

Evolution of the Verb State Category in Germanic Languages: A Neuroscientific Perspective

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Abstract: *Relevance of research. The article examines the process of verb formation in Germanic languages, as well as the peculiarities of the grammatical semantics of verbs at different historical stages of the development of Germanic languages. Using the comparative-historical method, the functioning of verbs in texts of Germanic languages was investigated as an aspect of neurolinguistic science. Research results. The article proves that most modal verbs of Germanic languages have undergone significant semantic transformations. The study of texts of different historical stages of language development shows that verbs evolved through semantic transformation. Time frames of the formation of secondary semantics were revealed. The theoretical and practical significance lies in the fact that this research allows a detailed study of the features of the emergence of the primary, as well as the secondary, subjective semantics of verbs in Germanic languages from a neuroscientific point of view. It should be noted that the list of subjective values still raises many questions and discussions. The German language has an extremely clear system of means of expressing modal values. The scientific novelty of the article lies in the neurolinguistic approach to the study of the evolution of Germanic verbs. The article aims to study the evolution of verbs in the German language in the context of neurolinguistics. To achieve the goal, the method of comparative analysis was used. This made it possible to consider the evolution of the verb through a comparative study of texts at the main stages of speech development. To solve these problems, texts reflecting the state of the language at each historical stage were studied.*

Keywords: *German language; modal verb; grammaticalization; semantics; neurolinguistic study.*

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Introduction

Any unit of the language system interacts both with units of its level and with units of other levels. As for word forms, it should be noted that they enter into relations both with units of their morphological level and with units of syntactic and lexical levels. Grammatical categories also enter into certain relations and interact with each other. With clearly expressed relationships of grammatical categories included in such groups, these multicategorical units represent a special system with its structure, whose elements are separate categories, and connections between them. This “special kind” of the system should be considered concretely and historically since its elements (grammatical categories) are historically changing categories. The meaning of the forms within a distinct grammatical category and their composition is not static, which means that the relationships between categories also evolve.

Regarding the synchronous state of the verbal system of the modern German language, it is legitimate to talk about hierarchical relationships between categories. In this regard, it seems possible to use the phenomenon of syncretism in morphological categories as one of the criteria for establishing their hierarchy.

The subject of investigation in this article is the “semantic evolution” of the above-mentioned verbs, as they have passed through the centuries with both minimal and strong semantic changes in the context of a neuroscientific perspective. The novelty and relevance of this article are ensured not only by the study of the time frames of the emergence of the main verb meanings but also by that of the formation of the modal semantics of the verb. In modal semantics, one includes not only epistemic modality but also evidentiality. The category of evidence has been the object of research in many scientific works, but the problem of its status (and belonging to modal meanings) still raises many questions and disputes. The scientific novelty of the article lies in its neurolinguistic aspects. The practical significance is evident in the potential application of the research findings in the history of the German language course, as well as in the theoretical grammar of the German language course.

The purpose of the article is to investigate the evolution of the verb status category in Germanic languages in the context of a neuroscientific perspective.

Characteristics of the neurolinguistic factor in the context of germanic languages evolution

The presence of today's languages in the curriculum is inspired by the tradition of teaching classical languages such as Latin and Germanic languages. The grammar-translation method has been the standard model for teaching modern languages: learning vocabulary, and grammatical rules, and then applying this knowledge to translate from the target language to the mother tongue and vice versa. However, since it is necessary to focus on communication, especially its oral aspect, it is necessary to rely on what is called the "communicative approach".

This article discusses the neurolinguistic approach in language learning, which is a new paradigm for teaching communication skills. Various attempts are made to change the traditional paradigm to accommodate the new reality of language research. Cognitive psychology focuses on the thought processes required to acquire and use knowledge. Even though researchers agree that the ability to speak requires the development of implicit speech competence (unconscious or automatic use of language forms), it is assumed that the acquisition of explicit knowledge (vocabulary, verbal forms, grammatical rules) is necessary before learning to communicate spontaneously (Khvorova, 2010). The development of communication skills is conceptualized as a process similar to learning other subjects. According to commonly accepted reference models, the learning process occurs in three stages: first, the acquisition of basic knowledge about language (vocabulary, rules and verb conjugations), then the consolidation of this knowledge through exercises and, finally, its transfer into communicative activities. According to this paradigm, explicit knowledge of language is developed in the brain through exercises and can be used automatically or unconsciously for spontaneous communication. In other words, knowledge is transformed into skills or abilities through exercises. According to cognitive psychology, the learning formula should be explicit knowledge + exercise = tacit competence (Tarasun, 2018).

Textbooks contain vocabulary, verb conjugations, grammatical rules and exercises for the practical application of knowledge. However, the results obtained from this approach to the development of communication skills are disappointing. It becomes obvious that the paradigm of communication training based on cognitive psychology does not achieve the expected results. The missing link in the language learning equation may come from the new perspective of second language learning offered by the neurolinguist and, having two or more foreign languages:

- implicit competence, supported by procedural memory, and explicit knowledge, supported by declarative memory, represent two different aspects of neuronal functioning;
- there is no direct connection between them; if such a thing existed, the mere fact of knowing the rules of a language allowed a person to speak a foreign language, and the fact of being able to speak that foreign language would mean that that person knew the rules of that language;
- explicit knowledge does not “turn” into implicit competence (Tarasun, 2018).

The contribution of neurolinguistics is not in defining the process of language learning, but in underlying the need to develop two different entities, namely, implicit competence and explicit knowledge. Implicit competence is necessary for oral communication, while explicit knowledge is required when using written forms of speech. Each entity is an independent but insufficient component of the ability to use language for communicative purposes. From a neurolinguistic training perspective, the equation looks as follows: implicit competence + explicit knowledge = communicative ability. The idea of developing both components to enhance communicative ability is an integral part of the neurolinguistic approach (Ostrowska, 2013).

The next contribution of neurolinguistics concerns the development of implicit competence. Since implicit competence and explicit knowledge are two necessary elements of communication, the question of mastering each of these components arises. The mastery of explicit knowledge is not problematic because teaching usually focuses on declarative knowledge. However, the mastery of explicit competence is a challenge. It consists of pathways or networks of neural connections that develop through the use of language to express meaning or convey information. These networks develop without conscious attention from learners since they are a product of the frequency of use of language structures (Sheremet & Boriak, 2016). Given the unconscious nature of implicit competence, it can be developed in the process of concentrating on the information itself rather than on language forms. The process of developing communicative competence is realized more effectively when working with a limited number of frequently used language structures. The only way to develop implicit competence is the constant and continuous use of linguistic structures until the relationship between morphosyntactic phenomena is fixed in procedural memory.

Neurolinguistic evidence of implicit skill development is crucial to the concept of neurolinguistics. Implicit competence is a skill, not

knowledge, and there are specific conditions necessary to ensure its development. A further contribution of neuroscience to the concept of neurolinguistics is the understanding of the importance of mastering the oral form of speech. According to recent research in neuroeducation, the acquisition of spoken language precedes the acquisition of explicit linguistic knowledge. When learning a foreign language, special attention should be paid to the spoken form of the language, especially as it is related to facial expressions and gestures due to the dominant role of prosody. This means that language learning can begin with the use of the spoken form of language for authentic communication (Culham & Nind, 2003).

Another contribution of neuroscience to the concept of neurolinguistics is the principle of an appropriate data process. Research in cognitive neuroscience shows that the brain stores data in place in context. The importance of these findings for neurolinguistics is that language should be learned in context, furthermore, learning contexts should be similar to the contexts in which the learned language will be used. This is promising for both spoken and written forms of speech. A common learning strategy is to memorize the declensions of verbs (Koniukh, 2010). In real conversation, only one appropriate word form is used, followed by an adverb, an object, or any other logical sequence of words. The memorization of various word forms affects the development of communicative skills and plays a crucial role in the effectiveness of different learning situations and strategies.

A defining characteristic of neurolinguistics is to independently develop two components of effective communication: a) implicit competence or the ability to spontaneously use neurolinguistics; b) explicit knowledge or understanding of the functioning of language, rules of grammar and vocabulary. Internal and external grammatical expressions are commonly used in developing the two components. Explicit knowledge is the conscious knowledge of vocabulary, grammatical rules and other aspects of language that can be found in the text, discussed, and assessed through exercises or tests. This component is considered external grammar. Implicit competence is the unconscious ability to use vocabulary and language structures in authentic communication situations and consists of neural pathways or networks of connections. The unconscious nature of implicit competence means that its presence and development are hidden from both the teacher and the student. This is called internal grammar, even though there is no connection between this grammar and grammatical rules. To understand the basic programme of Germanic language evolution in the light of neurolinguistic research, it is necessary to formulate five basic principles underlying pedagogical strategies for teaching the acquisition of

communication skills. These principles, reformulated in pedagogical terms, are as follows:

- creation of implicit competence - acquisition of internal grammar;
- the primacy of oral form development - use of pedagogical techniques aimed at the formation of literacy skills;
- emphasis on meaning rather than form - use of design methodology;
- authenticity of language and communication situations - creation of authentic communicative situations in the classroom;
- interaction of students in the classroom - use of interactive communication strategies (Kornosenko et al., 2021).

The first step is to investigate the basic Germanic language program to determine to what extent the above principles are present in the resources and teaching strategies used. It is worth noting that there is not enough time and enough activity to develop internal grammar. The spoken aspect of language is frequently overlooked. Education often prioritizes language acquisition over the enhancement of communicative skills, while reading and writing abilities tend to be neglected. Emphasis is placed on mastering correct forms instead of understanding the meaning behind statements. Most teaching activities fail to incorporate authentic language use, focusing solely on linguistic accuracy.

These observations lead to the need for principles, each of which can be formulated in the form of attitudes, pointing to its source in cognitive neuroscience. Indeed, the development of internal grammar necessitates the frequent use of a limited set of language structures in authentic communication contexts. This high frequency enables the brain to establish fundamental patterns and create neural connections for storing information in procedural memory, allowing for spontaneous use in the communicative process.

Using these steps, the teacher can interrupt the sequence to quiz any of the students about their peers' reactions, allowing them to use natural language. The concept of internal grammar, developed by the neurolinguistic research method, gives rise to another learning strategy, namely, the introduction of complete sentences to represent the latest language structures. Internal grammar consists of compounds that have a horizontal character on the morphosyntactic plane, it cannot develop from partial statements and responses composed of single words. In neurolinguistics,

error correction is important given that, in a sense, it replaces explicit grammar instruction. The spoken form of a language is learned in a communicative context, and error correction is integrated into the learning process to ensure effective information transfer in a variety of situations. Research in cognitive neuroscience demonstrates the importance of using an intensive approach at the beginning of learning (Kosholap et al., 2021).

Without intensive exposure to language use, neural circuits cannot be fully formed. Spontaneous communication or internal grammar can only develop with relatively intensive use (Kuhn, 1996). Research in neural formation highlights that, for developing internal grammar in a language, particularly German, greater emphasis should be placed on cultivating skills in the spoken form. This focus is essential due to its connection with gestures, facial expressions and the significant role of linguistic phenomena. Focusing on the development of the spoken word requires a literacy development perspective. This means that language learning emphasizes the spoken word. In general, literacy is defined as the ability to use language. It is this perspective that complements neurolinguistic research. The literacy development perspective allows educators to view language learning as skill development rather than knowledge acquisition, prioritize oral language development and reinforce the idea of the reading-writing sequence.

A morphological study of the evolution of the verb state category in germanic languages

The phenomenon of syncretism in a morphological category can serve as one of the indicators of the category of dependence. Consequently, the mood category has no syncretic forms. This means that both grams of the mode (realis/irrealis) are expressed by both cases: active and passive, in any tense, number, or person, i.e. this opposition is not limited by any other categories. Then, taking into account the percentage of expression of this or that morphological category, which, in turn, depends on the presence of syncretic forms in the category, there will be such a picture of the hierarchy of verb categories in present-day German (Cooper et al., 2007).

A detailed analysis of grammatical categories reveals that not all verb grammemes are consistently represented in specific forms. For instance, in the plural across all tenses and modalities, the first and third persons are not indicated, while the second person is omitted (e.g., “wir”, “sie” in “loben”, “werden loben”, “haben gelobt”). In contrast, the first and third persons are expressed in the singular. The grameme of the plural of the verb is not combined with the grameme of the first and third person in present-day German. This combination appears in the singular for

the present tense as “ich lobe”, “er lobt”, the perfect as “ich habe gelobt”, “er hat gelobt”, and future tense I as “ich werde loben”, “er wird loben”. However, in the preterite tense (“ich lobte”, “er lobte”) and the pluperfect tense (“ich hatte gelobt”, “er hatte gelobt”), the first and third persons of the singular are not expressed. In the same way, the opposition between the first and third persons of the singular is not expressed in all tenses of the irreal and contractive case, i.e. the grammeme of the preterite and pluperfect indicative and of the contractive and irreal cases in conjunction with that of the singular is not compatible with the grammar of the first and third persons.

The syncretic form in morphology represents an augmented grammeme. It is understood within the context of discretization, namely, the process of isolating corresponding homogeneous grammemes in other parts of the morphological system of the language as it evolves.

The grade of the person depends on the grade of the mode, type of speech, number and time. In the actualis (indicative) mood, six time grammemes are expressed: present (lobe), preterite (lobte), perfect (habe gelobt), pluperfect (hatte gelobt), futurum I (werde loben) and futurum II (werde gelobt haben). In contrast, the irrealis mood contains only two grammemes: the non-past grammeme (lobte~werde loben) and the past grammeme (hatte gelobt~werde gelobt haben). The verbs “können”, “dürfen” and “mögen” function as key modal verbs in German. The verb “können” (kunnan; kunnen; können) in contemporary German conveys the meaning “to be able to” or “can”, serving as the primary means of expressing alethic modality. The emergence of the secondary semantics of “können” occurred in the Middle Ages, namely in the Middle-Upper German period. This modality was conveyed by the verbs “mögen” and “müssen”. It should be noted that the volutative semantics of the verb “mögen”, noted at the beginning of this article, was not dominant initially either. However in the Middle-Upper Germanic period, the situation began to change (Chlebowski et al., 2010).

An intriguing feature is that the verb “können” is used in the direct speech of characters, while the narrator employs the verb “kunnen”. This suggests that “können” began to take on a meaning that would later become classical during the Middle-Upper German period. It is important to note that “müssen” is used to express epistemic modality, particularly in terms of absolute certainty regarding the impossibility of a certain situation or statement. The remaining four examples illustrate the use of the verb “mögen”, which reflects its original alethic semantics. However, one cannot definitively assert that this semantic transition occurred exclusively in the Middle-Upper German period, as Martin Luther’s text “To the Christian

Nobility of the German Nation” (2015) also shows “mögen” and “müssen* employed to express alethic and epistemic modality instead of *können”.

In Germanic languages, this verb does not have the same semantics and is expressed using “können” (often with negation). In Old High German texts, the modal verb “können” primarily appeared in translations into modern German, while the role of this modality was fulfilled by the verb “mögen” (also known as “mugan-mugen-mögen”). However, by the time of “The Nibelungs” (Ryder, 1982), “können” began to emerge (e.g., “N. kunnen*). Despite this shift, “mögen” did not lose its position, and it continued to function actively as a modal verb. It was only with the formation of Upper German (present-day German) that “mögen” lost its original alethic semantics and adopted a current voluntaristic meaning.

In the early Upper Germanic period, the process of completing the semantic transition of the verb “dürfen” can be observed, highlighting the existing semantic similarity between “müssen” and “dürfen”. By the New Upper Germanic period, the semantics of these verbs underwent a complete transformation, leading to distinct meanings for “müssen” and “dürfen”. The verbs “sollen” and “müssen” are often considered a pair due to their similar semantics. However, the situation was initially different since in Old Upper German “sollen* had a meaning typical of nearly all other modal verbs in German.

This interpretation is also acknowledged in today’s research. Consequently, one can note the dominance of deontic semantics already in the Old Upper Germanic period. One of the key problems of psychology and cognitive neuroscience is questions about the mechanisms of human perception and cognition, which form the present sound of verbs in Germanic languages. Such representations are associatively connected with their referents, while the process of their formation has nothing to do with the characteristics of the objects they denote. This allows one to study language, memory, thinking and other cognitive functions as separate systems of information processing, unrelated to other systems of the organism.

Neurolinguistic factor formation of verbs in the context of communication

The extension of the theory of embodied cognition to the study of the role of experience in semantic acquisition has emerged from the integration with the field of associative learning theory in neural networks. This integration connects neural representations of various external events in the speech environment to one another and to the internal activities of

the organism. The idea of associative learning is rooted in the general principles of plasticity of neural networks. Neural networks are formed under the influence of frequent combinations of different events in the external environment that strengthen neural connections between the corresponding neural representations and/or each of the neural representations with a higher-level neural group. In a multilevel neural network shaped by experiences from interacting with an organized external environment, each isolated event has the potential to activate all the associated representations within it (Frith, 2007).

From the same point of view, a child's acquisition of word semantics in a natural speech environment should be based on associative learning of neural networks. It is important to explain how this principle works using the example of verbs of motion. Learning takes place through repeated coincidences between the action that activates the neural networks involved in its planning, initiation and execution, and the acoustic image of the word that stimulates the auditory cortex. The meaning of verbs arises from associations between the auditory neural networks processing the phonetic word form of the verb and the motor networks encoding the corresponding motor act. Learning leads to the development of a shared neural network, which represents one of the foundational levels of the multilevel neural representation of verb semantics (Deno, 1970). Subsequently, the same neural networks are re-activated when verbs denoting body movements are perceived.

The essence of the experiments is based on the principle of somatotopic representation of body parts in the motor cortex of the human brain, which due to its simplicity and logicality now enjoys great popularity. Motor representations of the hand, foot and head are located in different sections of the primary motor cortex, and their selective activation during real movements of the corresponding body parts is registered by advanced neuroimaging methods. Moreover, this activation, automatically propagating along the existing associative links between auditory and motor representations, should occur long before the so-called semantic stage of verb analysis (Dunn, 1968). After the main speech experiment, each subject performed a series of movements with the right or left leg and arm, as well as with the tongue. Registration of the fMRI signal during the performance of the actual movements made it possible to localize the motor representations of these limbs in the cortex. It was then possible to compare the areas of activation during the movements performed and the perceived number of words describing the actions of these limbs. Despite some methodological shortcomings, the authors demonstrate the presence of

word-specific activation in motor cortical areas during word reading (Ganz et al., 2021).

However, it should be noted that the pattern of activation in the motor cortex recorded using fMRI does not carry information about the time of its occurrence and may refer to both pre-semantic and semantic as well as post-semantic processes, triggered after the verb meaning has been retrieved from semantic memory. The presentation of the verb may trigger not only the processes of response initiation but also imagination, namely, the unconscious representation of body/limb movement or position that is associated with the verb meaning of limb movement (Kanner, 1943). Relying solely on fMRI data, it is impossible to separate all these qualitatively heterogeneous processes.

Key data for the associative learning hypothesis were obtained using EEG or MEG methods with high temporal resolution. They were used to find that somatotopic activation of the motor cortex during the presentation of verbs of body part movement occurs already in the first 100-200 ms from the moment of their distinction, which is a strong argument in favour of the hypothesis that the motor system is involved in verb processing automatically. The study results indicated that the verb “mouth” elicited a significant increase in the early evoked brainstem response (140 ms after word onset) in the ventral motor cortex compared to the verb “foot”. This difference was interpreted as evidence of somatotopic activation in the oral motor representation area (Martynets et al., 2020). For leg movement verbs compared to mouth verbs, activation was stronger in the dorsal part of the motor cortex, closer to the medial slit where the leg representation area is located. The fact that somatotopic activation is present is consistent with the predictions of the associative learning hypothesis and is regarded as its reliable confirmation.

Using the same experimental model with data from a Germanic language and significantly improved data analysis methods, another research team confirmed early activation in word-relevant areas of the motor cortex, though not in the primary cortex. A key new finding in this study suggests that, similar to actual movement, a word denoting that movement not only activates the somatotopic representation of the corresponding limb but also suppresses activity in the motor representations of other limbs. This fundamental information processing mechanism in the cortex is known as lateral inhibition, which enhances the selective processing of signals received by the brain. Therefore, substantial evidence has been gathered indicating that the motor cortex’s role in analyzing a motion-denoting word uses the same

mechanisms as those involved in processing real motion (Pellicano et al., 2017).

Against the background of the considered instrumental methods of proving the sensorimotor theory of verbal semantics, behavioural studies stand out separately. They utilize the effects of selective facilitation and/or interference in the simultaneous performance of a lexical or memory task concerning the verb denoting the movement of a limb and the actual movement of one or the other limb. The variables measured in behavioural studies are the number of errors and reaction time. Since these cumulative measures represent the entirety of the interaction between the motor system and verb processing, such studies cannot fundamentally address the central question of the automatic early integration of motor representations of the corresponding limbs into verb processing. Therefore, their main goal is to reveal whether interference and facilitation occur according to such a matotopic principle. In contrast to studies investigating simulation effects, where participants' responses were recorded while presented with sentences to examine processes of semantic processing interference, the authors used single words as stimulus material. Participants were asked to memorize a visually presented sequence of four different verbs that indicated either hand or foot actions during a specific trial. After a short delay of six seconds, they were required to name the verbs in the order of presentation. During this delay period, participants performed a rhythmic sequence of movements with their hands, feet, or mouth, depending on the series (Pellicano et al., 2017).

Several clinical studies have shown that patients exhibit impairments in speech that are independent of the modality in which stimuli are presented or the manner in which the subjects are asked to respond. Instead, these impairments are linked to difficulties in recognizing a specific class of objects. Given the repeated repetition of the same words in neurophysiological experiments with negative lexical mismatches, the brain can, due to the set formed, extract abstract representations of a word extremely quickly, much faster than it does in other experimental conditions or real life. In this approach, they hypothesize that semantic representations of words in the brain have an abstract amodal core, which in turn is linked to sensorimotor areas. If motor areas are excluded from semantic processing, this will impoverish individual concepts and groups of concepts, but will not eliminate them. In other words, activation of sensorimotor areas is necessary for the whole representation of a concept and also helps to adapt the abstract representation to a specific situation. At the same time, the authors insist that sensorimotor activation is not a necessary part of concept representation,

without which a concept cannot be recognized and/or retrieved from memory (Scambler et al., 2001).

Research in the field of neurolinguistics has shown that when forming internal grammar in students, the focus should be on the information conveyed rather than the language as internal grammar is learned unconsciously (Prots et al., 2021). Cognitively challenging tasks promote skill development. The use of the project allows teachers to gradually increase the complexity of tasks and that of speech constructions.

Neurolinguistic research shows the importance of using authentic language in real-life situations to develop the internal grammar necessary for spontaneous communication. Cognitive neuroscience emphasizes the complexity of different brain centres, especially those related to communicative motivation. For verbal expression to be effective, these centres must be activated. This is why internal grammar cannot be formed by controlled practice or memorization. Learning a language in this way focuses mainly on linguistic forms and invokes declarative memory, but does not contribute significantly to procedural memory. In addition, any dialogue or exercise is limited in length and difficult to integrate into a long discussion. Controlled exercises do not produce the sustained output needed to develop their cross-linguistic communication.

Besides, frequent use of language structures in procedural memory creates the neural networks necessary for spontaneous oral communication. Language use should not consist of repetition of sequences learned by heart. Internal grammar is a skill, not knowledge, whose formation depends on the frequency of use.

Conclusions

According to the theory of embodied cognition, cognitive processes are directly influenced by the body and its characteristics. In contrast, the theory of emotional cognition emphasizes the role of emotions in cognitive functioning. The theory of situational or contextually determined cognition (sometimes referred to as “situated cognition”) shows that cognitive processes primarily depend on social activity and the context of events. Meanwhile, the theory of extended cognition (often synonymous with “distributed cognition”) not only seeks to reassess the factors that influence human cognitive activity but also aims to expand the understanding of this activity. This theory suggests that cognitive processes extend beyond the individual, incorporating the physical, social and cultural environment, as well as communication, as integral components of the human cognitive system.

The presented theories can be categorized into two groups. The first emphasizes the significance of human physicality, encompassing embodied and emotional cognition, which is primarily studied in cognitive psychology, neuroscience and cognitive linguistics. The latter group focuses on environmental factors, known as contextualized cognition, which is mainly examined in the social sciences. The term “embodiment” carries a broad interpretation. Both concepts reflect the reactivation of internal representations of generalized characteristics of an object or phenomenon in the external world, which may differ from their precise representation and can also be evoked in the mind without the presence of their physical prototypes, particularly in the evolution of verbs in Germanic languages.

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Author 2 presented theoretical and methodological approaches to understanding verb evolution in Germanic languages.

Author 3 defined key concepts and characterized the psycho-pedagogical conditions of speech formation within the context of neurolinguistics. Author 4 categorized scientific works related to identifying neurolinguistic characteristics of speech. Author 5 systematized the concepts and terms relevant to the problem in question.

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