spider's Thread: Metaphor in Mind, Brain, and Poetry* (Holyoak, 2019). The title is a metaphor (inspired by a poem from Walt Whitman, "A Noiseless Patient Spider") meant to convey the sense in which a novel metaphor is a kind of leap of faith aiming to find a new connection between concepts or emotions. If the thread takes hold – if divergent thinking converges – we may experience the faint "click" of comprehension, or even the more dramatic moment of "aha, I see now!" And starting from that first connecting thread, a poet may continue on to weave the web of a poem.

Here I will continue the poet/psychologist conversation, aiming to suggest how a psychology of poetic creation might proceed (and perhaps serve as a model for the psychology of creativity in general). On the psychology side – the "outside" view of the objective scientist – I'll point out a few of the glaring gaps in our current knowledge, but also the promise of contemporary developments in neuroscience and machine learning that might be brought to bear on poetic composition. On the poetry side – the "inside" view of a poet at work – I'll call attention to some of the rich hints from poets and literary critics that resonate with ideas in cognitive science. And I'll add a small case study based on a contemporary poet – me. Needless to say, I do not pretend to be a representative (far less great) poet of the 21st century – my idiosyncracies include being a cognitive scientist immersed in the study of analogy, and a formal poet swimming against the tide of free verse. But good case studies of creators

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are hard to come by. Mihaly Csikszentmihalyi, the master of "flow" (Csikszentmihalyi, 1990), once told me how a well-known creator declined a request to be interviewed about his creative process – on the grounds that an important element of his method was to never waste time doing interviews with psychologists! In that respect I find myself more generous. So in the parlance of psychological methods, I provide a sample of convenience.

Why poetry?

For a psychologist investigating metaphor and symbolism, poetry provides a rich source of material. As a literary critic succinctly defines it, "Poetry essentially is figurative language, concentrated so that its form is both expressive and evocative" (Bloom, 2004, p. 1). Yet more succinctly, Robert Frost claimed that, "Every poem is a new metaphor inside or it is nothing" (Frost, 1946/2007, p. 147). Poetry is a special form of language in which symbolic meaning is wedded to the rhythmic patterns of speech sounds to generate an emotional response – sometimes profound. Turner and Pöppel (1983, p. 300) observed, "There is an awareness of one's own physical nature, of one's birth and death, and of a curious transcendence of them; and, often, a strong feeling of universal and particular love, and communal solidarity." The esthetic emotions triggered by poetry, like those elicited by music and other art forms, can cause a reader to experience the "chills," with goosebumps as attendant bodily signs (Wassiliwizky, Koelsch, Wagner, Jacobsen, & Menninghaus, 2017). The scientific study of poetry and its impact may provide a window on the mind and brain, because poetry "might be well suited to compactly demonstrate the complexities with which our brains construct the world in and around us, unifying thought, language, music, and images with play, pleasure, and emotion" (Jacobs, 2015, p. 2). Over the past decade, Jacobs and his colleagues have advanced an approach termed *neurocognitive poetics*, which combines behavioral and neural studies of poetry reception with analyses of poetic style made possible by work in artificial intelligence on machine learning. I will discuss insights gleaned from neurocognitive poetics as they may bear upon the process of creating poetry.

Comprehension and production of metaphors

A poem is the product of a creative process that generates a verbal composition – in literate societies, almost always one in written form. We immediately encounter an enormous gap in scientific research on poetry and its most prominent component, metaphor: a near total absence of research on the *generation* of poems and poetic metaphors. Almost all research has dealt with their reception – in particular, how metaphors are comprehended and appreciated – not their generation. Moreover, within the body of research on metaphor, only a modest number of studies have focused on *poetic* (or more broadly, literary) metaphors. Nonetheless, work on metaphor comprehension is likely to prove relevant to understanding poetic generation. Although poetry composition must involve additional processes, it seems likely that a poet needs to act in part as a self-critic, evaluating (and perhaps revising, or even abandoning) an emerging poem.

Work on comprehension of poetic metaphors has benefitted greatly from an early norming study of literary and nonliterary metaphors (Katz, Paivio, Marschark, & Clark, 1988). A professional writer edited all the selected literary metaphors into *A is B* format, where *A* is the target (or topic) being described, and *B* is the metaphorical source (or vehicle). An example of a literary metaphor from the norms is *Melancholy is a weeping cloud* (John Keats); a nonliterary example is *A tree is an umbrella*. This item set was extensively analyzed by Jacobs and Kinder (2017, 2018) using machine-learning algorithms and other quantitative methods. Although the differences are often subtle, machine-learning algorithms are able to distinguish literary from nonliterary metaphors with high accuracy. Jacobs and Kinder (2018) found that qualities distinguishing literary metaphors rated high in goodness include high surprisal (a statistical measure of the unexpectedness of words), relative dissimilarity of

source and target concepts, the combination of concrete words with relatively complex grammar and high lexical diversity, and extra difficulty in comprehending the metaphorical meaning. These properties collectively suggest that good literary metaphors are high in cognitive complexity.

A number of studies have specifically examined comprehension of literary metaphors, sometimes with a direct comparison to nonliterary ones (e.g., Gibbs & Bogdonovich, 1999; Marks, 1982; Stamenković, Ichien, & Holyoak, 2019, 2020; Stamenković, Milenković, Ichien, & Holyoak, this issue; Stamenković, Milenković, & Dinčić, 2019; Tourangeau & Rips, 1991; for a recent review see Glicksohn & Goodblatt, 2021). Many of these studies have focused on individual differences that impact metaphor processing. Classical theories of intelligence (Cattell, 1971) distinguish *fluid* and *crystalized* intelligence as separable factors. Fluid intelligence involves reasoning (often nonverbal) about novel problems detached from prior knowledge, and crystalized intelligence involves reasoning (typically verbal) that draws upon prior knowledge. Metaphor comprehension taps both of these basic forms of intelligence. In broad strokes, studies have found that crystalized intelligence (based on measures of vocabulary or recognition of semantic similarities) is a robust predictor of comprehension across the full range of metaphors, but especially for literary metaphors that are either relatively unfamiliar or more apt (Stamenković et al., this issue). Superior verbal knowledge thus appears to be particularly important when trying to find meaning in novel metaphorical expressions, and when exploring the rich interpretive potential of apt metaphors. For literary metaphors, the impact of variations in crystalized intelligence is enhanced when the metaphor is preceded by a supportive linguistic context (Stamenković et al., 2020). In contrast, individual differences in fluid intelligence (assessed by measures of working memory and inhibitory control) mainly impact comprehension of more cognitively complex metaphors, such as those that arise in literary sources.

Many neuroimaging studies have examined neural responses to a variety of metaphor reception tasks, using simple metaphors (usually nonliterary), most commonly presented in the *A is B* format. The findings from over 20 such studies were integrated into a meta-analysis by Bohrn, Altmann, and Jacobs (2012a). A number of brain areas tend to be activated to a greater degree when processing metaphors as compared with literal language. Notable areas that support metaphor include broad regions of the temporal cortex, the inferior frontal gyrus (often linked to semantic selection; Thompson-Schill, D'Esposito, Aguirre, & Farah, 1997), and sometimes the dorsolateral prefrontal cortex (a major substrate of working memory). Activation is typically bilateral, but sometimes more pronounced in the right hemisphere for relatively novel metaphors.

A small number of studies have examined the *production* of metaphors, sometimes in open conversation (Hussey & Katz, 2006), but more often in a task requiring completion of a metaphor given a target as prompt (Chiappe & Chiappe, 2007; de Barros, Primi, Miguel, Almeida, & Oliveira, 2010; Pierce & Chiappe, 2008; Silvia & Beaty, 2012). Several studies have focused on the production of metaphors rated as especially novel or creative (Beaty & Silvia, 2013). Generation of both novel and relatively conventional metaphors involves attentional resources and inhibitory control, but production of novel metaphors appears to depend on a more complex set of additional cognitive processes (Menache et al., 2020).

Studies of the neural basis for metaphor production have provided evidence that (particularly for novel metaphors) multiple broad networks play cooperative roles. Two networks of particular interest are the *frontoparietal control* network, which tends to be active during demanding cognitive tasks, and the *default* network, which includes midline and inferior parietal regions associated with spontaneous and self-generated thought, including "mind wandering" (e.g., Andrews-Hanna, Smallwood, & Spreng, 2014). Some regions within the default network (notably the left angular gyrus and posterior cingulate cortex) are also linked to semantic processing. Although often anti-correlated, evidence has emerged that key nodes of the control and default networks may collaborate in tasks involving creative cognition (Beaty, Benedek, Silvia, & Schacter, 2016). Most notably, a neuroimaging study by Beaty, Silvia, and Benedek (2017) investigated functional interactions between brain regions during novel metaphor production. This task selectively activated a distributed network that included nodes of the default network (precuneus

and left angular gyrus) and also the control network (right intraparietal sulcus). Connectivity analyses found increased coupling of the default and control networks later in processing, with a further *salience* network (related to attention) possibly acting as a switching mechanism. These findings suggest that metaphor production involves similar brain network dynamics as other forms of goal-directed, self-generated cognition. A general possibility is that the control network orients the general direction of associative thinking toward some goal, and then protects the default network from interruption as a memory search is conducted to find remote semantic connections.

Neurocognitive basis for poetry generation

Of course, poetry composition involves more than generation of metaphors (and indeed, even the more "creative" metaphors generated in psychological experiments are seldom very "poetic"). To the best of my knowledge, only one study has examined what happens in people's brains when they compose poems. Liu et al. (2015) used neuroimaging to trace the neural networks that are active when poetry is being composed and revised. The participants in their study were asked to perform several tasks, including composing a short poem, revising their new poem, and (as a non-creative control) recalling poems they had memorized – all while lying inside a scanner. Some of the participants were novice poets, and others were relative experts (graduate students in an MFA program who had published in poetry journals). Later, a panel of experienced poets evaluated the poems that had been produced, judging their craftsmanship and linguistic creativity.

Liu et al.'s (2015) findings support the general conception of creativity as depending on a delicate balance between the activity of different neural networks. The dorsolateral prefrontal cortex and parietal areas, including the precuneus – major nodes in the control network – were relatively *de*activated during the initial phase of composition, but were highly active later when poems were being revised. Notably, the rostrolateral prefrontal cortex – an area typically activated during complex analogical reasoning (see meta-analyses by Hobeika, Diard-Detoeuf, Garcin, Levy, & Volle, 2016; Vartanian, 2012) but not in comprehension of simple metaphors (Bohrn et al., 2012a) – was highly active during poetry composition. This area may play an important role in linking the control and default networks, acting to guide divergent thinking and make conscious use of the information it activates. The medial prefrontal cortex and a broad set of language-related areas were particularly active during the composition phase. The medial prefrontal cortex – important for motivation and self-initiated action – was highly active in revision as well as composition. The deactivation of parts of the control network during composition may allow unconscious processes to more freely activate ideas, emotions and words related to the emerging poem. During the revision process the control network may guide self-evaluation of the poem, identifying lines that need improvement.

Unsurprisingly, the experts wrote higher-quality poems than did the novices. Although the basic networks involved in writing poetry were the same for poets at both skill levels, the experts showed a more pronounced deactivation of the control network during composition, accompanied by greater activation of lower-level, subcortical brain areas. With increased experience, poets may be able to perform some basic subtasks, such as tracking rhythm and meter in an emerging poem, in a relatively automatic fashion, so that cognitive control is no longer needed.

The study also revealed some intriguing hints about the neural correlates of writing superior poems. When experts generated poems that garnered high craft scores, the medial prefrontal cortex was especially closely coupled with language areas, but less closely coupled with posterior parietal areas – the default network apparently was running with reduced direction from the control network. And when experts generated poems rated high in linguistic creativity, the dorsolateral prefrontal cortex was less closely coupled with sensorimotor areas. It seems that the control network lessened its regulation of these areas, allowing sensory imagery (often involved in poetry) to become available more freely, so that it found its way into the emerging poem.

In broad strokes, the ability to write good poetry depends on multiple factors – intrinsic motivation to create, intense emotional experiences, excellent memory for emotions and sensory details, a grasp of symbolic connections, and of course high verbal ability. Any kind of creative activity will be aided if a person has a rich associative memory in which very different concepts and experiences are linked, directly or indirectly. The literary critic I. A. Richards argued that, "Words are the meeting points at which regions of experience which can never combine in sensation or intuition, come together" (Richards, 1936, p. 119). Words provide a nexus linking cognition, perception, and emotion.

The right hemisphere of the brain may be especially important for finding relatively remote semantic connections. Beeman (1998) suggested that the right hemisphere may support *coarse coding* of meaning. Whereas the left hemisphere codes a small number of strong semantic associations for each word we know (e.g., *cut* might be linked to *knife* and *wound*), the right hemisphere codes a larger number of weak associations (e.g., *cut* might have connections to *foot, glass, join, bandage*, and many other words). Coarse coding in the right hemisphere may enable multiple weak associations to sum up, activating a word that is especially appropriate in a particular context. The broad but weak associations coded by the right hemisphere may be especially helpful in creative thinking, including producing and understanding novel metaphors. Damage to the right hemisphere impairs the ability to comprehend metaphors (Brownell, Simpson, Bihrle, Potter, & Gardner, 1990), as well as other aspects of language use that depend on sensitivity to context (Stemmer, 2017). Intriguingly, the right hemisphere is especially important for prosody, which underlies the rhythm and meter of poetry, and is closely linked to emotion. It is likely that similarities of sound interact with similarities in meaning in the process of finding words with which to create a poem.

The organization of words – not only in terms of their basic meanings, but also in their emotional impact, sensory associations, and phonological qualities – varies across individuals. Richards suggested that, "The greatest difference between the artist or poet and the ordinary person is found . . . in the range, delicacy, and freedom of the connections he is able to make between different elements of his experience" (Richards, 1948, p. 181). There is indeed evidence that individual differences in associative networks are related to creativity. Kennet, Anaki, and Faust (2014) divided young adults into two groups based on their score on a battery of standardized tests of semantic creativity. The participants provided word associations – given a target word, they had one minute to generate as many associated words as they could think of. Using statistical techniques, the researchers were able to reconstruct associative networks that best predicted the typical responses for the groups that scored low or high in creativity. The networks for those in the high-creativity group appeared to be less segregated into distinct clusters, and overall more interconnected. It is possible that the semantic networks of poets may be organized in a way that allows greater flexibility in how words can be accessed and used.

Out of the lab and into the poem

Laboratory studies of metaphor processing typically require responses within a few seconds. Even Liu et al.'s (2015) study of poetry composition was limited to a single session of just over half an hour, with the composition and revision phases artificially segregated from one another. In actual practice, a poet will often interleave composition and revision over a much more extended time period. As the poet Stephen Spender observed, " . . . the work on a line of poetry may take the form of putting a version aside for a few days, weeks or years, and then taking it up again, when it may be found that the line has, in the interval of time, almost rewritten itself" (Spender, 1946/1952, p. 118).

The gap between laboratory research and poetry composition is particularly acute for metaphor and symbolism. Poetic metaphors, relative to prosaic examples, tend to be especially directed at emotional impact. In addition, they aim to accomodate constraints associated with their genre, notably phonological patterns (meter, rhyme, alliteration, etc.). A prose passage may include "poetic" metaphors that have similar properties (e.g., John Donne's "No man is an Island" appears in what is often termed a "prose poem"). Behavioral and neural studies of metaphor processing have primarily focused

on examples in the *A is B* format (although some studies have examined predicate metaphors, such as "The violent image rattled in her head"; Cardillo, Schmidt, Kranjec, & Chatterjee, 2010; Stamenković et al., 2019). Besides serving to standardize the syntax of experimental stimuli, the *A is B* format matches the canonical form of analogies (e.g., Tourangeau & Sternberg, 1982), category statements (Glucksberg & Keysar, 1990), and conventional metaphors coded as slogans ("Life is a journey"; Lakoff & Johnson, 1980) – all of which have been proposed as theoretical underpinnings of metaphor (for a critical review see Holyoak & Stamenković, 2018). But although poems are certainly populated by *A is B* metaphors ("Juliet is the sun"), poetic metaphors can involve other syntactic elements, including verbs (John Dryden's "He glides unfelt into their secret hearts") and adjective-noun combinations (Donald Justice's "I indulge myself/in rich refusals"). Current psychological accounts of metaphor must strain to encompass the rich variety of their syntactic forms.

The *A is B* format is particularly limiting when translated into a typical paradigm for investigating metaphor production: completing a statement in the form *A is* ____, where *A* is the target (often accompanied by some characterization of what is to be said about *A* using some to-be-proposed metaphoric source). This production paradigm is very much in keeping with the canonical description of analogical retrieval: given some target analog as a retrieval cue, search memory for a source likely to generate useful inferences about the target (e.g., Gick & Holyoak, 1980). There is no doubt that poets often begin to compose with a target in mind, coupled with some idea of what they wish to say about it, and then search for some suitable source to create a metaphor. But there are good reasons to suspect that poets can be more flexible in their creative process, which is why metaphors in poems vary so widely in form as well as content. When Frost claimed, "Every poem is a new metaphor inside . . .," he did not mean it must include some particular sentence in *A is B* format. Whereas psychologists have focused on what I have termed *focal* metaphors, in which a specific word radically departs from its conventional meaning, *extended* metaphors are longer (sometimes involving an entire poem), and less dependent on radical changes in the meaning of specific words (Holyoak, 2019). Moreover, rather than beginning with a clear target, a poem may never (overtly) refer to the target at all.

As an example of an extended metaphor, here is a short poem by William Blake, which remains famous after more than two centuries. Most readers find it compelling, evocative, and enigmatic.

The sick rose

O Rose thou art sick.
The invisible worm,
That flies in the night
In the howling storm:

Has found out thy bed
Of crimson joy:
And his dark secret love
Does thy life destroy.

"The Sick Rose" appeared in the second half of Blake's 1794 collection *Songs of Innocence and Experience* (i.e., as "a song of experience"). On the surface, the poem describes the relationship between two key symbols, the rose and the worm. The rose usually represents love, fragile beauty, purity and innocence. It's under attack by the worm – strongly associated with disease and death, and perhaps phallic (especially in the context of *bed* and *crimson*). If these linked symbols are considered the metaphorical source, it is far from obvious that Blake could have simply "retrieved" this source as a unit pre-stored in his long-term memory. Rather, the rose and worm have been transformed by personification: this worm harbors a "dark secret love" for the rose whose life it destroys. And what is the target being described? Readers and critics have long debated the interpretation of the poem. Is the poem saying something about the way experience preys on innocence, and inevitably corrupts it? That innocence demands experience? We may be left uncertain about what the poem is really "talking

about," but this vagueness does not detract from – indeed, may enhance – our esthetic reaction to it. As Black (1962) famously emphasized, a metaphor may create an interaction between the source and target, changing the meaning of both. In a poetic metaphor, symbols may create an interactive aura of ideas, emotions and remindings in which source and (perhaps unstated) target seem to merge.

We have no way to know the sequence in which Blake found the words and ideas that gave rise to his poem. However, a common theme in first-person accounts by poets (and other creative artists) is that the creative act is accompanied by a loss of the sense of personal control or even identity. The emerging poem is experienced as being in some sense "received" from a source beyond conscious thought, sometimes lauded as a divine spark emanating from a muse or daemon. The American poet Amy Lowell provided an intriguing technological analogy: "Let us admit at once that the poet is something like a radio aërial – he is capable of receiving messages on waves of some sort; but he is more than an aërial, for he possesses the capacity of transmuting these messages into those patterns of words we call poems" (Lowell, 1930/1952, p. 110). Lowell describes how she formed the basic idea for a poem about horses, then "consciously thought no more about the matter. But what I had really done was to drop my subject into the subconscious, much as one drops a letter into the mail box. Six months later, the words of the poem began to come into my head ...." But the unconscious is seldom so generous as to yield a complete poem. According to Lowell, a poet "must fill in what the subconscious has left, and fill it in as much the key of the rest as possible." Similarly, the French poet Paul Valéry (1958), spoke of "one line given" by some mysterious source, which provides a seed for conscious poetic work.

Poetic seeds: a case study

Sometimes when I write as a poet, the psychologist makes a few observations while peeking in from the sidelines. I'll give a couple of examples of how a poem may get started. Of course, my anecdotes should be viewed with the skepticism appropriate for introspective reports. Many of the core processes that contribute to poetic creation are surely automatic and unconscious. Moreover, the original poetic inspiration or intention in using any specific metaphor may change with time. At best, the poet can offer some insights derived from personal knowledge related to the origins of symbols that found their way into the poem. In an effort to at least partially sidestep the biases that impact human memory, I have chosen examples of poems I wrote relatively recently.

The first is a poem I wrote over a couple of days at the end of July 2020.

A skimming stone

A child lets fly a smooth gray stone,
Sets it skimming across a lake
To glide, touch down, rebound, glide on,
With each touch leaving in its wake
Circular waves diminishing,
Each glide less strong, more quickly passed,
A wounded shorebird on the wing
That rises, drops, and sinks at last.

I was that child, counting each
Triumph of motion over weight,
Wondering how far my stone could reach
Before succumbing to its fate;
Or so it seemed – but then I found
How decades skip on by, each one
Gone more quickly, adding a wound
To mark me as the skimming stone.

For me, a poem almost invariably begins with an image, phrase, or idea that I find to be emotionally charged. To have a chance at success, the poem aims to evoke this emotion in a reader. In this instance, what provided the seed for the poem came to completely dominate it, from the title on – a skimming stone. Like most of us, I carry memories of many occasions when I've played the game of trying to make a small stone skip as many times as possible over the surface of water – as a child myself, and with my own children. Decades of accumulated experiences and occasional reflection turned the skimming stone into a symbol – meaningful to me, even if I couldn't articulate what it was a symbol *of*.

I finally wrote the poem when I was 70 years old, an age by which the brevity and fragility of life have become achingly apparent. Moreover, the world was in the midst of a deadly pandemic. The immediate seed was my realization that the skimming stone provides a source analog for a human life, in which the mapping – who is the stone, and who the thrower? – is reversible (something like a Gestalt image in which figure and ground can reverse). So in the first stanza the child plays with the stone; the second stanza announces "I was that child," or "so it seemed," until by the final line, life has "marked me as the skimming stone." Along the way, the dominating symbol is connected to its own metaphor, with the skimming stone seen as "a wounded shorebird" – a creature living between land and water, trying to fly but failing.

A question lingers at the end – if a person's life is the stone, who or what is the thrower? God, fate, or the younger self? No resolution is offered, or required. Unlike formal analogies, which ideally provide "clean" one-to-one mappings, a metaphorical symbol can act as what the literary theorist Philip Wheelwright (1968) termed a *plurisign*, in which multiple meanings merge into a new unity.

As a second example, quite different in origin, here is a poem I wrote in mid-August 2021.

Burn

Who marked the songbirds as the purest
Offering and set their wings ablaze?
Whose god laughs that the orange forest

Dances to death in praise?
A flock of shooting stars reversed,
They soar in aimless arcs that sear
The sky – streaks that sparkle, burst,
Flicker and disappear.

In final flight from earth undone
By fire their throats unite in wild
Lament, as though their cries were one
Scream of a human child.

In western North America, the summer of 2021 was marked by widespread and devastating forest fires, on a scale that could only be attributed to human-generated climate change. I was not directly affected by the fires, but one of the stricken areas was British Columbia, where I grew up and much of my family still lives. A terrible heat wave struck the Pacific Northwest in late June, and fire destroyed a small town. About a month later, my sister called me to say she was suffering from severe anxiety, triggered by the heat, smoke in the air, and news images of the fires. Always a lover of animals, my sister twice remarked that she kept thinking of the forest animals terrorized and killed by the flames. Her temperament had always been exceptionally even and calm, so I was shocked that my sister was suddenly suffering from anxiety. And I was angry at the human greed, stupidity, and willful ignorance that threatened to destroy our homes on this planet.

My emotional reaction to this phone conversation provided the impetus to write the poem. I had been struck by my sister's emphasis on the plight of the forest animals, the most innocent of all victims. At first I imagined the typical forest mammals, the deer and bear. But somehow I was

reminded of a different image – living birds on fire. Several months earlier, I had watched Season 2 of the Netflix series *Marco Polo*. In the opening scene of the first episode (a flashback), Genghis Khan orders thousands of swallows to be set on fire and then released to fly back to the city of their masters, which they set ablaze. The image of burning birds, streaking across the sky, was both horrific and beautiful. Taken completely out of its original context, this image became the seed for my poem.

As the poem developed, I blended in other associations. Like doves, the birds in the poem are being sacrificed to some cruel god. Like "shooting stars reversed," they each leave a track in the sky as they fly upwards in futile attempts to escape the devastated earth. As songbirds, their calls turn into cries of agony, ending as "one/scream of a human child." The suffering of the natural world inevitably leads to human suffering. So it was in the image from *Marco Polo* that provided my poetic seed: the birds burn first, and then the city.

In these sketches I've emphasized the seed from which a poem begins. Needless to say, many a seed fails to sprout or grow. Other images have struck me as laden with symbolic import, yet have not triggered a creative response (at least not yet). In Yellowstone National Park, there is an exuberantly multicolored hot spring (the largest in the United States) called the "Grand Prismatic Spring." I visited there a few months ago, and felt it could be a symbol worthy of a poem. But nothing more has come to me. I may never learn what the Grand Prismatic Spring was meant to be a symbol of.

A neurocognitive approach to poetry composition

The approach of neurocognitive poetics (Jacobs, 2015) has primarily been directed toward investigations of the reception of poetry by readers. Although research on poetry generation faces formidable methodological obstacles, in principle the neurocognitive approach can certainly be applied to the process of composition as well. New experimental methods will be required. For example, recently-developed paradigms for neuroimaging throughout a continuous two-hour session of listening to natural stories, coupled with analytic tools that allow detailed mapping of neural responses in specific brain areas over time (de Heer, Huth, Griffiths, Gallant, & Theunissen, 2017), may eventually prove adaptable to investigations of literary composition.

As I noted earlier, studies of poetry (and metaphor) reception are potentially relevant to composition as well, insofar as authors are guided by constraints based on the intended impact of their composition on readers. That is, factors that make a poem engaging or esthetically pleasing may well be internalized by poets, and hence also play a role in guiding the process of writing. An example of such a factor, emphasized by Jacobs and his colleagues (e.g., Bohrn, Altmann, Lubrich, Menninghaus, & Jacobs, 2012b), is *defamiliarization* – making the familiar strange by novel linguistic variation. This basic idea has a long history in literary criticism, from the Russian Formalists (Shklovsky, 1917/1988) to recent critics (Bloom, 2011, the chapter "Sublime Strangeness"). The philosopher H. D. Lewis, referring to art in general, claimed that, "its purpose is to make us see things as we have never seen them before .... All things are made new in art, they are made for the first time, they count for their own sake instead of being pointers by which we move about in our own orbit" (Lewis, 1946, p. 155). In a neuroimaging study in which people read variations of proverbs, Bohrn et al. demonstrated that defamiliarization is an effective way of guiding attention. In particular, when defamiliarization altered the content of the original proverb, neural activation was increased in affect-related regions (orbitofrontal and medial prefrontal cortex).

Defamiliarization (which can be enhanced by novel metaphors, as well as various other literary devices), is one of several factors that contribute to the cognitive complexity of poetry, and in some cases to its esthetic impact. In addition, certain phonological properties, such as phoneme sonority (related to acoustic energy) impact reading time and probability of fixation during eye movements when reading poems (Xue, Lüdtke, Sylvester, & Jacobs, 2019). The expert writer (or musician, or artist) may be able to integrate multiple constraints that jointly guide the search for elements that fit the emerging composition. There is evidence that adding constraints to a problem can sometimes

increase the creativity of eventual solutions (e.g., Finke, 1990). I've noticed, for example, that composing poetry under the formal contraints of meter and rhyme generates "creative difficulties" that interact with semantic pressures to shape a poem.

In addition to behavioral and neural studies, a deeper theoretical understanding of literary reception and composition may be guided by developments in computational modeling of lexical semantics. A basic problem posed by metaphor, as it stretches the combinatorial potential of word meanings, is to explain how the semantic representations of words interact to create emergent meanings. This problem has fed longstanding theoretical debates (Holyoak & Stamenković, 2018). A stumbling block in understanding metaphor processing has been finding a way to capture not only the core semantic meaning of a word but also its "aura" of connotations and associations, as well as the way in which word meanings seem to shift based on their local linguistic context.

In recent years, machine learning algorithms applied to large text corpora have been used to represent the meanings of individual words as high-dimensional vectors of continuous-valued features, termed *embeddings* (for a general overview see Günther, Rinaldi, & Marelli, 2019). Crucially, embeddings capture rich aspects of meaning that go beyond surface features and direct category relations. Using statistical techniques applied to word embeddings, Hollis and Westbury (2016; Hollis, Westbury, & Lefsrud, 2017) were able to use embeddings to predict such global semantic qualities as valence, arousal, dominance, and concreteness. Similarly, Utsumi (2020) was able to extract information from embeddings sufficient to predict the values of about 500 words on most of 65 semantic features for which neurobiological correlates have been identified (Binder et al., 2016).

As anticipated decades ago by Kintsch (2000), if words are represented by high-dimensional vectors, then combinatorial meanings (including metaphorical interpretations) can potentially be derived by simple mathematical operations (e.g., averaging) applied to vectors. By applying additional supervised learning techniques to word embeddings, vector representations can also be formed for semantic relations that hold between individual words (Lu, Chen, & Holyoak, 2019), enabling simple forms of analogical reasoning (Lu, Wu, & Holyoak, 2019). Similar distributed representations of semantic relations can also enable solution of more complex verbal analogies that require identifying optimal mappings between key concepts in source and target analogs (Lu, Ichien, & Holyoak, in press). Current machine-learning models of natural language processing such as BERT (Devlin, Chang, Lee, & Toutanova, 2019) can create embeddings not only for individual words in isolation, but also for words within a specific linguistic context, as well as for larger linguistic units such as sentences. Models based on BERT have achieved some success in automating the detection of metaphors in text (Choi et al., 2021), based on the general heuristic that a metaphorical word undergoes a strong contextual-driven shift in meaning, revealed by high dissimilarity of its embedding as an isolated word versus its embedding in the local linguistic context. Other artificial intelligence systems are able to generate novel poems after training with a set of poems written by humans (Köbis & Mossink, 2021), although it is unclear whether such computer algorithms will shed any light on the cognitive processes of human poets.

On the horizon, it is possible to imagine computational models that better capture the nuanced and often novel meanings expressed in poetry, including the interplay between cognitive, emotional, and sensory information characteristic of metaphor. As the field develops, it may become computational neurocognitive poetics. This broad approach may not only advance theoretical understanding of literary reception and composition, but also contribute to literary criticism. I have argued that neurocognitive criticism can be usefully combined with traditional biographical criticism (based on what is known about the personal history and influences that shaped an individual author) to help understand specific cases of literary composition (Holyoak, 2019). Let the conversation between poet and and psychologist continue.

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