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# Emergence of complexity in poetry: “Soleils couchants” by Verlaine

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**ABSTRACT** This work investigates emergence of complexity in poetry based on the analogy between the poetics of evocation and the physics of complex systems. For this purpose, we first discuss key concepts of the physics of complex systems, such as emergence, openness, and large variability. It is then suggested that a poem could be viewed as a representative complex system. Emergence of complexity in poetry is further probed in the context of poetics of evocation. As an example, we demonstrate how poetic complexity can indeed be realized, through the analysis of Verlaine’s poem, “Soleils couchants”. In this way, we propose a remarkable convergence of poetics and physics, yielding meaningful results for both fields. On the side of poetics of evocation, its essential characteristic, “relevant mysteries” that give rise to the great variability of interpretations, is verified; on the side of physics of complex systems, the concepts of complexity is validated to provide further understanding of literature as well as natural and social phenomena.

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## Introduction

Modern linguistics emerged in the early 20th century, as de Saussure declared “the scientific study of language” (de Saussure, 1916, p. 20). Likewise, modern poetics adopting such a linguistic approach began with Jakobson’s structuralist poetics that introduced objective analytical methods in the mid-20th century (Jakobson, 1960, p. 350, 1963, p. 210). At the early stage of this structuralist poetics, a poetic text was considered as an isolated system, which facilitated structuralist poetics to set up scientific methodology for the formal analysis of the texts. This perspective is similar to the viewpoint of physics: matter consists of components interacting with each other, by means of which various physical phenomena could be understood.

Compared with traditional approaches, the structuralist approach gave rationality and objectivity to the study of poetry. However, there are limitations in this approach, not taking due consideration of semantic aspects. Furthermore, a poetic text, with its autonomy overestimated, is isolated from the world around it. If we compare this to the study of life, it amounts to observing the structural organization of individual organs only. The lack of environments in the study of life should result in insufficient and restricted understanding of the nature of life phenomena, because life phenomena are delivered and maintained essentially through exchanges of information between the living organism and environment.

At the end of the 20th century, there emerged a new trend in poetic research: pragmatic-cognitive perspectives in which information processing and cognitive semantics play a key role. To this tendency belongs the poetics of evocation (Dominicy, 1990, 1992, 2008, 2011; Ruwet et al., 1996; Choi(-Diel), 2001, 2005, 2016; Gouvard, 2001), which proposes to associate the cognitive necessity with the formal one of the structuralist poetics (Jakobson, 1960, 1963; Ruwet, 1975). The poetics of evocation allows different interpretations according to the diversity of individual experiences and the socio-cultural context.

According to Sperber (1974, pp. 133–135), evocation is a way of solving the problem of “a half-understood idea”. He defined, from the viewpoint of cognitivism, the concept of evocation, which Dominicy borrowed for the poetics of evocation. It is therefore possible, with recourse to evocation, to “arrive at its best interpretation” (Sperber, 1996, p. 101), because the initial purpose of the evocation is to reconstitute the information background by recollection or by imagination. In a sense, the most evocative representations can never be definitively interpreted, and they are “relevant mysteries” (Sperber, 1996, p. 101). This gives rise to the large variability of interpretations.

Here the poetics advocating scientific thought encounters difficulties. To overcome these difficulties, it is necessary to draw attention to physics of complex systems, which appeared late in the 20th century (Mainz, 2007; Nicolis and Nicolis, 2012). We show in particular how the concepts of complexity, i.e., the emergence of large variability in an open system of interacting components, could provide a clue to the scientific foundations of the poetics of evocation. Moreover, theory of complex systems in physics is concerned not only with conventional matter but also with the role of information for the interpretation of natural phenomena, including life as well as society.

In this sense, we propose to study the emergence of complexity in poetry through the analysis of Verlaine’s poem, “Soleils couchants” (Verlaine, 1996). Our analysis of the poem is based on the formal principle of parallelism and on the semantico-cognitive principle of stereotypy in the poetics of evocation (Dominicy, 1990, 1992, 2008, 2011; Choi(-Diel), 2001, p. 20 and chap. 3). The interplay of these two principles makes the representation more evocative than the poem itself (Choi(-Diel), 2005, 2016).

This paper consists of four sections. In section “Complex systems and complexity: life and poetry”, characteristics of complex systems in physics are discussed whereas section “Emergence of complexity in Verlaine’s “Soleils couchants”” is devoted to the analysis of how the complexity of poetry is reflected on poetics of evocation. The interpretation of Verlaine’s “Soleils couchants” from the viewpoint of complex systems is also discussed. Finally, section “Conclusion” summarizes and concludes our key results.

## Complex systems and complexity: life and poetry

Theory of complex systems has been developed to understand various complex phenomena in matter, life, and society in the perspectives of universal knowledge. The theory was originally established in physics and has been extending its scope to social sciences and humanities as well as arts (Voss and Clark, 1978; Morin, 1990; Morin and Le Moigne, 1999; Rigau et al., 2008). In this new framework, we argue that life could be further understood in terms of exchange of information between a living organism and surrounding environment, rather than of mere biological functions as considered traditionally. In this section, we explore close analogies between life and poetry in detail.

According to Aristotle, every individual object is composed of form and material. In this view, both life and poetry are composed of form and material, but they are different in the form exposed and material used. First of all, poetry, differing from a pure natural living organism, is a creative work of human being. Obviously, these two objects are ostensibly very different complex systems; nevertheless they resemble each other in their properties and intrinsic attributes surprisingly.

Essentially, all substances in nature that we experience through our sensory organs are many-particle systems consisting of a large number of constituent particles, say, atoms or molecules. In such a many-particle system, appropriate interactions between components bring on so-called cooperative phenomena and give rise to collective properties of the whole system, which may not be reduced to the properties of individual components of the system (Sethna, 2006, p. 192; Choi, 2019, p. 423).

In physics, a complex system stands for the many-particle system displaying complexity. Although there does not exist a precise definition of complexity (otherwise the system is perhaps no longer complex), it is usually characterized by large variability arising from nonlinear interactions between components (Choi, 2003; Nicolis and Nicolis, 2012, p. 114). More precisely, a complex system is often described by the following three characteristics: First, a complex system is a many-particle system with a large number of components. Nonlinear interactions among components bring on emergence of collective properties irreducible to the individual components. Therefore, observing the complex system in fine-grained or coarse-grained views, one finds new details and diversity present at every stage and self-organized structures of all sizes. Second, a complex system is an open system. In consequence a complex system keeps exchanging energy and/or information with its surrounding environment, and exhibits emergence of new states, whilst a closed system in isolation from the outside world should reach an equilibrium. Third, a complex system implies large variability on the border of order and disorder. This means that the complex system builds a moderately stable structure between order and disorder, and possesses flexibility toward new possibilities.

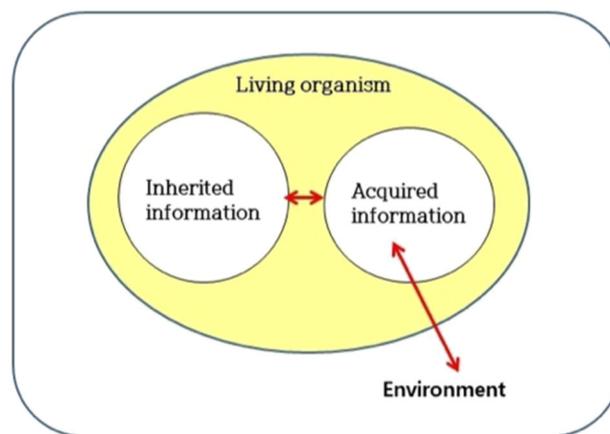
In general, the large variability results from frustration that disallows the optimal configuration satisfying all the relations between components of the system. This may in turn bring on unpredictability in the sense that tiny differences in the initial

conditions can lead to totally different results. A complex system with such large variability exhibits flexibility in adaptation to changes of the situation, such as the environment, and seeks constantly for other possibilities by exchanging influences with surroundings. In short, complexity implies new possibilities.

In the spirit of physics of complex systems, biological physics, unlike the traditional view of life, considers the essence of life to lie not in individual components (e.g., biomolecules) of the living organism but in the organization of such components (Nelson, 2008). From this viewpoint, life is collective properties emerging via cooperative phenomena among the components constituting the organism. In view of the enormous complexity inherent in life, one may regard a living organism as a representative complex system and life as the ultimate complex phenomenon. A living organism is made up of cells, each of which is made up of many molecules including protein and DNA. It is obvious that there does not exist the phenomenon of life in the individual molecules. Once a large number of such molecules form a cell, the arcane phenomenon, life, arises in the many-particle system called a cell. Such collective properties via cooperative phenomena are irreducible to the properties of individual components and rather irrespective of the details of the latter. Appearance of such collective properties is thus called emergence. Recently, this idea has been applied to understand various social phenomena such as consumers' referral (Jun et al., 2006), transportation network systems (Goh et al., 2012, 2014), and tweeting patterns (Kwon et al., 2013).

We argue that this idea could be applicable to the literary work as well. Consonants and vowels make a syllable, and syllables make a word. In the consonant and vowel, as the smallest unit of language, the meaning and concept do not come to exist yet; they emerge at the level of a word which is made of a combination of consonants and vowels. Despite being a creation of human, a syllable is analogous to a cell which is formed by atoms and molecules and gives rise to the life phenomenon. Likewise, a tissue or an organ, made of cells, may be compared to a clause or a sentence composed of words. Further, an organism, formed out of such tissues and organs, matches a literary work, which is constructed of sentences. In a creative poem or novel, diverse interpretations are allowed according to the interactions between components; such variability of interpretation corresponds to the complexity present in a complex system (Choi et al., 2017, pp. 22–23).

Here we begin with the recognition that “poetry is analogous to life”. The reason behind this idea is that while life of a living creature is most remarkable in its complexity, poetry also exhibits most remarkable complexity among all kinds of literary work. As information processing is crucial in delivering and maintaining such complexity, we pay attention to the information exchange between the object and environment in the study of life or poetry. With regard to this, all living organisms including the human being possess two types of information: inherited information descending from ancestors and acquired information obtained from the environment. The primary characteristics of a living organism is that it is well-organized out of various components. Such structure depends largely on the inherited information transferred from generation to generation. Indeed, a cell, which is a living thing at the most fundamental level, is amazingly well-organized. However, the term ‘well-organized’ does not mean perfect order. As mentioned already, a well-organized structure is associated with complexity existing on the border of order and disorder, and characterized by a huge amount of information. Such complexity allows a living organism to respond to changes of environments flexibly, and thus there is room for acquired information through experiences of individuals to give influence on the structure (see Fig. 1).



**Fig. 1** Living organism and information exchange

As life is organized hierarchically out of atoms, molecules, cells, organs, etc., so language is organized out of phonemes, syllables, words, clauses, sentences, etc. Moreover, grammar of the language regulates relations between the components of a sentence. Such grammar, like inherited information of a living organism, is transferred stably from generation to generation.

In general, poetic discourse is characterized by two types of organization. Like any other type of discourse, it obeys grammar. In addition, unlike other types of discourse, poetic discourse obeys a formal principle of parallelism (at metric, phonological, morphological, syntactic, and semantic levels). This double organization in turn gives rise to double reading in the process of interpreting poetry. On the one hand, the grammatical linear reading allows the semantic representation of given poetry. On the other hand, the nonlinear reading of the formal principle allows its symbolic interpretation, this time based on the semantico-cognitive principle of stereotypy. At this stage of the symbolic interpretation, acquired information in the process of an individual life, namely, individual experiences in the socio-cultural context, plays an important role.

As a result, poetry is characterized by dual structure, where the general grammar and the formal principle of parallelism overlap with each other. Through the dual structure, the economic principle of language, which amounts to a delivery of maximum information using minimum language materials, is applied to poetry. Note again that the dual structure of poetry does not imply perfect order. Allowing omission or ungrammatical sentences and using abundant figurative or metaphorical expressions, poetry expedites processes of symbolic evocation, which leaves room for individual readers to put autonomous interpretations via imaginations and not to be confined in standardized, one-sided meanings.

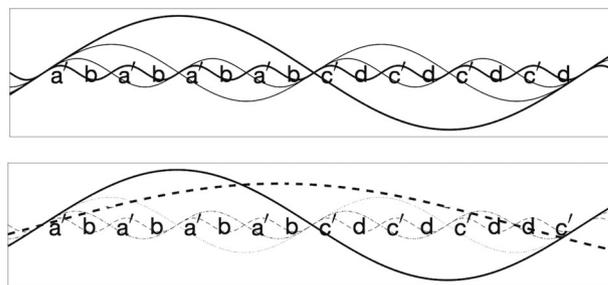
Since 1990, such a point of view has developed in the poetics of evocation, which supports the idea that evocation in poetry is based on the reciprocal play of a formal principle (superficial parallelism) and a semantico-cognitive principle (stereotypy). With regard to the theory of complex systems, this reciprocal play contributes, as we shall see in the next section, to generating poetic complexity.

### **Emergence of complexity in Verlaine's “Soleils couchants”**

We now analyze a poem of Verlaine. In particular, we examine how the characteristics of complex systems are manifested in the poem, paying attention to the emergence of complexity induced by frustration. The concept of frustration was first introduced as the expression of “frustrated waiting” in structuralist poetics,

**Box 1: Schema of rhyme in “Soleils couchants”**

Soleils couchants	Schema of rhymes	Setting suns
1Une aube affaiblie	a'	A weakened dawn
2Verse par les champs	b	Scatters onto the fields
3La mélancolie	a'	The melancholy
4Des soleils couchants.	b	Of the setting suns
5La mélancolie	a'	The melancholy
6Berce de doux chants	b	Rocks with sweet songs
7Mon coeur qui s'oublie	a'	My heart that forgets itself
8Aux soleils couchants.	b	To the setting suns
9Et d'étranges rêves,	c'	And strange dreams
10Comme des soleils	d	Like suns
11Couchants sur les grèves,	c'	Setting, on the sandbanks
12Fantômes vermeils,	d	Vermeil ghosts
13Défilent sans trêves,	c'	Parade without truces
14Défilent, pareils	d	Parade, alike
15A des grands soleils	d	To big suns
16Couchants sur les grèves	c'	Setting on the sandbanks



**Fig. 2** Typical rhythmic oscillations in ordered (top panel) and slightly disordered (bottom) complex systems. Solid and dotted lines denote stable and meta-stable rhythms, respectively

which is devoted solely to formal analysis (Jakobson, 1963, p. 228, 232, 1973, p. 207). Here we seek to extend the concept of frustration, so that it could further be applied to the interpretation in the perspectives of poetics of evocation.

Verlaine’s “Soleils couchants” (see Box 1) is the first poem of “Paysages tristes” in the collection *Poèmes saturniens* published in 1866. With the short meter (five syllables) and abundant repeats of words (“soleils couchants (setting sun)”, “la mélancolie (the melancholy)”, “sur les grèves (on the sandbanks)”, “défilent (parade)”), the poem looks apparently simple. Despite this, there are three independent studies (Fonagy, 1973; Combet, 1980; Choi(-Diel), 2001) offering very distinctive interpretations according to the viewpoints of researchers. The studies share at least the following: The poem appears simple at the first glance, but it has an extremely complex architectural structure whose components bind tightly to each other. Being reminiscent of complexity, this raises a possibility of interpreting the poem as a complex system.

In this section, we therefore probe the complexity of the poem in the perspectives of theory of complex systems. Our analysis of the poem is based both on the formal principle of parallelism and on the semantico-cognitive principle of the stereotype. Especially, we will focus on cooperative phenomena emerging via nonlinear interactions between all kinds of components (phoneme, vocabulary, syntax, semantics, metric, rhyme, etc.) of poetry, and show how these phenomena contribute to making the most evocative representation of the poem.

This poem arouses “frustration” from the beginning, which yields large variability in the interpretation of the poem. The syntagma, “soleils couchants”, is repeated, in addition to the title, four times in the body of the poem. Moreover, it is not in the singular, but in the plural. The unusual use of the plural favors the convocation of several concrete images of the sun visible in different places (land or sea), rather than an image perceived in a specific place, and allows diverse interpretations. This frustration is reinforced by the openness of the poem: The poem begins with “Une aube (a dawn)” that is temporally the opposite of the sunset and interpretable in different ways.

Let us consider typical features of the representation given by the title, stored in the long-term memory representation:

twilight glow  
 the grand ruddy sun on the horizon  
 light reflection in water

Taking these aspects into account, we attempt to show how the poem evokes or brings out the stereotypical image of the sun through the formal process of parallelism. Moreover, our study leads to the parallel between the evoked image and the paintings of Monet, *Impression, soleil levant* (1872) and *Soleil couchant sur la Seine, effet d’hiver* (1880): One represents the sunrise and the other the sunset (e.g., see Choi(-Diel), 2001, pp. 119–134). These two natural phenomena share some typical properties: They are at the hinge of a day and a night, and diffuse vague and ghostly light. The best example of these two categories is the sun reflected in the water, as seen in Monet’s paintings.

Frustration is also caused by formal organization. Despite the vagueness and sentimentality coming at the first glance, the poem possesses a complex organization, while maintaining the balance between order and disorder. This formal organization performs at various levels: syntactic, semantic, phonological, and of rhyme. The poem is entirely in the present tense, and consists of a sequence of 16 verses without stanzaic interruption, i.e., without any typographic blank. Notwithstanding this, one may observe its internal bipartition in several aspects. The resulting two octets overlap, and at the same time oppose to each other in terms of parallelism.

Note here the particular organization of rhymes that are not found anywhere else. All lines with five syllables are equivalent at the level of the meter. But in terms of rhymes (see the above schema of rhymes), the poem divides clearly into two parts: eight verses in the upper part (a’ba’ba’ba’b) and eight verses in the lower (c’dc’dc’ddc’), where feminine rhymes are denoted by a’ and c’ and masculine rhymes by b and d. This manifests that the stanzaic form of the poem does not coincide with the rhyme scheme. Moreover, the lower half causes a conflict between alternate rhymes (c’dc’d) and rhymes embraced (c’ddc’). This conflict structure gives rise to a formal complexity and opens the possibility of various interpretations. The emergence of these new interpretations could further be understood by the theory of complex systems, as illustrated in Fig. 2. For example, introducing slight disorder (i.e., reversing of c’d to dc’ in the bottom panel) induces a new rhythm (thick dashed line) to emerge at the cost of losing the stability of the nominal oscillations (thin lines).

In a complex system, various components are often placed at specific places in an ordered or slightly disordered pattern. In the case of an ordered system, typical rhythmic oscillations arise as shown in the top panel. When frustration comes into play by introducing some irregularity, e.g., reversing of c’d to dc’ in the bottom panel, stable oscillations would become unstable and a new rhythm could emerge as shown in the bottom panel.

We now proceed to analyzing the organization of phonemes. First, let us focus on cooperative phenomena generated by the nonlinear interactions between the three vowels /i/, /ā/, /ε/. They form the core of rhymes of the poem, and reappear within the

poem. They create both balance and tension in the overall shape of the poem. In particular, we turn our attention to the locations of the phoneme /ã/, highlighting a specific configuration, which refers to one of the typical features of the image of the sunset or sunrise.

There is striking composition of phonemes that makes perceptible the opposition between the two parts. The upper part is characterized by the alternation of vowels /i/ and /ã/, corresponding to the fundamental opposition (acute/grave, closed/open, diffused/compact, and oral/nasal). On the other hand, the lower part presents greater cohesion: Both rhymes include the mid-open vowel /ɛ/. The difference between the two parts is further enhanced in terms of words arranged in the rhyme position: The first presents the alternation of singular and plural (“2champs”, “4,8couchants”, “6chants”), as opposed to the second where all words bear the plural mark.

All these formal features provide clues that stimulate the imagination activity based on encyclopedism knowledge. Unlike the distinction arising from the first part, the formal features of the second suggest the fusion that is a characteristic of water. This symbolic interpretation, accessible from the formal features of the poem, is validated, owing to the presence of the lexeme “11,16grèves” which brings water to the memory. In poetry, the access to the symbolic knowledge inevitably involves semantic components (lexical and syntactic) of the language.

In addition, the parallelism between the two parts is supported by the chiasmus that realizes the sound relationship of rhymes and main verbs: “2Verse”, “6Berce”, and “13,14Défilent”. We are aware that the consonants /b/ and /v/ are labial sounds distinguished by a single trait (occlusive vs. constrictive), which allows virtually the phonic identification of /bers/ and /vers/. Phonemes /ver/ in the first syllable reappear in the feminine rhymes of the second octet, specifically in the inversion of the consonants /rev/ and also in /vermej/ (without inversion). The most acute vowel /i/, extended by the liquid /l/, appears in the second part, e.g., in the verb “13,14Défilent”. These two phonemes are, in the same way, connected to the rhymes of the first octet via inversion: /li/.

In this manner, all these phonemes participate fruitfully in cooperative phenomena. From this point of view, what is even more striking is the pattern formed by the nasal vowel /ã/ (also called a “heavy” or “full” vowel in France). This vowel appears six times in each part, but in different layouts. In the upper part, the vowels are presented in the form of two vertical lines, twice in the third syllabic position plus four times in the fifth syllabic position (rhyme) whereas in the lower part, they appear inside, following the zigzag path of syllables 3, 2, 1, 4, 3, and 2. We observe a very interesting cooperative phenomenon of the vowel /ã/, in the sense that it brings out one of the most typical formal features of the image of the sunset reflected in water (see Fig. 3). It should be noted that the vowel, as such, has no meaning, but the cooperation between several phonemes distributed in a spatial pattern could produce an evocative value in the context of the poem.

In this poem, the vowel /ã/ in the zigzag layout contains great potential variability. The scene now changes to “9d'étranges rêves (strange dreams)”, being the subject of the second octet. The position of “12Fantômes vermeils (Vermeil ghosts)” produces ambiguity and results in variability or complexity. Moving this group to line 10, following the subject, would not pose any syntactic and semantic problem. If this movement could give a single schema embraced regularly to the rhyme of the second part (c' ddc' c' ddc'), it would deteriorate the overall structural characteristics of this poem. On one hand, it would change the positional structure of the phoneme /ã/; on the other, it would unbalance the second part by removing the term “vermeils” together with its pivotal role. The observed structure thus imposes its own interpretation: “12Fantômes vermeils” can be associated

lines \ syllables	1	2	3	4	5
1					li
2	ver				jà
3			ã		li
4				ã	jà
5			ã		li
6	ber				jà
7					li
8					jà
9			ã		rev
10					lej
11			ã		rev
12	ã			ver	mej
13	de fil			ã	rev
14	de fil				rej
15			ã		lej
16			ã		rev

**Fig. 3** Phonological structure of “Soleils couchants” vs. of Monet’s Impression, soleil levant

not only with “9d'étranges rêves” but also with “10des soleils couchants”. These specific traits guide our interpretation through the process of symbolic evocation. Indeed, they reveal the evocative representation of the sunset reflected in water. The blurred and ephemeral reflection is often related to remembrance or reverie containing illusion. This reverie is a recurrent theme in the 18th and 19th centuries. For example, Rousseau relied on the theme in his search for “self” while Baudelaire sought to express his reverie of tortuous fantasy (Bénichou, 1988; Richard, 1971).

There exist two modes of reception of the poem: spatial reading and temporal reading. Spatial reading organizes the text as a picture and brings out the stereotypical image of sunrise and sunset, as in Monet’s paintings, Impression, Soleil levant and Soleil couchant sur la Seine, effet d’hiver. Temporal reading induces emotional availability, such as that would be if the reader has been before the natural spectacle which the poem pictorializes. Note further that the poem begins with “Une aube” and ends with “les grèves”. Dawn, the boundary between the day and night, announces the day, as the sunset, the boundary between the night and day, announces the night. Further, the sandbank is the boundary between the land and sea. The prototypic sun sets on the horizon or on the sea rather than on the sandbank. On the horizon of the sunset, the sky and the sea meet and merge. The poem thus stimulates the imagination activity, whereby we enter a universe in perpetual circulation without beginning or end, as the sunsets in their plural repeat day after day.

Finally, it should be remarked that the image of the sunset reflected in water is not immediately accessible but reconstituted through the process of evocation. Accordingly, we emphasize, on one hand, the importance of the dosage between the implicit and explicit in the creation of the evocative object, and on the other, the imagination activity of the interpreter in the interpretive process of evocation. We thus conclude that the poem, Verlaine’s “Soleils couchants”, is a striking example of a complex system exhibiting large potential variability.

## Conclusion

In this work, we have analyzed Verlaine's poem "Soleils couchants" to probe emergence of complexity in poetry, based on the analogy between the poetics of evocation and the physics of complex systems.

Firstly, we have taken notice of the key characteristic of a complex system: emergence of complexity (i.e., large variability) via cooperative interactions between components in open environment. Considering poetry as a complex system representative of literature, we have then investigated emergence of its complexity in the context of the poetics of evocation. According to this, poetic discourse is characterized by two types of organization. As in any type of text, it is first subject to grammatical and pragmatic constraints. In addition, unlike other types of discourse, it also obeys a formal principle of parallelism. This double organization in turn gives rise to double reading in the process of interpreting poetry. On the one hand, the grammatical linear reading allows the semantic representation of given poetry. Whereas the nonlinear reading of the formal principle allows its symbolic interpretation, this time based on the semantico-cognitive principle of stereotypy. In this manner, the poetics of evocation is based on the two principles: Evocation in poetry emerges from the interplay of the formal principle (superficial parallelism) and the semantico-cognitive principle (stereotypy).

Secondly, we have demonstrated how poetic complexity can actually be realized through the analysis of Verlaine's poem, "Soleils couchants". This poem exhibits at first glance the formal and semantic simplicity with the abundant repetition of the following phrases: "soleils couchants", "la mélancolie", "sur les grèves", "défilent". Despite this apparent symmetry, it displays excellent poetic complexity. In this regard, the most remarkable is the way in which the poem represents the image of the setting sun reflected in water, by appealing to the cooperation of vowel /ā/. As a result, from the viewpoint of the poetics of evocation, this poem creates evocative effects through the interaction between typical features of the setting sun and the games of parallelism. Such evocative effects have a close link with the poetic complexity, leaving a margin of freedom for the individual.

To conclude, we have pursued a pioneering meeting of poetics and physics in the perspective of complex system theories, which is, to our knowledge, the first attempt to obtain meaningful results both in poetics and physics. From the viewpoint of poetics, the essential characteristic of the poetics of evocation, which consists in calling attention to "relevant mysteries" that give rise to the great variability of interpretations, has been verified in the theoretical framework of complex systems.

On behalf of physics, the theory of complex systems has been applied to poetry beyond natural and social phenomena, which further expands the horizon of physics methodologies. Furthermore, our work has extended the scope of interdisciplinary research, which eventually offers possibilities for integrated studies of significance in science and humanities.

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## Additional information

**Competing interests:** The authors declare no competing interests.

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