

## MATHEMATICAL LINGUISTICS

ROBERT ABERNATHY

### 1. CHRONOLOGICAL SKETCH

The emergence of mathematical linguistics as a specialized field is in the USSR, as elsewhere in the world, quite a recent development. The following brief chronology of events, spanning eight years, may serve to highlight the stages in this process.

1955: First machine translation experiments in the Soviet Union.

1956: Opening of discussion on structuralism in the pages of *Voprosy jazykoznanija*.<sup>1</sup> Inauguration of a seminar in mathematical linguistics at the Moscow State University.

1957: Publication of O. S. Kulagina's set-theoretic language model.<sup>2</sup> Conference on speech statistics in Leningrad, 1-4 October.<sup>3</sup>

1958: Moscow conference on machine translation. Participation of workers in this field in the Fourth International Congress of Slavists (Moscow, 1-10 September). Publication of Volume 51 of the *Bol'saja sovetskaja ènciklopedija*, containing an article on "Mathematical linguistics" (by V. V. Ivanov).

1959: Conference on mathematical linguistics held in Leningrad, 15-21 April, attended by almost five hundred linguists, mathematicians and others from various parts of the Soviet Union and from Eastern Europe and China: 58 papers, on a wide range of topics in both theory and applications.<sup>4</sup>

1960: Resolution of the Presidium of the Academy of Sciences "on the development of structural and mathematical methods of linguistic research", with corresponding organizational changes in a number of the Academy's institutes.<sup>5</sup> Inclusion of "structural and mathematical methods" in the problematics of the Fifth International Congress of Slavists, to be held 1963.

1961: A series of well-attended conferences touching various aspects of formalized linguistic investigation (machine translation and data processing, lexicography, trans-

<sup>1</sup> Editorial, *VJa* 5/4 (1956), and various articles in this and succeeding numbers.

<sup>2</sup> Kulagina, "Ob odnom sposobe opredelenija lingvistièeskix ponjatij".

<sup>3</sup> All but one of the papers delivered published in the collection *Voprosy statistiki reèi*, edited by L. R. Zinder.

<sup>4</sup> More or less extensive summaries of papers in: *Tezisy soveščanija po matematièeskoj lingvistike (15-21 aprèlja 1959 goda)* (Leningrad, 1959). (Abbreviated in the bibliography as *TezSML59*).

<sup>5</sup> Grigor'ev, "O razvitii strukturnyx i matematièeskix metodov issledovanija jazyka".

formational methods, stylistics). Papers and discussions on linguistic problems figured in the program of the Fourth All-Union Mathematical Congress (Leningrad, 3-12 July), although no special section of the congress was set aside for the purpose.

1962: Publication of books by I. I. Revzin<sup>6</sup> and S. K. Šaumjan<sup>7</sup> seeking to provide, respectively, a general survey of a large part of the subject of mathematical models in linguistics and a detailed mathematical-logical treatment of the particular problems of phonology. Widespread interest in Soviet work in the field was indicated by the fact that one plenary session of the Ninth International Congress of Linguists (Cambridge, Massachusetts, 27-31 August) was devoted to the reading and discussion of N. D. Andreev's paper, "Linguistic theory of translation", reflecting the work of the Leningrad machine translation laboratory and of the recently formed Mathematical Linguistics Group of the Leningrad division of the Academy of Sciences' Linguistic Institute.

## 2. DELIMITATION OF THE SUBJECT

The foregoing catalog is at least sufficient to show that something called "mathematical linguistics" leads a recognized and even a thriving existence in the Soviet academic world. It does not, however, thereby become easy to determine just what recent works by linguists or others are properly "in" the field. A superficial and popular view would assign this label to anything dealing with natural-language material and making use of numbers (in the popular sense, viz. real-number arithmetic). A more sophisticated version would recognize as mathematical also such apparatus as that of abstract algebra or formal logic (cf. the enumeration of methods in the cited article of the Soviet Encyclopedia). Both views are inadequate in that they allow everything to hinge on the "mathematical" part of the label, and neglect (or assume away as obvious) the difficult problem of deciding what makes a study "linguistic". This, which is surely one of the most crucial problems confronting our science today, is one on which satisfactory clarity does not seem to exist anywhere; it remains a subject for cloudy metaphysical profundities or for the dogmatism of schools.

One cannot (especially in a survey of the present kind, which must take cognizance of its place in an overall scheme) simply follow Soviet practice on this point, as reflected say in the editorial policies of various journals.<sup>8</sup> For one thing the guidelines obtained in this way are neither clear nor congruent, and for another, so far as they go, they would lead to much too broad a delimitation of the field for present purposes. One difficulty of this nature is already apparent from the cursory chronolo-

<sup>6</sup> Revzin, *Modeli jazyka*.

<sup>7</sup> Šaumjan, *Problemy teoretičeskoj fonologii*.

<sup>8</sup> Compare - or contrast - the character of articles appearing in the journal *Voprosy jazykoznanija* (*VJa*) and in the series *Problemy kibernetiki* (*PK*), under the Readings, respectively, of "Prikladnoe i matematičeskoe jazykoznanie" and "Voprosy matematičeskoj lingvistiki".

gy given above: for historical reasons to be touched on later, the link between modern Soviet linguistic research and work on such "applications" as machine translation (and others less publicized, such as coded transmission of messages, information storage and retrieval, voice-directed mechanisms, etc.) is especially close. Yet it seems plain that many of the problems which loom large in such connections are no more essentially concerned with linguistic subject matter *per se* than are, say, the metallurgical problems of typesetting. Engineering solutions in dealing with human language or surrogates for it may certainly be productive of important insights for a science of language, but do not thus become the substance of the science.

On the other hand, in a theoretical direction, linguistics cannot become – some enthusiasms notwithstanding – a branch of mathematics; there is no such branch, and if there were it would mean merely that we needed another name for the study of language in a state of nature. For such a study, abstract properties of formally constructed "languages" are of interest not for their own sake but for their possible usefulness as models which in one way or another serve to increase our understanding of natural languages. This aim may be furthered by the employment of diverse types of usual or unusual mathematical apparatus; it is in any case incorrect to "define" linguistics in terms of some circumscribed class of admissible models.

On this view of the matter (which will certainly not command universal assent, but I do not know of any that does) one can seek to identify those strands in recent Soviet work which properly belong to the subject under consideration. Special comment is perhaps called for with regard to the physical-acoustic investigation of speech sounds, which, like that of non-speech sounds, makes long-established use of special mathematical techniques (Fourier analysis, in particular). For the purposes of the present survey, research in this area and the problem of its relations to linguistic phonology are left out of account.

### 3. GENERAL FEATURES OF THE SOVIET DEVELOPMENT

As was remarked above, although the evolution of mathematical linguistics in the USSR has much in common with that in other countries, certain historical circumstances have tended to shape its course and emphases. In the early 1950's, Soviet linguistics was just emerging from a long period of virtual dormancy (at least so far as serious thinking about basic problems was concerned) imposed by the Marr régime. The Marrist doctrine held in effect that linguistics really has no subject matter of its own, but only the function of a species of marginal commentary on non-linguistic sociological facts. Consequently, in the words of a recent retrospect (1960), "The period of domination by the 'new theory of language' was distinguished by extreme neglect of problems of internal linguistics and of 'speech mechanisms'. Just for this reason, in Soviet linguistics, which strives to draw on everything valuable and fruitful in the world arsenal of linguistic science, a very prominent place should be occupied

at the present time by research on basic questions of semiotic, of information theory, and of applied linguistics . . ."<sup>9</sup>

During the period alluded to, it was of course precisely the question of "internal" or "immanent" features of language which was under intensive cultivation in Western Europe and America, in large part and increasingly under the banner of structuralism. By the 1950's this tendency, characterized throughout by the search for logical rigor, had evolved naturally to a stage of explicit rapprochement with the abstract methods of formal logic and mathematics. Another factor (reflected in the foregoing quotation) was, from 1948 on, the development in communications work of the powerful new apparatus of information theory, which quickly captured the imagination of a number of linguists and led to a search for ways of bringing its concepts to bear on linguistic problems.

By virtue of the historical circumstances noted, the impact of these novelties on Soviet linguistic thinking was more abrupt and more nearly simultaneous than it was elsewhere. (It should be remarked that the assimilation of Shannon's information-theory concept was immediate so far as mathematicians were concerned; it is well known that Soviet mathematicians [e.g. Xinč'in] made early and important contributions to the development of this theory and in particular to its rigorous axiomatization. But for linguists this and other new ideas seem to form part and parcel of the "structural" reorientation from 1956 on.) One broad effect of this may have been to cause the liberated imagination of workers in the field to soar on occasion to remarkable heights; for an accessible example, cf. the previously mentioned paper by N. D. Andreev for the Ninth International Congress of Linguists, with its sweeping vision of a world-wide network of interconnected "national computers", employing an intermediary language (of the sort being experimented with in Leningrad) to conduct a continuous and instantaneous exchange of scientific information – and waiting to be linked, eventually, into a vaster system for communication with hypothetical extraterrestrial intelligent beings! And other examples could be cited to show that the atmosphere of novel theoretical and technical possibilities has provided a strong stimulus to conjecture and even quite fanciful speculation.<sup>10</sup>

As the quotation above suggests, one feature of the recent period has been the energetic assimilation of both earlier and contemporary work done outside the USSR. Numerous articles, lectures, etc. have been devoted to such matters as: glossematics (at least terminologically quite influential), glottochronology, Harary and Paper's set-theoretic treatment of phoneme distribution, Prague phonology (again very influential, especially via interest in Jakobson's distinctive-feature concept), structural typology, the syntactic connexity investigations of Bar-Hillel, transformation grammar (a subject of lively interest, witness the holding of a conference on "transformational

<sup>9</sup> Editorial, "O perspektivnom plane našix jazykovedčeskix issledovanij na bližajšie gody", *VJa* 9/2 (1960).

<sup>10</sup> Cf. also, e.g., Mel'nikov, "Jazyk mašiny i plan soderžanija", and "O vozmožnosti avtomatizacii lingvističeskix issledovanij".

method" in December 1961 under the auspices of the Academy's Russian language Institute), Yngve's gap analysis and his more recent depth hypothesis, and Zipfian statistics. Translation activity includes not only textbooks (e.g. Gleason's, which devotes considerable attention to mathematical methodology) but also a number of important shorter articles from Western sources.<sup>11</sup>

The programmatic statement of 1960 declares that

The leading place in the aforementioned scientific trend [toward compensating for earlier neglect of "internal" approaches to language] is occupied by the application of mathematical methods in linguistics, which may permit the exactitude of linguistic analysis and of conclusions from it to be elevated to a new level. Here such problems as the following are important: application of probability analysis, set theory and mathematical statistics, investigation of all "levels" of language structure in connection with the general theory of semiotic and "information theory" – work should be carried on not only on the theoretical plane, but also on every practical one (machine translation, determination of phonological variation and phonetic combinations, systematization of grammatical rules of combinability of morphemes and words into certain possible wholes and determination of classes of these wholes, and also rational rules of planning and composition of various kinds of dictionaries).<sup>12</sup>

One notes the stress on "applications" which was remarked on earlier, in connection with the fact that the radical reshaping of linguistic theory seems to have coincided closely with (or been somewhat anticipated by) the demand for such applications arising from the promise held forth by cybernetics and computer technology. "Mathematical and applied" or "structural and applied" linguistics are commonly mentioned in one breath, so notably and officially (in the second version) in the designation, from 1960, of the relevant section of the Linguistic Institute of the Academy of Sciences; references to the stimulating role of technological developments generally figure even in highly theoretical discussions. It seems not unreasonable to suppose that this ascription of importance to technological factors is really more nearly accurate with respect to the Soviet evolution than it is elsewhere (contrast Chomsky's strictures on this "strange and factually quite incorrect view" of motivations for generative grammar, with particular reference to expression of such an opinion by I. A. Mel'čuk).<sup>13</sup> It is also true that the philosophy of science prevailing in the USSR is insistent on the close interrelationship of theory and practice, whence an emphasis on "engineering" attitudes becomes the more intelligible. One can perhaps detect, however, a tendency to recognize an increasing measure of autonomy for the purely linguistic aspects of such problems.

A symptomatic effect of the comparatively abrupt onset of a new phase might be seen in the disposition of some authors to use the terms "structural" and "mathematical" as virtually interchangeable synonyms in application to linguistic methods and models. Another effect would seem to be that of making the contrast or conflict between the modern and the traditional ("structural" vs. "classical", or the like)

<sup>11</sup> Cf. in particular the series *Novoe v lingvistike*, edited by V. A. Zvegincev (Moscow, 1960, 1962).

<sup>12</sup> Cf. footnote 9.

<sup>13</sup> Chomsky, "The logical basis of linguistic theory", p. 513.

appear sharper than it may for linguists elsewhere in the world, with a consequent tendency for adherents of either sort of view to overstate the differences and to overlook the ways in which modern theories, odd and even outlandish as their symbolic garb may appear, can often be taken just as the formalization of notions already contained or applied in traditional treatments. The progress of innovating tendencies in the Soviet Union has not been without its sharp critics, e.g. B. V. Gornung, who has posed (in order to answer it negatively) the question as to whether structural and traditional linguistics can "coexist",<sup>14</sup> and who, while granting the legitimacy of using mathematical methods, has insisted strongly on their "limited problems and limited scope" as ancillary to linguistic methods properly speaking.<sup>15</sup> Such criticism and that of some of the foregoing lines of thought whose influence was noted above<sup>16</sup> seems to be framed largely in terms of assertions about the philosophical unacceptability of certain ideas, rather than on refutation of specific results, and in the existing intellectual climate it does not appear to be very effective.

#### 4. PARTICULAR TRENDS IN SOVIET MATHEMATICAL LINGUISTICS

Mathematical methods and models invite schematic classification, but the grounds adopted for such classifications vary and are not always clear; also, of course, the work of particular individuals may range over a variety of topics. A favored *principlum divisionis* with Soviet writers, as with others,<sup>17</sup> is that distinguishing "structural" and "statistical" approaches. So far as this represents a really basic distinction, it would seem to be rather a mathematical than a linguistic one, and comparable say to the distinction between "elementary" and "analytic" methods in number theory, or between "discrete" and "continuous" in topology.<sup>18</sup> In terms of this dichotomy, in the USSR as elsewhere more successful effort has been devoted in the last few years to elaborating the former type of concepts. There is evident moreover a certain differentiation of interests in this respect between the "center" (i.e. primarily Moscow and Leningrad) and the "periphery" of the Soviet academic world (cf. especially the Černovcy conference of September, 1960);<sup>19</sup> this is probably correlated with the "center's" commitment to machine-translation research and for the most part to the attack on

<sup>14</sup> Criticism of a paper by Šaumjan on structural study of meaning, at the 6th plenary session of the committee on problems of lexicology and semantics of the Academy of Sciences, Literature, and Language Division, October 1960. Cf. "Naučnaja žizn'", *VJa* 10(1).163 (1961).

<sup>15</sup> Gornung, "Mesto lingvistiki v sisteme nauk i ispol'zovanie v nej metodov drugix nauk", p. 32.

<sup>16</sup> Cf. Zvegincev, "Neopozitivizm i novešije lingvističeskie napravlenija".

<sup>17</sup> This basis is adopted by Warren Plath, "Mathematical linguistics", in *Trends in European and American linguistics* (Utrecht, 1961).

<sup>18</sup> Cf. on this point, in particular: Andreyev, "Models as a tool in the development of linguistic theory"; Revzin, "Ob otnošenii meždu strukturnymi i statističeskimi metodami"; Zinov'ev, "O matematičeskoj lingvistike".

<sup>19</sup> *Pytannja prykladnoki lingvistyky. Tezy dopovidej mižvuzivs'koji naukovoji konferenciji 22-28 veresnja 1960 roku* (Černivci, 1960).

its problems via the formalization of grammar, which, traditional or modern, offers mostly non-quantitative explicanda and/or explicata. Some interest in statistical methods arises from the same source in connection with the compilation of dictionaries, particularly various specialized lexica aimed at mechanical exploitation.

Another, increasingly popular, principle of classification is the division into "analytic" and "synthetic" models or methods.<sup>20</sup> Intuitively, an analytic scheme, given a language (or, realistically, a sample of the language) produces a systematic description of it, "deciphers" it in some sense, while a synthetic one produces (a sample of) the language from some axiomatically given starting point; it is further frequently proposed that these two kinds of systems should be paired as inverses to one another, a requirement which can easily encounter grave logical difficulties. For all its intuitive plausibility, this distinction tends to become elusive in theoretical contexts, when the difference between "models" and "interpretations" is made to hinge on a sometimes vague notion of degree of abstraction.<sup>21</sup> Recent Soviet investigations show a tendency to focus on the problems of analysis, while regarding those of synthesis as solved at least in principle by the concept of a generative grammar.

A third distinction sometimes stressed is that between "paradigmatic" and "syntagmatic" properties of language models.<sup>22</sup> That the difference intended involves the kinds of classes which play a part in the model is evident, but that it does so in any really significant way is not always clear. Possibly what is felt to be essential here is a division between descriptions constructed respectively with and without reference to classes of elements not obtainable by operations on the linear ordering of such elements (e.g. the "neighborhoods" of the Kulagina set-theoretic model). At all events it is difficult to escape the impression that a preference for paradigmatic models and a feeling that a purely "syntagmatic" treatment leaves essential things unsaid may reflect, even at the level of abstract discussion, native experience with a highly inflected language and perhaps habituation to its traditional grammar, and correspond to the preference which Russian linguists using more traditional terms frequently express for words over morphemes.

The set-theoretic model of language published by O. S. Kulagina in 1957<sup>23</sup> excited a great deal of interest from its first appearance, and has since served as a starting point for numerous elaborations and variants. It assumes as given a finite or countable set of "marked phrases" (finite strings in a finite alphabet, or vocabulary, since the elements are supposed to be interpreted as words), and allows replacement of element-occurrences by other elements or by subsets of the whole alphabet, the definition of "markedness" of the phrase being extended to embrace the latter possibility. Replacement preserving markedness is used to induce an equivalence ("B-equivalence")

<sup>20</sup> Cf. Fitialov, "Formal'no-matematičeskie modeli jazykov i struktura algoritmov perevoda"; Revzin, *Modeli jazyka*.

<sup>21</sup> On the general notion of "models" cf. Zinov'ev & Revzin, "Logičeskaja model' kak sredstvo naučnogo poznanija".

<sup>22</sup> Revzin, *op. cit.*, p. 16.

<sup>23</sup> Cf. footnote 2.

and this to define the "derived partition" based on any arbitrarily given partition of the underlying set. The principal objective of the original formulation was the explication of the troublesomely vague traditional concept of part of speech in terms of "type", defined as the derived partition of the partition into "neighborhoods", understood to answer to the assignment of word-forms to paradigms.

On this basis Kulagina and others have built up various additional concepts, such as those of "uniformity" and "simplicity" as properties of languages (of those with respectively at least and at most one element occupying each cell of a cross-cutting classification). V. A. Uspenskij pointed out that the definition of "type" fails of its aim (in terms of its intended interpretation) for some theoretically possible relationships between given and derived partitions, and proposed to define a "regular" language as one for which the definition does not fail in this way.<sup>24</sup> The original scheme made no provision for homonymy, although this is a problem which looms large in Russian grammar (e.g. homonymy of noun case-forms);<sup>25</sup> proposals for incorporating such a possibility, by defining "elementary grammatical category" in such a way as to determine in general overlapping classes, were made by R. L. Dobrušin,<sup>26</sup> and more recent suggestions for refining the treatment of classes by A. A. Xolodovič.<sup>27</sup> Its original version the relation of Kulagina's model to the "analytic-synthetic" dichotomy is not clear, though it owes a great deal to the schemes of distributional analysis developed by structural linguists. In more recent writings it tends to be regarded as of interest mostly from the analytic standpoint (whence problems arise out of questions left open to begin with, e.g. that of finite or transfinite character of the "set of marked phrases")<sup>28</sup> and efforts are made to work it into analytic counterparts of various types of synthetic or generative grammar. Extending the replacement operation to sequences of more than one element gives rise to the notion of "configuration", similar to that of constituent,<sup>29</sup> and I. I. Revzin has made an (admittedly tentative and inadequate) attempt to elaborate this further into a system of "transformational analysis".<sup>30</sup>

In connection with the "analytic-synthetic" distinction, notice should be taken of the influential part played in Soviet thinking by the idea of an "intermediary language" (*jazyk-posrednik*); this, like much of the model-building activity mentioned above, is closely connected with machine-translation work, and some of its popularity stems from a rather excessively simple argument about economy of translation systems: given  $n$  languages,  $n(n-1)$  binary algorithms of translation would be needed, but by going through an intermediary this can be reduced to  $2n$ ; one suspects, however, that if it were a question of translating between say Russian and Bulgarian by means of an

<sup>24</sup> Uspenskij, "K opredeleniju časti reči v teoretiko-množestvennoj sisteme jazyka".

<sup>25</sup> On this question, and suggestions for exploiting case-form homonymy for simplifying description of the language, cf. Padučeva, "Nekotorye zamečanija o padežnoj sisteme suščestvitel'nogo".

<sup>26</sup> Dobrušin, "Elementarnaja grammatičeskaja kategorija".

<sup>27</sup> Xolodovič, "Opyt teorii podklassov slov".

<sup>28</sup> Revzin, "O nekotoryx ponjatijax teoretiko-množestvennoj koncepcii jazyka".

<sup>29</sup> Kulagina, "Ob odnom sposobe opredelenija grammatičeskix ponjatij".

<sup>30</sup> Revzin, *Modeli jazyka*, pp. 145-152, 166f.



intermediary language equally appropriate for Chinese, it would be necessary to recognize something like a "triangular inequality" as relevant to the problem, and it has been justly pointed out that human languages, with all their quaint features, probably resemble one another more than any of them do the constructed languages of logic or computer programming (to which kinds the "intermediary language" is usually supposed to belong, though it assumes somewhat Protean forms in various discussions).<sup>31</sup> At all events, the concept is surely of linguistic interest if only for its bearing on the vexed question of meaning.

The developments considered above are overwhelmingly of the "structural" kind; clearly much of their interest resides in discovering that natural languages are a great deal more complicated than one or another simple model, i.e. such languages generally fail to live up to the austere requirements of "uniformity", "simplicity", etc. It is sometimes suggested<sup>32</sup> that actual languages can be significantly characterized by the extent to which they deviate from such ideal schemes, and if such suggestions were worked out in detail – as so far as I know they have not been – this would seem to call for quantitative or measure-theoretic methods, hence for the model's sharing essential properties with the "statistical" kind; this latter label is really unsatisfactory, but owes its popularity to the fact that probability is the only part of measure theory commonly considered in connection with linguistic problems.

With respect to the aforementioned dichotomy, an effort at an eclectic synthesis of both approaches, with practical ends in view, exists in the shape of N. D. Andreev's "statistical-combinatorial algorithm"<sup>33</sup> for language analysis. As the name implies, this is intended to use both probabilistic and algebraic methods to produce a (primarily algebraic) description from a text sample, assumed given with a segmentation into words, or in an alphabet including a "blank". The procedure which Andreev describes involves investigating the material statistically, partitioning the sample space and singling out maximally probable elements, and forming new sample spaces on the basis of the results of preceding operations, in such a way as to identify certain especially frequent and redundant portions of words as "affixes" and their remainders as "bases", this process to be carried on until it is no longer efficacious according to some fixed criterion. (The criterion is supposed to be such that, for a language in which word equals morpheme, the procedure will apply vacuously.) This is coupled with classifying operations similar to those of the Kulagina scheme, on the material thus placed in an appropriate form for such handling, and eventual further procedures are envisaged to elicit syntactic relationships. The whole is designed to be realized automatically, and it is reported that practical results have been obtained in particular in identifying Russian adjective endings (which would appear to be an especially

<sup>31</sup> For a survey of six types of "intermediary language" concepts, cf. Andreev & Fitialov, "Jazyk-posrednik mašinnogo perevoda i principy ego postroenija".

<sup>32</sup> E. g. by Revzin, *op. cit.*, pp. 85-90.

<sup>33</sup> Cf. especially Andreev, "Modelirovanie jazyka na baze ego statističeskoj i teoretiko-množestvennoj struktury", also other writings of the same author.

favorable case by virtue of their unusually distinctive shapes). Since the scheme is meant to be justified by practical results, it is perhaps beside the point to observe that it involves strong assumptions about the nature of the given material and has a number of features that appear quite *ad hoc* (e.g., why divide a set of probabilities into upper and lower subsets at one point rather than another? – but even a small displacement of this point could radically affect the further course of the analysis). However, such features tend to diminish its strictly linguistic interest.

Andreev has also proposed, though not in any detail, probabilistic approaches to some other problems: transformation grammar<sup>34</sup> and semantics, the latter in terms of six-dimensional vectors to be determined from a rather heterogeneous array of data.<sup>35</sup>

Linguistic statistics of one kind or another are of course no novelty, though relatively little such work has been done by linguists (an exception is the work of Zipf, whose “law” and its refinements continue to be an object of interest also in the Soviet Union),<sup>36</sup> and most of it has dealt with written material<sup>37</sup> – a famous example is A. A. Markov’s use of Russian letter-frequency data as illustration for the mathematical theory which bears his name. Whatever philosophical arguments may exist for and against the relevance of quantitative data to various problems, this situation does no credit to the courage of linguists’ convictions; apparently everyone believes strongly enough in letters, printed words, etc. to count them, but the linguist to whom, say, phonemes or past participles are “realer” than print is likely to be nonetheless seized with misgivings at the idea of placing these entities in correspondence with the inexorable series 1, 2, . . . . The misgivings may be justified; if so, they ought to be investigated, and, if possible, removed.

I am not convinced that this long-standing situation has changed fundamentally in the USSR in the recent period, even though a large number of research projects of a statistical nature are reported (languages on which frequency investigations of various kind and scope have been made include Russian, Belorussian, Ukrainian, English, French, Rumanian, and Vietnamese, in addition to the widely publicized work on deciphering Maya inscriptions),<sup>38</sup> and though some of the few which have been published in accessible form show a markedly improved level of linguistic sophistication over what used to be the rule. Soviet writers on linguistic theory commonly assign an important place to its statistical aspects<sup>39</sup> and to the illuminating possibilities of new

<sup>34</sup> Andreyev, “Models as a tool in the development of linguistic theory”.

<sup>35</sup> Andreyev, “Linguistic aspects of translation”, p.7f.

<sup>36</sup> Cf. Frumkina, “K voprosu o tak nazyvaemom ‘zakone ‘Cipfa’”; Segal, “Nekotorye utočnenija verojatnostnoj modeli Cipfa”.

<sup>37</sup> It is interesting to note in this connection that one of the byproducts of work on machine handling of (usually written) language material has been a recrudescence of interest in graphic representations for their own sake. Among Soviet authors this tendency is shown by T. M. Nikolaeva (well-known otherwise in machine-translation research); cf. her articles: “Pis’mennaja reč’ i specifika ee izučenija” and “Klassifikacija russkix grafem”.

<sup>38</sup> Cf. Knorozov, “Mašinnaja dešifrovka pis’ma majja”, and the counter-polemic Letter to the Editors by S. L. Sobolev, *VJa* 11(3).147 (1962).

<sup>39</sup> Cf. note 18 and: Ivanov, “Matematičeskaja lingvistika”; Frumkina, “Primenenie statističeskix metodov v jazykoznanii;” Toporov, “Vvedenie verojatnosti v jazykoznanie i ego posledstvija”.

developments in cybernetics and information theory, but it is not clear that sufficiently well-defined research goals exist or that new mathematical apparatus has been effectively integrated into the conceptual framework of linguistics. Consequently much of the concrete work done is open to criticism on grounds of "insufficient mathematical exactitude, excessive preoccupation with mathematical terminology and, most important, a not-always-clear conception of the ultimate purpose of research".<sup>40</sup>

A large amount of statistical investigation has been motivated by an interest in literary style, particularly in the group centering around the mathematician A. N. Kolmogorov.<sup>41</sup> Here, in a sometimes disputed border zone of linguistics, an effort is made (along lines similar to those adopted by some workers in Western Europe and in Poland) to use methods of mathematical statistics and communication theory to resolve elusive problems of artistic value, individual stylistic traits of authors, etc. This is one of the cases in which it is difficult to draw a line between what properly belongs to the subject matter of linguistics and what does not. For all the outward differences, the question here is remarkably similar to that which arises in connection with machine-translation research: both lines of thought involve forms of language and both, though in different ways, have a bearing on the knot of concepts commonly lumped together as "meaning" - which (as a problem, not as a *deus ex machina* providing pseudo-solutions) can scarcely be exorcized from linguistics and leave much of interest. As to the apparatus of information theory, after all due warnings have been voiced about the inadvisability of confusing such notions as "information" and "redundancy" with their everyday homonyms, it most surely be recognized that this constitutes an explication of part of what is meant by meaning, though one which has some disconcerting properties when compared with intuition.

Information-theory concepts have been stressed by a number of Soviet linguists, notably by E. V. Padučeva, R. G. Piotrovskij, and V. V. Ivanov.<sup>42</sup> The writings of the last-mentioned, in particular, range over a wide variety of subjects; he has advanced interesting ideas in connection with the possible use of mathematical-linguistic methods in the comparative-historical field. The problems which arise here have considerable points of contact with those which invite algebraic solutions in translation,<sup>43</sup> and, on the other hand, the idea naturally arises of defining "linguistic time" in relation to communication-theory entropy in somewhat the same fashion in which physical time and entropy are related.<sup>44</sup> (The "linguistic time" concept suggests glottochronologic methods, but Ivanov reports dissatisfaction with the results of his experimentation

<sup>40</sup> Remark ascribed to Frumkina at conference on structural and mathematical linguistics in Černivci, September 1960 (cf. "Naučnaja žizn'", *VJa* 10(1).157 (1961).

<sup>42</sup> Cf. Ryčkova, "Lingvistika i matematika".

<sup>43</sup> Cf. Padučeva, "Statističeskoe issledovanie slogovoj struktury" and "Vozmožnosti izučeniya jazyka metodami teorii informacii"; Piotrovskij, "Problema mesta v slove u elementov, nesuščix informaciju"; Grigor'ev, "O kode i jazyka"; Jaglom, Dobrušin, & Jaglom, "Teorija informacii i lingvistika".

<sup>44</sup> Ivanov, "Teorija otnošenij meždu jazykovymi sistemami i osnovanija sravnitel'no-istoričeskogo jazykoznanija".

<sup>45</sup> Ivanov, "Verojatnostnoe opredelenie lingvističeskogo vremeni".

with these). Proposals for formalizing the vague appeal to probabilistic factors which often figures in discussions of linguistic evolution have also been made by A. B. Dolgopol'skij,<sup>45</sup> and M. I. Steblin-Kamenskij has contributed some interesting views on synchrony and diachrony.<sup>46</sup> It might be remarked that comparative-historical linguistics is renescent in the USSR, after having suffered almost total eclipse during the Marr period.

Notice should be taken here of some other quantitatively oriented work: V. M. Zolotarev's proposal of a stochastic-process model for the sentence,<sup>47</sup> Ju. K. Lekomcev's investigation of Vietnamese constructions along lines similar to those incorporated in the Andreev algorithm,<sup>48</sup> and I. A. Mel'čuk's examination of the problem of "idioms" in terms of numbers of permitted combinations;<sup>49</sup> also of the publication of descriptive statistical studies dealing e.g. with frequencies of phonemes,<sup>50</sup> of lexical items,<sup>51</sup> of grammatical forms,<sup>52</sup> and sentence lengths.<sup>53</sup>

As some of the topics noted above already illustrate, classifications by the properties of models or methods tend to cut across the long-standing division of linguistic subject matter into phonology, morphology, and syntax, and modern theories perhaps to deny that such levels have any significant degree of autonomy. An exception to this tendency can be seen in the writings of S. K. Šaumjan, focusing closely on problems of phonology and the endeavor to complete the logical formalization of phonological theory begun by the Prague School.<sup>54</sup> Šaumjan holds that attempts to construct phonology on a single level inevitably lead to certain "antinomies", and that to avoid these it is necessary to use a "two-level theory of phonology", in which observational facts and "constructs" are connected by correspondence rules: some of the properties usually ascribed to phonemes, say, belong to the former kind of entities, some to the latter. In working out and defending this view, the author makes increasing use of formal apparatus of mathematical logic (set-theory and relation-theory concepts, mostly), so that his treatment has points of contact with those of some Western investigators (e.g. Ungeheuer, Halle), especially since a prominent role is assigned to the Jakobsonian scheme of binary distinctive features, which of course lends itself readily to algebraic representation. (Šaumjan is far from being the only Soviet linguist to be strongly interested in the last-mentioned scheme; but much of this interest translates

<sup>45</sup> Dolgopol'skij, "Faktory razvitija jazyka i častotnost' jazykovyx znakov".

<sup>46</sup> Steblin-Kamenskij, "Struktural'naja točka zrenija v istorii jazyka".

<sup>47</sup> Zolotarev, "Verojatnostnaja model' predloženiya".

<sup>48</sup> Lekomcev, "Struktura v'etnamskoj glagol'noj sintagmy".

<sup>49</sup> Mel'čuk, "O terminax 'ustojčivost' i 'idiomatičnost'".

<sup>50</sup> Cf. Zinder, "O lingvističeskoj verojatnosti".

<sup>51</sup> Cf. Frumkina, "Statističeskaja struktura leksiki Puškina"; Belonogov, "O nekotoryx statističeskix zakonomernostjax v ruskoj pis'mennoj reči".

<sup>52</sup> Cf. Nikonov, "Bor'ba padežej".

<sup>53</sup> Cf. Lesskis, "O razmerax predloženiya v ruskoj naučnoj i xudožestvennoj proze 60-x godov XIX v."

<sup>54</sup> Šaumjan, "O suščnosti strukturnoj lingvistiki", "Der Gegenstand der Phonologie", "Generalizacija i postulirovanie konstruktov v izučeni struktury jazyka", "Operacionnye opredelenija i ix primenenie v fonologii", "Dvuxstupenčataja teorija fonemy i diferencial'nyx elementov", "Concerning the logical basis of linguistic theory", and *Problemy teoretičeskoj fonologii*.

itself into research in acoustic phonetics, outside the purview of the present summary.<sup>55</sup>)

In another border area, viz. psychology, mention should be made of the work of N. I. Žinkin, in view of the conspicuous interest in formal-logical modelling of phenomena (influenced particularly, it seems, by the ideas of Church) expressed already in this author's 1958 book<sup>56</sup> and still more in some of his recent papers. Žinkin has treated in this fashion, among other things, his experimental study of the vocalizations of baboons – surely one of the most exotic “languages” to have been so dealt with.<sup>57</sup>

## 5. CONCLUSIONS

Within less than a decade, mathematical linguistics in the Soviet Union has developed into a recognized discipline, though, naturally enough, its precise outlines and content are still uncertain in many respects (and this could be said also of much older fields). The suddenness of this development and the resulting break with traditional approaches has perhaps been sharper here than in other parts of the world, and the effect of this and possibly some other localized factors can be traced on work done to date; but, by and large, the international communicability of results in this area is probably greater than in linguistics otherwise. The closeness of the tie between theory and “applications” (especially machine translation) is emphasized in the USSR, and this, in conjunction with other factors (such as the general absence among linguists of long-standing commitments to theories of a formal or semi-formal kind) leads to a certain eclecticism in choice of methods.

It must be noted that, in the USSR as elsewhere, the growth of this trend has not proceeded without producing its excesses and aberrations; Soviet publications are by no means free of the sort of thing which betrays a naive belief that just adopting mathematical terminology or literal symbolism somehow automatically confers rigor on an argument. There is just enough truth in this to make it dangerous (it has been remarked that in mathematics a good notation is half the battle), but in some instances the terminology degenerates into jargon, and it is perfectly possible to write nonsense in an impeccable notation. One trusts that such instances will in the course of time become fewer and disappear.

That speculation at present frequently ranges ahead of concrete research should not, however, be counted as a defect. In the present stage it would be rash to predict which of today's proposals will eventually be included among the solid gains of linguistic science and which will be rejected as *hubristikà kai geloia* (as Socrates calls his own linguistic theorizing). A certain *hubris* is natural to young and rapidly developing fields of knowledge, and portends well for their survival into a healthy and balanced maturity.

<sup>55</sup> Cf. for a most recent example at present writing: Kibrik, “K voprosu o metode opredelenija diferencial'nyx priznakov pri spektral'nom analize (na materiale glasnyx novogrečeskogo jazyka)”.

<sup>56</sup> Žinkin, *Mexanizmy reči*.

<sup>57</sup> Žinkin, “Zvukovaja komunikativnaja sistema obez'jan” and “Four communicative systems and four languages”.

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