The article discusses a subject of logic and some prospects for its development. It is argued that logic is the science of thinking. That is, thinking is an object of the science of logic. The subject of logic is a special structure of thoughts and thinking processes which is called (quite unsuccessfully, according to the author of the article) forms of thoughts and processes of thinking. These structures are discovered by partial abstraction from both semantic and substantive meanings of non-logical terms which are included in the language expressions that represent thoughts and processes of thinking. The modern logic differs from the traditional logic in using methods which are similar to mathematical methods — methods of symbolic logic. However, it preserves all achievements of traditional logic which are important for both scientific and everyday knowledge. The logic that is described in some textbooks published in the forties of the last century in the USSR is called surrogate. There are said to be empirical and theoretical levels of research in logic, as well as logic and “as-if-logic”, classical and non-classical logics. The prospects for the development of “as-if-logic” and the logic itself are under discussion. The usefulness of research in the field of “as-if-logic” is highlighted — there can be created a range of “as-if-logical” systems with some of them being interpreted as actual logical systems itself afterwards. There can be developed new methods for proving meta-theorems, which will be applied in proving some results concerning actual logical systems. Two directions are indicated to be prospects for the development of logic — empirical and theoretical researches. Possible applications of quasi-matrix logic in the field of logic as well as in the other areas of cognition are identified.

Keywords: the object of the science of logic, the subject of logic, traditional logic, modern logic, “as-if-logic”

Logic is a science of thought. The following argument is made against this statement: we do not know how thoughts are born. Indeed, in some cases we are not aware of the source of our knowledge and do not control the process of obtaining it. In such cases people talk about “insight” or intuition. Intuition is a process of obtaining knowledge apart from sense organs and conscious reasoning.

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Logic is a science about comprehensible processes and elements of thinking (conclusions and reasoning, judgments, concepts, etc.), in other words, a science of thinking. What does logic study in thinking; in other words, if the object of the science of logic is thinking, what is its subject? For example, conclusions of the following type are not the subject of logic: “It is raining. Therefore, rooftops are wet”, since the conclusion was drawn based on a mental experiment “if it is raining then where will the raindrops go; this is not the Sahara Desert, they cannot evaporate just like that”.(see [5]).

Logic is a science about specific thought structures that are not quite aptly called forms of thoughts.

A form of thought (of the thought process) is its structure revealed as a result of partial abstraction from the essence and meaning of illogical terms included in the phrase that expresses this thought (this thought process). So the question about the subject of logic is reduced to the issue of distinguishing logical and illogical terms, as well as of understanding “partiality” of abstraction from the essence and meaning of illogical terms. There is some common basis for separating logical terms. The fact that logical terms express the most common ties and characteristics of objective and subjective reality phenomena serves as such a basis: quantitative characteristics (“all”, “some”, “most”, ...), relations between situations (“if... then...”, “and”, “or”, ...), relations between thoughts (“therefore”, “compatible by truth”, ...), etc. Ultimately, the issue of distinguishing logical and illogical terms is resolved through existing practice, in other words, virtually by agreement. (The statements mentioned are not yet logical terms. In natural language they are used in different meanings. A natural language expression becomes a logical term, if it is given an exact meaning.) Examples of logical terms: (1) simultaneous conjunction — two situations exist simultaneously, designation $\&\neg\neg$; (2) consecutive conjunction — two, three, etc. situations occur consecutively, designation $\&\rightarrow^2$, $\&\rightarrow^3$, etc.

The “partiality of abstraction” from essence and meaning of illogical terms is in the following: there remains information about the type of terms, from the essence and meaning of which the abstraction was derived, as well as information about where the same term was used, and where they were different.

Knowing the types of illogical terms implies knowledge of the types of objects that are denoted (or expressed) by these terms. The main objects are things, characteristics of things, relations between things, functional dependencies between things. The other part of knowledge expressed through logical form of thought is information represented by logical terms.

Logic studies types of logical forms, relations between thoughts according to logical forms, including relations that are called logical laws.
Definition of logic: logic is a science about specific structures (forms) of thoughts and thought processes, as well as about relations between thoughts and thought processes according to these structures.

**Traditional and modern logic.** Traditional logic was founded by Aristotle. His teachings, augmented, developed and partly distorted in many respects, continued until the early 20th century. In the early 20th century, a peculiar scientific revolution occurred related to the broad application of relations between thoughts and thought processes according to the above structures (forms) of symbolic (mathematical) logic methods for research purposes. Modern logic preserves all the achievements and all the problems of traditional logic that are important for science and ordinary knowledge.

**Traditional and surrogate logic.** Traditional logic is sometimes unfairly criticized in Russia. What is meant by traditional logic is the logic taught in some textbooks published in the USSR in the late 1940s and 1950s, as well as later. During this time, textbooks appeared that did not consider the achievements of modern logic, nor those of traditional logic. The authors of these textbooks, for objective reasons, knew neither symbolic nor traditional logic, therefore they described issues of logic in a simplified and distorted manner. It is quite natural to name such logic as surrogate. Apparently, the only textbook on proper traditional logic published in the USSR during this period is a textbook compiled by V.F. Asmus. See [1].

**Empirical and theoretical levels of study in logic.** Empirical and theoretical levels of study are distinguished in many sciences. At the first level, facts are gathered (information about objects under study is accumulated) and initially systematised in the form of tables, diagrams, graphs, etc. (see [16]).

What is meant by theory? **Theory** is a system of concepts and assertions about a certain area of reality that has a number of features. Let me give you one of these features: theory is a special model of objective or subjective reality. Just as any other model, theory (1) is similar in certain aspects to the modeled reality, (2) it is its simplification (and because of this, it is sometimes also a certain distortion), and (3) it serves the goals of making reality cognition easier. Systems of so-called theoretical objects serve as models. These objects are contracted with empirical objects (including observed objects), as they are introduced into science through certain cogitative activity.

Examples of theoretical objects in logic are the uncertain conjunction ($\&$), (when forming it, we abstract ourselves from timing parameters of events), material implication, etc. Material implication ($\supset$) has a certain similarity to both different types of conditional association ($\rightarrow$) and logical entailment relation ($\Rightarrow$). Material implication is a simplification (and therefore a certain distortion) of both conditional association and logical entailment relation. The simplification is obvious because neither conditional association
nor logical entailment relation (understood as relation by information content) is indeterminate in a tabular way.

**Examples of distortion.** The result of negating an implicative opinion \( (A \& \neg B) \) is stronger than the result of negating a conditional opinion \( \Diamond (A \& \neg B) \). (\( \Diamond \) – possibility sign, \( \neg \) – negation sign). Any utterance does not follow from false premises. (Of course, known material implication paradoxes are conditioned not only by identifying the relation of logical entailment with material implication.) Introducing such a theoretical object as material implication facilitates the study of relations between opinions, concepts, etc., according to logical forms; in other words, it serves **the goals of making reality cognition easier**.

As a rule, the empirical study of logical forms was conducted in traditional logic. (An exception is, apparently, Aristotelian syllogistics.)

**Logic and “as-if-logic”.** In modern studies relating to the area of logic, it is natural to distinguish two large parts: logic itself and “as-if-logic”. Logic itself (hereinafter — logic) has the above structures of thoughts and thought processes, as well as relations between thoughts and thought processes according to these structures as its subject. Such relations between thoughts of certain types, for instance, between opinions of certain types, norms of certain types, etc, at the empirical or theoretical level are represented in the form of logical diagrams that are built semantically, axiomatically, etc.

“As-if-logic” is certain constructs that in some respect are similar to logic, that is, to empirical or theoretical descriptions of the above constructs (they may be similar even only with regard to some symbols), but have no relation, at least at the time of their creation, to logical forms of thoughts. Most often, such constructs are built by way of “modernizing” logical systems. For example, to clarify the notion of logical entailment, C.I. Lewis has built logical systems using an axiomatic method. Modernization (transformation) of logical systems through adding (removing) axioms or rules of inference, as well as through other methods, made it possible to create a large number of new constructs, which are sometimes also called logical systems. There was even an understanding of logic as a science about transforming logical systems and “as-if-logical” systems as well as about relations between “as-if-logical” systems. Given such an understanding of logic, this science, naturally, does not study structures (forms) of thoughts. In this case, **logic is a science about transforming “as-if-logical” systems and about relations between such systems.** Ultimately, given this approach, logic can be defined as a **doctrine about the collation and transformation of partially ordered sets of formulas containing at least some of the signs \&, \neg, \land, \lor, \supset, \equiv, \forall, \exists, \Box, \Diamond, \vdash \ldots** Those who work in the area of such systems are scholars who believe that the goal of science
is not the study of nature, social life or processes of cognition, but rather the collation and transformation of texts.

During more than 20 years as head of the chair of logic of the philosophy department of Lomonosov Moscow State University, I facilitated research both in the area of logic itself and in the area of “as-if-logic”. Studies in the latter area may prove to be useful for a number of reasons: (1) built systems can be re-interpreted as purely logical, i.e. there might be found, for instance, opinions, relations between which according to the structures are described by the resulting systems; (2) study results may be new methods for proving a theorem or metatheorem; (3) the number of people considered to be working in the area of logic is growing.

**Classical and non-classical logic.** Classical logic is called propositional logic (as well as its expansion — predicate logic) — Frege-Russell’s logic — which is the most simple model of relations by forms between assertive statements. This logic is based on the following principles.

1. **The principle of bivalence.** Statements assume values from an area consisting of two elements.

2. **The principle of truth and falsehood.** This is the area \{t, f\}.

3. **The principle of non-contradiction.** A statement cannot assume more than one value from this value area.

4. **The principle of the excluded middle.** A statement must assume one of two values.

5. **The principle of identity.** In a complex statement, system of statements, or reasoning, the same statement assumes the same value.

6. **The principle of functionality.** Logical terms are represented as functions.

7. **Principle of material implication.** Material implication is a model of conditional association and entailment relation.

Non-classical logics are formed, **first of all**, by considering new types of statements instead of assertive ones, **secondly**, by considering new types of statements along with assertive ones, as well as, **thirdly**, by changing types of logical term models. Therefore, there are three main ways to form non-classical logics. Of course, combinations are possible.

**Future development of logic.** “As-if-logic” will develop most of all. As a result of studies in the area of “as-if-logic”, “as-if-logical” systems will first be formed, some of which will find the interpretation as logical systems themselves; secondly, there may develop new methods for proving a metatheorem, which
will be used for proof regarding logical systems themselves; thirdly, the number of logicians with PhD degrees in Logical sciences will not diminish but may even increase, which will prevent reductions in the number of dissertation committees for the subject of logic.

There are many lines of study in the area of logic itself. Let me describe just a few of them, mainly related to quasi-functional logic.

**Lines of empirical studies.** Continuing studies of relations by forms between opinions containing the following logical terms: $\&^=, \&\rightarrow^n (\&^\rightarrow^2, \&\rightarrow^3$ etc.), $\&^0$ (conjunction of a possibly-conjunctive opinion — an opinion, which expresses the validity of fulfilling either one of two possibilities, for example: figure 6 is divisible by 2 and 3); $(c)\rightarrow, (p)\rightarrow, (i)\rightarrow, \leftrightarrow$ (depending on the variety of conditional association: cause-effect relation, the presence of one property determines the presence of another property, restrictive conditional association, for example, if a dog bites off one of the chicken’s legs, the chicken will be able to stand on one leg), etc.

Interpretation of these and other logical terms through quasi-functions. (If a function is a correspondence, by virtue of which a certain object from some set corresponds to a certain object from the same or another set, then the quasi-function is a correspondence, by virtue of which some object from a certain subset of some set corresponds to some object from a certain subset of the same or another set. The particular case of a quasi-function is a function.) For example, representation of various types of modal terms (alethic, deontic, epistemic, etc.) through quasi-functions. (See [10]–[15].)

**Lines of theoretical studies.** Building of quasi-functional predicate logic, in which subject quasi-functors play the role of subject functors. Developing quasi-matrix algebra modeled on quasi-matrix algebra of acts (actions or inactions). See [2]. Use of the quasi-functionality principle in other branches of mathematics.

**Other possible applications of quasi-matrix logic.** Quasi-determinism in biology. Quasi-determinism in biology is used, for example, when characterising coincidence. The main types of coincidence are: classic coincidence is a phenomenon that is ambiguously determined by the essence of a subject, system; functional coincidence: the attribute is coincidental if the performance of certain functions by the attribute carrier is ambiguously determined or not determined by its carrier existence conditions; coincidence by circumstances is a phenomenon, the existence or the origination of which is ambiguously determined by external circumstances (see [2]).

A special type of coincidence is a change in the gene pool of small isolated populations, which is called genetic drift. This coincidence can be illustrated by the “violation of the principles of selection” from general population into “a sample” as though it was done by nature itself (see [2]). This, among
others, includes the following principles: for the purposes of the study, objects should be selected from all subclasses of the general population; the principle of proportionality should be followed (by selecting more objects from larger subclasses of general population); an optimal number of objects should be taken for studying. For genetic drift, nature "violates" the principles of selection; however it is possible to foresee the results of genetic drift in a quasi-functional way.

Neural networks. A neuron can be represented as an object with one input and one output. This, of course, is a particular theoretical neuron model, which can easily be generalized in the event that there are several inputs and several outputs. When discussing the issue of the applicability of the quasi-functionality principle to describing the operation of neural networks, we can limit ourselves to binary logic (a signal is either positive or negative). We shall consider the applicability of ternary logic here. A signal from a subset, for example, from \{n, c\}, of the possible set \{n, c, i\} of signals comes to a neuron’s input. One, and only one, signal from a subset, for example, from \{n, i\}, comes to the neuron’s output. Let there be two neurons, whose outputs receive the same signal \(c\). Then the input of the system of neurons consisting of two new neurons will receive either signal \(c\), or signal \(i\), if we are to assume that these two latter neurons are described by the formula that conforms to conjunction.

Therefore, the behavior of neurons may not be determined, or determined in part, whereas the behaviour of the system of neurons may be determined in full, may be determined in part, and may be quite uncertain. It is possible that such behavior of neurons is the explanation for intuition: the brain operates like a machine, which, although complex, is still finite; its operation is not understood and the results at the output are sometimes correct, and sometimes incorrect, i.e. variative.

Genetics (heredity). In [2] there are notions of unambiguous and ambiguous determination of an organism’s characteristics. For example, the same genetic anomaly sometimes leads to a disease, and sometimes does not. Perhaps such processes can also be described by quasi-matrix logic, unless the ambiguities are caused by a lack of information about the influence of some side factors, conditions.

Abstract and real quasi-automata. An automaton has an input and an output. A signal comes to the input, the automaton processes it and generates a signal at the output. There is a functional dependence between the input signal and the output signal. In a quasi-automaton the dependence is quasi-functional. A signal from a subset of a set of possible input signals comes to the input. A signal from a subset of a set of possible signals is generated at the output. We can imagine a particular case of such a situation. A certain signal comes to the input. A signal from a subset of a set of possible signals is generated
at the output. Let us assume that there is a set of such quasi-automata. Output signals are the movements of the quasi-automata themselves. At a given time, the locations of each automaton cannot be determined, but it is possible to calculate where the system of quasi-automata will ultimately end up. Each of the quasi-automata can be represented as a modal propositional logic formula, and the system of quasi-automata can be represented as a system of formulas, or as a more complex formula. Input signals are sets of values of formula variables, and an output signal is a value of a more complex formula.

Example. Let us assume that a system of quasi-automata is represented by the formula \(((p \lor q)\&\Diamond q\) of ternary quasi-functional logic \(S_r\). When the value of each of the variables in the formula is \(c\), the formula takes the value \(c\).

Let us assume that a movement of the system of quasi-automata in a certain direction corresponds to this value. The system of quasi-automata receives a signal, which is value \(c\) of variables \(p, q\). Then the formula would take on a value from the area \(\{n, c\}\). This situation corresponds to the continuing movement of a quasi-automata in the same direction as before, or in a different direction corresponding to the value \(n\). (Values \(n, c, i\) respectively mean “necessary”, “coincidental”, “impossible”; \(\lor\) — sign of inclusive disjunction; \(\&\) — sign of conjunction, \(\Diamond\) — sign of ontological possibility.)

Social forecasting. (1) Linear extrapolation, (2) the exponential growth model, (3) asymptotic model, (4) sinusoidal model, etc. are used in forecasting the future in the social sphere.

The use of the quasi-functionality principle allows us to consider possible scenarios in such a way that the results of developing individual components of a social system are only partially (quasi-functionally) predictable, whereas the result of system developing as a whole is fully predictable (and possibly, of course, only in part).

\[
P_1.r, P_2.r, \ldots P_k.r [\sum s.r(\ast\ast\ast)] \\
\uparrow \uparrow \uparrow \uparrow \uparrow \\
\vdots \\
Q_1.1, Q_2.1, \ldots Q_k.1 [\sum_{2.1}(\ast\ast\ast)] \ldots Q_1.2, Q_2.2, \ldots Q_k.2 [\sum_{2.2}(\ast\ast\ast)] \\
\uparrow \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow \\
P_1, P_2, \ldots P_k [\sum_1(\ast\ast\ast)]
\]

The arrows show possible alternatives in developing the system of objects \(\sum_1(\ast\ast\ast)\), while the top formula corresponds to the case when scenarios of developing the system of these objects lead to a certain state of the system. (Here \(P_1, P_2, \ldots P_k\) are initial attributes of the system of objects, \(Q_1.1, Q_2.1, \ldots Q_k.1\) etc. are (possibly) new attributes of the modified system.)
**Argumentation.** There might be no opinion about an utterance (concept). Then the value of the utterance is 0. Stronger values are cot and cof (convinced of being true and convinced of being false). Even stronger than cot are the values cot_n, cot_c, cot_C, cot_N, which are read, respectively, “convinced that it is true and ontologically necessary”, “convinced that it is true and ontologically coincidental”, “convinced that it is logically coincidental”, “convinced it is logically necessary”. It is obvious how the stronger values for cof were formed. Relationships between utterances (concepts) are expressed through quasi-functions.

**Management decision.** At a theoretical level of cognition, the model of a process of developing a management decision is represented as a complex quasi-function. This model is described in a number of publications by the author of this article. See [4], for example.

**Quasi-functional model of a specialist.** To facilitate the competitive selection of specialists, we can use the following model. Let us assume that managers of a certain level are selected for an enterprise system. An advert is posted that specifies initial requirements for applicants. For example, relevant education and managerial experience of at least two years in the industry. In other words, from the set of possible applicants we select a subset; let us define it in this way: \( M_1 \). This subset is the domain of a quasi-function. Let us form the quasi-function. We shall represent the qualities of a manager as a circle, the bottom part of which corresponds to negative qualities, and the top part corresponds to positive ones. Among the negative qualities we can distinguish unacceptable (inappropriate) and appropriate ones. Negative qualities may be “compensated” by positive qualities. Positive qualities include necessary and unnecessary ones.

Let us identify sectors 1, 2 and -1, -2 in the circle. We shall assume that sector 1 corresponds to a positive quality such as an ability to make decisions under difficult conditions (maximum grade is 10 points); sector 2 would correspond to managerial skills (maximum grade is 18 points), etc. Sector -1 denotes a negative quality such as rudeness (marginal grade is -8 points); sector -2 would denote a lack of restraint (marginal grade is -6 points), etc.

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1You can enter the expression “Management decision” on the Internet and see the text “Ivlev Yu.V. Management decision”, as well as the same text without an acknowledged author and the same text with a different author. In all cases, the author of the given text is the author of this article.
Let us assume that we are evaluating the qualities of a specific manager. Let an ability to make decisions under difficult conditions be graded at +4 points, managerial skills at +8 points, whereas rudeness and lack of restraint would get -2 and -5 points respectively. (The ability to make decisions under difficult conditions can be identified, for example, by placing the manager into deliberately difficult situations, and managerial skills can be checked through an exam. The problem of evaluating each quality is very complex and requires special investigation.) A general score is given with regard to these four qualities:

\[(+4) + (+8) + (-2) + (-5) = +5.\]

By examining all positive and negative qualities this way, we can give a general score of the managerial qualities. If there are unacceptable qualities, the score is 0. A score of +50 to +120 points, for example, may be considered acceptable (the latter score, the sum of points, is considered to be maximum). If a manager gets less than +50 points, no further work will be done with him/her. As a result of such a study we can segregate a subset of the initial subset \((M_1)\) of applicants; let us define the latter subset like this: \(M_{1,1}\). For example, from the initial subset of applicants who meet the requirements “have relevant education and managerial experience of at least two years in the industry” we segregate a set of applicants who received at least 100 points. This is the set \(M_{1,1}\). Let us say there are 20 such applicants. We need to select 8 of them. Now, individual work is carried out with each one of the selected applicants. Therefore, the model represents a quasi-function.

This model was developed by the author of this article to evaluate the managers of internal affairs’ bodies in the 1970s. It was first published in a
small printing and then included in the book “Logic in management” [4, p. 27–29].

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Предмет и перспективы развития логики

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В статье обсуждается вопрос о предмете логики и о некоторых перспективах ее развития. Утверждается, что логика является наукой о мышлении. То есть мышление — это объект науки логики. Предмет логики — это особые структуры мыслей и процессов мышления, называемые, не совсем удачно, по мнению автора, формами мыслей и процессов мышления. Эти структуры выявляются путем частичного отвлечения от смысловых и предметных значений нелогических терминов, входящих в языковые выражения, которыми представлены мысли и процессы мышления. Современная логика отличается от традиционной использованием методов, сходных с математическими, — методов симптоматической логики. Однако все значимые для научного и обыденного познания достижения традиционной логики сохраняются. Логика, изложенная в некоторых учебниках, изданных в сороковых годах прошлого столетия в СССР, называется суррогатной. Выделяются эмпирический и теоретический уровни исследований в логике, а также логика и «как-бы-логика» («as-if-logic»), логика классическая и неклассическая. Обсуждаются перспективы развития «как-бы-логики» и собственно логики. Отмечается полезность исследований в области «как-бы-логики» — могут быть созданы «как-бы-логические» системы, некоторые из которых найдут интерпретацию в качестве собственно логических систем, могут быть разработаны новые методы доказательства метатеорем, которые будут применяться для доказательств относительно собственно логических. В качестве перспектив развития собственно логики указываются два направления — исследования эмпирические и теоретические. Названы возможные приложения квазиматричной логики в области логики, а также в других областях познания.

Ключевые слова: объект науки логики, предмет логики, традиционная логика, современная логика, суррогатная логика, «как-бы-логика»

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