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From the fortress of ideas to the house of cards of certainties: an epistemological essay on science and linguistics in modernity and postmodernity

Da fortaleza das ideias ao castelo de cartas das certezas: um ensaio epistemológico acerca da ciência e da linguística na modernidade e na pós-modernidade

Reiner Vinicius Perozzo
Universidade Federal do Rio Grande do Sul (UFRGS) | Porto Alegre | RS | BR
reiner.vinicius@ufrgs.br
https://orcid.org/0000-0002-7778-9690

Felipe Flores Kupske
Universidade Federal do Rio Grande do Sul (UFRGS) | Porto Alegre | RS | BR
felipe.kupske@ufrgs.br
https://orcid.org/0000-0002-0616-612X

Abstract: Linguistics consolidated itself as an independent science in the last century, being shaped by different approaches. During the modern era, promising trends, such as North American structuralism and generative theory, began to adopt methods and conceptual structures that brought them closer to the natural sciences, especially under the influence of positivism. However, a significant change has been observed in the epistemological panorama of linguistics, driven by the values of postmodernity. This new perspective shakes up truths previously considered absolute and proposes an alternative way of thinking about linguistic phenomena, for which Complexity Theory may account. In this new scenario, conceptually vast and endowed with transdisciplinarity, attention turns to diversity, flexibility and the influence of external factors on language structure and functioning. In this article, we offer epistemological considerations on the trajectory of linguistics in modernity (focusing on both the Bloomfieldian and the Chomskyan enterprises) and in postmodernity (addressing the perspective of complexity) and how this path relates to the construct of science in light of the entities and events of language. This objective is justified by the ability of Complexity Theory to embrace instability, unpredictability and heterogeneity as constitutive elements of language, using an ecological, non-linear and multidimensional view of linguistic phenomena and processes.

Keywords: linguistics; science; modernity; postmodernity; complexity.

Resumo: A linguística consolidou-se como ciência independente no século passado, sendo moldada por diferentes abordagens. Durante a modernidade, vertentes promissoras, como o estruturalismo norte-americano e o gerativismo, passaram a adotar métodos e estruturas conceituais que as aproximaram das ciências naturais, sobretudo sob influência do positivismo. Entretanto, tem-se observado uma mudança significativa no panorama epistemológico da linguística, impulsionada pelos valores da pós-modernidade. Essa nova perspectiva abala verdades antes tidas como absolutas e propõe uma forma alternativa de pensar os fenômenos linguísticos, os quais podem encontrar respaldo na Teoria da Complexidade. Nesse novo cenário, conceitualmente vasto e dotado de transdiciplinaridade, a atenção se volta para a diversidade, a flexibilidade e a influência de fatores externos no funcionamento da língua. Dessa forma, propomos neste artigo uma apreciação epistemológica da trajetória da linguística na modernidade (com foco nos empreendimentos bloomfieldiano e chomskyano) e na pós-modernidade (visando à perspectiva da complexidade) e como ela se relaciona com o construto de ciência à luz dos entes e dos eventos da linguagem. Tal objetivo se justifica a partir da capacidade de a Teoria da Complexidade acolher a instabilidade, a imprevisibilidade e a heterogeneidade como elementos constitutivos da linguagem, valendo-se de um olhar ecológico, não linear e multidimensional sobre fenômenos e processos linguísticos.

Palavras-chave: linguística; ciência; modernidade; pós-modernidade; complexidade.

1 Introduction: setting the stage

The systematization of knowledge and the tireless human task of solving problems are a memorable feat in the evolution of civilizations. The Scientific Revolution, approximately between the 16th and 18th centuries, consists of a series of events that marked the emergence of modern science, when developments in areas such as mathematics, physics, astronomy, biology, and chemistry transformed views of society over nature. The scientific endeavors of this period also had an impact on the design of language studies, particularly in the United States, whose objective was to "elevate" linguistics (especially in the 20th cen-

tury) to the level of natural sciences. In this scenario, modern linguistics began to incorporate inquiry mechanisms that reflected proposals from other sciences, operating mainly in the wake of analytical reductionism, empirical observations, commitment to universality, and closed linear systems. The appeal to rationality and the prestige of ideas as sources of knowledge served as a *fortress* against the apparent chaos and disorder of the world, protecting both scientific incursions and research methods.

Postmodernity (which began in the last decades of the 20th century), however, broke with the prevailing paradigm until then and established a new way of doing science. Thus, the new scientific approach questions some elementary principles of its predecessor paradigm[1] and points to phenomena that escape more conventional methods of treating them. The scope of much scientific research in postmodernity becomes related to substantially non-linear events, which have interdisciplinarity at their core and can only be adequately conceived if thought of as complex and adaptive systems. Again, this trend spread to other areas of knowledge, reaching, unsurprisingly, linguistics. As a consequence, the main points of linguistic science are challenged and new perspectives of analysis emerge to account for linguistic facts and units, which no longer comply with a system of transformational rules, nor with a set of violable universal constraints. No *fortress* is plausible here, and the most we can count on is a *house of cards*, as subtle as it can be, together with a body of certainties — equally changeable and smooth.

The present article offers a brief epistemological appreciation of three linguistic constructs in modernity and postmodernity, considering the undeniable influence of the precepts of science, in both periods, on the agenda of linguists. More specifically, aligned with the first branch of discussion proposed in this edition's theme, *questions of general linguistics in the light of different theoretical-methodological orientations*, this article aims to present an alternative view for the study of language, based on postmodernity and on the principles of Complexity Theory. This objective is justified to the extent that proposing to envision the study of language through a contemporary lens, grounded in the precepts of Complexity Theory, stems from both a critical reassessment of traditional linguistic paradigms and a broader epistemological shift currently occurring across the sciences and humanities. At its core, this proposal reflects an attempt to better capture the dynamic, adaptive, and emergent nature of language — a construct that resists being fully explained by means of linear, mechanistic, or overly reductionist models.

In order to accomplish our goal, we intend to draw parallels between science and linguistics, taking as a starting point the Scientific Revolution, and, as an ending point, postmodernity. This paper is, then, divided into five sections considering this brief introduction, which corresponds to the first section. The second section provides a bird's eye view to the study of language, in general terms, highlighting the efforts made by linguistics to reach scientific legitimacy. Its purpose is to introduce the reader to a few scholars and linguists that significantly contributed to the consolidation of the field in the last century. The third section

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[1] As this article counts on concepts from Epistemology and Theory of Science, we use the term paradigm to acknowledge Kuhn's (1962) approach to the notion of Scientific Revolutions. In this regard, the concept of "paradigm" is used to describe the conceptual structures, theories, and practices that dominate a particular area of science at a given time. In the case of modern linguistics, such a paradigm has never disappeared, even though a postmodern (alternative) paradigm has emerged. Therefore, whenever we characterize a paradigm as happening previously to another, it is solely for the sake of a timeline with didactic purposes, and we do not mean that paradigm is over or has been supplanted.

addresses a comparison between science and linguistics in modernity, indicating their main characteristics and developments. From numerous perspectives in linguistics, we focus solely on North-American Structuralism and on generativism because they capture the principles of modern science. The fourth section discusses science and linguistics in postmodernity, also listing its characteristics and improvements in contrast to the previous paradigm. This is done based on the notion that Complexity Theory represents an approach (out of many others) that is able account for linguistic phenomena as seen through the lens of postmodernity. Finally, the last section offers a conclusion — which does not claim to be exhaustive or definitive — about the reflections carried out in this text.

2 The scientific legitimacy of linguistics in the last century

Over the course of the twentieth century and into the twenty-first, linguistics has undergone significant transformations in its quest to be recognized as a scientific discipline. This endeavor has involved not only the refinement of its object of study — language — but also the systematic development of its methods, theoretical frameworks, and epistemological foundations. From the early structuralist movements to the emergence of generative grammar, and from the rise of corpus linguistics to interdisciplinary engagements with cognitive science and neuroscience, linguistics has persistently sought to align itself with the methodological and conceptual rigor typically associated with the natural sciences.

In the early decades of the twentieth century, the emergence of structuralism marked a decisive step toward the scientific formalization of language study. In Europe, Ferdinand de Saussure's *Cours de Linguistique Générale* (1916) introduced a conceptual shift by proposing that language should be studied as a system of signs defined by internal relations rather than by historical development alone. Saussure distinguished between langue (the structured, collective system of language) and parole (individual speech acts), emphasizing the necessity of analyzing language synchronically — as a system at a given point in time. This approach allowed linguistics to distance itself from philological traditions and align more closely with the structural and systemic thinking that characterized other emerging scientific disciplines of the era.

Meanwhile, in the United States, Leonard Bloomfield advanced a version of structuralism that was explicitly aligned with the principles of behaviorism and logical positivism: data-driven, objective, and free from speculative or metaphysical constructs. In his seminal work *Language* (1933), Bloomfield argued for a linguistics rooted in observable, measurable data. He advocated for the collection and classification of linguistic forms based on their physical properties (especially phonology and morphology), while deliberately excluding introspective accounts of meaning.

By the mid-twentieth century, this behaviorist and descriptivist model came under scrutiny. Noam Chomsky, beginning with *Syntactic Structures* (1957) and, later, *Aspects of the Theory of Syntax* (1965), revolutionized the field by proposing a mentalistic and formal approach to grammar, now known as generative grammar. Chomsky argued that linguistic competence — the internal knowledge speakers have of their language — could not be accounted for by surface behavior alone. Instead, linguistics must aim to uncover the abstract rules and principles that generate all possible grammatical sentences in a

language. He introduced the distinction between *competence* and *performance*, focusing on the underlying, idealized knowledge of language. Generative grammar employed formal models and rule systems, borrowing tools from logic and mathematics, and thereby repositioned linguistics within formal sciences.

Chomsky's work reoriented linguistics toward the cognitive sciences, contributing to the establishment of a new interdisciplinary framework that included psychology, neuroscience, philosophy, and computer science. This shift emphasized language as a cognitive faculty, and by doing so, linguistics became central to theories of the mind. The generative paradigm fostered rigorous hypothesis testing, formal modeling, and computational simulation — all hallmarks of scientific inquiry. Chomsky's approach was also deeply concerned with explanatory power, arguing that a truly scientific linguistics must not merely describe linguistic data, but explain it by positing innate structures and universal principles.

Parallel to these developments, the field expanded its empirical base through the rise of psycholinguistics and neurolinguistics, which introduced experimental methods for investigating language processing, comprehension, and production. These fields of study adopted tools such as reaction-time experiments, eye-tracking, ERP (event-related potentials), and brain imaging techniques (fMRI, PET), which provided neurological and cognitive evidence for linguistic theories. Such empirical techniques further strengthened the scientific profile of linguistics by grounding abstract theories in observable and measurable phenomena.

Another scholar that must be addressed is Mikhail Bakhtin. Bakhtin was a Russian philosopher and literary theorist whose contributions to linguistics emerged primarily between the 1920s and 1970s, though his influence on language studies became prominent internationally only after his death in 1975. His work introduced a radically social and interactional perspective on language, emphasizing that all utterances are dialogic — that is, shaped by and directed toward other voices. Key concepts such as dialogism, heteroglossia, and the utterance challenged formalist and structuralist models by foregrounding the social, historical, and ideological dimensions of language use.

Émile Benveniste was a French linguist whose work, primarily active from the 1930s through the 1970s, significantly shaped modern linguistic theory by emphasizing the centrality of the speaking subject in the construction of meaning. His most influential contributions lie in his development of enunciative linguistics, where he argued that language is not a static system but a dynamic act of enunciation, rooted in the relationship between speaker, listener, and context. By analyzing personal pronouns, tenses, and deixis, Benveniste demonstrated how subjectivity is linguistically constituted, marking a departure from models that treated language as an autonomous system.

In the latter part of the twentieth century, the advent of corpus linguistics and usage-based models brought new dimensions to linguistic science. The development of large digital corpora and computational tools enabled the study of language as it is used in real communicative contexts. Corpus linguistics emphasized frequency, distribution, and collocational patterns, offering a statistically grounded account of language structure and use. This approach complemented formal theories by providing extensive empirical data, and it supported the emergence of probabilistic models of grammar, which view language as shaped by patterns of usage and cognitive processing. Such models often integrate insights from cognitive linguistics, which, in contrast to generative grammar, emphasizes conceptual structures, metaphor, embodiment, and the interaction between linguistic form and meaning.

The history of linguistics over the last hundred years reveals a dynamic and multi-faceted effort to define itself as a science. From the structuralist focus on systemic organization, through the formal rigor of generative grammar, to the empirical breadth of corpus studies and the experimental precision of cognitive and neurolinguistic approaches, linguistics has consistently adopted and adapted scientific methods to deepen its understanding of language. At the same time, the field has embraced theoretical pluralism and epistemological self-awareness, recognizing that the scientific study of language must account for both its formal properties and its contextual, social, and cultural dimensions. This combination of methodological rigor and theoretical diversity continues to shape linguistics as a robust and evolving scientific discipline.

3 Analytical reductionism as the building blocks of science and linguistics

The Modern Age was relentless in the theoretical-methodological treatment of phenomena that manifested within the framework of science. The rise of analytical thinking and reason was guided by a new way of seeing the world, supported by a strong inclination towards rationalism, active knowledge, and a rigid method of investigation. As Aranha and Martins (2013) point out, this stance largely stems from a historical context marked by radical transformations, such as the abandonment of geocentrism, the growth of commercial activities, the expansion of urban centers, reformist movements impugning the power of the Church, and the technical and technological improvements that reconfigured the relationships between individuals and their surroundings.

By counting on a strong connection between science and technique, the Scientific Revolution of the Modern Age did not develop according to a simple evolution of scientific thinking, but in conformity with a drastic rupture that triggered another conception of what came to be understood as scientific knowledge. Thus, an allegedly rigorous and ordered empirical construct for conducting scientific research was disseminated, which underpinned and propelled the reflections of Galileo Galilei, Isaac Newton, Johannes Kepler, and Francis Bacon, to name a few. Therefore, mathematics and physics, recognized scientific disciplines at the time, became a model — or paradigm — of how the search for knowledge should be implemented.

In general terms, in this view of science, if the functioning of a given object of investigation is not tangible to the researcher, the obvious way to conduct a scientific study lies in observing the parts of that object in order to later be able to understand the whole. This approach is commonly referred to as analytical reductionism (Colchester, 2016). The basic premise of analytical reductionism is based on the investigation of an object in its individuality and suggests that large phenomena (in general, complex) can be divided and modeled into smaller parts, that is, reduced. These parts are then recombined so as to provide a description of the whole. According to Colchester (2016), analytical reductionism is a resource used by most sciences, especially physics, and many systems — especially the ones that are isolated, linear, deterministic, and static — are better suited to this type of investigation method.

The analytical reductionist perspective allows for a thorough examination of various types of systems and, when the parts of these systems are examined, it is possible to

discover that they are composed of more basic elements. For example, when studying the human body, it is observed that it is made up of different organs, which represent a combination of tissues, which in turn are made up of cells, which are made up of organelles, formed by molecules, which are made up of atoms, which are formed by elementary particles, etc. (Colchester, 2016). At the same time, the commitment to universality is another striking characteristic of analytical reductionism, since, in this perspective, there are individual elements that permeate different levels of the same object or system (in the example above, this individual element could be the atom, which would be present from molecules to body organs).

Scientific practice licensed by analytical reductionism was not only reserved for the natural sciences, but also had an impact on the humanities. Perhaps the most prototypical plot in which this extrapolation can be seen is in the field of Sociology, based on the reflections of Auguste Comte. The scholar believed that the understanding of how society functions could only be achieved through scientific investigation and the general laws that governed both social stability and change. For Auguste Comte, the scientific understanding of these laws could reshape society, and science could be used to build a better world (Simoni, 2015).

Another field of human sciences influenced by analytical reductionism, and which is of particular attention in this article, concerns linguistics. Cunha, Costa and Martelotta (2017) explain that the scientific study of language must be based on a general theory of how it is structured and functions, and the linguist's work consists of systematizing their observations as they relate to such a theory. For the authors, rigorous methods for describing languages are built upon this theory:

> The ultimate goal of linguistics is to understand the fundamental principles that govern this exclusively human capacity for expression through languages. To achieve this goal, linguists analyze how natural languages are structured and function. The investigation of different aspects of the different languages of the world is the procedure followed to detect the characteristics of the language faculty: what is universal and innate, what is cultural and acquired, among other things (Cunha; Costa; Martelotta, 2017, p. 21).[2]

Cunha, Costa and Martelotta (2017) also draw attention to the fact that linguistics proposes the study of languages as a way to obtain information about the nature of language in general. It should be noted that the authors' view is completely immersed in the universalistic character of linguistic facts derived from the linguist's observation. This positioning is consistent with one of the concerns of analytical reductionism, which revolves around the universality of patterns attested. Another point addressed by the authors, which is in line with the reductionist assumptions upheld by modern science, is that "linguistics tends to be

[2] Original version in Portuguese: "o objetivo final da linguística é depreender os princípios fundamentais que regem essa capacidade [a linguagem] exclusivamente humana de expressão por meio de línguas. Para atingir esse objetivo, os linguistas analisam como as línguas naturais se estruturam e funcionam. A investigação de diferentes aspectos das diversas línguas do mundo é o procedimento seguido para detectar as características da faculdade da linguagem: o que há de universal e inato, o que há de cultural e adquirido, entre outras coisas" (Cunha; Costa; Martelotta, 2017, p. 21).

empirical, rather than speculative or intuitive, meaning it tends to base its findings on strict methods of observation" (Cunha; Costa; Martelotta, 2017, p. 20).[3]

Costa (2017) argues that, in linguistics, structuralism presumes the existence of concepts and methods that imply the recognition that a language corresponds to a structure or a system. This definition of structuralist linguistics is very suitable for this discussion as it is compatible with the characteristics of a system for which analytical reductionism accounts — isolated, linear, deterministic, and static (Colchester, 2016). In this perspective, linguistic systems are autonomous and cohesive (Moura; Cambrussi, 2018), attributes that are related to Colchester's (2016) designation of systems described by modern physics.

Despite different paths, the epistemological rapport between the natural sciences and the science of language can be seen both in linguistic structuralism (empirical observations) and in the subsequent period, generative linguistics (universalistic aspects). Regarding this parallel, central to the discussions in the present article, let us examine some reflections concerning linguistic structuralism as developed by Leonard Bloomfield first, and then, generativism, coined by Noam Chomsky.[4]

Leonard Bloomfield's linguistic structuralism represents a foundational moment in the history of modern linguistics, particularly in the United States, where it came to define what is now known as North-American structuralism. Developed during the first half of the 20th century, Bloomfield's approach sought to establish linguistics as a rigorous and objective science, comparable in its methods to the natural sciences. In doing so, he distanced his work from introspective or speculative traditions and, instead, aligned linguistics with the principles of empiricism, logical positivism, and behaviorist psychology.

One of the central tenets of Bloomfield's structuralism is the belief that linguistics must be grounded exclusively in observable, verifiable data. For Bloomfield, language is best understood as verbal behavior, and its study should be confined to elements that can be physically recorded and systematically analyzed. As a result, he deliberately avoided engaging with mentalistic explanations or with constructs that could not be directly observed (Battisti; Othero; Flores, 2022). This perspective is especially evident in his treatment of meaning, which he famously described as the "weak point in language study and will remain so until human knowledge advances very far beyond its present state" (Bloomfield, 1933, p. 139). Because meanings were seen as internal, subjective, and not easily accessible to scientific scrutiny, Bloomfield downplayed semantics in favor of a more mechanistic account of language.

In practice, Bloomfield's linguistics focused on the formal structure of language, especially in its phonological and morphological dimensions. He developed methods for identifying and classifying phonemes through the use of minimal pairs, and for segmenting words into morphemes, which he defined as the smallest units of form that carry meaning or grammatical function. Syntax, too, was studied through a formal lens, with emphasis placed on distributional analysis — that is, examining the environments in which linguistic units occur in order to determine their grammatical roles. Camara Jr. (2021) affirms that Bloomfield relied heavily

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[3] Original version in Portuguese: "a linguística tende a ser empírica, e não especulativa ou intuitiva, ou seja, tende a basear suas descobertas em métodos rígidos de observação" (Cunha; Costa; Martelotta, 2017, p. 20).

[4] The reflections we propose in this article take into account specifically two theoretical ventures in modern linguistics: North-American structuralism, with a focus on Leonard Bloomfield, and generative linguistics, developed by Noam Chomsky. This is due to the fact that these perspectives represent quite well the principles of modern science.

on Immediate Constituent (IC) analysis as a way of breaking sentences into hierarchical components, thereby revealing their internal structure without invoking mental representations.

Many components of Bloomfield's linguistics emblematically exemplify the precepts of analytical reductionism. Since different possibilities of combination among language units are envisioned, different niches of analysis can be observed. In the phonological dimension, phonemes combine rigorously to form syllables (which, in turn, come together and form words). In the morphological sphere, words are formed by morphemes, their constitutive units. In terms of syntax, words conjoined to form phrases, which make up sentences.

It should be clear by now that factors such as [i] the recognition of language as a closed and static system; [ii] the allocation of smaller units within larger ones; [iii] the pursuit of knowledge widely based on empiricism; and [iv] the notion of hierarchical structures in all levels of analysis led Bloomfieldian linguistic structuralism to reflect the *modus operandi* captured by the Modern Age and highly valued by the natural sciences (Lyons, 1987). Epistemologically, Leonard Bloomfield's linguistics closely mirrors the positivist framework that characterizes the scientific worldview of modernity, particularly in its empiricism, objectivism, and methodological rigor. In other words, his linguistic theory is deeply rooted in the tenets of logical positivism and the broader scientific ethos of the early 20th century, which sought to establish a value-free, observation-based, and mechanically verifiable foundation for all forms of knowledge.

The school that temporally succeeds structural linguistics, known as Generative Linguistics, maintains some of these factors — but ceases to place the burden of seeking the source of linguistic knowledge under the aegis of empiricism — and brings innovations. For the generative school, instituted by Noam Chomsky, the study of human language follows a rationalist conception, as opposed to an empiricist one, assumed by Leonard Bloomfield.

It is worth mentioning that during the 17th century, a time period represented by the classical era of rationalism in Europe, the most influential general grammars emerged and aimed to elucidate that all natural languages obeyed logical and rational principles. The most widespread model in the period was called *Grammaire générale et raisonnée*, also known as the Port-Royal Grammar, dated to 1660, which proposed to demonstrate that [i] the structure of a linguistic system was derived from reason and [ii] different languages were just varieties of a more general rational and logical system (Moura; Cambrussi, 2018). Due to its orientation towards universality, epistemologically consistent with modern scientific practice, the Port-Royal Grammar would later inspire theoretical assumptions and analytical mechanisms of generative grammar.

The development of the generative program (Chomsky, 1957) represents a milestone in the history of linguistics because of its massive contribution to explaining the internalized knowledge of natural languages and their mental representation. Widely based on deductive reasoning, the generativist perspective proposes to offer elegant and potentially exhaustive explanations of linguistic facts, arguing that the ability to speak and understand a language results from a genetic predisposition innate to human beings.

Chomsky was diametrically opposed to the argument that language corresponded to [i] a system of signs external to humans and [ii] a set of habits generated in response to stimuli and fixed through repetition, categorical positions in Bloomfieldian structuralism when it comes to language acquisition. For Chomsky, creativity would be "the main characterizing

aspect of human linguistic behavior, what fundamentally distinguishes human language from animal communication systems" (Kenedy, 2017, p. 128).[5]

One very interesting reflection stated by Chomsky (1966), which has to do with his discussions on his book Cartesian Linguistics, is the preposition that men have a capacity that is particular to their species, a quite special type of intellectual organization. That feature cannot be credited to peripheral organs or related to general intelligence. For the author, such a capacity manifests in "the 'creative aspect' of ordinary language use" (p. 14) and is said to be both unbounded in scope and stimulus-free. Thus, at all times, we would be producing and understanding new and unprecedented sentences, from the most elementary to the most elaborate, at different stages of life — an inconceivable scenario from a framework according to which languages are completely determined by the outside world. From a generative perspective, languages do not constitute socially conditioned behavior, but are seen as a natural mental faculty.

The focus of generative research lies in the competence of speakers (accessed, however, through performance), a set of properties that makes an individual capable of speaking and understanding a language. In the light of generative grammar, only through the study of competence is it possible to develop a formal theory that will explain the functioning of language in the minds of its speakers/listeners. In a more detailed fashion,

> Due to this central interest in linguistic competence, classical generative studies do not usually use real linguistic data (performance), taken from the concrete use of language in everyday life. What is fundamentally interesting to generativist researchers is the functioning of the mind that allows the generation of linguistic structures observed in the data of any speech corpus, but they are not interested in these data in themselves or their relationship with any extralinguistic factor, such as the communicative context or the social variables that influence language use. These researchers use data for analyses that mainly consider (1) grammaticality judgment tests, in which sentences are presented to native speakers of a language, who must use their intuition and distinguish between grammatical and ungrammatical sentences, and (2) the intuition of linguists themselves, who, after all, are also native speakers of their own language (Kenedy, 2017, p. 134).[6]

Three major moments can be chosen as representatives of the trajectory that generative theory has had since its inception: [i] Generative-Transformational Grammar; [ii] Principles and Parameters; and [iii] Optimality Theory. Although generative theory took shape from syntax, its premises were extended to other modules of grammar, such as phonology and morphology.

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[5] Original version in Portuguese: "o principal aspecto caracterizador do comportamento linguístico humano, aquilo que mais fundamentalmente distingue a linguagem humana dos sistemas de comunicação animal" (Kenedy, 2017, p. 128).

[6] Original version in Portuguese: "Em razão desse interesse central na competência linguística, os estudos clássicos do gerativismo não costumam usar dados linguísticos reais (performance), retirados do uso concreto da língua na vida cotidiana. O que interessa fundamentalmente ao gerativista é o funcionamento da mente que permite a geração das estruturas linguísticas observadas nos dados de qualquer corpus de fala, mas não lhe interessam esses dados em si mesmos ou em função de qualquer fator extralinguístico, como o contexto comunicativo ou as variáveis sociais que influenciam o uso da linguagem. Os gerativistas usam como dados para as suas análises principalmente (1) testes de gramaticalidade, nos quais frases são expostas a falantes nativos de uma língua, que devem utilizar sua intuição e distinguir as frases gramaticais das agramaticais, e (2) a intuição do próprio linguista, que, afinal, também é um falante nativo de sua própria língua" (Kenedy, 2017, p. 134).

The first elaboration of generativism was called Generative-Transformational Grammar and was "developed and reformulated several times during the 1960s and 1970s" (Kenedy, 2017, p. 131).[7] Basically, the objective of this model was to describe and explain how units and constituents were transformed into others through the application of ordered rules, considering that the infinite sentences of a language could be generated from the application of a finite system of rules. The linguistic knowledge existing in the mind of the speaker/listener is, then, built upon this finite system of rules.

In the early 1980s, the second development of the generative theory occurred, known as the Principles and Parameters Theory. This period was responsible for clearly assuming the view of a Universal Grammar (UG) based on two criteria: [i] a set of common grammatical properties shared by all natural languages (principles) and [ii] predictable interlinguistic differences in accordance with the range of options available in the UG (parameters). According to Kenedy (2017), the UG hypothesis represents a refinement of the notion of language faculty, seen as an innate device to humans, which provides an algorithm for language acquisition. In syntax, the first phase of this model was marked by the Government and Binding Theory, and the second, by the Minimalist Program.

The third development of the generative program was brought about by the Optimality Theory, proposed by McCarthy and Prince (1993) and Prince and Smolensky (1993). As illustrated by Schwindt (2014), this is a globalist view of grammar, in which several possible realizations of a linguistic form compete through a ranking of constraints (as opposed to a grammar design in which an output is generated from successive rules or processes from an input). The model operates with universal constraints, but with a particular ranking, which distinguishes one language from another. Furthermore, Optimality Theory dispenses with grammatical modules and, ideally, phonological constraints can be alongside syntactic and morphological ones. As it does not exhibit distinct grammatical modules, there is no hierarchy of one level over another (syntax does not precede phonology, for example), and all constraints involving languages are allocated to a particular component available in UG (McCarthy, 2008).

Although each moment of generative linguistics has its specificities, its fundamental principle is that linguistic knowledge is exclusively associated with the mental expedient and is philosophically characterized by rationalism. Grammatical units are available via UG, a centralizing system that generates linguistic forms through transformations, derivations and/or the result of a hierarchy of universal constraints. Other relevant points about generativism are [i] the binary/Cartesian aspect that permeates several analyses, whether in the structure of the constituents, in the distinctive features, or even in the more general taxonomy of the theory; [ii] the essentially top-down mechanism by which grammar is organized, reflecting the rationalist view of linguistic knowledge; and [iii] the concern with the universal properties of linguistic systems and the processes that occur within them.

The alignment between modern science and the two linguistic schools presented in this section, North-American structuralism and generativism, occurs as these schools respond to the precepts of scientific *praxis* that has analytical reductionism as one of its great allies. Despite their differences, North-American structuralism and generativism are circumscribed to the notion that language corresponds to a linear, static, and closed sys-

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[7] Original version in Portuguese: "desenvolvida e reformulada diversas vezes durante as décadas de 1960 e 1970" (Kenedy, 2017, p. 131).

tem, and also to the conception that smaller units are nestled within larger ones. As seen at the beginning of this exposition, linear, closed, and static systems, as well as the analytical reductionist treatment of the units of these systems, are the flagship of modern science and permeate the two linguistic approaches described here. The next section will address a new direction in science and linguistics, which proposes a novel perspective on scientific work and the way linguistic systems are taken into account.

4 Science and linguistics taken as more than the sum of their parts

Postmodernity is not a uniform construct in terms of its origin or scope. This partial lack of clarity arises because various elements are instantiated in culture, arts, sciences, and humanities, while ethical, aesthetic, and epistemological interpretations, for example, start to change. For the purposes of this article, we follow the French philosopher François Lyotard to stipulate the beginning of postmodernity, which occurs in the last decades of the 20th century (Lyotard, 1986). The way in which the modern world is seen and, consequently, the way in which science is conducted in modernity, start to take on new directions, which migrate from the current paradigm to a new one, the so-called postmodern world.

With regard to science, as Colchester (2016) points out, the Newtonian paradigm and the theory of linear systems — which tried to reduce the world to different deterministic equations (Stewart, 2014) — were increasingly questioned throughout the 20th century, as they failed to encompass descriptions and explanations of other types of systems. By making his point in line with ecology, Colchester (2016) states that the analytical reductionist perspective, so elementary in the modern paradigm, can provide a detailed description of each tree and animal or living being; however, it prevents observation of the forest as a whole. On the same note, Berticelli (2010) highlights that the modern success and the connection it maintained with nature ended up making man a stranger in the real world by means, for example, the deletion of subjectivity from its agenda. In this sense, and contrary to modern ideals and ideas, Colchester (2016) emphasizes that, in order to carry out a complete and balanced investigation, we must imbue ourselves not only from the perspective of the parts, but also from the perspective of the relations that make up the whole.

Cilliers (1998) clarifies that thinking in terms of relations, and not in terms of deterministic rules, is not new to science, but this has always been seen as an attribute of qualitative descriptions, and not as characteristics of quantitative descriptions and calculations considered necessary to reach science-oriented investigations. Many of the phenomena of interest in the world today are inherently non-linear and gradient, akin to almost all socio-political, ecological, and economic events (Colchester, 2016). In this sense, Cilliers (1998) indicates that such phenomena, including physical and mathematical ones, cannot be adequately understood within the framework of deterministic and rule or constraint-based processes. Furthermore, descriptions of quantum mechanics of sub-atomic processes "are essentially relational, and even on a more macroscopic level, relations determine the nature of matter" (Cilliers, 1998, p. 35). Given this remonstrance, the most coherent maneuver would be, for both authors, to treat various phenomena from the perspective of complexity. Complexity, as a construct, refers to Complexity Theory, which accounts for the study of complex systems. Complex systems are typically composed of several distributed parts, whose order is formed

from local interactions that give rise to overall organization. Colchester (2016) reinforces that, within complex systems, we do not look for global rules which govern the entire system, but we seek to understand how local interactions result in emergent organization.

We call emergent a process through which new properties or structures are formed as we combine elementary parts (Cilliers, 1998; Colchester, 2016). When we combine elements in a specific way, a new system is formed. The outcome is an organization in which the whole is greater than the sum of its parts, ensuring that such a system is emergent *par excellence*. Colchester (2016) exemplifies that walking is a type of an emergent phenomenon, as when walking both legs are coordinated to allow movement. However, with only one leg, one cannot walk; only hop. On the other hand, walking is not simply a combination of two hops: as a movement system, walking becomes much more efficient than performing two hops combined. Therefore, hopping does not involve coordination between the parts, while walking requires a very specific type of coordination.

The interaction of two or more elements for the development of a certain action is called synergy (Colchester, 2016). The emergent properties in a system are, therefore, a product of the synergy between the parts and cannot be seen as directly derived from a centralizing unit. It is with respect to this observation that one of the main counterpoints to linear systems is evident: in complex systems, there is no centralizing entity or central control that governs the countless units that constitute them. Global organization is an emerging characteristic of local interactions between parts or units (Cilliers, 1998; Colchester, 2016).

Both the synergy and the emergence of patterns in a complex system come from a crucial factor in this type of scenario: self-organization. To explain this concept, Cilliers (1998) underlines the following situation: blocks of information from the external world flow into the system and influence the interaction of some of its components. If a certain block is present regularly, a specific pattern of activity will be caused in the system. Additionally, if two blocks of information are regularly present and together, the system will automatically develop an association between the two. Thus, as the system encounters different conditions in the environment, it generates new structures to represent these conditions.

As we can notice, Complexity Theory may offer lenses through which to interpret the intricate dynamics of linguistic phenomena. Complexity Theory explores the emergent properties arising from interactions among numerous agents. Scholars such as Edgar Morin (2008) highlight the interconnectedness and non-linear nature of complex systems, echoing postmodern thinkers like Lyotard (1986) who, as already mentioned, draws attention to the decentralization of systems and the fragmentation, plurality, and fluidity of human phenomena. From this general description of Complexity Theory, we summarize some key concepts that Larsen-Freeman and Cameron (2008) use to explain and model complex systems:

◆ *Heterogeneity*: It is constituted by the presence of different types of elements, agents, or processes in a complex system.

◆ *Dynamicity*: It causes the elements and agents that make up a complex system to change over time and constantly, causing changes in the state of that system.

◆ *Adaptability*: It assumes that any change in any aspect of the complex system leads that system to change as a whole, as its parts act and react to each other's behavior.

- ◆ *Non-linearity*: It focuses on the fact that, in a complex system, there is no way to predict which emerging patterns will result from the synergy of its parts, which makes it non-linear due to the lack of predictability that is an inherent characteristic of the system.

- ◆ *Openness:* It allows a complex system to be open for energy or matter to enter. Such openness allows the system to evolve and continue, on the one hand, adapting to new scenarios, and, on the other hand, maintaining stability.

Postmodern science, especially Complexity Theory, proceeds differently from the assumptions of modern science regarding the complex phenomena present in human activity. Although Complexity Theory is a recent endeavor in linguistics, Larsen-Freeman (1997) being considered the pioneer, recently, several linguists have seen in the theory an opportunity to conceive their main object of study: human language. The parallels between linguistic systems and complex systems are increasingly evident, leading scholars to consolidate a research program whose focus is the description, analysis, and explanation of language as a complex system (De Bot; Lowie; Verspoor, 2007; Larsen-Freeman, 1997; Larsen-Freeman; Cameron, 2008; Beckner *et al.*, 2009; Cornish; Tamariz; Kirby, 2009; Ellis; Larsen-Freeman, 2009; Schoenemann, 2009).

It is of paramount importance to state that applying Complexity Theory to linguistics also resonates with contemporary developments in sociolinguistics, cognitive linguistics, psycholinguistics, and applied linguistics, in which language is increasingly viewed as situated, adaptive, and shaped by feedback loops between individuals, institutions, technologies, and environments. On this note, Complexity Theory can be considered a conciliatory framework in linguistics because it transcends traditional dichotomies that often polarize the field, such as mind versus environment or competence versus performance. Rather than isolating cognitive processes from external influences, Complexity Theory takes language as an emergent, dynamic system shaped by the continuous interplay between internal (neurological and cognitive) mechanisms and external (social, cultural, and contextual) factors, including socio-interactionist approaches. Complexity Theory therefore offers a unifying lens through which both individual/internal and collective/social dimensions of language can be fully taken into consideration. Furthermore, we understand that the complexity approach fosters interdisciplinarity by encouraging collaboration between linguistics and fields such as systems theory, computational modeling, ecology, and even philosophy of science. It promotes methodological openness, blending qualitative and quantitative techniques, ethnographic insight and computational simulation, inductive observation and theoretical abstraction.

We also believe that, in essence, studying language through a complex approach is not merely a methodological alternative — it is an epistemological repositioning. It reflects an awareness that language is not a finished product to be dissected, but an ongoing process to be understood in motion. By embracing complexity, contemporary linguistics can better accommodate the rich variability, contextual sensitivity, and emergent creativity that define human communication in the modern world.

Larsen-Freeman and Cameron (2008) point out that, from the perspective of Complexity Theory, linguistic knowledge is not seen as something given, but constructed and achieved in an adaptive way by the individual in the environment. In fact, Larsen-Freeman (2013) suggests that Complexity Theory is even capable of challenging the conception that

language is a static and rule-governed system, and that language use itself can change its very own patterns. According to Cilliers (1998), concepts and meanings emerge through relations between the structural components of the system itself, and not through an individual correspondence of a symbol with some external concept or object; otherwise, the adaptability and dynamicity of the system would be compromised. Complexity Theory thus does not advocate the necessity of an innate acquisition device, since it assumes that the creation of a complex system does not demand an initial stage characterized by detailed plans or templates (Larsen-Freeman, 2013). Cilliers (1998) also stresses that meaning is the result of a dialectical process, involving elements from inside and outside, and also historical, in the sense that the previous states of the system are of vital importance for its constitution over time. Additionally, Larsen-Freeman and Cameron (2008) understand that:

> Meaning is not located in the brain, in the body, in the environment or in a particular linguistic form: it is a function of the global state of the system, and it emerges in the interaction (Varela, Thompson, and Rosch 1991: 149-50). To concretize this notion, let us say that we do not choose words that contain meanings and then place them on the table for our interlocutor to pick up, but rather we use words and phrases as 'prompts for meaning construction' (Evans and Green 2006: 214), selected and adapted in the dynamics of interaction. Thus, in the negotiation of meaning, which accompanies every dialogic interchange, new meanings are routinely created for old forms, both unintentionally and on purpose (Larsen-Freeman; Cameron, 2008, p. 109).

In this light and according to Beckner *et al.* (2009), the language must be taken as a complex system given the following characteristics: [i] the language consists of multiple agents that interact with each other, such as, for example, speakers in a community; [ii] the language is adaptive, as speakers' behaviors are based on their past interactions, and those interactions with current/new ones will delineate future language behaviors; [iii] speakers' behaviors result from competing linguistic and extralinguistic factors; and [iv] the grammar emerge from interrelated patterns of experience, social interaction and cognitive mechanisms/processes.

The considerations about Complexity Theory and its relationship with human language may have been shedding light on a new conception of linguistic systems. However, three specific questions ought to be answered promptly, even if their answers are implicit in what has been discussed so far: [i] what is the nature of the variables that constitute a linguistic system? [ii] what is the impact of experience on the linguistic system? and [iii] what is the mechanism by which linguistic knowledge is formed?

Regarding the first question, based on Larsen-Freeman (1997), Larsen-Freeman and Cameron (2008), Beckner *et al.* (2009), the variables that constitute a linguistic system are of multiple natures, linguistic and extralinguistic. The authors provide support for an understanding of language as a system in which phonological, morphological, syntactic, semantic, pragmatic, social, cultural, psychological variables, etc. are constantly in consonance and interrelated. The situational context in which communicative interactions occur cannot be disconnected from the form and function of the elements considered grammatical, just as the complex system that is language cannot and should not be closed off from the outside. In a nutshell, Complexity theory then offers an ecological framework for understanding how extralinguistic variables also impact grammar. Traditionally, modern linguistic analysis focuses pri-

marily (if not solely) on internal linguistic structures and rules, often overlooking the influence of external factors. Complexity theory, on the other hand, emphasizes the interconnectedness of linguistic phenomena with broader socio-cultural, cognitive, and environmental contexts.

Concerning the second question, there is some divergence among theorists in the area. Cilliers (1998) points out that the external world, and, therefore, experience, do not determine the structure of a system, but exerts influence on it, in a kind of feedback loop. In contrast, Larsen-Freeman (1997) and Larsen-Freeman and Cameron (2008) argue that experience can determine the structure of the complex system — language in this case. It is worth remembering that one of the most salient characteristics of complex systems is openness, a factor that allows the system to receive matter or energy from the external environment. Thus, a conciliatory vision would perhaps be one that stipulated how open the system may be and, based on that, greater or lesser potential for its structure to be determined by the external environment. Alternatively, another position could be that, in the initial stages of a complex system, there is greater resistance to being determined by the external environment, but, through its evolution, resistance decreases to the point where experience becomes decisive.

As for the third question, it can be stated that the mechanism by which linguistic knowledge is formed from the perspective of a complex system is relational, and not derivational or hierarchical. Therefore, there is no central unit, along the lines of UG, that manages and transforms/derives linguistic forms within a substantially linguistic grammar, as already mentioned. In a complex system, as previously addressed (Cilliers, 1998; Colchester, 2016), the different patterns emerge from local synergies. Such synergies may imply abrupt changes in the system, or even just small alterations that would not destabilize it (Kupske; Perozzo; Alves, 2019). Contrary to traditional linguistic models, Complexity Theory advocates that language is grounded in domain-general cognitive processes or, in other words, the theory does not consider the existence of specific machinery for language development. Language is indeed a central and special trait of humans, but it does need specialized components to take shape (Perozzo; Kupske, 2021).

Even though Complexity Theory is gaining a sound form in postmodern linguistics with its own questions and methods (e.g., Hiver; Al-Hoorie, 2020), it is still understood as a metaphor, and may rely on other language approaches that are consistent with its postulates. This approximation allows the theory to take a scientifically valid form, representing an effective benefit to linguistics as a whole.[8] As we have already stated, Complexity Theory allows us to think of language as a complex system and finds room for dialogue with other proposals that encompass the formation of knowledge, such as usage-based approaches (Bybee, 2001; Bybee; Hopper, 2001; Bybee, 2010) and the construct of statistical learning (Peterson; Anderson, 1987; Hastie; Tibhsirani; Friedman, 2009).

As previously noted, modern linguistic theory has often centered on the concept of categoricity. However, usage-based approaches to language, in synchrony with the Complexity Theory, emphasize the role language use plays in shaping its own structure. Usage-based

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[8] Bakhtin, for instance, is considered by some authors to be a postmodernist, since he criticized structuralism and formalism, showing that totalizing explanations were monological. The nature of language, according to the Russian scholar, is to be dialogic and interdiscursive. Although both Bakhtinian Theory and Complexity Theory share the view that language is a dynamic, procedural and inter-relational phenomenon, we believe that Complexity Theory further expands this scope by offering theoretical and methodological models suitable for dealing with non-linear, adaptive and emergent systems (central characteristics of linguistic functioning).

approaches prioritize real-world language use to better understand how it is organized in the mind (Beckner; Bybee, 2009; Bybee; Beckner, 2010) and are therefore a sound way to give complex science a form. Languages are constructed through, and only through, the categorization of real instances of language use (Bybee, 2001). That is, humans create a structured inventory of linguistic constructs from the language they hear used around them (Tomasello, 2005).

Like any new theoretical enterprise, assuming that linguistics is guided by the precepts of Complexity Theory requires a reconception of how it is established in relation to the knowledge already accumulated in the area and how it moves towards the new, what is yet to be discovered. We identify at least three situations that summarize points of view regarding the conjunction between science and linguistics in the postmodern context: [i] rejection of grand narratives and absolute certainties; [ii] emphasis on interdisciplinarity and a systemic approach; and [iii] acceptance of uncertainty and ambiguity.

As for the first situation, both Complexity Theory and postmodernity question the ideas of absolute truth and unifying narratives that explain all human knowledge. In postmodernity, there is a distrust of grand metaphysical or historical narratives that seek to impose a single, totalizing worldview. Likewise, Complexity Theory recognizes that complex systems are intrinsically unpredictable and cannot be reduced to a simple or linear explanation. In terms of the second situation, a common ground to complexity and postmodernity is the importance of an interdisciplinary approach to understanding the world. Complexity theory recognizes that complex phenomena emerge from interactions between multiple elements and levels of organization, and that a full comprehension of these phenomena calls for a systemic approach that integrates insights from different disciplines. Similarly, postmodernity promotes an interdisciplinary approach that recognizes the multiplicity of perspectives and discourses that contribute to understanding the world. Concerning the third situation, Complexity Theory and postmodernity meet when they both recognize the intrinsically uncertain and ambiguous nature of the world. While Complexity Theory suggests that complex systems are self-organizing and characterized by heterogeneous elements, postmodernity emphasizes the lack of certainty and stability in cultural and social constructions, including (unsurprisingly) language. Both perspectives come to challenge the idea that we can have complete and definitive knowledge about the world.

In postmodernity, linguistics is inserted in an epistemological landscape that values the socially constructed nature of knowledge. From this perspective, language is understood as a phenomenon that emerges from social and cultural interactions, rather than being an objective representation of reality or an innate capacity that manifests itself via transformations from input to output forms. Instead of seeking solid and absolute foundations for our ability to use and represent language, this approach recognizes the contingency and instability of knowledge, questioning the notion of a universal truth.

A key point here is recognizing the crucial role of context and individuality in language production, perception, and comprehension. Linguistic meaning is seen as fluid and variable, depending on the cultural, social, and historical context in which it occurs. This contextualist approach highlights the importance of considering the environment in which communication occurs, taking into account factors such as social indexicality, pragmatic relations and discursive practices.

Furthermore, a postmodern orientation to linguistics celebrates the diversity of perspectives and multiplicity of voices. Postmodern linguistics recognizes that there is no single correct or true approach to studying language, but rather a variety of legitimate viewpoints

that contribute to understanding the complexity of linguistic systems and forms of communication. This plurality of perspectives is considered enriching and essential for a more complete understanding of how humans perform in the world by means of language.

5 Final remarks

The evolution of human knowledge was marked by changes in paradigms and approaches over time. In this sense, the trajectory of linguistics as a discipline mirrors the broader shifts in scientific paradigms from modernity to postmodernity. Initially, the drive towards empirical observation, analytical reductionism, and a quest for universal principles during the reign of modern science profoundly influenced linguistic studies, leading to the structuring of language analysis within a framework that sought to emulate the natural sciences. This modern approach prized rationality and an orderly system of universal transformational rules or constraints as methods to dissect and understand language, resembling the methodological rigor and aims of contemporary scientific endeavors.

The search for universal and objective laws led to the development of an empiricist and positivist approach to science, in which scientists were devoted to observation, experimentation, and formulating theories that aimed to unlock the secrets of the natural world, seeking a unified and complete understanding of reality. In linguistics, modernity saw the flourishing of structuralist and formalist approaches, essential for the description, analysis, and explanation of phonological, morphological, and syntactic facts, for example.

Moving into postmodernity, we are witnessing a paradigm shift. Perspectives that value complexity, diversity, and context, such as Complexity Theory, are emerging and showcasing the intrinsically non-linear, gradient and unpredictable nature of natural systems, including language. In this regard, postmodern linguistics intends to give space to individuality, indexical factors, the congregation of linguistic and extralinguistic variables, performance as an agent of abstractions, and the formation of linguistic knowledge based on our actions in the world.

As the postmodern critique of science began to unfold in the late 20th century, it brought with it a fundamental reassessment of modern methodological commitments. The advent of postmodernity in linguistics has therefore challenged the very notions that underpinned linguistic studies during modernity, especially North-American structuralism and generativism. Postmodern linguistics questions the possibility of universal rules and embraces, as already mentioned, the complexity, adaptability, and interdisciplinary nature of language phenomena.

In this light, this article sought to establish a parallel between science in general and linguistics in modernity and in postmodernity. The main characteristics of each period were addressed, focusing on scientific endeavors and their scope regarding language. Despite the generous contribution that modern science has provided to linguistic studies, optimistic paths have been offered by Complexity Theory, instituted in postmodernity, to understand human language as a complex system.

In postmodernity, the field of linguistics has moved away from seeking a fortress of immutable laws, instead navigating a mutable landscape of ideas more akin to a house of cards, characterized by its subtlety and transient stability. This transition underscores a more general movement towards acknowledging the uncertain and constructed nature of knowledge, which aligns with the postmodern critique of the foundational assumptions of earlier scientific methods.

The development of linguistics from the Scientific Revolution to postmodernity encapsulates a significant transformation in our understanding of language, reflecting the evolving nature of scientific inquiry itself. This evolution from a search for universal truths to an embrace of contextual, fluctuating insights offers a richer, albeit more challenging, landscape for exploring linguistic phenomena. The ongoing dialogue between science and linguistics not only enriches our understanding of language but also highlights the dynamic interplay between different domains of knowledge in shaping intellectual inquiry.

We live in an era in which both rationality and empiricism can be cooperative and mutually informative. This combination proves to be quite fruitful, ensuring a more realistic and comprehensive (yet equally profound) treatment of natural languages, from how the units of these systems interact to how their elements are perceived, produced, and accessed by users in interactions. Complexity Theory, therefore, positions itself not as an end to understanding the relationships that constitute human language, but as a means to grasp it in its entirety.

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The first author, Reiner Vinicius Perozzo, was responsible for the Conceptualization of the work and Writing — original draft. The second author, Felipe Flores Kupske, was responsible for Writing — review and editing.

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