

CULTURE AS COLLECTIVE INTELLECT AND PROBLEMS OF ARTIFICIAL INTELLIGENCE

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Translator's Note

In this paper Lotman returns again to the problem of culture as a network of inter-relating semiotic systems, a problem that has concerned him in many of his recent writings. Here he tackles the question of how new ideas (new systems) come into being. He approaches the problem using the analogy of culture as intellect, and considers what light this analogy can throw on the problems of artificial intelligence.

1. If culture is viewed as a single semiotic mechanism then one may see in it an object of the same type as an intellect. Culture, taken as a whole, not only has a special apparatus for collective memory but also has procedures for producing messages that are in principle new in languages that are in principle new, i.e. it can create *new ideas*. The combination of these qualities makes it possible to regard culture as a *collective intellect*.

1.1. The comparison of collective intellect with the individual intellect is a problem that has never been studied, and indeed has never yet been faced in its totality. It must be pointed out that collective intellect is secondary in regard to the individual intellect (speaking structurally, not historically) and presupposes its existence. The profound material differences, together with the obvious functional isomorphism, between the two, makes such a comparison exceptionally fruitful, since in the course of the study it will be possible to isolate the concept of intellectual activity from the concrete examples that we already have of it, and to make a generalized functional model of it.

1.2. This makes such an approach particularly relevant to the problem of artificial intelligence. A comparison between, on the one hand, the research-object of an artificial intellect and, on the other, not just one natural object (the intellect of a particular individual), but two materially different, though functionally similar, objects, will throw light on the question: what is the essence of intellectual activity, and what are the causes of the forms of it that we know, and, consequently, what are the essential features of a mechanism which is to be defined as a thinking one.

1.2.1. We must emphasize that collective intellect, as a model for artificial intellect, has several advantages over individual intellect. Since collective intellect is a mechanism created by the history of mankind, it is far more explicit, its procedures are manifest in the language of culture and are recorded in numerous texts, unlike the hidden languages of the human brain. Past studies

of cultures have accumulated vast material which, properly interpreted, could reveal exceptionally interesting cognitive-mnemonic procedures.

1.2.2. It may be argued that certain periods and manifestations in the history of human culture, which are of an obviously pathological nature, contradict the definition of culture as intellect. And yet, after all, the capacity to 'go out of one's mind' is a good working characteristic of an intellect. Indeed a thinking mechanism could, in this respect, be defined as one which, as an alternative to rational behaviour, has a potential for mad behaviour, and which itself constantly makes a choice between these strategies. An apparatus which in principle cannot 'go out of its mind' cannot be called an intellect. It follows that pathological moments in the functioning of a culture, which generate in the widest context the theme of madness as a fact of culture ('The history/autobiography of a madman')¹ do not contradict, but paradoxically confirm, the definition of culture as a mechanism of collective intelligence.

2. The essence of the intellectual act in the light of semiotic culturology

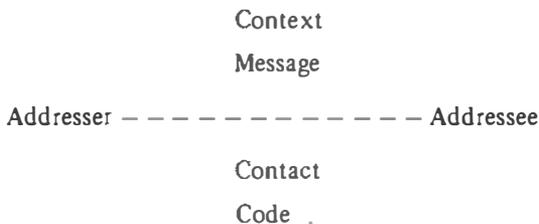
2.1. There is no satisfactory generally accepted definition of intellectual behaviour. The equation of the notions 'intelligent' and 'human' will not do. (Turing, for instance, was inclined to define intellectual reactions as those which a man, after long communication, could not distinguish from human reactions. But this is to risk raising the failings of an actual form of intelligence to the rank of an essential characteristic. In many works there is a tendency to avoid altogether any definition of intelligence, but rather to see intelligence as the combination of different capacities and skills not one of which, taken in isolation, is specific to intelligence. The refusal to attempt 'to find the one thing without which intellect does not exist' is, from this point of view, seen as a step forward.³ It is difficult to agree with this either; not only because, when modelling an artificial intellect, we find ourselves in the situation of the fairy-tale hero who was ordered: 'Go you know not where and bring you know not what'; but also because there is no assurance that the artificial models of separate cognitive operations will, in the final analysis, combine into a single intelligence.

To risk using the trivial and commonly accepted definitions of intelligence: they all in the final analysis come down to a capacity to behave, in radically altered conditions, in a manner that is both new and expedient (conditions, that is, for which the given subject has no decoding stereotype in its consciousness, and which cannot be easily related to such a stereotype or its variant). To translate these requirements into the language of semiotics: if one imagines a new situation as a text requiring decoding into a language unknown to the decoder, then the task can be formulated as the capacity to create new languages. Then behaviour that is both expedient and new can be interpreted as the creation of new and correct texts.

2.2. In this connection the question of the nature of new texts (messages) is of particular significance. A new text we understand to be a message that does not coincide with an initial text, and which cannot be automatically deduced from it. Hence all correct transformations of the initial text (i.e. those formed in accordance with certain previously given rules) do not create a new message, inasmuch as the initial text, and any correct transformation of it, can in fact be regarded as one and the same message. Hence a contradiction arises between the notions of a 'new' and a 'correct' text. The new text (e.g. new behaviour) can, however, be correct in the sense that it effectively correlates with the altered conditions. In that case, new rules can be formulated on the basis of the new text, and, in the light of these rules, the text will appear wholly legitimate. This process can be interpreted as the creation of texts which, while incorrect within one given language, are correct and useful within a new language which has yet to be created.

From the foregoing one may conclude that any apparatus laying claim to the quality of intellectuality must have a procedure for the generation of texts, such that for a given chain it would not give a uniformly preordained output. In other words, if it is consistently subjected to transformations in one direction and then in the reverse, it would not reproduce the original message.

2.3. A broad spectrum of the sciences of man, from the ethnology of Marcel Mauss and Claude Lévi-Strauss to information theory, linguistics and semiotics, take their point of departure from the notion that at the basis of human relations lies the act of communication which can be looked at as an exchange of equivalent values: in trade, the exchange of equivalent goods, in marriage relationships the exchange of equivalent women, in the structure of semiotic relations, the exchange of equivalent signs. All these different kinds of communication are generalized in Jakobson's well-known schema:⁴



The essence of the process of communication is thus seen to lie in the fact that a message, as a result of encoding-decoding, is transmitted from the addresser to the addressee. The very crux of the act lies in the fact that the second person receives the same message as that transmitted by the first (if

not the same, the message may be fully equivalent according to certain accepted rules). A violation of equivalence looks like a defect in the functioning of the communication chain. The idealized schema of communication, conventionally free of all kinds of noise, which displays the very essence of the communicative act, ensures that precisely the same message is received as that which was transmitted.

It is not difficult to see that the functional emphasis of such a communications schema, while explaining the procedure for the circulation of already existing messages in a collective, not only does not explain, but also directly excludes, the possibility of the production of new messages within the 'addresser-addressee' chain. Consequently all scientific constructions that analyse the circulation of messages within any one communicative chain, while they enrich our ideas about the form of the transmission, accumulation and preservation of information, add nothing to our knowledge of the origin of a new message, i.e. of the very nucleus of the intellectual act.

2.4. The semiotics of culture, from the moment when it became aware of itself as an independent branch of science, has had to try to explain the functional necessity of the polyglot structure of culture. The application of semiotic methods to the material of culture came about at first as the realization of Saussure's promise to found 'a science that would study the life of signs in the life of society'... 'We would call this science semiology'.⁵ At this stage the main thrust was directed to the application of linguistic-semiotic methods of description to the various 'languages' of culture. The result was the establishment of the unity of the different systems of social communication as semiotic objects. (Cf. I.I. Revzin's definition at the II Summer School on the study of secondary modelling systems, at Kaariku, 1966: 'Semiotics is the science that studies objects that can be described with the aid of linguistic procedures'.) Thus most attention was paid to the discovery of the unity of these systems, and the different languages of culture were taken, at the meta-level, to be a single language. At this stage the study of culture was a sphere from which interesting examples were drawn, but not an independent field of science.

The delineation of a distinctive semiotics of culture came about when the problems were posed about the functional interdetermination of different semiotic systems, the nature of their structural asymmetry, their mutual untranslatability. From the moment when it became clear that these separate semiotic systems form a structural whole, thanks to their mutual distinctions, a special object of research began to emerge, an object that was not amenable to the semiotic study of the isolated communicative system. This point was made in the *Proposals to the IV Summer School* which were laid before the Organizing Committee of the School:

Separate sign systems, while they are immanently organized structures, function only in combination, in dependence on each other. No one sign system possesses a mechanism which allows it to function in isolation. From this it follows that together with the approach that results in the construction of a series of relatively autonomous sciences of the semiotic cycle, we must admit of another approach from the point of view of which they are all regarded as partial aspect of the *semiotics of culture*, that is the science of the functional correlation of different sign systems.⁶

In this sense the semiotics of culture can be conceived of as the theoretical discipline which studies the mechanism by which different semiotic systems form a unity and are necessary to each other. It is concerned, for instance, with such questions as how to explain cultural universals of the type of the opposition 'system with iconic sign vs. system with conventional signs', or about the minimal internal variety of the semiotic mechanism of culture, about the internal untranslatability of languages and procedures, and about how to overcome this untranslatability. All these and many other problems can be seen as material for an abstract model of a culture taken in isolation. But another approach is possible as well: this is to examine the internal procedures of a given culture by comparing it with a broad context of other human cultures. This approach is connected with the construction of typological models, and this too is of direct relevance to the semiotics of culture.

2.5. One of the features of the existence of culture as a whole is the fact that the internal connections which ensure its unity are realized with the help of semiotic communications — languages. In this sense culture is a polyglot apparatus; and it is because of this that culture as a suprabiological entity differs from any biological entity whose internal connections are realized by biological and not semiotic communications. For semiotic (sign) communication is the connection between two (or several) quite autonomous units. If presemiotic communications bind the parts into a single whole, the parts being incapable of fully autonomous existence, then semiotic systems unite fully independent, structurally autonomous formations which can exist in isolation and which, only when they become part of a more complex integration, acquire the secondary features of parts without losing their autonomy on the lower level.

It might be argued that the semiotic connection is, from the point of view of the whole, a less effective system: unlike the prelinguistic impulses of a biochemical and biophysical nature, language signs can be perceived or not perceived, they can be false or true, understood adequately or not. Situations typical of language, as when the transmitter misinforms the receiver or the

receiver decodes the message in a distorted way, are unknown to prelinguistic communications. Because of this, language is an instrument that gives rise to many difficulties. Nevertheless the appearance of semiotic communications marked an enormous step forward towards the stability and survival capacity of mankind as a whole. In order to understand this we must emphasize one fact which is an immutable law for supracomplex systems of the cybernetic type: the stability of the whole grows with the growth of the internal diversity of the system. For diversity is connected with the fact that the elements of the system at the same time become specialized as its parts and acquire increasing autonomy as independent structural formations. But the process does not stop here. The autonomous, 'out-for-themselves', elements of the system act, from the point of view of the whole, as identical and mutually interchangeable elements. But at this point another mechanism comes into play: the natural 'spread' of variants in nature results in the fact that structurally identical elements come into being as variants. But this variety is not a structural fact and, from the point of view of the structure as such, does not exist.

At the next stage the picture becomes more complicated: the connection between the elements is realized with the help of semiotic communication, and this stimulates their independence, which, in its turn, leads to the individual differences becoming structural ones, and the actual elements becoming individuals (personalities).

This process can be illustrated with the following example. The simplest form of biological reproduction is the division of one-cell organisms. In this case each separate cell is quite independent and has no need of another. The next stage is the separation of biological species into two sexual classes and now for the continuation of the species it is necessary and sufficient to have any one element from the first and any one element from the second class. With the appearance of zoosemiotic systems individual differences between individuals become significant and an element of selection comes into the mating relationships of the higher animals. Culture arises as a system of supplementary constraints imposed on physically possible actions. The combination of complex systems of marriage constraints and structurally significant violations of them turns the addresser and the addressee of the marriage communication into personalities. The 'man and woman' given by Nature is replaced by the 'only him and only her' given by Culture. And it is precisely the inclusion of separate human units in the complex formations of Culture that makes them at the same time parts of the whole and unrepeatable individualities, between whom the difference is a bearer of certain social meanings.

This example illustrates the proposition that as a system grows more complex so the autonomy of its parts increases, and in supracomplex systems this

process leads to the substitution of the concept 'personality' for the concept 'structural node'. But it is legitimate to ask how this process influences the effectiveness of a system.

If one looks at a system as a whole possessing homeostasis and certain intellectual capacities, then it is obvious that one of its chief difficulties is the necessity of acting in conditions of insufficient information. Attempts at effective behaviour when there is incomplete information leads to the attempt to fill up the incompleteness by diversity. The system, if it has only a small part of the information that it needs for effective action, is vitally interested that this information should be qualitatively diverse and that it should fill the incompleteness by being stereoscopic.

Hence the characteristic of culture which we may call the principle of polyglottism. No culture can be satisfied with one language. A minimal system is formed from a set of two parallel languages, for example, verbal and visual. Subsequently the dynamics of any culture involves the multiplication of the set of semiotic communications. Since the image of the external world, which is translated in the texts of one or other language, is subject to the modelling action of that language, the system, as a single organism, has at its disposal for each outside object a whole set of models, and this fills up the incompleteness of its information about it. The more sharply drawn are the specific features of a language (and the result of this will be the increasing difficulty of translating its texts into other languages), the more individual will be its way of modelling and, consequently, the more useful it will be for the system as a whole.

2.6. The stereoscopic quality of culture is the result not only of its polyglottism. As the structure of the personality of addresser and addressee becomes more complex, as the set of codes which make up the content of the consciousness of the personality becomes more individualized, the statement that addresser and addressee of a message use the same language becomes ever less justified. The addresser encodes the message with the help of a set of codes, of which only a part are present in the decoding consciousness of the addressee. It is for this reason that all understanding, no matter how many developed semiotic systems are used is partial and approximative. But it is important to emphasize that a degree of non-understanding cannot be interpreted only as 'noise' — a harmful consequence of an imperfection of the system, which is not present in the idealized schema. The growth of non-understanding and/or inadequate understanding may bear witness to the technical defects in the system of communications, but it may also be an indicator of the increased complexity of this system, its capacity to fulfil ever more complex and important cultural functions. If one draws up a scale, according to the degree of complexity, of systems of social communication

from the language of traffic signals to the language of poetry, then it becomes obvious that the growth of ambiguity in the decoding cannot be ascribed only to the technical faults in any particular type of communication.

It follows that the act of communication (in any sufficiently complex, and consequently culturally valuable, instance) should be seen not as a simple transmission of a message which remains adequate to itself from the consciousness of the addresser to the consciousness of the addressee, but as a *translation* of a text from the language of my 'I' to the language of your 'you'. The very possibility of such a translation is determined by the fact that the codes of both participants in the communication, although not identical, form intersecting sets. But since, in the given act of translation, a certain part of the message is always cut off, and 'I' am submitted to a transformation in the course of translation into language 'you', what is lost is just the individuality of the addressee, that is, what, from the point of view of the whole, is the most valuable thing in the message.

The situation would be hopeless if the received part of the message did not contain indications as to how the addressee should transform his personality in order to understand the lost part of the message. In this way the non-identity of the partners in the communication turns just this fact from a passive transmission into a game of conflict in the course of which each side aims to reconstruct the semiotic world of his opponent according to his own model, and at the same time is interested in the preservation of his partner's individuality.

The tendency to increase semiotic diversity within the organism of culture has the result that each meaning-bearing node of its structural organization begins to show a tendency to turn into a peculiar 'cultural personality', a closed immanent world with its own internal structural-semiotic organization, its own memory, individual behaviour, intellectual capacities, and procedure for self-development. As a result, culture as an integral organism represents a combination of structural-semiotic formations, constructed according to the model of separate personalities, and the systems of connections (communications) between them.

The growth of different closed formations, which is of the very essence of the mechanism of culture, contributes to the capacity of the information circulating within the culture, and, consequently, the effectiveness of its ability to orient itself in the world. But it is threatened by a kind of 'cultural schizophrenia', disintegration into numerous mutually antagonistic 'cultural personalities': cultural polyglottism may grow into a Tower of Babel for the semiosis of that culture.

2.7. To prevent the threat becoming a reality, culture has its counteractive mechanisms.

The very system of communicative connections between the structural nodes of a culture, plus the constant demand for mutual translating, give grounds for another type of organization: a single structure that 'wipes out' the diversity of the parts in the name of the ordering of the whole. The fullest realization of this tendency is to be found in the ramifications of the system of metalingual and metatextual formations, without which no culture can exist.

The moment when a given culture reaches a certain structural maturity, a moment which coincides with the point when the autonomy of the separate partial mechanisms of culture reach a certain critical point, there arises the need for self-description, for the creation of that culture's own model of itself.

Self-description demands the creation of a metalanguage for the given culture. On the basis of the metalanguage there arises the metalevel on which the culture constructs its ideal self-portrait. The self-description of culture is a legitimate stage in its development, the significance of which lies partly in that the very fact of description deforms the object described by giving it greater organization. A language, when it gets a grammar, is by this fact put onto a higher degree of structural organization compared with its pre-grammatical stage. Just as the appearance of grammatical description is not only a fact in the history of the study of a language, but also a fact in the history of the language itself, the appearance of a metadescription of culture bears witness not only to the progress of scientific thought, but also to the achievement of the culture at a particular stage (it would be more precise to see in the one and the other different aspects of a single process). The appearance of an image of culture on the metalevel signifies the secondary structuration of this very culture. It becomes more rigidly organized, certain aspects of it are declared to be non-structural, i.e. 'non-existent'. A mass obliteration of 'incorrect' texts takes place in the memory of the culture. The remaining texts are canonized and subjected to a strict hierarchical structure.

This process entails a certain impoverishment of the culture (this is especially sharply felt when the obliterated texts are physically destroyed; when this happens the model of culture loses dynamism since the extra-systematic texts as a rule make up the reserve for the construction of tomorrow's systems, play between the systematic and the extra-systematic being the basis for the mechanism of the development of a culture). In cases, however, when texts declared apocryphal, are merely shifted to the periphery of culture and become 'as it were non-existent', this impoverishment has a relative character: at the next stage of development, in the light of new meta-models, what is apocryphal may be discovered once more and pass into the canon.

The metamechanism of culture establishes a unity between the parts that strive for autonomy and becomes a language in which internal intercourse

inside that culture is carried on. It contributes to the unification of separate structural nodes. Through it the isomorphism of the culture as a whole and its parts comes into being.

The secondary organization of culture, as it comes into being in this way, at the same time creates impulses for a new deepening of the individuality of the separate partial structures, and this, in its turn, leads to a new intensification of the metastructures.

The conflict between the opposing tendencies in the mechanism of culture shows itself in another way too. The different subsystems of culture pass through dynamic periods at different rates. One has only to compare such static systems as language with mobile ones such as fashion, for this fact to be obvious. There is a difference too in the time taken by separate arts to pass through typologically similar cycles. As a result, any synchronic cross-section of culture will give us, in its different parts, different moments of the typological diachrony. At any moment in culture different epochs coexist. On the metalevel this diversity is taken out of consideration. Moreover, the meta-mechanism creates not only a canon for the synchronic state of culture, but also its own version of the diachronic process. It actively selects texts not only from the present, but also from the previous states of the culture and establishes its own, simplified, model of the historical movement of the culture as the normative one. It would be a mistake to see in this only a negative aspect: thanks to this simplification, culture acquires a common language for its communicative connections with past historical epochs.

2.8. Thus, the internal apparatus of culture presupposes a certain specialization both of the separate languages and of the closed nodes, 'the personalities', that come into being; and this gives rise to a situation where there can be no translation between texts composed in these languages, or between the world-models that organize these personal worlds. Since mutually unambiguous correspondences do not, and cannot, exist between the elements of the one and the other, precise translation is in principle impossible. The situation is like that of literary translation: the demand for the translation, although a translation is known to be impossible, forces the establishment of one-off correspondences or correspondences that have a metaphoric character. To one element in the text to be translated there may correspond a set of elements, and vice versa. The establishment of a correspondence always implies a *selection*, it is fraught with difficulties and is like a revelation or a sudden illumination. It is this translation of the untranslatable that is *the mechanism for the creation of a new thought*. At its base lies not a one-for-one transformation, but an approximative model, a resemblance, a metaphor.

2.8.1. At this point we can observe the striking isomorphism between culture — the apparatus of collective consciousness, and individual consciousness.

We have in mind the fact of the asymmetry of the human brain – the semiotic specialization in the work of the left and the right hemispheres.⁷ V.V. Ivanov has connected this feature of brain-structure with the asymmetry of human culture, and in many papers presented at the Tartu University semiotic seminars and at VINTI in Moscow has pointed out that the appearance of such fundamental features of human consciousness as language, the basic human semiotic models, and so on, evidently dates from the same period as the specialization of the hemispheres of the brain.

No 'monologic' (i.e. monoglot) apparatus could produce messages that are in principle new (thoughts), i.e. could be called a thinking apparatus. A thinking apparatus must have in principle (in the minimal schema) a dialogic (bilingual) structure. This deduction, incidentally, gives new meaning to the prophetic ideas of M.M. Bakhtin about the structure of dialogic texts.

I have attempted to point out the common features in the study of individual and collective consciousness, and to indicate a new approach to the problem of artificial intellect.

The study of what would seem to belong purely to the humanities, such as the structure of the literary text, the procedures of literary translation, the nature of metaphoric consciousness, on the one hand, and, on the other, the study of different forms of semiotic modelling of the world (spatial, mythological, and other models), the study of the very nature of semiotic polyglottism and of the asymmetry of semiotic models created by mankind in the course of its history, all these topics acquire in the light of the foregoing, a quite new meaning and this becomes part of a general scientific perspective.

2.9. The analogy between the asymmetry of culture and the asymmetric structure of the brain highlights the problem of the correlation of discrete and non-discrete languages and the problem of the mutual equivalence of the texts created in them. It should be noted that non-discrete languages are still in the elementary stages of study and in practical terms we do not yet have the means to describe them. But their role (like the role of 'right-hemisphere' consciousness) is in no sense just auxiliary. We might suggest that for our artificial system to be a 'thinking' one it would need to contain a mechanism which one might conventionally term 'the block of child consciousness' or 'the mechanism of myth-generation'. The polar opposition of the texts created here to the mechanism of logical discrete thinking would give the texts, when translated, the necessary metaphoric quality for new messages to arise.

3. A no less pressing problem is the nature of the cultural memory of the collective. It also covers questions about the physiology of individual memory, the structure of social memory, and the ways for developing the optimal forms of machine memory.

3.1. In the course of historical development there came a moment when

the number of texts needing to be memorized exceeded the capacities of man's individual memory. Written culture came into being, which made it possible to fix a limitless number of texts in the memory of the collective. The significance of written memory was so enormous that images of a book, a library, became identified in people's minds with the very notion of memory. But the epoch of writing led to the domination of the least compact methods of fixation – separate ready texts were preserved. But the analysis of how culture concentrates in itself knowledge about its past states, confronts us with the exceptional (from the point of view of technical effectiveness) structures of memory. The memory-procedures of culture have an exceptional power to reconstruct. This leads to the paradoxical situation: more can be taken from the memory of a culture than was put into it. This capacity retrospectively to accumulate memory is evidence of a principle difference in its apparatus structuring than that so far given to artificial intelligences.

3.2. There are grounds for thinking that the memory of culture is as bilingual (or rather: polyglot on the basis of an initial bilingualism) as the structure of the human brain and the model of culture. Both types of memory are oriented towards the fixing of codes and not texts, though the nature of these codes is different: some of them approximate to generative procedures of a logical type; others to integral models or images of a holographic type. A particularly active role in the organization of memory of culture is played by metamodels (the self-description of the previous experience of a culture).

3.3. Organically connected with the structure of cultural memory are the procedures for useful and purposeful forgetfulness, the study of which could also contribute an exceptional amount to the general theory of Intelligence.

3.4. From the example of culture as an intellectual apparatus we can learn that memory is not an immobile store, but an apparatus for active and ever new modelling, although it is directed towards the past.

Notes

1. A.I. Herten, 'Doktor Krupov', *Sobr. Soch.* v 30 t., IV, Moscow, 1955, p.264.
2. A.M. Turing, 'Computing machinery and intelligence', *Mind*, 59, 1950, pp.433-460.
3. M. Arbib, *Metaforicheskiy mozg [The metaphoric brain]*, Moscow, 1976, p.137.
4. Roman Jakobson, 'Linguistics and poetics', *Style in Language*, ed. T. Sebek, 1964, p.353.
5. F. de Saussure, *Cours de linguistique générale*, 1916. (Russian translation: *Kurs obshchei lingvistiki*, Moscow, 1933) p.40.)
6. *Tezisy dokladov IV Letnei shkoly po vtorichnym modeliruyushchim sistemam [Summaries of papers at the IV Summer School on secondary modelling systems]*, Tartu, 1970, p.3.
7. V. Degin, 'Funktional'naya asimmetriya unikal'naya osobennost' mozga cheloveka' ['Functional asymmetry is the unique feature of the human brain'], *Nauka i zhizn'*, 1, 1975; Vyach. Vs. Ivanov, 'K predystorii znakovykh sistem' ['On the prehistory of sign

systems'] , *Materialy Vsesoyuznogo simpoziuma po vtorichnym modeliruyushchim sistemam*, 1(5), Tartu, 1975; idem, *Ocherki po istorii semiotiki v SSSR (Outline history of semiotics in the USSR)*, Moscow, 1976, pp.22-23; P. Milner, *Physiological psychology*, New York, 1970 (Russian: *Fiziologicheskaya psikhologiya*, Moscow, 1973); H. Jackson, 'On the nature of the duality of the brain', *Selected Writings*, II, London, 1932.