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**Sh.M. Sultanova**[a]
E-mail: ms.sultana74@mail.ru. *Corresponding author: ms.sultana74@mail.ru

**Q.B. Khujaakhmatova**[b]
E-mail: qunduzxojaaxmatova@gmail.com

[a]*Renaissance University,Tashkent, Uzbekistan*
[b]*SSVMLBU Tashkent Branch, Uzbekistan*

# NATURAL LANGUAGE PROCESSING AND MENTAL GRAMMAR ISSUES IN MODERN SPEECH MODELS

**Abstract**

This article addresses a range of interrelated issues, including contemporary language (speech) models and the linguistic evaluation of natural language processing (NLP) mechanisms underlying their data analysis. Particular attention is devoted to identifying theoretical and practical limitations within these systems and examining how linguistic structures are represented, processed, and generated in computational environments. Furthermore, the study explores the principles of language processing in both humans and artificial intelligence from the perspective of psycholinguistics—one of the central branches of linguistics concerned with the relationship between language, cognition, and consciousness. Within this framework, language acquisition, speech production, and comprehension are viewed as cognitively grounded processes shaped by internalized grammatical competence and mental representations. Special emphasis is placed on the formation of the speech production process in human language compared to artificial intelligence systems. The article analyzes the functional properties of mental grammar in communicative contexts, highlighting its role in structuring phonological, morphological, syntactic, and semantic information during real-time speech generation. By contrasting biologically grounded linguistic competence with algorithmic and probabilistic language modeling, the study aims to clarify both convergences and fundamental distinctions between human cognitive language mechanisms and contemporary AI-driven speech systems.

**Keywords:**

speech models, psycholinguistics, artificial intelligence (AI), mental grammar, TTS (text to speech), STT (Speech to text) systems, ChatGPT, Gemini

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## Introduction

The progressive development of contemporary society across various sectors is particularly evident in the rapid advancement of digital technologies and information systems, which provide individuals worldwide with unprecedented opportunities and convenience. A notable example of such technological innovation is artificial intelligence (AI). Artificial intelligence refers to computational systems designed to operate on the basis of structured frameworks, large-scale datasets, and extensive textual corpora. These systems employ advanced algorithms to analyze, process, and generate information. At present, AI technologies exist in diverse forms and are developed for a wide range of applications tailored to specific objectives. Artificial intelligence is now extensively utilized across nearly all domains, including education, healthcare, business, finance, and many other sectors. Among the most widely recognized AI-based platforms are ChatGPT, Gemini, and DeepSeek, among others. Through these systems, users are able to receive and process information in textual, audio, image, and video formats. This naturally raises an important question: how are large-scale data repositories utilized within such systems, and do these technologies possess linguistic competencies that enable meaningful interaction? In any artificial intelligence system, users may submit queries in their native language or in foreign languages to retrieve the required information in a desired format. However, a critical issue concerns the mechanisms by which these systems interpret, analyze, and generate responses. This process is primarily carried out through the stage known as Natural Language Processing (NLP), which constitutes a fundamental component of modern AI systems.

## Materials and Research Methods

Within the NLP framework, contemporary language models are predominantly based on artificial neural networks, particularly the transformer architecture. These models segment text into smaller units (tokens) and model contextual relationships, as well as the grammatical and semantic structures of sentences. By capturing long-range dependencies and contextual coherence, transformer-based models achieve high levels of linguistic performance in both comprehension and generation tasks.For this reason, language models are increasingly regarded as representing a new stage in the development of modern linguistics. They demonstrate both theoretical and practical significance across various subfields, including corpus linguistics, psycholinguistics, linguistic typology, and applied linguistics. Through NLP methodologies, it becomes possible to identify and analyze psycholinguistic and applied linguistic issues that may arise in language production and comprehension within AI systems. The primary objective of Natural Language Processing (NLP) is to enable computers to comprehend structured textual data and to interpret it in a semantically accurate manner.[Joan. B and Ronald M.K,2017]. NLP encompasses several major subfields, including machine translation, speech recognition, sentiment (emotion) analysis, question answering, text summarization, chatbot systems, text classification, and named entity recognition, among others. Through NLP technologies, digital systems are capable of processing, identifying, and interpreting both written and spoken language in electronic environments. From a linguistic perspective, the analysis of language models involves examining how these systems operate with linguistic units and the extent to which they conform to established linguistic principles.

## Literature Review

In this context, it is essential to address the concept of mental grammar. Mental grammar refers to the internalized system of linguistic rules formed within the human mind, which enables individuals to comprehend words, combine them grammatically to construct sentences, and apply them appropriately according to context during communication.This concept is closely related to the theory of Universal Grammar proposed by Noam Chomsky, who argued that humans possess an innate grammatical capacity that allows them to acquire and use language based on internalized

structural principles. Accordingly, the natural formation of mental grammar during communication can be identified through several linguistic features. From a phonological perspective, correct pronunciation, stress placement, intonation patterns, and phonetic alternations are automatically governed by an individual's internal linguistic system. These processes are particularly evident in native language communication, where phonological rules are applied unconsciously and fluently,[Łukasz.B,2025]. From a morphological perspective, mental grammar enables the correct formation of words, the appropriate use of derivational and inflectional affixes, and their accurate grammatical interpretation within context. For example, in Uzbek, derivational and inflectional processes such as o'qimoq – o'qidi (read – read [past tense]) and kitob – kitobxon (book – reader) demonstrate how multiple lexical forms can be generated from a single root and correctly applied across tense or semantic categories. These processes occur automatically within human cognition. From a syntactic perspective, mental grammar governs sentence structure, including the formation of simple and complex sentences, the identification of actions and their agents, and the capacity to construct novel grammatical utterances.[.Derek.C and Keith J,2025] For instance, Uzbek sentence structure typically follows a Subject + Object + Predicate (SOV) order, whereas in some other languages the structure may follow a Subject + Predicate + Object (SVO) pattern. From a semantic perspective, mental grammar facilitates the interpretation and production of meaning in context, including polysemy, metaphor, irony, humor, and other figurative or context-dependent expressions.

## Discussion and Results

In contemporary language models – such as ChatGPT, Gemini, Suno AI, ZeroGPT Detector, Gamma, and Alice, among others – the process of natural language processing involves multiple interconnected stages designed to simulate aspects of linguistic comprehension and production. The first stage of this systematization process is tokenization, in which a text is segmented into smaller units known as tokens (i.e., words, phrases, or symbols). Each token is subsequently converted into a numerical identifier that can be processed computationally. The next stage is embedding (vectorization), whereby each token is transformed into a high-dimensional vector representation. These vectors encode semantic meaning, syntactic function, and contextual relationships. Through deep learning mechanisms, the model captures complex linguistic patterns by mapping tokens into a multidimensional semantic space, where relational similarities and contextual dependencies can be quantitatively modeled. Modern language models are primarily based on the transformer architecture. They are trained on extremely large textual corpora, where the principal learning objective is next-token prediction. During the training phase, the model learns to estimate the probability distribution of a subsequent token given the preceding sequence. In the generation phase, tokens are produced sequentially. At each step, the model calculates a probability distribution over possible candidate tokens based on the previously generated tokens and selects the most probable (or contextually appropriate) one. This process is repeated iteratively, resulting in coherent text generation.From this explanation, it becomes evident that human language processing and computational language modeling operate on fundamentally different principles. In humans, language processing is conscious (to varying degrees), biologically grounded, and governed by internalized grammatical structures. In contrast, artificial models function through algorithmic computation, mathematical optimization, and probabilistic inference.

This distinction can be summarized as follows:

Human Language Processing

- Biologically and cognitively grounded
- Based on internalized (mental) grammar
- Influenced by consciousness, intention, and experience
- Context interpreted through real-world knowledge and perception

AI Language Model Processing

- Algorithmically and mathematically driven

• Based on statistical learning from large datasets
• Operates through probability distributions and optimization functions
• Context modeled through vector representations and learned patterns

Modern Large Language Models (LLMs) are based on the transformer architecture proposed by Ashish Vaswani and his colleagues[Daniel.J, 2025]. This architecture does not explicitly construct syntactic trees (i.e., it does not generate formal parse trees); rather, it encodes syntactic and structural relationships implicitly within a high-dimensional hidden space. In other words, hierarchical linguistic structures are represented in latent vector form instead of being symbolically constructed.

## Conclusion

In artificial intelligence (AI) systems, the relationship between language and logic constitutes a fundamental research problem. The integration of these two components is essential for the development of genuinely intelligent systems. The issue of language–logic integration implies that natural language understanding—comprehending what is conveyed in a text – is closely interconnected with logical reasoning. Human beings express judgments, inferences, and cause–effect relationships through language; thus, linguistic expression inherently reflects logical structure. Artificial intelligence is often contrasted with natural intelligence possessed by humans and other living organisms. However, not all robotic systems possess artificial intelligence, since intelligence implies the capacity for reasoning, learning, and autonomous decision-making. Therefore, for an AI system to fully comprehend textual meaning and derive accurate conclusions, coherence must be established between language modeling mechanisms and logical inference processes.

At present, researchers propose combining neural and symbolic approaches in order to achieve effective integration between language and logic. As emphasized by researchers at SRI International, practical AI systems require the coordinated application of knowledge-based (symbolic) and data-driven (statistical) methods. Systems relying exclusively on formal logical rules tend to solve only narrowly defined problems, whereas systems trained solely on data lack the capacity for deep logical inference. Consequently, enriching language-understanding models with enhanced logical reasoning capabilities – or conversely, equipping logical systems with natural language processing capacities – is expected to elevate artificial intelligence to a qualitatively new stage of development.

## References

Joan B and Ronald M. Kaplan, Introduction: Grammars as Mental Representations of Language, 2017.

Łukasz B. Language Models Model Language, Snowflake AI Research, 2025, p-23-26.

Derek C. Penn, a Keith J. Holyoak,b and Daniel J. Povinellia, Universal grammar and mental continuity: Two modern myths a Cognitive Evolution Group, University of Louisiana at Lafayette, New Iberia, LA, 70560; b Department of Psychology, University of California, Los Angeles, Los Angeles, CA 9009, 2025.

Daniel J. An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition with Language Models, Stanford University, 2025.

Daniel J. Speech and language processing: An introduction to natural language processing, computational linguistics, and speech recognition, University of Coloradom, 2025.

Fernandez N, Speech and language processing: An introduction to natural language processing, computational linguistics, and speech recognition,2023

Asore O.J. The depth of natural language processing on speech recognition synthesis model, 2024 / URL:

https://www.researchgate.net/publication/380357355_THE_DEPTH_OF_NATURAL_LANGUAGE_PROCESSING_ON_SPEECH_RECOGNITION_SYNTHESIS_MODEL

Daniel J, James H.M. Speech and Language Processing, Stanford University, 2026 / URL: https://web.stanford.edu/~jurafsky/slp3/ed3book_aug26.pdf

Grzegorz.Ch, Putting Natural in Natural Language Processing,Department of Cognitive Science and Artificial Intelligence Tilburg University grzegorz@chrupala.me, 2023 / URL: https://aclanthology.org/2023.findings-acl.495.pdf

Kim .Ch.W, Models of Speech Production, 2000 / URL: https://doi.org/10.1007/3-540-07016-8_9

**Ш.М. Султанова**[a]
E-mail: ms.sultana74@mail.ru. *Байланыс үшін автор: ms.sultana74@mail.ru

**К.Б. Худжаахматова**[b]
E-mail: qunduzxojaaxmatova@gmail.com

[a]*Ренессанс білім беру университеті, Ташкент, Өзбекстан*
[b]*SSVMLBU Ташкент филиалы, Ташкент, Өзбекстан*

## ТАБИҒИ ТІЛДІ ӨҢДЕУ ЖӘНЕ ЗАМАНАУИ СӨЙЛЕУ ҮЛГІЛЕРІНДЕГІ МЕНТАЛЬДЫ ГРАММАТИКА МӘСЕЛЕЛЕРІ

**Аңдатпа.** Мақалада қазіргі тіл (сөйлеу) үлгілері және олардың деректер талдауының негізінде жатқан табиғи тілді өңдеу (NLP) тетіктерінің лингвистикалық бағасын қоса алғанда, өзара байланысты мәселелер ауқымы қарастырылады. Бұл жүйелердегі теориялық және практикалық шектеулерді анықтауға және лингвистикалық құрылымдардың есептеу орталарында қалай ұсынылатынын, өңделетінін және жасалатынын зерттеуге ерекше назар аударылады. Сонымен қатар, зерттеу тіл, таным және сана арасындағы қарым-қатынасқа қатысты тіл білімінің орталық салаларының бірі – психолингвистика тұрғысынан адамда да, жасанды интеллект жүйелерінде де тілді өңдеу принциптерін зерттейді. Осы шеңберде тілді меңгеру, сөйлеуді шығару және түсіну ішкі грамматикалық құзыреттілік пен психикалық көріністер арқылы қалыптасатын когнитивті негізделген процестер ретінде қарастырылады. Жасанды интеллект жүйелерімен салыстырғанда адам тілінде сөйлеуді өндіру процесін қалыптастыруға ерекше назар аударылады. Мақалада ментальды грамматиканың коммуникативті контексттегі функционалдық қасиеттері талданады, оның нақты уақытта сөйлеуді қалыптастыру кезінде фонологиялық, морфологиялық, синтаксистік және семантикалық ақпаратты құрылымдаудағы рөлі көрсетіледі. Биологиялық негізделген лингвистикалық құзыретті алгоритмдік және ықтималдық тілдік модельдеуді салыстыра отырып, зерттеу адамның когнитивтік тіл механизмдері мен қазіргі заманғы AI басқаратын сөйлеу жүйелері арасындағы конвергенцияларды да, іргелі айырмашылықтарды да нақтылауға бағытталған.

**Тірек сөздер:** сөйлеу үлгілері, психолингвистика, жасанды интеллект (AI), психикалық грамматика TTS (мәтіннен сөйлеуге), STT (сөйлеуден мәтінге) жүйелері, ChatGPT, Gemini

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**Ш.М. Султанова**[a]
E-mail: ms.sultana74@mail.ru. *Автор для корреспонденции: ms.sultana74@mail.ru

**К.Б. Худжаахматова**[b]
E-mail: qunduzxojaaxmatova@gmail.com

[a]*Образовательный университет Ренессанс, Ташкент, Узбекистан*
[b]*Ташкентский филиал ССВМЛБУ,Ташкент, Узбекистан*

# ОБРАБОТКА ЕСТЕСТВЕННОГО ЯЗЫКА И ПРОБЛЕМЫ МЕНТАЛЬНОЙ ГРАММАТИКИ В СОВРЕМЕННЫХ МОДЕЛЯХ РЕЧИ

**Аннотация**. В данной статье рассматривается ряд взаимосвязанных вопросов, включая современные языковые (речевые) модели и лингвистическую оценку механизмов обработки естественного языка (ОБЯ), лежащих в основе анализа их данных. Особое внимание уделяется выявлению теоретических и практических ограничений в этих системах и изучению того, как лингвистические структуры представляются, обрабатываются и генерируются в вычислительных средах. Кроме того, в исследовании рассматриваются принципы обработки языка как у людей, так и у искусственного интеллекта с точки зрения психолингвистики — одной из центральных отраслей лингвистики, занимающейся взаимосвязью между языком, познанием и сознанием. В рамках этой концепции усвоение языка, производство речи и понимание рассматриваются как когнитивно обоснованные процессы, формируемые интернализированной грамматической компетенцией и ментальными представлениями. Особое внимание уделяется формированию процесса производства речи в человеческом языке в сравнении с системами искусственного интеллекта. В статье анализируются функциональные свойства ментальной грамматики в коммуникативных контекстах, подчеркивается ее роль в структурировании фонологической, морфологической, синтаксической и семантической информации в процессе генерации речи в реальном времени. Путем сопоставления биологически обоснованной лингвистической компетенции с алгоритмическим и вероятностным моделированием языка исследование направлено на прояснение как сходств, так и фундаментальных различий между когнитивными языковыми механизмами человека и современными системами речи, управляемыми ИИ.

**Ключевые слова:** модели речи, психолингвистика, искусственный интеллект (ИИ), ментальная грамматика, системы преобразования текста в речь (TTS), системы преобразования речи в текст (STT), ChatGPT, Gemini.

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*Information about the authors:*

*Shokhista Mukhammadjonovna Sultanova,*Professor, Department of Philology Renaissance Educational University,19 Qurilish Street, Shaykhontohur District, Tashkent, Uzbekistan

ORCID: 0009-0001-3846-5159

*Khujaakhmatova Kunduzoy Bakhtiyorovna* - Assistant of the Department of Uzbek and Foreign Languages, Tashkent Branch of SDVMCHBU, Tashkent, Chilonzor district, 20-daha, Uzbekistan

ORCID:0009-0008-9438-3714

*Авторлар туралы мәлімет:*

*Султанова Шохиста Мухамеджоновна*, Ренессанс Білім беру университеті филология кафедрасының профессоры, Ташкент қаласы, Шайхантахур ауданы, Курилиш көшесі, 19, Өзбекстан. ORCID: 0009-0001-3846-5159

*Ходжаахматова Кундузой Бахтиёровна* – SDVMCHBU Ташкент филиалының өзбек және шет тілдері кафедрасының ассистенті, Ташкент қаласы, Чилонзор ауданы, 20, Өзбекстан

ORCID:0009-0008-9438-3714

*Сведения об авторах:*

*Султанова Шохиста Мухаммаджоновна,* профессор кафедры филологии образовательного университета Ренессанс, Ташкент, Шайхантахурский район, улица Курилиш, 19, Узбекистан

ORCID: 0009-0001-3846-5159

*Ходжаахматова Кундузой Бахтиёровна* — ассистент кафедры узбекского и иностранных языков Ташкентского филиала СДВМХБУ, Ташкент, Чилонзорский район, 20.Узбекстан

ORCID:0009-0008-9438-3714

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