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Linguistic Data Model for Natural Languages and Artificial Intelligence. Part 5. Introduction to Logic

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Introduction. The article continues the series of publications on the linguistics of relations (hereinafter R-linguistics) and is devoted to an introduction to the logic of natural language in relation to the approach considered in the series. The problem of natural language logic still remains relevant, since this logic differs significantly from traditional mathematical logic. Moreover, with the appearance of artificial intelligence systems, the importance of this problem only increases. The article analyzes logical problems that prevent the application of classical logic methods to natural languages. This is possible because R-linguistics forms the semantics of a language in the form of world model structures in which language sentences are interpreted.

Methodology and sources. The results obtained in the previous parts of the series are used as research tools. To develop the necessary mathematical representations in the field of logic and semantics, the formulated concept of the interpretation operator is used.

Results and discussion. The problems that arise when studying the logic of natural language in the framework of R–linguistics are analyzed. These issues are discussed in three aspects: the logical aspect itself; the linguistic aspect; the aspect of correlation with reality.

A very General approach to language semantics is considered and semantic axioms of the language are formulated. The problems of the language and its logic related to the most General view of semantics are shown.

Conclusion. It is shown that the application of mathematical logic, regardless of its type, to the study of natural language logic faces significant problems. This is a consequence of the inconsistency of existing approaches with the world model. But it is the coherence with the world model that allows us to build a new logical approach. Matching with the model means a semantic approach to logic. Even the most General view of semantics allows to formulate important results about the properties of languages that lack meaning. The simplest examples of semantic interpretation of traditional logic demonstrate its semantic problems (primarily related to negation).

Key words: R–linguistics, ascription operation, interpretation operator, semantics.

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Лингвистическая модель данных для естественных языков и искусственного интеллекта. Часть 5. Введение в логику

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Введение. Статья продолжает серию публикаций по лингвистике отношений (далее R–лингвистика) и посвящена введению в логику естественного языка применительно к рассматриваемому в рамках серии подходу. Проблема логики естественного языка до настоящего времени сохраняет свою актуальность, поскольку эта логика существенно отличается от традиционной математической логики. Более того, с появлением систем искусственного интеллекта важность этой проблемы только возрастает. В статье анализируются логические проблемы, препятствующие применению методов классической логики к естественным языкам. Это оказывается возможным, поскольку R–лингвистика формирует семантику языка в виде структур модели мира, в которые интерпретируются предложения языка.

Методология и источники. В качестве инструментов исследования используются результаты, полученные в предыдущих частях серии. Для разработки необходимых математических представлений в области логики и семантики использовано сформулированное понятие оператора интерпретации.

Результаты и обсуждение. Проанализированы проблемы, которые возникают при изучении логики естественного языка в рамках R–лингвистики. Эти проблемы обсуждаются в трех аспектах: логическом; языковом; аспекте соотнесения с действительностью.

Рассмотрен весьма общий подход к семантике языка и сформулированы семантические аксиомы языка. Показаны проблемы языка и его логики, связанные с самым общим взглядом на семантику.

Заключение. Показано, что применение математической логики вне зависимости от ее разновидности к изучению логики естественного языка сталкивается с существенными проблемами. Это является следствием несогласованности существующих подходов с моделью мира. Но именно согласование с моделью мира позволяет выстраивать новый логический подход. Согласование с моделью означает семантический подход к логике. Уже самый общий взгляд на семантику позволяет сформулировать важные результаты о свойствах языков, в которых отсутствует смысл. Самые простые примеры семантической интерпретации традиционной логики демонстрируют ее семантические проблемы (прежде всего связанные с отрицанием).

Ключевые слова: R–лингвистика, операция приписывания, оператор интерпретации, семантика.

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Introduction. This article continues a series of publications devoted to the introduction to the linguistics of relations – R-linguistics) – a formal direction in linguistics. Here we will talk about the logic that follows from the previously published material, and if what was stated in the series is close to the truth, then the logical constructions given here are related to the foundations of natural language logic. Of course, these constructions are not a full-fledged logical theory, but rather they are about preparing a springboard for other logical solutions.

The logic of natural language can be viewed from several angles. The first view is from the side of mathematical logic itself. The second view is the view from the side of the language. Finally, this problem can be viewed from the perspective of the surrounding reality.

From the point of view of the first glance in the logic of predicate calculus (first or second order), some initial data specified in the form of predicates are subjected to various manipulations in the form of application of logical operations and operations of binding by quantifiers (variables, functions or predicates). For example, for the propositional algebra, we use the AND, OR, NOT actions for transition from one statement to another. The transition to calculus involves specifying a certain system of axioms and inference rules. The system of axioms in this case describes the properties of the Boolean lattice, and the only derivation rule modus ponens (the syllogism rule) allows you to determine which manipulation results satisfy the axioms of the Boolean lattice. Yes, it all has to do with a particular lattice, but what does that have to do with language?

From a purely technical point of view, in the previous parts we saw how a logical approach to language faces significant problems. We are talking about changing universes, about the changing arity of predicates [1], etc. Say, the binary predicate “girl beats the boy” in the language easily turns into ternary (“girl beats the boy with a stick”) or even 5-arity (“on the street the girl beats the boy with a stick on the head”). How should these transformations be treated in terms of traditional logic?

In this series, the reader's attention has been drawn more than once to the importance of the predictive nature of the model, which is our main evolutionary advantage. From the point of view of this advantage, it would be extremely important for a human to use a logic tool to enhance this advantage, and not just to increase the informational expressiveness of the language. If logic allowed new predictions to be obtained from some initial predictions by various manipulations, this would significantly increase the survival rate of the species. For example, the prediction of global warming is derived from many different simpler predictions of various parameters that affect the planet's climate. It is clear that the prediction of global warming and its parameters is extremely important for our survival, and representatives of the animal world do not have this advantage. Unfortunately, logic alone does not increase our predictive capabilities, since, as we have seen, a predictive function in a language is inside sentences (predicates), and logic operates on sentences as if from outside. Nevertheless, we successfully generalize simple predictions into more general ones. Can this process really be described by existing means of logic?

From the second point of view, the language uses categories and variables connected by verbs. The language reflects the work of a linguistic model that uses “pieces” of relationships (predicates), since, for example, two categories connected by a verb describe only some part of the relationship. These “pieces” always look like complete relations on some “small” universe, since they are Cartesian products of two or three categories. For unary verbs, categories or variables are related to the trajectories of changing tuples of parameter values or to the parameter or feature values themselves. For example, the phrase “girl spinning” means that a certain tuple of parameters, recognized as “girl”, has periodic fluctuations (cyclic trajectory) within a certain type. All this is very different from what we have in traditional logic.

From the point of view of the third view, we will indicate three aspects. The first aspect is what I will very conventionally call “the soul”. The linguistic model makes predictions, but it does not say what decisions should be made in a particular case.

The soul contains within itself the grounds on which a certain consciousness, which has a model, makes choices. When we know a person well, predicting his possible choices, we just use knowledge about his soul, that is, about his system of values, emotional characteristics of the person, etc.in linguistics, we find attempts to study this factor of language formation in the theory of speech acts, pragmatics, and psycholinguistics. However, in linguistics, this factor is still significantly simplified: it is one thing to understand how decisions are made, and another-how the result of this choice is reflected in the language in the form of requests, orders, etc. For example, the theory of speech acts studies only echoes of something more significant.

So, two people who have exactly the same model of the world will exhibit different behaviors and generate different texts about the same situation. Does the soul factor affect the logical component of these texts? If you believe the famous article by D. V. Beklemishev about women's logic [2], then yes, since the principles of modeling the world are the same for women and men, and, consequently, the differences in the logic of behavior are most likely related to the soul factor.

The second aspect can be called a state problem. The phrase “I want to plant fruit trees on the site” has a different content for a resident of the South and North-West of Russia. When someone in the North-West utters this phrase, he definitely does not mean cherries, apricots, etc., but these plants are part of the concept of “fruit trees” for a resident of the Krasnodar territory. Consider the phrase “schoolchildren came on a tour of the Hermitage”. It is clear that not all schoolchildren of the world came to the tour. In addition, there may be several different school excursions in the Hermitage at the same time, which need to be distinguished somehow. From the point of view of classical logic under the same name there are many different(!) previously unknown predicates. Which of these predicates corresponds to the relation associated, for example, with the phrase, “schoolchildren came on a tour of the Hermitage”? What is the reliability of any logical constructions in these conditions?

From the point of view of the third aspect, we must ask the traditional linguistics question about the nature of truth in language. This issue excited a stunning collection of outstanding minds, but the problem has not solved yet.

So, there is an unstructured set of statements (sentences of the language), and we are trying to introduce some structure into it from the outside. For example, we choose the structure of Boolean algebra from two elements “true” and “false”. Now all we have to do is to display the statements in a set of two elements, or, in other words, mark the statements with these two symbols. Instead of statements, we could use shells, ants, or something else. Why do we do this with statements? In what sense does this structure correspond to the nature of statements? This is one part of the question and, as noted, there is no answer to it in the classical approach to natural language logic. By the classical approach, I understand the idea of imposing an external order on language constructs, depending on the tastes of the researcher: someone is a proponent of a Boolean lattice, and someone likes residual lattices and MV-algebras (fuzzy logic) more.

The materials of the series show that the language reflects (encodes) the model of the human world, while the model of the world already reflects the external world. Animals have a model of the world and are able to act adequately, but they do not speak the language. Does this mean that their behavior is out of logic? The question of truth is a question about the adequacy of the model, not about the properties of language sentences.

In [3], an analogy with exporting/importing spreadsheets was used to explain the place of the language. Roughly speaking, a "properly" organized export of a spreadsheet allows you to convert it into a sequence of signals in a communication line (in a language sentence) so that the original table can be exactly restored on the receiving side. The question of how well the spreadsheet reflects some aspect of the real world has nothing to do with export/import. Language does not correspond directly with the world: it corresponds with the model. What does this mean? This means that language structure reflects the structure of the model. But the model itself is a structure – it is interconnected nested linguistic spaces. It follows that we don't need to impose any logical structures on the proposals: we just need to fit into the model structures.

But what does "to fit into the model structures" mean? This means that the language sentence must be interpreted (displayed) in the model. Nouns should be related to the categories of the model. Variables must get a definition scope or value. Adjectives must relate to signs (and not only). Verbs must relate to transitions from one category and variable to another one, or to the trajectories of data tuples. Adverbs (in particular) must correct the work of trajectory generators corresponding to verbs, etc. This process for each person depends on his model, desires, emotional state, etc., and only depending on the result of the interpretation, he will tell whether it is possible to believe what he was told. The statement "all devils are green" has different truth values for different people. An atheist logician will say that this statement is true, because there are no devils, and anything follows from a lie. A believer will only argue about color, and someone will simply say that this statement does not make sense. It may be objected that this is not a scientific fact, that is, not verifiable. But the fact of UFO sightings was verified hundreds of thousands of times, but this did not become scientific. In addition, we learn the language, that is, what we can talk about (for which there is a model). In this sense, green devils are no worse than multicolored quarks.

The problems described in this section force us to do at least three things.

1. To refuse to assign truth values to sentences in any way. This in turn leads to the fact that we are forced to abandon traditional operations AND, OR, NOT. In the algebraic case, they are lost because they cannot be defined through truth tables, and in the case of calculus, they cannot be defined through axioms that bind them to a Boolean (or other) lattice.

2. Since the language is full of logical operations, you must also analyze the use of logical operations in the language to understand their functions.

3. Finally, the refusal to markup language sentences forces us to move this question to another level: the level of equivalence of phrases or the derivation of some phrases from others.

All these efforts can only make sense if there is a natural language logic in itself outside of semantics. Otherwise, it is necessary to keep the semantics of the text in mind at all times. Is it possible to distinguish any rules of thinking that are not related to meaning and are valid in any sense? It turns out that even with the most general views on semantics, which are much broader than the views of R-linguistics (a view at the level of semiotics), we are forced to answer these questions very skeptically.

Methodology and sources. The results obtained in the previous parts of the series are used as research tools. To develop the necessary mathematical representations in the field of logic and semantics, the formulated concept of the interpretation operator is used.

Common view.

Let us have some natural language at our disposal and Π – a set of sentences in this language. By sentence, we mean a sequence of words in a language that can be interpreted. This means that there is some interpretation operator Ψ that converts sentences into semantics or meaning. We actually call a sentence such finite sequences of language words that are within the scope of the definition of the Ψ operator.

The interpretation operator Ψ interprets the sentence "s" taking into account the semantics of C already accumulated at the time of "s" interpretation (previous events or sentences can change or Refine the interpretation of s) and forms the meaning of the sentence C'. So, the semantics of the sentence s is defined as $C' = \Psi(C, s)$. In particular, for a separate interpretation of a sentence without preliminary meanings, we get $C' = \Psi(\varnothing, s)$. A separate interpretation of the sentence "s" is understood here as an interpretation that is not preceded by some semantics for "s". For example, when you start reading an SMS message from an unknown phone number, you have zero initial semantics.

At this point, we do not know how this interpretation works and what semantics consists of, so C does not yet denote a set, but the semantic structure found by linguists of the future, which is obtained when interpreting "s". In particular, ∅ denotes here not an empty set, but an empty semantic structure that corresponds to the absence of meaning in the sentence. Of course, each person has their own interpretation operator at a particular time. It depends on the model of the world, on the mood, desires, etc. For example, in a state of severe fright, a person's interpretation of the same text may differ significantly from that in a good mood. But all these factors are fixed at a particular moment of interpretation, only the accumulated meaning changes, so that at the time of interpretation of the sentence, each person has a specific operator Ψ.

On a set of sentences Π in the language, an attribution operation (*) is defined, which assigns to one sentence another sentence so that the result is some text. Under the text $s = s_1 * ... * s_n$, we will understand the final sequence of sentences from Π. We will assume that the interpretation of the text $s = s_1 * ... * s_n$ occurs as follows. First, the first sentence $C_1 = \Psi(\varnothing, s_1)$ is interpreted. Here it is assumed that there is no preliminary meaning in relation to the text before starting the interpretation. Based on the interpretation of the first sentence, the second $C_2 = \varphi(C_1, s_2)$ is interpreted, the third sentence is interpreted based on the interpretation of the first two sentences, and so on. Two points need to be made here.

1. We should not confuse the current interpretation of the text C and the model of the world M in the human head. The model of the world certainly determines interpretation: in fact, interpretation is carried out in the model. But the model of the world determines the operator of interpretation Ψ and through it to determine the result of the interpretation of the text C. Yes, the results of the interpretation of the text can later change the model M, but for the period of interpretation they are accumulated without changing the model. This is why the text often has a zero initial interpretation. This is similar to the difference between RAM and permanent memory in computers.

2. Although we have defined the text as a sequence of sentences, it would be more correct to understand a paragraph under the text. Unfortunately, the uncertainty associated with this

semantic concept does not allow us to give it a strict definition that is not limited to tautology. In a language, as a rule, sentences are not interpreted one at a time. Usually, the interpretation is based on paragraphs that are highlighted by longer pauses in oral speech. The division of oral speech into paragraphs is clearly visible when a person speaks under translation, pausing and as if inviting the translator to start translating a paragraph. If a sentence is a unit of interpretation, then a paragraph is a unit of completed thought. The end of a paragraph usually means that the speaker has provided enough information to enable the listener to complete the interpretation, ask the questions necessary for the interpretation, and make a logical conclusion. It is extremely important to understand the reasons why the speaker defines the end of a paragraph. In particular, for expert systems, this is a signal for the beginning of output, or rather-a full output.

No matter how the semantic structure of C looks, two axioms are fulfilled for natural languages.

The first axiom states that there is an empty sentence "e" in the language, attributing it to any text on the right and on the left does not change the interpretation of the text. This means that "e" itself has empty semantics (φ(C, e) = C for any C) and does not change the semantics of any text: Ψ(C, e*s) = Ψ(C, s*e) = Ψ (C, s). For example, if there is a section of blank paper after the text (before the text), this does not change the semantics of the text. This semantic rule is displayed in the language as s*e = e*s = s. It is obvious that only one semantically empty sentence can exist in a language, since if there were more than one (for example, e and e'), then e = e*e' = e'. It should be noted that by definition an empty sentence is interpreted and has zero meaning (corresponds to a zero semantic structure).

The second axiom (the idempotency axiom) States that repeating the same test s (sentence) does not change the semantics of the text: Ψ(C, s) = C' = Ψ(C', s) for any semantics of C. In the language, this property of interpretation is reflected by the equality s = s*s. for Example, we skip the re-printed text because it does not carry additional information. At first glance, the axiom of idempotence contradicts the proverb "repetition is the mother of learning". However, this proverb means that the results of interpretation can later change the model and thereby correct the interpretation operator, so that the results of interpretation of the same text may be changed in the future. However, due to the above remark, at the stage of text interpretation, we consider the operator Ψ unchanged. This of course also means that the attention of the person who perceives the text remains unchanged in the process of interpretation.

Definition 1. We will say that the sentence "s" has the right conditional negation s^{-1}, if the interpretation of the text $s*s^{-1}$ at zero initial sense (condition) generates an empty meaning ("I will go to the store. I won't go to the store"). In other words, if C = Ψ(∅, s), then $Ψ(C, s^{-1})$ = ∅. In a language, we get the negation of a sentence when we put "not" before a verb, thereby negating the predicate of the sentence. The semantic property of the right conditional negation in the language is expressed by the rule $s*s^{-1} = e$, where "s" is a sentence and the initial meaning of the text is zero.

We say that a sentence s has an unconditional right of negation, if for any sense C of equality is performed: if Ψ(C, s) = C', then $Ψ(C', s^{-1}) = C$. in Other words, $Ψ(C, s*s^{-1}) = C$. This semantic property of the sentence means that the operation * is associative for text $s*s^{-1}$, i. e., for any text "t" the validity of the equation $(t*s)*s^{-1} = t*(s*s^{-1})$ is fulfilled. Of course, if the operation * is associative in General, it gives rise to languages with an unconditional right negations.

Example 1. In natural language the property of unconditionally of the right of negation in the general case fails. So, in the famous film “Beware of the car”, investigator Maxim Podberezovikov, acting as a witness to Detochkin's actions, says: “He is certainly to blame, but he... is not to blame.” This phrase does not cause the listener to feel zero sense, because in addition to the film itself, which forms certain semantics, Podberezovikov before this phrase utters sentences that create semantics that preserve the non-empty semantics of the phrase. Namely, it gives the positive part of the phrase the meaning of the illegality of Detochkin's actions, and the negative part – the meaning of the justice of His actions. As a result, the meaning of justice cannot neutralize the meaning of illegality, and vice versa.

The law of double negation in language is provided by unconditional right negation. In fact, $(s^{-1})^{-1} = e*(s^{-1})^{-1} = (s*s^{-1})*(s^{-1})^{-1} = s*(s^{-1}*(s^{-1})^{-1}) = s*e = s$. if we assume that logic was abstracted from the language, then most likely the prototype of the conjunction operation was the attribution operation, and the prototype of logical negation was the operation of unconditional negation. As you know, logical conjunction and negation operations are sufficient to express all operations of the logic algebra. However, the following is true.

Theorem 1. Any sentence that has an unconditional right negation does not make sense.

Proof. Let the sentence s have an unconditional right negation of s^{-1}, then $s = s*e =$ $= s*(s*s^{-1}) = (s*s*)s^{-1} = s*s^{-1} = e$.

The investigation. If the text consists of sentences that have unconditional right negations, then the semantics of the first sentence is equal to $\Psi(C, s) = \Psi(C, e) = C$. We also get for the second, etc., sentences of the text. In particular, for $C = \varnothing$, we get an empty interpretation of the text. If almost all sentences of a language have unconditional negations, then the following statement is not an error: *any text in any language with unconditional right negations does not make sense*.

Since natural language sentences make sense, there are no unconditional right negatives in the language, and the double-negative rule does not apply to them.

Theorem 1 is very important in understanding the semantics of a language. Semantics “glues” sentences into a single whole. This is its most important function. Even the smallest attempt to break (simplify) this connection leads to the elimination of semantics, and therefore the possibility of interpreting the language in a some model. In fact, the presence of an unconditional right negation only allows us to interpret the text of $s*s^{-1}$ separately, regardless of the context. The order of sentences in the text and its consecutive interpretation is preserved. Yet this destroys the semantics of the sentence. In fact, let the sentence s have the semantics of C. The idempotency axiom states that the sentence s*s has the same semantics C. In other words, the semantics of sentences are superimposed on each other (“linked”) and, if they coincide, they give the same result. But then adding the negative clause s^{-1} should destroy the semantics of C regardless of how it was formed: via s or s*s. As a result, we should get zero semantics, which corresponds to an empty sentence. But the same sequence calculated as $s*(s*s^{-1})$ generates the semantics of C, which means that the semantics of C is null. Otherwise, we would have to admit that either the same sentence can have different semantics (with the same Ψ), or the semantics do not “overlap” with each other. In other words, this would mean that semantics does not “glue” the meanings of sentences.

All of the above fully applies to associative languages, and the assumption of associativity is often found in linguistics (mathematical linguistics). Yes, and in logic, the operations of disjunction and conjunction are associative, and negation is unconditioned. Does this mean that logic not only formalizes logical operations between language sentences, separating them from meaning, but it also makes meaningless any natural language to which it is applied? To clarify these issues, we will deal with in the continuation of the article.

REFERENCES

1. Polyakov, O.M. (2019), “Categorization in Natural Languages for Verbs of Increased Arity”, *Intellectual Technologies on Transport*, no. 4, pp. 14–21.

2. Beklemishev, D.V. (2013), *Zametki o zhenskoi logike* [Notes on female logic], available at: wikimipt.org/wiki/Заметки_о_женской_логике (accessed 20.12.2019).

3. Polyakov, O.M. (2019), “Linguistic Data Model for Natural Languages and Artificial Intelligence. Part 3. Recognition”, *DISCOURSE*, vol. 5, no. 6, pp. 132–143. DOI: https://doi.org/10.32603/2412-8562-2019-5-6-132-143.

4. Novikov, P.S. (1973), *Elementy matematicheskoi logiki* [Elements of mathematical logic], 2nd ed., Nauka, Moscow, USSR.

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СПИСОК ЛИТЕРАТУРЫ

1. Поляков О. М. Категоризация в естественных языках для глаголов повышенной арности // Intellectual Technologies on Transport. 2019. № 4. С. 14–21.

2. Беклемишев Д. В. Заметки о женской логике. 2013. URL: wikimipt.org/wiki/Заметки_о_женской_логике (дата обращения: 20.12.2019).

3. Polyakov O. M. Linguistic Data Model for Natural Languages and Artificial Intelligence. Part 3. Recognition // DISCOURSE. 2019. Vol. 5, № 6. P. 132–143. DOI: https://doi.org/10.32603/2412-8562-2019-5-6-132-143.

4. Новиков П. С. Элементы математической логики. 2-е изд. М.: Наука, 1973.

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