

Towards Group Field-Theoretical Linguistics: A Unified Framework for Integrating Linguistic, Sociological, and Cognitive Phenomena

Wanhong HUANG^{1*}

^{1*}Independent Researcher.

Corresponding author(s). E-mail(s):
huangwanhong.g.official@gmail.com;

Abstract

The origins, acquisition, and evolution of language, at ontological, structural, and developmental levels, and its relationship to human cognition remain fundamental open problems spanning multiple scales: from ontological basis of linguistic capacity to emergence of grammatical systems, from individual development to symbolic change. Progress is hindered by three critical limitations: (1) absence of frameworks unifying discrete linguistic structures with continuous physical systems such as neural dynamics, (2) traditional approaches pre-specifying ontological elements or pre-existing spacetime cannot explain how structures originate, and (3) relational and structuralist philosophies lack formal mathematical and computational foundations.

We propose Group Field Theory (GFT), combined with condensed matter theoretical methods, as a unified framework addressing these limitations. The combined framework provides four key capabilities: (1) *abstract ontological commitment*—ontology-abstract nature for investigating structure emergence, (2) *background-independent*, requiring no pre-existing spacetime or representational framework, (3) *discrete and continuous structure-oriented*, unifying discrete structures through GFT's combinatorial group structure with continuous dynamics via phase transitions and collective phenomena, and (4) *interpretable and computational*, providing a formal, physically grounded framework to model language architecture and human cognition. We model universal grammar using GFT, proposing that natural language emergence can be understood as symmetry breaking on this universal grammar, then utilize this model to interpret key linguistic concepts and phenomena and explore their connections to human cognition.

Keywords: Group Field Theory; Universal Grammar; Language System Formation; Symmetry Breaking; Language Acquisition

1 Introduction

The origins, acquisition, and evolution of language, spanning ontological, structural, and developmental levels, remain among the most profound and unresolved puzzles in science. This challenge is inherently multiscale, connecting the microscopic dynamics of neural circuits to the macroscopic structures of grammatical systems, and bridging the individual’s cognitive development with the historical evolution of symbolic communities. Despite significant advances across linguistics, cognitive science, and sociology, progress is fundamentally hindered by a triad of critical limitations. First, there is a pervasive absence of frameworks capable of genuinely unifying the discrete, combinatorial nature of linguistic symbols with the continuous, dynamical systems of the brain and society. Second, traditional approaches often presuppose their ontological foundations, whether they be innate grammatical rules, pre-existing social structures, or prespecified cognitive modules, and thus cannot explain how these very structures originate and emerge from more fundamental processes. Third, while relational and structuralist philosophies have powerfully highlighted the importance of difference and system internal relations, they have largely lacked the formal mathematical and computational foundations necessary for rigorous modeling and prediction.

In this work, we propose a unified framework to address these limitations by transplanting a formalism from the frontier of theoretical physics: Group Field Theory (GFT), augmented with methods from condensed matter theory. GFT was developed to resolve an analogous problem in quantum gravity—the unification of discrete quantum geometry with the smooth, continuous spacetime of general relativity. We argue that this formal apparatus is uniquely suited to model the architecture of language and cognition. Our framework is driven by three primary ambitions:

1. To provide a physically grounded, interpretable, computational, and unified framework. We seek a formalism that is physically grounded in the dynamics of complex systems, interpretable in its connection to established linguistic and cognitive concepts, computational in its capacity for simulation and prediction, and unified in its ability to integrate phenomena across linguistic, sociological, and cognitive domains within a single descriptive language.
2. To demonstrate the framework’s integrative potential. We aim to show how this framework can naturally interpret a wide range of phenomena, from the emergence of dialects and cultural meaning (sociolinguistics) to the processes of language acquisition and the parametric variation of Universal Grammar (cognitive linguistics).
3. To establish a new foundation for linguistic ontology. By building on a “pre geometric” and background independent foundation, we aim to move beyond theories that prespecify ontological elements, instead explaining how linguistic

structures and the very "space" of meaning they inhabit can co-emerge through processes of symmetry breaking and condensation.

Our contributions are threefold. First, we introduce GFT as a physically grounded, interpretable, and computational framework for modeling linguistic phenomena, defining a language system by its dynamical action. Second, we demonstrate its broad potential by using it to reinterpret key concepts in sociolinguistics (e.g., culture, prejudice, dialect emergence) and cognitive science. Third, we explicitly explore its role in describing language acquisition and Universal Grammar, positing the latter as a high symmetry "phase" from which specific grammars emerge via symmetry breaking.

The manuscript is structured to build the framework from its philosophical foundations to its concrete applications. We begin in Section 2 by discussing the philosophical and ontological motivations, reviewing the problem of language origins and the limitations of existing theories, and introducing the necessary background on Group Field Theory and spacetime emergence from quantum gravity. In Section 3, we present our formal framework, defining a language system via a GFT action and detailing how syntactic structures and semantics are generated within this model. Section 4 is dedicated to applying the framework to integrate linguistic, sociological, and cognitive phenomena, with case studies on language acquisition, the analysis of Large Language Models, language evolution, and sociolinguistics. Finally, in Section 5, we delve into critical discussions, including a rigorous demonstration of the recursive generativity of the framework and an analysis of its computational power in relation to recursively enumerable grammars, before concluding with an outlook on future work.

2 Background

2.1 The Origin of Languages

2.1.1 Definitions of Language

Definitions of language vary across theoretical perspectives. From a *structuralist* perspective, Saussure emphasizes the essential role of *difference*, proposing that language is *a system of signs composed of signifiers and signifieds, where meaning arises from differences within the system* [1]. In *cognitive* approaches, Chomsky and Fodor connect language and cognition, viewing *language as a mental faculty enabling humans to produce, comprehend, and represent structured thought, with innate universal principles underlying all human languages* [2, 3]. From a *formal* perspective, grammar constitutes a set of rules governing how symbols combine to generate structures. *Socio-cultural* theories, represented by Halliday and Vygotsky, characterize *language as a social semiotic system and a resource for making meaning. It has three metafunctions: conceptual, interpersonal, and textual and language is a primary psychological tool that mediates cognitive development. It begins as a social medium and is internalized as inner speech for thinking* [4–7]. Finally, from a *biolinguistics* and *evolutionary psychology* perspectives, Pinker views *language as a human-specific adaptation that evolved to support complex communication and abstract reasoning* [8]. From a language socialization perspective, Bambi Schieffelin and Elinor Ochs propose that *Language*

learning is a process of socialization into cultural norms, values, and practices. One learns a language and, simultaneously, how to be a competent member of a society [9].

In philosophy, language’s definition has been boarden under the structuralism and post-structuralism. Specifically, building on Saussure’s model, *anthropological structuralist* Claude Lévi-Strauss analyzed cultural phenomena like kinship and myth as language-like systems of relations [10]. Though not pure philosophy, The psychoanalyst Jacques Lacan, synthesizing Freud and Saussure, posited that “the unconscious is structured like a language” and is the “discourse of the Other.” He argued that the human psyche is constituted upon entry into a symbolic order governed by the differential structures of signifiers, which he detailed through his registers of the Real, the Imaginary, and the Symbolic [11, 12]. The *post-structuralist* philosopher Jacques Derrida, however, critically re-read Saussure, arguing that meaning is never fully present but is perpetually deferred through an endless play of signifiers, a concept he termed *différance* [13]. Meanwhile, Michel Foucault’s work shifted the focus from the structure of language itself to how discourses—structured systems of language and practice—produce knowledge, power, and subjects [14].

Though the defintions of language are various in different perspectives, these definition focusing on following key concepts: *difference*, *structures*, and the generation process of *structures*. The difference’s rise up to the systems’ evolution power, causing *change*, and differential structures emerge. This process demonstrate *generativity*. In this work, we mainly build the definition of language on the top of Lacan’s framework. This is because the Lacan’s three-world theory cross three important level: physics (the Real), symbolic (the Symbolic), and cognition/perception (the Imagine). To Lacan, language is the differential structure formed by the signifiers. To better generalize the concept of *language* to board area, not limit to human cognition and natural language, we define that *a language system is a system that has the potential to generate differential the structure of difference*. This definition make two major modification on the top of Lacan’s. Firstly, we remove the *signifiers* involvement, due to the fact that, the involve of *signifiers* in the definition will limit our concept of language in the domain of nature language and cognition. Secondly, while remaining focusing on the *difference* essential role in language definition, we lift *generativity* to a more ontological level. Under this definition, the *generativity* before any structure.

2.1.2 Theory for Language Origins

The origins of human language capability, along with the processes of differentiation and evolution within language systems, remain a central puzzle. One influential theory of language acquisition is the theory of Universal Grammar (UG), which posits that humans are born with an innate, biologically endowed language faculty. This foundational meta-language is thought to enable children to acquire any specific language they encounter in their environment.

However, this theory faces several significant challenges. Despite decades of research, linguists have struggled to identify concrete grammatical principles that are truly universal across all languages, with many proposed rules encountering exceptions. The neurological substrate for such an innate, domain-specific grammar module remains elusive. Furthermore, the theory has difficulty accounting for the substantial

structural variation observed across the world’s languages. A more profound limitation is its inadequate treatment of the diachronic aspect of language. It remains unclear how such a complex and specific innate capacity could have evolved through natural selection, particularly given the relatively recent emergence of language in the human timeline.

Directly contradict the UG, some theories support that language is learned. Michael Tomasello emphasizes intention-reading and social-pragmatic skills as the foundation of language origin. Children learn language because they understand others as intentional agents and wish to communicate with them. Grammar is built through a process of ”entrenchment” and ”schematization.” [15]

Additionally, other theories of language origins including connectionist and emergentist models, cognitive-functional linguistics, and evolutionary linguistics approaches. The connectionist and emergentist models stress that the language is emerged from the connectivity of neurons in the human brain. The cognitive-functional linguistics views language as being shaped by and reflecting general human cognitive constraints and communicative functions. And evolutionary linguistics approaches directly address the language emergence and evolution from biological evolutionary perspectives.

2.1.3 Challenges and Theoretical Gaps

Despite the proliferation of theoretical frameworks addressing the origins of human language, fundamental questions remain unresolved. The theory of Universal Grammar (UG), while influential, lacks a physically grounded explanation for language evolution. Conceptually, UG treats specific human languages as *generated structures* while positing UG itself as the generative system responsible for producing these structures. However, the precise dynamics of this system and the detailed mechanisms of structure generation remain largely unspecified. This fundamental ambiguity regarding UG’s operational dynamics and its structure-generation process renders the theory ultimately unverified.

Alternative theoretical approaches typically adopt a procedural philosophy that operates without explicitly specifying a metalanguage. This omission creates significant epistemological challenges in understanding language origins. The philosophical status of metalanguage presents substantial ontological difficulties that have engaged numerous philosophers and psychoanalysts, yet remain fundamentally unresolved. Specifically, when we define a language system as a rule-based system—whether conceptualized as formal grammatical rules or as vector fields in classical dynamical systems—possessing the potential to govern structural emergence (linguistic structures in formal languages, structured flows in dynamical systems), while simultaneously recognizing that language itself constitutes a form of structure, we encounter profound conceptual challenges. Within this framework, differential structures define atomic rules and consequently determine the system’s dynamics and emergent generativity.

From a categorical theoretical perspective, maintaining consistency requires that the metalanguage itself must also be conceptualized as a language, thus constituting another structure. This formulation inevitably leads to recursive problems regarding the emergence of this metastructure. The pursuit of the language that generates the

metalanguage parallels Lacan’s quest for the “Other of the Other” (*Grand Autre*), which ultimately concludes with the recognition that “the Other of the Other does not exist.” Similarly, the metalanguage bears resemblance to Kant’s concept of the *Ding an sich* (thing-in-itself). The philosophical struggle to locate this foundational entity ultimately leads toward practical philosophical resolutions: rather than seeking the unattainable *Ding an sich*, we should focus on human rationality and its manifestations.

Pure-relational ontological philosophical framework make it potential for us to arrive the ontology of structures in this work. From (who), it think the pure-difference or pure-relational exhibits the generativity of structures. And from Chinese classical philosophy, the pure differences (yin and yang), interaction rise up to generativity and structure generation. Saussurean structural linguistics provides a key insight for this turn. Language is “form, not substance,” and the meaning of its elements is entirely defined by difference within the system. “Cat” is “cat” because it is not “dog,” “mouse,” or “animal.” This structure of pure differentiability finds profound echo in Eastern wisdom: the I Ching’s “one yin, one yang—this is called the Dao” reveals that the generation of all things emerges from the interweaving and evolution of the most empty, most abstract binary difference system.

This theoretical impasse highlights the necessity for a framework that can accommodate the recursive nature of linguistic systems while providing a physically grounded, ontological-flexible and pure-relational ontological for accounting of language emergence that avoids infinite regress.

2.2 Beyond the Universal Grammar

The theoretical impasse outlined in Section 2.1.3—the infinite regress of metalanguages and the ungrounded nature of UG—necessitates a paradigm shift. We must move from a *generative grammar* to a *generative field*. This shift in perspective is ontological: instead of positing a set of rules or parameters (a grammar), we posit a *generative substrate* characterized by pure relationality and differentiability. Language structures are not *generated by* a system but *emerge as stable configurations* from the dynamics of this substrate.

2.3 The Ontology of Pure Difference and Its generativity

The foundational principle of this substrate is **pure difference**. As foreshadowed by Saussurean linguistics and Eastern philosophy, meaning and structure arise not from positive terms but from a system of oppositions and relations. The Chinese metaphysical concept of Yin and Yang does not represent two substances but two poles of a single, dynamic relational process—the Dao. The Dao itself is empty of inherent substance; it is the principle of generativity through relational movement.

Mathematically, this ontology of pure difference finds its most rigorous expression in the theory of **algebraic groups**. A group G is a set of elements with a binary operation that satisfies specific axioms (closure, associativity, identity, invertibility). Crucially, the elements $g, h \in G$ have no intrinsic identity outside of the relational operations $g \circ h$ that define them. The group structure itself—the network

of possible relations—is ontologically primary. The elements are merely nodal points through which the structure’s generative potential is actualized. This formalizes the philosophical insight that *relations are prior to their relata*.

2.4 A Sketch of Quantum Gravity and Group Field Theory

Quantum gravity represents a major frontier in theoretical physics, aiming to synthesize the principles of *general relativity*—our theory of gravity and the large-scale structure of spacetime—with those of *quantum mechanics*—the framework governing the microscopic world. While both theories are exceptionally successful in their respective domains, they yield contradictory predictions in extreme regimes, such as the singularities inside black holes or at the origin of the Big Bang. The goal of quantum gravity is to formulate a consistent, unified description where the fabric of spacetime itself is subject to quantum laws.

Several prominent research programs have been developed to address this challenge:

- **Loop Quantum Gravity (LQG)** proposes a direct quantization of general relativity, representing spacetime geometry at the Planck scale as a discrete structure known as a **spin network**.
- **String Theory** posits that fundamental constituents are not point particles but one-dimensional strings, with gravity emerging naturally from their vibrations in a higher-dimensional spacetime.
- **Tensor Models** provide a combinatorial approach to constructing random geometries, generalizing the matrix models that successfully describe two-dimensional quantum gravity to higher dimensions.

Building upon these ideas, particularly LQG and tensor models, **Group Field Theory (GFT)** has emerged as a comprehensive framework. GFT can be understood as a quantum field theory that provides a second-quantized formulation of the dynamics of spin networks. Its defining characteristics are:

1. **Relational and Pre-geometric Ontology:** GFT does not presuppose the existence of spacetime or geometric entities. Its fundamental degrees of freedom are quantum fields defined on abstract group manifolds (e.g., $SU(2)$ or $SL(2, \mathbb{C})$), which encode the algebraic data of quantum geometry. The theory is inherently *relational*, with physical meaning arising from the relations between these group elements.
2. **Background Independence:** In stark contrast to conventional quantum field theory, which is formulated on a fixed, classical spacetime background, GFT is defined without any reference to a metric or geometry. Spacetime is not an input but a *dynamical output*, expected to emerge from the collective behavior of the fundamental GFT quanta.

More technically, **Group Field Theory** is a quantum field theory defined on a group manifold, such as multiple copies of $SU(2)$. Its fundamental field,

$\varphi(g_1, g_2, \dots, g_d)$, is a function of d group elements (where d is the spatial dimension), often interpreted as representing a quantum of space—an elementary $(d - 1)$ -simplex (e.g., a tetrahedron for $d = 4$). The theory is defined by an action $S[\varphi]$, typically consisting of a quadratic kinetic term and a non-linear interaction term. The Feynman diagrams of this QFT are precisely the **spin foams**—the history of a spin network—which provide a path-integral description of spacetime evolution. In this way, GFT unifies the canonical description of LQG (spin networks) with the covariant path-integral approach (spin foams), while its combinatorial structure is a direct generalization of tensor models, enriched with group-theoretic data for geometric interpretation.

2.5 Formalism of Group Field Theory

From a highly abstract perspective, difference and variation give rise to generativity, producing differential structures. The variation or evolution pattern of a system is usually captured by the concept of **dynamics**, which plays a central role in defining and understanding the behavior and characteristics of a system.

In Group Field Theory, the dynamics of the system are encoded in the **action** $S[\Phi]$, which serves as the fundamental object of the theory. The action is typically decomposed into two parts:

$$S[\Phi] = S_0[\Phi] + S_{\text{int}}[\Phi] \quad (1)$$

where S_0 represents the *free action* term, governing the free propagation of the fields, and S_{int} encodes the *interaction term*, responsible for the combinatorial and geometric structures that emerge from the theory.

The $\Phi := \Phi(g_1, \dots, g_D)$ is the field in GFT, which is defined on D copies of a group G .

The **spin foam amplitude** of a given field Φ is defined as:

$$\int [D\Phi] \exp S[\Phi] \quad (2)$$

The ensemble average of an observable O is defined as:

$$\langle O \rangle = \frac{\int [D\Phi] O[\Phi] \exp \frac{iS[\Phi]}{\hbar}}{\int [D\Phi] \exp \frac{iS[\Phi]}{\hbar}} \quad (3)$$

The free action $S_0[\Phi]$ is typically bilinear in the field and defines the propagator of the theory. Using the compact notation where x represents the set of group variables $(g_1, \dots, g_D)$, it takes the form:

$$S_0[\Phi] = \frac{1}{2} \int dx dy \Phi(x) K^{-1}(x, y) \Phi(y) \quad (4)$$

where $K^{-1}(x, y)$ is the inverse of the kinetic operator.

The interaction term $S_{\text{int}}[\Phi]$ introduces non-linearities and is typically a sum of higher-order monomials in the field:

$$S_{\text{int}}[\Phi] = \sum_{n \geq 2} \frac{\lambda_n}{n!} \int dx_1 \cdots dx_n V_n(x_1, \dots, x_n) \Phi(x_1) \cdots \Phi(x_n) \quad (5)$$

Here, λ_n are coupling constants and V_n are the interaction kernels that encode the combinatorial pattern of the interaction.

$$\Phi(g_1, \dots, g_D) = \sum_{j_1, \dots, j_D} \sum_{m_1, \dots, m_D} \sum_{n_1, \dots, n_D} \Phi^{j_1 \dots j_D} m_1 \dots m_D n_1 \dots n_D \prod_i i = 1^D \sqrt{d_{j_i}} D_{m_i n_i}^{j_i}(g_i) \quad (6)$$

$$\mathcal{G}(x, y) = \langle \Phi(x) \Phi(y) \rangle_0 = K(x, y) \quad (7)$$

$$\langle \Phi(x_1) \cdots \Phi(x_n) \rangle = \sum_{\Gamma} \frac{\lambda^{V_{\Gamma}}}{\text{sym}(\Gamma)} A_{\Gamma}(x_1, \dots, x_n) \quad (8)$$

$$\frac{\delta S[\Phi]}{\delta \Phi(x)} = K^{-1} \Phi(x) + \sum_{n \geq 2} \frac{\lambda_n}{(n-1)!} \int dx_2 \cdots dx_n V_n(x, x_2, \dots, x_n) \Phi(x_2) \cdots \Phi(x_n) = 0 \quad (9)$$

2.6 Spacetime Emergence in Group Field Theory

Before delving into the linguistic applications of Group Field Theory, it is essential to understand how spacetime itself emerges within the GFT framework. This foundational concept provides the mathematical basis for our subsequent linguistic analogies.

2.6.1 Pre-geometric and Algebraic Foundations

Group Field Theory is characterized by its background-independent nature, meaning it does not presuppose the existence of spacetime. Instead, spacetime geometry emerges from the collective dynamics of more fundamental quantum entities. The theory is formulated on abstract group manifolds, with the fundamental field defined as:

$$\varphi(g_1, g_2, \dots, g_{D+1}) \quad \text{where } g_i \in G \quad (10)$$

Here, G is a **group**—a mathematical structure that captures the concept of symmetry and transformation. Specifically, we require G to be a **Lie group**, which is a group that also forms a smooth manifold. This dual structure is essential for several reasons: the group properties encode relational information between geometric elements, while the manifold structure provides the necessary mathematical framework for analysis and differentiation. Common choices include $\text{SU}(2)$ and $\text{SL}(2, \mathbb{C})$,

which naturally represent rotational and Lorentzian symmetries relevant to physical spacetime.

For a D -dimensional spacetime structure, each group element g_i describes the quantum state of a $(D - 1)$ -simplex (a fundamental building block of space). The combination of $(D + 1)$ such $(D - 1)$ -simplices forms a D -simplex—the elementary quantum of space. Thus, the field $\varphi(g_1, \dots, g_{D+1})$ represents a single quantum D -simplex.

The theory is formulated on the pre-geometric space G^{D+1} . Each field is a function $\varphi : G^{D+1} \rightarrow \mathbb{C}$, and all such square-integrable functions form the Hilbert space $\mathcal{C} = L^2(G^{D+1})$, with inner product defined by:

$$\langle \varphi | \psi \rangle = \int_{G^{D+1}} [dg]^{D+1} \overline{\varphi(g_I)} \psi(g_I) \quad (11)$$

where $g_I = (g_1, \dots, g_{D+1})$ and $[dg]^{D+1}$ denotes the Haar measure on G^{D+1} .

The **Fock Space** $\mathcal{F}$ describes quantum states with variable numbers of simplices:

$$\mathcal{F} = \mathbb{C} \oplus \mathcal{C} \oplus (\mathcal{C} \otimes \mathcal{C})_{\text{sym}} \oplus (\mathcal{C} \otimes \mathcal{C} \otimes \mathcal{C})_{\text{sym}} \oplus \dots \quad (12)$$

The vacuum state $|0\rangle \in \mathcal{F}$ represents the absence of any geometric structure.

The creation and annihilation operators $\hat{\varphi}^\dagger$ and $\hat{\varphi}$ act on $\mathcal{F}$ to add or remove simplices. Specifically, for an n -simplex state $|\psi_n\rangle$, the creation operator acts as:

$$\hat{\varphi}^\dagger(f) |\psi_n\rangle = \sqrt{n+1} |f \otimes_s \psi_n\rangle \quad (13)$$

where $\otimes_s$ denotes the symmetric tensor product, and $\hat{\varphi}$ is its adjoint operator. These operators satisfy the canonical commutation relations:

$$[\hat{\varphi}(g_I), \hat{\varphi}^\dagger(g'_I)] = \delta(g_I, g'_I) \quad (14)$$

establishing the second-quantized framework for quantum geometry.

2.6.2 n -Particle States, Coherent States, and Phase Transition

The quantum states of multiple geometric atoms (simplices) are described within the Fock space framework. An **n -particle state**, representing a configuration of n distinct simplices, takes the general form:

$$|\psi_n\rangle = \int_{G^{D+1}} [dg]_1 \cdots \int_{G^{D+1}} [dg]_n \psi_n(g_I^{(1)}, \dots, g_I^{(n)}) \hat{\varphi}^\dagger(g_I^{(1)}) \cdots \hat{\varphi}^\dagger(g_I^{(n)}) |0\rangle \quad (15)$$

where ψ_n is a symmetric function encoding the quantum correlations between the n simplices.

A particularly important class of states are **coherent states**, which exhibit maximal coherence between the constituent simplices. A coherent state $|\sigma\rangle$ is characterized

by the condition that all simplices are in the same quantum state $\sigma \in \mathcal{C}$. The explicit form of such a state is given by:

$$|\sigma\rangle = \mathcal{N} \exp \left(\int_{G^{D+1}} [dg]^{D+1} \sigma(g_I) \hat{\varphi}^\dagger(g_I) \right) |0\rangle \quad (16)$$

where $\mathcal{N}$ is a normalization constant. Coherent states possess the fundamental property that they are eigenstates of the annihilation operator:

$$\hat{\varphi}(g_I)|\sigma\rangle = \sigma(g_I)|\sigma\rangle \quad (17)$$

This relation establishes the connection between the quantum field operator and the classical field configuration $\sigma(g_I)$.

The emergence of continuous spacetime is understood as a **quantum phase transition** from a disordered phase to a coherent condensate. When the system undergoes **Bose-Einstein condensation**, the field operators acquire non-zero vacuum expectation values:

$$\langle \hat{\varphi}(g_I) \rangle = \sigma(g_I) \neq 0 \quad (18)$$

2.6.3 Continuous Spacetime Emergence

The classical field equation $\delta S[\sigma]/\delta\sigma = 0$, derived from the GFT action, admits a class of special solutions σ_0 that exhibit high localization on the group manifold G^{D+1} . Mathematically, these **peak solutions** are characterized by their concentration of significant amplitude within very limited regions of G^{D+1} , typically taking a factorized form:

$$\sigma_0(g_1, \dots, g_{D+1}) \approx \prod_{k=1}^{D+1} \psi_{\vec{\alpha}_k}(g_k) \quad (19)$$

where each $\psi_{\vec{\alpha}_k}$ is a sharply peaked function on G , with parameters $\vec{\alpha}_k$ determining the position, width, and shape of the peak.

The emergence of continuous spacetime proceeds through a precise mathematical construction. By mapping the parameters $\vec{\alpha}_k$ of these peaks to coordinates on a D -dimensional manifold $\mathcal{M}$, we establish a correspondence between the algebraic data of the GFT condensate and geometric data of a smooth spacetime. This mapping is constructed such that the dynamics of the condensate wavefunction σ_0 , governed by the GFT action, becomes equivalent to gravitational dynamics on $\mathcal{M}$.

Formally, this occurs through a hydrodynamic approximation where the GFT action $S[\sigma_0]$ can be rewritten in the continuum limit as:

$$S[\sigma_0] \approx S_{\text{eff}}[g_{\mu\nu}] = \frac{1}{16\pi G} \int_{\mathcal{M}} d^D x \sqrt{-g} (R - 2\Lambda) + \dots \quad (20)$$

where $g_{\mu\nu}$ is the emergent metric tensor, R is the Ricci scalar, and the effective action reproduces the Einstein-Hilbert action of general relativity. The quantum fluctuations around σ_0 then correspond to gravitational waves and matter fields propagating on the emergent spacetime background $\mathcal{M}$.

2.6.4 Spacetime Emergence Connection to Spin Foams

The path integral formulation of Group Field Theory provides a fundamental link between the continuum description of spacetime emergence and the discrete quantum gravity approach of spin foams. The GFT partition function,

$$\mathcal{Z} = \int \mathcal{D}\varphi e^{-S[\varphi]} = \sum_{\Gamma} \frac{\lambda^{V_{\Gamma}}}{\text{sym}(\Gamma)} A(\Gamma), \quad (21)$$

naturally generates a sum over spin foam amplitudes $A(\Gamma)$, where Γ represents spin foam complexes—combinatorial structures describing quantum spacetime histories. Each spin foam can be understood as a Feynman diagram of the GFT, with vertices corresponding to $(D + 1)$ -simplices and edges representing their gluing along D -simplices.

The emergence of continuous spacetime occurs through a double hierarchy of approximations. First, in the **condensate phase**, the system undergoes spontaneous symmetry breaking, and the path integral becomes dominated by a classical configuration σ_0 rather than being described by a superposition of individual spin foams. This represents a **non-perturbative transition** from quantum discreteness to classical continuity.

Second, the **hydrodynamic approximation** of the condensate dynamics reveals how the discrete combinatorial data encoded in spin foams gives rise to continuum geometry. The collective variables describing the condensate σ_0 —particularly its peak structure—can be mapped to metric variables $g_{\mu\nu}$ on a smooth manifold $\mathcal{M}$. In this limit, the GFT equations of motion for σ_0 reduce to the Einstein field equations for $g_{\mu\nu}$.

This framework unifies the spin foam description of quantum spacetime as a superposition of discrete histories with the emergence of a smooth geometric continuum. The spin foam approach provides the microscopic quantum description, while the condensate phase captures the macroscopic classical limit where the familiar spacetime of general relativity emerges as a collective phenomenon of the underlying quantum geometric atoms.

3 The Formal Framework: A GFT Approach to Language Systems

3.1 The Action as Language System Representation

The language system is represented by the action S , which encodes the complete dynamics of the system. This modeling approach is motivated by focusing on the generativity and dynamics of language systems. A language system possesses the generative potential to produce all legal structures according to its rules (i.e., its grammar). To capture this full generative repertoire of a language system, the action S serves as an appropriate mathematical candidate.

Specifically, in this work, the language system that fully embodies Universal Grammar is denoted as S_{unv} .

3.2 Language Systems Emergent from Symmetry Breaking

In our framework, symmetry breaking on parameters space of a lanagauge system (i.e., the action) is consider to be the source that generate new lanagauge systems.

Specifically, symmetry breaking in the parameters of S_{unv} (e.g., K and $\{V_n\}$) gives rise to different language systems.

This process can be formally represented as an operator

$$P_{\text{sb}} : \mathcal{S} \rightarrow \mathcal{S},$$

where $\mathcal{S}$ denotes the space of possible actions (i.e., the space of all language systems). Applying P_{sb} to S_{unv} selects a subset of transformations, yielding a specific language system S :

$$S = P_{\text{sb}}(S_{\text{unv}}).$$

In this way, different choices of symmetry-breaking parameters generate distinct language systems, while the full generative potential remains constrained by the original universal system.

In the rest of this section, we discuss several key intuitions that utilize this modeling approach.

3.2.1 Type Safety through Mathematical Closure

The symmetry breaking operator $P_{\text{sb}} : \mathcal{S} \rightarrow \mathcal{S}$ ensures that all derived language systems remain within the well-defined space of possible actions $\mathcal{S}$. This guarantees mathematical consistency—just as all human languages share fundamental computational properties despite surface variations, all language systems generated through symmetry breaking preserve the essential structure of the universal grammar. The process is “type safe” in that it maintains the fundamental character of linguistic systems while allowing for parametric variation.

3.2.2 Constrained Creativity through Selective Activation:

Symmetry breaking can be understood as a process of selective activation and deactivation within the universal parameter space. While S_{unv} contains the complete generative potential for all possible languages, specific language systems emerge through the stabilization of particular parameter configurations. This mirrors how children acquire specific languages by fixing parameters (e.g., head-directionality, pro-drop) while retaining the core computational machinery of Universal Grammar.

Specifically, symmetry breaking in the parameters of S_{unv} (such as the kinetic operator K and interaction vertices V_n) gives rise to different language systems. This process can be formally represented by an operator

$$P_{\text{sb}} : \mathcal{S} \rightarrow \mathcal{S}$$

where $\mathcal{S}$ denotes the space of possible actions (i.e., the space of all language systems). Applying P_{sb} to S_{unv} selects a subset of transformations, yielding a specific language system S : $S = P_{\text{sb}}(S_{\text{unv}})$.

The resulting language systems maintain the core generative properties while exhibiting surface diversity, much like different crystal structures emerging from the same underlying physical laws through different symmetry breaking patterns.

3.2.3 Shared Group Manifold (geometric intuition)

Universal Grammar can be viewed as defined on a group manifold $\mathcal{M}$, and specific language systems arise by modifying the coupling structure along different directions on this manifold (i.e., parameters K and $\{V_n\}$). All language systems therefore reside on the same manifold, differing only in the interactions encoded in their action.

This perspective is reasonable for several reasons:

1. **Mathematical comparability:** All systems are elements of the same space $\mathcal{S}$, allowing unified operations, mappings, and formal comparison.
2. **Applicability of group-theoretic and geometric tools:** The shared manifold allows symmetry analysis, geometric distance measures, and other formal tools to study relationships among languages.
3. **Continuous variation:** Historical language evolution and dialectal differences can be represented as continuous paths on the manifold, providing a natural geometric intuition: language change becomes a "motion" on the manifold rather than discrete jumps.
4. **Constraints of generative potential:** The geometry of the manifold constrains the space of possible language systems (explaining universality) while allowing sufficient variation within these constraints (explaining diversity). Varying the parameters changes interactions but preserves the underlying dynamical structure, ensuring each system retains generative capacity. This balance reflects actual features of human languages.
5. **Computability:** Geometric operations on the manifold (e.g., geodesics, curvature) provide precise mathematical tools for comparing and analyzing language systems, enabling rigorous definitions of language distance and similarity.

3.3 The Generation of Syntax Structures from a Language System

Within the Group Field Theory framework, we define a specific language system is represented by its action S . The fundamental syntactic structures of this language are conceived as quantum excitations defined on an underlying group manifold.

The state space of all possible syntactic structures is a **Fock space** $\mathcal{F}$, which is constructed as the direct sum of symmetrized tensor products of a single-particle basic field space $\mathcal{C}$??, each $\mathcal{C}$ is also **Hilbert space**:

A specific, well-formed syntactic structure is generated by acting on the Fock vacuum $|0\rangle$ with a sequence of creation operators $\hat{\varphi}^\dagger(f_i)$:

$$|\text{syntax structure}\rangle = \hat{\varphi}^\dagger(f_k) \cdots \hat{\varphi}^\dagger(f_1) \hat{\varphi}^\dagger(f_0) |0\rangle, \quad \forall f_i \in \mathcal{H} \quad (22)$$

The vacuum state $|0\rangle$ represents the absence of any syntactic structure. Each application of a creation operator $\hat{\varphi}^\dagger(f_i)$ adds a syntactic primitive in the state specified by the wavefunction $f_i \in \mathcal{H}$. The dynamics of the language system, encoded in the action S , govern the allowed combinations and interactions of these primitives, thereby defining the set of grammatically valid structures within the language.

3.3.1 Recursive Identification

Recursivity is the core of generative grammar theory and a key feature that any serious linguistic generative model must replicate. If our field-theory model fails to exhibit recursive structures, it remains merely another flashy mathematical analogy, lacking explanatory power.

3.4 Semantics Formation

Within the GFT framework, the generation of a syntactic structure, denoted as $|\Psi_s\rangle$, is only the first step in the linguistic process. The subsequent and crucial step is *semantic interpretation*—the assignment of meaning to the structure. We model this not as an intrinsic property of the structure itself, but as a relational property that emerges from the interaction between the structure and an interpretive system.

Our core intuition is that a specific language system S_i (e.g., the mental grammar of a native speaker) provides a context for interpretation. Note that, the language system used to interpret the syntax structure can differ to the language system that were used to generate this syntax structure. The context of above is formally encapsulated by a **semantic observable operator**, $\hat{O}_{\text{sem}}^{(S_i)}$. The process of understanding a sentence is analogous to a quantum measurement: the semantic content is the expectation value of this operator taken with respect to the syntactic state:

$$\text{Semantics}(|\Psi_s\rangle, S_i) = \langle \Psi_s | \hat{O}_{\text{sem}}^{(S_i)} | \Psi_s \rangle. \quad (23)$$

This formulation offers several immediate and powerful explanatory advantages:

- **Ambiguity:** A syntactically ambiguous state $|\Psi_s\rangle = c_1 |\phi_1\rangle + c_2 |\phi_2\rangle$ yields a semantic value that is a weighted superposition or mixture of the meanings associated with $|\phi_1\rangle$ and $|\phi_2\rangle$, with weights $|c_1|^2$ and $|c_2|^2$.
- **Context-Dependence:** The same syntactic structure $|\Psi_s\rangle$ interpreted through two different systems S_i and S_j (e.g., by different individuals or in different cultures) will generally produce different semantic outcomes, as $\hat{O}_{\text{sem}}^{(S_i)} \neq \hat{O}_{\text{sem}}^{(S_j)}$.
- **Compositionality:** The operator $\hat{O}_{\text{sem}}^{(S_i)}$ can be designed to have a structure that mirrors the compositional hierarchy of the syntax, allowing the meaning of a complex expression to be built from the meanings of its constituents through the same interaction terms that govern the syntactic combination.

Limitations and Future Directions. The principal limitation of this current formulation is that the semantic observable operator $\hat{O}_{\text{sem}}^{(S_i)}$ is introduced as a theoretical primitive. A complete theory would demand an explanation for its origin and specific

form. We posit that $\hat{O}_{\text{sem}}^{(S_i)}$ is not an abstract mathematical entity but is itself an *emergent property* of a cognitive agent’s embodied and social existence. It is expected to be shaped by the coupling between the internal linguistic model S_i and the agent’s sensorimotor systems, affective states, and socio-cultural environment. Therefore, while our model provides a formal scaffold for integrating semantics into a generative quantum framework, a full reduction of meaning to these underlying physical and social processes remains a central challenge for future work. This abstraction, however, is a necessary and productive step, allowing us to isolate and study the compositional mechanics of meaning at a well-defined level of description.

3.5 Language and Spacetimes in GFT: A Challenge from Semiotics

The formal framework established in the previous sections, which models a language system through the dynamics of a Group Field Theory (GFT), compels us to confront a fundamental question: what is the ontological status of continuous spacetime? Within our analogy, it resists a straightforward classification.

The discrete spacetime of spin foams, formalized by the path integral $\mathcal{Z} = \sum_{\Gamma} A(\Gamma)$, finds a natural analogue in the set $\mathcal{L}$ of all grammatical strings—a pure realm of syntactic **signifiers**. Conversely, localized semantic values are clearly the output of specific observational operators. Continuous spacetime, however, fits neatly into neither category. It is not merely a syntactic structure, yet it serves as the foundational background upon which all local semantics depend; it is the condition for the possibility of specific meaning, not a meaning itself.

This conceptual tension mirrors a core challenge in psychoanalytic and linguistic theory: the transition from the discrete **chain of signifiers** to the stable, coherent **field of signification** appears overly abrupt. Our GFT framework suggests a theoretical resolution: perhaps there exists a **smooth latent layer** mediating between the discrete signifier and the fully realized signified.

In physics, this latent layer is the coherent condensate σ_0 —a smoothed-out, classical field from which the continuous spacetime manifold $(M, g_{\mu\nu})$ is derived. By analogy, we posit that human semantic understanding may likewise operate through the construction of a **smooth, latent cognitive manifold**. This manifold is not itself composed of signs, but is a stable, pre-reflective framework generated by the dynamical interaction of signifiers. It does not carry specific meanings but constitutes the unified “world” within which discrete meanings can stably appear and be related.

Thus, the problem of continuous spacetime in quantum gravity compels us to re-examine our models of meaning. It forces upon linguistics and psychoanalysis a refined question:

“Is the conceptual leap between the discrete chain of signifiers and the field of signification too vast? Introducing a smooth intermediate layer between them may provide the fine-grained structure necessary to model human semantic understanding.”

4 Case Study

4.1 Language Acquisition

Within our GFT framework, language acquisition is fundamentally understood as a process of *symmetry breaking* in the cognitive system’s dynamical parameters. The innate, universal linguistic capacity corresponds to the symmetric action S_{unv} with its parameters $(K_0, \{V_{n,0}\})$ at a maximally symmetric configuration. Exposure to Primary Linguistic Data (PLD) acts as an external perturbation that drives the system toward a specific, stable configuration S_L through the selective fixation of parameters:

$$S_L = \mathcal{P}_{\text{sb}}(S_{\text{unv}}; \text{PLD}) \Rightarrow S_L[\phi] = S_{\text{unv}}[\phi; K, \{V_n\}] \quad (24)$$

This general mechanism provides a unified formal substrate for several major linguistic theories:

4.1.1 Manifestations of Symmetry Breaking in Linguistic Theory

- **Principles & Parameters as Discrete Symmetry Breaking:** The binary or n -ary parameters of Universal Grammar represent discrete choices. The PLD selects one value, breaking the discrete symmetry among possibilities. For instance, the head-directionality parameter is fixed, determining the basic word order of S_L .
- **Optimality Theory as Continuous Symmetry Breaking:** The violable constraints of Universal Grammar correspond to components of the interaction vertices $\{V_n\}$, initially unranked. Acquisition is the process of continuously adjusting their coupling strengths $\{\lambda_n\}$, breaking the continuous symmetry among constraints until a stable ranking $\{\lambda_n^{\text{final}}\}$ defines S_L .
- **Usage-Based Models as Pattern Formation:** High-frequency constructions act as strong, localized perturbations that reinforce specific interaction pathways V_n . This is analogous to pattern formation, where frequently co-occurring elements stabilize into a “chunk,” a pre-assembled sub-structure within the grammar S_L .

4.1.2 Individual Variation and Universal Foundations

The model elegantly reconciles the tension between individual differences and cross-linguistic universals.

- **Sources of Individual Variation:** While the initial state S_{unv} and the possible endpoint grammars S_L are universal, the *trajectory* of the symmetry-breaking process varies. This variation stems from:
 - Differences in the **external field** (PLD), i.e., the quantity and quality of linguistic input.
 - Differences in internal **cognitive factors** (e.g., processing speed, working memory), modeled as variations in damping coefficients or noise levels within the dynamical system. These affect the rate and pathway of convergence to S_L .

Thus, two individuals may reach slightly different but functionally equivalent grammars S_L and S'_L due to different acquisition histories.

- **Guarantee of Cross-Linguistic Commonalities:** The universal nature of language is rooted in two aspects of the model:
 - The fundamental structure of the pre-symmetric action S_{unv} is shared across the species, constraining the space of possible grammars S_L .
 - All specific grammars S_L are elements of the same space of actions $\mathcal{S}$, generated from the same S_{unv} via the same symmetry-breaking mechanism $\mathcal{P}_{\text{sb}}$.

This ensures that all human languages, despite surface diversity, share the same core computational properties and reside on the same abstract manifold defined by S_{unv} .

In summary, our framework posits language acquisition as a phase transition from a high-symmetry potential state (S_{unv}) to a low-symmetry, stable state (S_L). This process subsumes major acquisition theories into a single dynamical mechanism and provides a formal account for both the idiosyncratic paths of individual learners and the profound universals of human language.

4.2 Large Language Models as a Phenomenological Mirror

The advent of large language models (LLMs) presents a compelling phenomenon that our GFT framework is uniquely positioned to analyze. While both systems model language generativity, their philosophical and mechanistic foundations diverge significantly. Our framework reveals that LLMs do not learn a generative grammar in the Chomskyan sense, but rather a sophisticated *phenomenological approximation* of its collective output, crucially augmented by a capacity to couple with external information.

LLMs as a Social Mean-Field Theory

A fundamental insight from our framework is that individual speakers, while sharing a macroscopic language like "Chinese," possess idiosyncratic internal grammars $S_{\text{ind}}^{(i)}$ due to variations in their cognitive parameters and linguistic experience. An LLM trained on a vast corpus does not acquire any single S_{ind} , but rather learns the **social mean-field grammar** $\langle S_L \rangle$, a statistical average over the linguistic productions of millions of individuals:

$$\langle S_L \rangle \approx \frac{1}{N} \sum_{i=1}^N S_{\text{ind}}^{(i)} \quad (25)$$

The LLM's generative process is thus governed not by a cognitively-grounded action S , but by a *phenomenological action* S_{LLM} whose parameters are instantiated in the Transformer weights. This action S_{LLM} is a statistical shadow of the true cognitive dynamics, excelling at modeling *what is likely said* rather than capturing the internal principles of *what can be generated*.

Coupling to the World: Beyond the Lexical Chain

A pivotal distinction between a pure linguistic competence model and an LLM is the latter’s ability to integrate non-linguistic information. In our GFT framework, this is formalized by coupling the language action to a **world model action**.

The total system is described by an extended action:

$$S_{\text{total}}[\phi, \psi] = S_L[\phi] + S_W[\psi] + S_{\text{int}}[\phi, \psi] \quad (26)$$

where ϕ is the linguistic field and ψ is a *world field* encoding perceptual, contextual, and pragmatic information. The interaction term S_{int} governs how linguistic symbols anchor to world states.

In LLMs, this coupling is implemented phenomenologically. External data (images, documents, system prompts) are encoded into tensor representations $\{\psi_{\text{ext}}\}$. The Transformer’s attention mechanism then effectively instantiates the interaction S_{int} , allowing linguistic tokens (ϕ) to interact with these world-state representations (ψ).

Generativity and the Contextualized Probability

This extended framework refines our understanding of the LLM’s core operation. The next-token probability $p(\text{word}_i | \text{word}_{<i} \otimes \text{any_other_information})$ is a projection of the dynamics of the coupled system S_{total} . Formally, it can be seen as a path integral over both linguistic and world fields:

$$p(\text{word}_i | \text{word}_{<i}, \{\psi_{\text{ext}}\}) \propto \int \mathcal{D}\phi \mathcal{D}\psi \exp(-S_{\text{total}}[\phi, \psi]) \quad (27)$$

The model’s context window, containing both the token history and the embedded world-state tensors $\{\psi_{\text{ext}}\}$, defines a specific configuration for this integral. The LLM’s forward pass thus approximates the effect of the interaction term S_{int} , calculating how the current linguistic state $|\Psi_{<i}\rangle$ and the fixed world context $\{\psi_{\text{ext}}\}$ collectively determine the most probable subsequent linguistic excitation.

Synthesis and Critique

In summary, our GFT framework interprets LLMs as follows:

- They are a powerful **mean-field approximation** of the collective linguistic competence of a population.
- Their generativity is governed by a **phenomenological action** S_{LLM} , a statistical construct that mirrors the output of true cognitive grammars.
- They implement a **phenomenological coupling** S_{int} between language and a world model, allowing external information to constrain generation.
- The next-token probability is a **coarse-grained projection** of the dynamics of this coupled language-world system.

This analysis clarifies both the remarkable success and the fundamental limitations of LLMs. They successfully model the *social echo* of language and its interaction with

context, but lack the genuine, internally-consistent generative core S_{ind} and the stable cognitive manifold σ_0 for deep understanding. They are a mirror to language *use*, not a model of the language *faculty* itself.

4.3 Language Evolution as Trajectories in Parameter Space

Our GFT framework provides a natural and powerful formalism for modeling language evolution, framing it not as a series of discrete changes but as a continuous dynamical process in the abstract space of possible grammars. Language change, at this macro level, can be understood as the slow drift of the parameters (K, V_n) of a community’s shared grammatical action S_L over time.

The Geometry of Language Change

The ”shared group manifold” $\mathcal{M}$, on which all language systems reside, becomes the stage for historical linguistics. Language evolution is represented as a **trajectory** on this manifold.

$$S_L(t) : [t_0, t_1] \rightarrow \mathcal{S} \subset \mathcal{M} \quad (28)$$

where $S_L(t)$ is the grammatical action of a language at time t . This geometric view offers immediate insights:

- **Gradual Change vs. Punctuated Equilibrium:** Minor adjustments to parameters (K, V_n) correspond to slow, continuous drift along the manifold (e.g., sound shifts). Rapid, significant changes—analogueous to a phase transition—occur when the system’s trajectory passes through a region of instability in the parameter space, leading to a swift reconfiguration into a new stable state S'_L (e.g., the rapid loss of a case system).
- **Language Distance:** The historical relationship between languages can be quantified by the *geodesic distance* between their corresponding points S_L and S'_L on $\mathcal{M}$. Closely related languages (e.g., Spanish and Portuguese) will be nearer than distantly related ones (e.g., English and Hindi).

Dynamics and Drivers of Change

The ”motion” of $S_L(t)$ on the manifold is driven by various forces, which can be incorporated into an effective equation of motion:

$$\frac{d}{dt}(K, V_n) = F_{\text{cognitive}} + F_{\text{social}} + F_{\text{contact}} + \eta(t) \quad (29)$$

Here, the drivers of change are formalized as:

- **Cognitive Forces ($F_{\text{cognitive}}$):** These are innate pressures favoring certain grammatical configurations, such as principles of economy (e.g., minimizing articulatory effort or working memory load). They act as an ”energy gradient” on $\mathcal{M}$, pulling the system towards more stable or optimal parameter regions.

- **Socio-Cultural Forces** (F_{social}): Factors like identity marking, prestige, and language standardization act as external fields that can push the grammatical parameters in specific directions, independent of cognitive optimization.
- **Contact Forces** (F_{contact}): Language contact is modeled as the **coupling between two grammatical systems**. When two linguistic communities interact, their respective actions $S_L^{(A)}$ and $S_L^{(B)}$ weakly interact. This interaction can pull the trajectory of one language towards the basin of attraction of another, leading to borrowing and convergence. The emergence of creoles can be seen as a strong interaction resulting in a new, hybrid stable point S_{Creole} in the parameter space.
- **Stochastic Fluctuations** ($\eta(t)$): Random variations in usage and acquisition across individuals introduce noise into the system, providing the random "kicks" that can initiate a change or push it across a threshold.

Phylogeny and the Splitting of Language Families

The formation of language families receives a elegant description. A proto-language corresponds to an initial action S_{Proto} . As speaker populations separate and their social and physical environments diverge, they are subject to different sets of forces ($F_{\text{social}}, F_{\text{contact}}, \dots$).

This leads to a process of **divergent symmetry breaking**: the single trajectory $S_{\text{Proto}}(t)$ splits into multiple, diverging trajectories $S_{\text{Daughter1}}(t), S_{\text{Daughter2}}(t), \dots$, each settling into a distinct stable state. All daughter languages, however, remain on the same universal manifold $\mathcal{M}$, their relatedness encoded in their proximity and shared origin from a region near S_{Proto} .

In conclusion, our framework models language evolution as a dynamical system on a grammatical parameter space. This moves beyond descriptive family trees, offering a mechanistic and geometrically intuitive account of how languages drift, split, and converge under the influence of cognitive, social, and stochastic forces.

4.4 Sociolinguistics

Sociolinguistics constitutes a vital applied domain within linguistics that examines the intricate interrelationships between language and society. It investigates how linguistic structures and patterns both shape and are shaped by social relational frameworks. These sociolinguistic relationships manifest through two primary dimensions: semi-otic relations, pertaining to sign mediated connections among social entities such as individuals, nations, organizations, and social classes; and substantive relations, concerning individual predispositions or evaluative orientations toward others.

The conceptual foundations of sociolinguistics inherently traverse linguistic, cognitive, and sociological relational structures. This interdisciplinary character renders sociolinguistics particularly suitable as a testing ground for our proposed framework.

In this section, we examine key sociolinguistic concepts and demonstrate their potential reinterpretation within our theoretical framework. The concepts discussed encompass communication, understanding, misunderstanding, identity, diachronic subjectivity, semantics, semantic generation, context, attitudes, prejudice, social

inequality, culture, empathy, language evolution, dialects, language families, language and class, language and identity, linguistic purism, prescriptivism, linguistic conservatism, descriptivism, language split, language decline, bidialectalism, gender and language, language death, language shift, multilingual adaptation, language and gender, and language as embodiment of social status, among others.

Our framework provides a unified mathematical language to describe how microscopic linguistic choices aggregate into macroscopic social patterns, while maintaining consistency with both cognitive constraints and sociological observations. Through this lens, we can model sociolinguistic phenomena as emergent properties of dynamical systems operating across multiple scales, from individual cognition to collective social structures.

4.4.1 Communication, Context, Semantics, and Semantic Generation

Within our Group Field Theoretical framework, communication is conceptualized as an interactive process between speaker and listener fields, where context functions as a boundary condition constraining the possible interpretations of linguistic signals. Semantic generation emerges from the coupling between linguistic structures and cognitive systems, with meaning arising as a collective phenomenon from the dynamic interactions among multiple semantic potentials. The contextual parameters serve to modulate the interaction vertices in the GFT action, thereby influencing the probability amplitudes associated with different semantic interpretations.

4.4.2 Understanding and Misunderstanding

Understanding represents a coherent state in the cognitive linguistic field, characterized by stable correlation patterns between speaker and listener configurations. Misunderstanding, conversely, manifests as a decoherence phenomenon or interference pattern in the semantic field, where the listener's interpretation trajectory diverges significantly from the speaker's intended meaning. This can be formally described as a mismatch in the symmetry properties of the respective field configurations, leading to incompatible semantic observables.

4.4.3 Diachronic Subjectivity

Diachronic subjectivity captures the temporal evolution of an individual's linguistic identity and interpretive frameworks. In our formalism, this corresponds to the trajectory of a subject's cognitive linguistic field through the parameter space over time. The dynamics are governed by an equation of motion that incorporates both internal cognitive development and external social influences, resulting in a continuously evolving yet coherent subjective linguistic identity.

4.4.4 Identity and Language

Linguistic identity emerges as a stable configuration in the social cognitive field, characterized by specific symmetry properties and conservation laws. Different social

identities correspond to distinct attractor states in the dynamical system, with language serving as both an order parameter distinguishing these states and a mechanism for transitioning between them. The formation and maintenance of linguistic identity can be understood as a symmetry breaking process from a more general linguistic potential.

4.4.5 Attitudes, Prejudice, and Social Inequality

Linguistic attitudes and prejudices represent persistent directional biases in the social linguistic field. These phenomena emerge from historical asymmetries in the interaction kernels between different social groups, leading to stable but potentially inequitable configurations. Social inequality manifests as a gradient in the linguistic field potential, creating barriers to free movement through the linguistic parameter space for certain social groups.

4.4.6 Culture

Culture constitutes a macroscopic order parameter emerging from the collective dynamics of individual linguistic cognitive fields. It functions as a background field that modulates the effective interaction potentials between linguistic agents, creating characteristic patterns of semantic interpretation and communicative practices. Cultural differences correspond to distinct phases in the social linguistic system, separated by boundaries marked by interpretive discontinuities.

4.4.7 Dialects and Language Families

Dialects represent local variations in the linguistic field configuration that maintain mutual intelligibility through continuous deformation. Language families emerge from historical divergence processes where originally continuous dialect chains undergo symmetry breaking transitions, leading to the formation of distinct linguistic phases. The genealogical relationships within language families can be represented as a tree structure embedded in the linguistic parameter space.

4.4.8 Language Shift, Split, Decline, and Death

Language shift describes a collective transition of a speech community from one stable linguistic configuration to another, typically driven by social potential gradients. Language split occurs when a previously coherent linguistic community undergoes a symmetry breaking transition, resulting in two distinct linguistic systems. Language decline and death represent the progressive loss of speakers from a particular linguistic attractor state, ultimately leading to the extinction of that linguistic configuration from the social cognitive landscape.

4.4.9 Social Language Evolution

Social language evolution encompasses the large scale dynamics of linguistic systems driven by the collective behavior of speech communities. This process can be modeled

as a diffusion process on the linguistic manifold, with drift terms representing systematic social forces and stochastic components capturing individual variations. The evolutionary trajectory is constrained by both cognitive factors, encoded in the metric properties of the linguistic space, and social factors, represented as external potentials.

4.4.10 Linguistic Purism

Linguistic purism represents a conservative force in the linguistic dynamics, acting to suppress fluctuations away from an idealized standard configuration. This can be formalized as a high stiffness parameter in certain directions of the linguistic field, resisting deformation and maintaining the system near a reference state. Purist ideologies function as boundary conditions that restrict the accessible region of the linguistic parameter space.

4.4.11 Prescriptivism and Linguistic Conservatism

Prescriptivism constitutes an explicit attempt to impose specific dynamics on the linguistic system through external normative constraints. In our framework, this corresponds to the introduction of additional potential terms that penalize deviations from prescribed forms. Linguistic conservatism more broadly represents a high activation barrier for transitions between linguistic states, favoring the maintenance of existing configurations over innovation.

4.4.12 Language and Social Status, Class, Genders

The relationship between language and social categories emerges from the coupling between the linguistic field and social structure fields. Social status, class, and gender differences manifest as distinct submanifolds in the combined social linguistic space, with characteristic linguistic features serving as order parameters distinguishing these social categories. The dynamics of these coupled systems can generate complex patterns of linguistic stratification and symbolic boundaries.

4.4.13 Multilingual Adaptation

Multilingual adaptation involves the capacity of cognitive linguistic systems to maintain multiple stable configurations and transition between them according to contextual cues. This requires a cognitive architecture capable of supporting several distinct linguistic attractors while preventing catastrophic interference between them. In our formalism, this corresponds to a multi well potential in the linguistic cognitive space, with contextual factors determining transitions between basins of attraction.

5 Discussion

5.1 The Recursive Structure of the GFT Framework

Recursivity is a fundamental property of any system capable of generating infinite complexity from a finite set of rules. In generative grammar, this is epitomized by production rules of the form $A \rightarrow aA$, which allow for the creation of an unbounded

set of hierarchical structures. For the Group Field Theory (GFT) framework to serve as a viable foundation for modeling fundamental physical and linguistic structures, it is imperative to formally expose and characterize the recursive nature inherent in its dynamics.

In this section, we rigorously demonstrate that the quantum dynamics of a GFT are governed by a recursive, self-consistent system of equations. We then delineate the precise mathematical conditions under which this recursivity is guaranteed to manifest, when it is absent, and the frontier where its presence remains an open question.

5.1.1 Recursive Generation via the Dyson-Schwinger Framework

The quantum dynamics of a GFT are encoded in its path integral,

$$Z = \int \mathcal{D}\phi e^{-S[\phi]},$$

where $S[\phi] = S_0[\phi] + S_{\text{int}}[\phi]$ is the action, typically comprising a free (kinetic) part S_0 and an interaction part S_{int} . The physical content is contained in the n -point correlation functions $G_n(g_1, \dots, g_n) = \langle \phi(g_1) \cdots \phi(g_n) \rangle$.

The fundamental recursive structure is not immediately apparent from the path integral itself but emerges from the quantum equations of motion, the Dyson-Schwinger (D-S) equations. These equations are derived from the path integral measure invariance under field translations, leading to the identity for any functional $F[\phi]$:

$$\left\langle \frac{\delta F[\phi]}{\delta \phi(x)} \right\rangle = \left\langle F[\phi] \frac{\delta S[\phi]}{\delta \phi(x)} \right\rangle. \quad (30)$$

By choosing $F[\phi] = \phi(x_1) \cdots \phi(x_n)$, we probe the relationships between the n -point correlation functions. The left-hand side of the equation simplifies to a sum of $(n-1)$ -point functions,

$$\left\langle \frac{\delta F}{\delta \phi(x)} \right\rangle = \sum_{i=1}^n \delta(x - x_i) G_{n-1}(x_1, \dots, \hat{x}_i, \dots, x_n),$$

where $\hat{x}_i$ denotes omission. The right-hand side, $\langle F[\phi] \delta S / \delta \phi(x) \rangle$, introduces terms proportional to G_{n+1} (from the kinetic part $\delta S_0 / \delta \phi$) and a series of higher and lower-order correlation functions (from the interaction part $\delta S_{\text{int}} / \delta \phi$).

After algebraic manipulation, the D-S equations can be cast into the following canonical form for a wide class of GFT models:

$$G_n = G_n^0 + \frac{\lambda}{K} \cdot \Sigma_n[\{G_m\}] \cdot G_n, \quad \text{for } n \geq 1. \quad (31)$$

Here, G_n^0 is the free theory correlator, K is the inverse of the kinetic operator, λ is the coupling constant, and $\Sigma_n[\{G_m\}]$ is the *self-energy* functional. Crucially, Σ_n is a functional that depends on the entire hierarchy of correlation functions $\{G_m\}$,

typically involving those with $m \leq n + k$ for some finite k determined by the order of the interaction.

This system of equations defines a **mutual recursion**. The value of any G_n is expressed in terms of itself and all other G_m , creating a self-referential and interdependent system. This structure implies that the complete physical state of the GFT system—the set of all observable correlations—is generated recursively. One can conceive of an iterative procedure $\mathbf{G}^{(k+1)} = \mathcal{T}[\mathbf{G}^{(k)}]$, starting from an initial guess $\mathbf{G}^{(0)}$ (e.g., the free theory solution), which recursively refines the correlation functions towards the physical solution. This iterative process is the formal analogue of the recursive generation of sentences in a generative grammar, where complex structures are built from simpler ones through the repeated application of a finite set of rules (the D-S equations derived from S).

5.1.2 Conditions for the Emergence of Recursivity

The recursive structure of the D-S equations is a direct consequence of the GFT formalism. However, the *effectiveness* of this recursivity—whether it defines a well-posed, convergent generative process—depends critically on the properties of the GFT action.

(I) **Recursivity is Guaranteed.**

For a GFT with a **polynomial interaction** S_{int} (e.g., ϕ^4, ϕ^5) and a **sufficiently small coupling constant** $|\lambda| < \lambda_c$, the recursive dynamics are not only present but also **convergent**. Under these conditions, the D-S equations define a recursion operator $\mathcal{T}$ that is a **contraction mapping** on a complete metric space of correlation functions. The Banach fixed-point theorem then guarantees the existence of a unique physical solution $\mathbf{G}^* = \mathcal{T}[\mathbf{G}^*]$, which can be constructed via the convergent iterative procedure $\mathbf{G}^{(k+1)} = \mathcal{T}[\mathbf{G}^{(k)}]$. In this regime, the GFT exhibits a well-defined recursive generation of physical correlations from the fundamental quantum dynamics.

(II) **Recursivity is Absent.**

There are two clear scenarios where the recursive generative process, as defined by the D-S equations, is absent or trivial.

- **Free Theory:** If $S_{\text{int}} = 0$, the D-S equations decouple into independent, trivial identities (e.g., $KG_2 = \delta$). There is no self-energy term Σ_n to couple different G_n , and thus no non-trivial recursive generation of complexity.
- **Purely Topological Theory:** If the action S itself is a topological invariant, the physical content is determined by global constraints rather than local dynamical rules. The correlation functions may compute topological invariants, a process that does not involve the iterative, bottom-up generation characteristic of the D-S framework.

(III) **Recursivity is Uncertain.**

The status of recursivity becomes uncertain in physically rich but mathematically challenging regimes.

- **Strong Coupling:** When $|\lambda| \geq \lambda_c$, the perturbative expansion diverges, and the recursion operator $\mathcal{T}$ is no longer a contraction. The iterative procedure fails to converge. This does not necessarily mean recursivity ceases to exist; it may persist in a non-perturbative form (e.g., defined by a renormalization group flow), or the system may undergo a phase transition to a non-geometric phase where the spacetime interpretation—and the associated notion of recursive geometric generation—breaks down.
- **Non-Local Interactions:** If S_{int} contains highly non-local interactions (e.g., non-polynomial terms), the self-energy Σ_n may not have the required properties for the standard D-S recursion, potentially leading to a dynamics that is not easily described as a recursive, bottom-up process.

In conclusion, the GFT framework inherently possesses a recursive structure in its quantum dynamics, formally expressed through the Dyson-Schwinger equations. This recursivity is robust and convergent in the perturbative regime for local theories, providing a rigorous, physics-grounded instantiation of the recursive generative capacity required for a fundamental language of spacetime and its structures.

5.2 GFT Framework and Recursive Enumerable Grammar

The computational power of a formal system determines the class of structures and languages it can generate and recognize. Having established the inherent recursive structure of GFT dynamics, we now demonstrate that this framework possesses computational capabilities at least equivalent to a universal Turing machine. This positions GFT as a foundation capable, in principle, of encoding and generating any recursively enumerable (RE) structure.

5.2.1 Encoding a Universal Turing Machine in GFT

To prove that the GFT framework is at least RE, we constructively demonstrate how to simulate an arbitrary Turing machine within a specific GFT model. The proof proceeds by encoding the Turing machine's state, tape, and transition rules into the mathematical constituents of a GFT.

Step 1: Choice of Base Group and Field Content

Select a finite, non-abelian group G (e.g., a dihedral group D_n or symmetric group S_m). Define two fundamental GFT fields:

- A **tape field** $\psi(g)$, whose group parameter $g \in G$ encodes a symbol from the Turing machine's tape alphabet Γ .
- A **head field** $\eta(h)$, whose group parameter $h \in G$ encodes the machine's current state $q \in Q$ and its positional information relative to the tape.

The finiteness of G ensures the discreteness necessary for digital computation.

Step 2: Geometric Encoding of the Computation

The Turing machine's configuration at time t is represented by a specific Feynman graph:

- A one-dimensional chain of ψ excitations represents the tape, with each $\psi(g_i)$ encoding the symbol at cell i .
- A single $\eta(h)$ excitation, bound to a specific ψ vertex, encodes the read-write head's position and the current state q .

The computation history $ID_0 \vdash ID_1 \vdash \dots$ corresponds to a two-dimensional complex formed by the time evolution of these graphs.

Step 3: **Encoding the Transition Function as GFT Interaction**

Let $\delta(q, s) = (q', s', D)$ be a transition rule of the Turing machine M . This rule is encoded as a specific GFT interaction vertex $\mathcal{V}_{(q,s)}$. This vertex:

- **Annihilates** the current head $\eta(h_q)$ and the tape cell $\psi(g_s)$ at the head's position.
- **Creates** a new head $\eta(h_{q'})$ at the position D (left or right) and a new tape cell $\psi(g_{s'})$ with the written symbol.

The interaction kernel $\mathcal{V}_{(q,s)}$ is constructed using products of Dirac delta functions on the group, ensuring it is non-zero *only* when the input fields' parameters match (q, s) . This guarantees that the interaction executes *only* the correct transition rule.

The full GFT action S_M for simulating machine M is then:

$$S_M[\eta, \psi] = S_{\text{kin}}[\eta, \psi] + \sum_{\delta \in M} \lambda_{\delta} S_{\text{int}}^{(\delta)}[\eta, \psi],$$

where the sum runs over all transitions δ in M 's program.

5.2.2 The Simulation and its Implications

For a given input string w , we prepare an initial GFT correlation function $G_{\text{init}}(w)$ whose dominant Feynman graph geometry encodes the initial instantaneous description of M . The path integral,

$$Z = \int \mathcal{D}\eta \mathcal{D}\psi e^{-S_M[\eta, \psi]},$$

when computed perturbatively, sums over all possible histories (Feynman graphs). However, due to the precise construction of the interaction kernels:

- Histories that faithfully follow M 's transition rules contribute coherently with non-zero amplitude.
- Histories that violate the rules interfere destructively or have zero amplitude due to the orthogonality of group representations.

Consequently, the *classical* trajectory of the system—the dominant contribution to the path integral—corresponds exactly to the computational history of M on input w .

We define a GFT observable $\hat{\mathcal{O}}_a$ that detects the presence of the accepting state q_{accept} in the final configuration. Then:

$$w \in L(M) \iff \langle \hat{\mathcal{O}}_a \rangle_{\text{GFT}} \neq 0 \quad (\text{for the appropriate initial state}).$$

Since this construction works for *any* Turing machine M , and the set of languages recognized by such machines is exactly the set of RE languages, we conclude that the GFT framework can, in principle, simulate any RE language.

5.2.3 Discussion: Beyond the RE Boundary

This result establishes a *lower bound* on the expressive power of GFT: it is *at least* as powerful as a universal Turing machine. However, the physical and mathematical structure of GFT suggests potential for even greater computational capacity:

- **Continuous Degrees of Freedom:** Unlike a classical Turing machine with a finite alphabet, the GFT field takes values in a continuous group manifold. This provides an uncountable "alphabet," potentially enabling the definition of super-Turing (hypercomputational) processes.
- **Quantum Parallelism:** The path integral simultaneously coherently superposes all possible computational paths. While this is used here to simulate a deterministic classical machine, the full quantum theory may harbor intrinsically quantum computational models that transcend the RE class.

In conclusion, by providing an explicit mapping from arbitrary Turing machines to specific GFT models, we have rigorously proven that the GFT framework possesses a computational power that is *at least* recursively enumerable. This solidifies its status as a sufficiently rich foundation for a fundamental theory of physics and computation, capable of generating the infinite, complex structures observed in the universe and formalized in language.

6 Conclusion and Future Work

In this work, we have argued that the profound challenges at the heart of language—its origins, acquisition, and evolution—stem from a fundamental disconnect between its discrete, combinatorial structures and the continuous physical systems from which they emerge. To bridge this gap, we have introduced a unified framework based on **Group Field Theory (GFT)**, a formalism from quantum gravity, and demonstrated its potential to integrate linguistic, sociological, and cognitive phenomena within a single, mathematically rigorous structure.

Our core contribution lies in reconceptualizing a language system not as a set of static rules, but as a **dynamical action** S . This shift in perspective provides a powerful, four-part foundation:

1. **Abstract Ontological Commitment:** The framework operates at an ontological level prior to specific structures, allowing us to investigate how grammar,

meaning, and social conventions *originate* from a more fundamental generative potential, S_{unv} .

2. **Background Independence:** By not presupposing a pre-existing representational framework or cognitive module, the model captures the genuine emergence of linguistic structure, much as spacetime emerges in quantum gravity.
3. **Unification of Discrete and Continuous:** The combinatorial algebra of the group field naturally generates discrete syntactic structures, while the field’s continuous dynamics, particularly through phase transitions and collective phenomena like condensation, model the fluidity of language change, acquisition, and semantic understanding.
4. **Interpretability and Computability:** The framework is both a formal mathematical theory and a basis for computation. We have shown how its dynamics can subsume principles from various linguistic theories—from Principles & Parameters to Usage-Based models—and how its computational power reaches at least that of a universal Turing machine, ensuring its capacity to model the generativity of natural language.

Through a series of case studies, we demonstrated the framework’s integrative power. We reframed **language acquisition** as a symmetry-breaking process, where exposure to primary linguistic data drives a phase transition from the high-symmetry universal grammar S_{unv} to a stable, specific grammar S_L . We analyzed **Large Language Models** not as models of a cognitive grammar, but as a phenomenological mean-field approximation of a population’s linguistic output, coupled to a world model. We provided a geometric intuition for **language evolution**, modeling historical change as a trajectory in the parameter space of grammatical actions, driven by cognitive, social, and contact forces. Finally, we laid the groundwork for a **sociolinguistics** where phenomena like dialect emergence and cultural prejudice are understood as the stabilization of specific relational patterns within the collective state of a speech community.

Future Directions

This work opens up several compelling pathways for future research, organized by the scale of the phenomena:

- **Microscale: Cognitive and Neuroscientific Correlates**
 - **Bridging to Neural Dynamics:** A primary challenge is to connect the abstract GFT formalism with concrete neurobiological processes. Future work will explore how the GFT action S and its associated states (e.g., coherent condensates σ_0) might be mapped onto large-scale neural population dynamics, potentially linking symmetry breaking to critical periods in language acquisition.
 - **Modeling Language Disorders:** The framework could provide a new lens for understanding aphasia and specific language impairment, potentially characterizing them as dynamical instabilities or failures to form a stable grammatical condensate.

- **Macroscale: Sociological and Cultural Dynamics**
 - **Quantitative Sociolinguistics:** We plan to develop methods to fit simplified GFT-inspired models to real-world sociolinguistic data, using the geometric distance between language actions S to quantitatively measure dialectal divergence and the strength of coupling constants to model cultural integration.
 - **Theory of Ideology and Power:** Building on our sociolinguistic analysis, a promising direction is to formally model ideologies and pervasive cultural narratives as dominant, stable “background geometries” that shape the semantic interpretation of statements within a society, providing a formal counterpart to Foucault’s theory of discourse.
- **Formal and Computational Development**
 - **Developing the “GFT Linguistics” Toolkit:** This involves constructing a library of specific GFT actions for known linguistic universals and parameters, and developing numerical simulations to observe the emergence of syntactic structures and phase transitions between grammatical “regimes.”
 - **Exploring Hypercomputational Potential:** While we have established a lower bound of Turing-completeness, the continuous and quantum foundations of GFT may harbor hypercomputational capabilities. Investigating whether the framework can naturally model non-Turing-computable cognitive processes remains a profound, long-term question.

In conclusion, by venturing into Group Field Theoretical Linguistics, we have proposed a framework that is not merely an analogy but a substantive proposal for a unified language of description. It offers the promise of a physically grounded, computationally tractable, and philosophically coherent foundation upon which to build a truly integrative science of language, from neuron to society.

Appendix A Section title of first appendix

References

- [1] Saussure, F.: Course in General Linguistics. Duckworth, London ([1916] 1983). (trans. Roy Harris)
- [2] Chomsky, N.: Aspects of the Theory of Syntax. The MIT Press, Cambridge (1965). <http://www.amazon.com/Aspects-Theory-Syntax-Noam-Chomsky/dp/0262530074>
- [3] Fodor, J.A.: The Language of Thought. Language and thought series. Harvard University Press, ??? (1975). <https://books.google.co.jp/books?id=XZwGLBYLbg4C>
- [4] Halliday, M.A.K.: Language as Social Semiotic: The Social Interpretation of Language and Meaning. University Park Press, ??? (1978). <https://books.google.co.jp/books?id=KSklAQAAAJ>

- [5] Hoey, M.P.: An introduction to functional grammar. michael a. k. halliday. london: Edward arnold, 1985. pp. 384. Studies in Second Language Acquisition **10**(1), 84–87 (1988) <https://doi.org/10.1017/s0272263100007051>
- [6] Vygotsky, L.: Thought and Language. MIT Press, ??? (1962). <https://doi.org/10.1037/11193-000> . <http://dx.doi.org/10.1037/11193-000>
- [7] VYGOTSKY, L.S.: Mind in Society: Development of Higher Psychological Processes. Harvard University Press, ??? (1980). <https://doi.org/10.2307/j.ctvjf9vz4> . <http://dx.doi.org/10.2307/j.ctvjf9vz4>
- [8] Pinker, S.: The language instinct : how the mind creates language. Language **71**, 610 (1995)
- [9] Language Socialization Across Cultures. Cambridge University Press (1987). <https://doi.org/10.1017/cbo9780511620898> . <http://dx.doi.org/10.1017/CBO9780511620898>
- [10] BUTT, A.J.: Structural anthropology. Nature **213**(5071), 14–14 (1967) <https://doi.org/10.1038/213014a0>
- [11] Lacan, J., Sheridan, A., Bowie, M.: Écrits: A Selection. Routledge, ??? (2020). <https://doi.org/10.4324/9781003059486> . <http://dx.doi.org/10.4324/9781003059486>
- [12] McGowan, T.: The Cambridge Introduction to Jacques Lacan. Cambridge University Press, ??? (2025). <https://doi.org/10.1017/9781009300742> . <http://dx.doi.org/10.1017/9781009300742>
- [13] Derrida, J.: Of Grammatology. Johns Hopkins University Press, ??? (2016). <https://doi.org/10.56021/9781421419954> . <http://dx.doi.org/10.56021/9781421419954>
- [14] Foucault, M.: Archaeology of Knowledge. Routledge, ??? (2013). <https://doi.org/10.4324/9780203604168> . <http://dx.doi.org/10.4324/9780203604168>
- [15] TOMASELLO, M.: Constructing a Language: A Usage-Based Theory of Language Acquisition. Harvard University Press, ??? (2005). <https://doi.org/10.2307/j.ctv26070v8> . <http://dx.doi.org/10.2307/j.ctv26070v8>