The background of transformational and metalanguage analysis[†]

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This article provides a record of the background and the steps of analysis that led to grammatical transformations and to the recognition of the metalanguage as being a part of natural language, with the ensuing development to an operator-argument theory of language.

The work began as an attempt to organize the analyses made in descriptive linguistics, and to specify and formulate its methods. The later steps were called into being by this work of specification. The background for the work came largely from the foundations of mathematics and logic, and the analysis of formalisms; this was relevant to language because in all of these systems there were sentences (propositions, formulas) with partially similar structure (syntax). More specifically, there was the then current constructivism: in the criticisms by the intuitionists in mathematics (L.E.J. Brouwer), in Russell's theory of types, in the work of Emil Post, and in the Turing Machine procedure. Later, I considered that I had philosophical support in the constructivist (nominalist) approach of Nelson Goodman's *The Structure of Appearance*. Going back to the early background, there was also the development of recursive methods by Gödel, Tarski, and others; and in logic there was J. Łukasiewicz' Sentential Calculus, S. Leśniewski's Categorial Grammar, and the syntax of logic in W. V. O. Quine's *Mathematical Logic* of 1940.

Within linguistics, the success of de Saussure's phonemic analysis showed the usefulness of complementary and free variation as a basis for defining more unrestricted entities, stated as having various alternate values that were usually more restricted. In morphology and syntax, the 'distributional' method followed by Franz Boas, and more explicitly by Edward Sapir and Leonard Bloomfield, analyzed likewise the occurrence and combination of grammatical elements in the particular environments of other elements. I think, and I am glad to think, that the intellectual and personal influence of Sapir and of Bloomfield colors the whole of the work that is surveyed below. It seemed natural to formulate all the methods above in the spirit of the syntax of mathematics and logic noted here.

This methodological program involved finding the maximum regularity in the occurrence of parts of utterances in respect to other parts. In its most general form it required the description of the departures from randomness in the combinations of elements, i.e. the constraints on freedom of occurrence of elements in respect to each other. Although decades of work were needed for applying the methods, and for further directions that grew out of the book, it is indicative of the intellectual background cited above that the general program could be stated from the beginning, e.g. in a paper in the *Journal of the American Oriental Society* 61 (1941) pp. 143, 166; also in "The Phonemes of Moroccan Arabic," *ibid.* 62 (1942) Sec. 4; (*Methods in*) *Structural Linguistics* p. 364 (the latter was completed and circulated in 1946, though it appeared only in 1951). Some of the papers cited here are also in *Papers in Structural and Transformational Linguistics*, Reidel 1970; also *Papers on Syntax*, Reidel 1981.

As originally applied by the distributional linguists, the method involved collecting complementarily-, or similarly-, combining entities into a class, and then defining the class as a new 'higher' entity. The higher entity is in general more unrestricted (has greater freedom of occurrence) than the entities which it classifies. In addition, sequences of entities, or of these higher entities, may be found to constitute more regularly or freely occurring entities. All these classifications may be repeated to compose a hierarchy of higher entities (*Structural Linguistics* p. 369).

Formulating this hierarchy of distributional classifications, which came to be called structural linguistics, made it necessary to establish procedures for determining the primitive elements at the bottom of the hierarchy, for their simplicity and objective characterizability is as important to the system as are the

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classifications and sequences that state the departures from randomness of the entities at each level. Thus stated, the final system is finitary, in the sense of S. C. Kleene, *Introduction to Metamathematics* (1952).

In particular, the pair test of sound discrimination among speakers of a given language was offered as a basis for phonemic distinctions (*Structural Linguistics* p. 32), these being the ultimate and necessarily discrete primitives of the language structure. Phonemes were defined as a convenient arrangement of how these phonemic distinctions appeared in utterances, in complementary or free alternation. Morphemes and word boundaries were then obtained by a stochastic process on phoneme sequences in utterances; they were the points of least restriction in the phoneme sequence ("From Phoneme to Morpheme," *Language* 31 (1955) 190–222; the method had been presented at Indiana University in the 1940s, and its possibility is recognized in *Structural Linguistics* p. 363).

In going on to morphology and syntax, there was a conscious effort to apply, mutatis mutandis, the methods that had been famously successful for the phonemic substrate. This program was carried out in "Morpheme Alternants in Linguistic Analysis," *Language* 18 (1942) 169–180, and a number of following papers. Thereafter no a priori justifiable general method was found to reach the structure of a sentence (or an utterance) by a hierarchy of constituent word sequences, or other partial structures of words. The problem was finally resolved by a single general procedure of building, around certain words of a given sentence, graded expansions in such a way that the sentence was shown to be an expansion of a particular word sequence in it, this word sequence being itself a sentence. (The first application of the method was in Hidatsa, a Siouan language; then an application to a Dravidian language was published in "Emeneau's Kota texts," *Language* 21 (1945) 283–289; the full method was presented at the Linguistic Institute, and appeared together with the Hidatsa analysis in "From Morpheme to Utterance," *Language* 22 (1946) 161–183.

The relevance of the hierarchy of word expansions, which was organized into an ascending chain of equivalences, was not simply in providing a direct procedure that yielded the structure of a sentence in terms of its words, but in opening a general method for the decomposition of sentences into elementary sentences, and thus for a transformational decomposition system. This unexpected result comes about because, first, the small sentence which is at the base of the expansions is recognizable as the grammatical core sentence of the given sentence, and, second, each expansion around a particular word can be seen to be a reduction or deformation of a component sentence within the given one. The status of expansions as component sentences was visible from the beginning: when the expansion method was presented at the Linguistic Institute, a question was raised as to how the method would distinguish the two meanings of *She made him N* in *She made him a good husband because she made him a good wife*; the answer was in showing that two different expansions obtained from two different component sentences yielded here the same word sequence (sec. 7.9 in the paper cited above).

The expansion analysis was formulated later as a decomposition of the given sentence into word strings ("Computable Syntactic Analysis," *Transformations and Discourse Analysis Papers* 15 (1959); *String Analysis of Sentence Structure* (1962)). The string status of the words of a sentence then made possible a stochastic procedure for finding, in the word sequence of an utterance, points of least restriction which were the sentence boundaries in that utterance (*Mathematical Structures of Language,* Interscience Tracts of Pure and Applied Mathematics 21 (1968) pp. 36–40).

While the machinery for transformations was provided by the "Morpheme to Utterance" equivalences, the motivation for developing transformations as a separate grammatical system was furthered by the paraphrastic variation in sentences that was found in discourses. In 1946, with the completion of *Methods in structural linguistics*, the structure of a sentence as restrictions on the combination of its component parts seemed to have gone as far as it could, with the sentence boundaries within an utterance being the bounds of almost all restrictions on word combination. I then tried to see if one could find restrictions of some different kind which would operate between the sentences of an utterance, constraining something in one sentence on the basis of something in another. It was found that while the grammatical structure of any one sentence in a discourse was in general independent of its neighbors, the word choices were not.

In a discourse, the component sentences revealed by the Morpheme to Utterance expansions were often the same sentence appearing in different paraphrastic forms in neighboring sentences. The use of reductions and deformations of sentences both to produce expansions and also to produce separate paraphrastic forms of a sentence motivated the formulation of a whole transformational system; and a list of English 'grammatical transformations' was included in the report presented to the Linguistic Society of America in 1950 ("Discourse Analysis," *Language* 28 (1952), 1–30, sec. 2.33). The transformational system (sketched below) was presented to the Linguistic Institute at Indiana University in 1951–52. The formal presentation, with detailed structural-linguistic evidence that the expansions were indeed transformed sentences, was given at the Linguistic Society meeting in 1955 ("Co-occurrence and Transformation in Linguistic Structure," *Language* 33, (1957) 289–340).

In those years I had conversations about transformations with many people: with Piaget, and the psychologist David Rapaport, with Carnap and his follower Y. Bar-Hillel, with Max Zorn (of the lemma) to whom I showed the whole system at the Indiana Linguistic Institute, and with others. I had many very helpful discussions with Henry Hoenigswald, M. P. Schützenberger, and Maurice Gross, and enlightening comments from André Lentin. My closest work was with Henry Hiż, who did a great amount of work on the methods, especially such as brought in considerations from mathematical logic, e.g. in "Congrammaticality, Batteries of Transformations, and Grammatical Categories," in *Proceedings of the Symposium of Applied Mathematics*, American Mathematical Society, 12 (1961) 43–50; "The Role of Paraphrase in Grammar," *Monograph Series on Language and Linguistics*, Georgetown University 17 (1964); also on establishing zeroings and transformations by eliciting sentence-completions and the like from speakers of the language. I also had a great many conversations with my students, above all with Noam Chomsky, who moved on in the direction of a comprehensive generative transformational system in his *Syntactic Structures* (1957), "A Transformational Approach to Syntax" in A. A. Hill, *Proceedings of the Third Texas Conference on Problems of Linguistic Analysis in English 1958* (U. of Texas 1962), and many major later books.

The consideration of paraphrase in discourse occasioned considerable investigation as to what should be stated as the criterion for one's saying that a difference between two sets of sentences is to be counted as a transformation from one set to the other. In the early years, after the initial success of the passive as a transformation, I had tried unsuccessfully such pairs as *I sold books to him* / *He bought a book from me* and *I lost a game to him* / *He won a game from me* (but *I lost the book* / *He found the book*); and somewhat differently *He cut through the wrapping with a knife* / *(In my hands,) the knife cut through the wrapping*. The solution, which was tested (with many people) on many sentence sets was the preservation of the grading of speakers' acceptance for the same word choices in two sets of sentences, preferably otherwise recognized sets (e.g. *The cat drank the milk* / *The milk was drunk by the cat* as vs. *The cat drank the word* / *The word was drunk by the cat*). The non-transformational status of most synonyms (e.g. *oculist* / *eye doctor*) was established then (whence the discussion in "Distributional Structure," *Word* 10 (1954) 146–162, sec. 2.3).

An important factor in thinking of a transformational system that would isolate structural paraphrase was the Skolem normal form in logic, which made me think of the possibility of a canonical form for sets of paraphrastic sentences. Transformations thus came out as paraphrastic equivalence relations among sentences. They were called transformations (rather than deformations, or other terms I had considered) because they were partial transformations in the set of sentences, mapping sentences in one subset onto same-word-choice sentences in the other, thus preserving word choice. The transformations provide a decomposition in the set of sentences, and the ultimate elementary sentences were called sentences of the kernel, because given the factor set (the set of sentences over the set of transformations), then in the natural mapping of the set of sentences onto its factor set, the sentences which are sent into the identity of the set of transformations are the elementary sentences of the language.

Thus defined, the transformational system had various convenient features. It had a constructivist: character, since it was possible to state the applicability of a transformation in terms of the last event in the construction of the sentence on which the transformation acted, so that transformations become steps in the construction of a sentence, rather than only phenomenological relations between sets of sentences. It was also found that many relations and mappings of sentence sets could be defined on the basis of transformations. While these were of little interest as applied mathematics, they were relevant in that almost every class and event in a given sentence structure could be defined by such relations, operations, and mappings, beginning from the elementary sentences which were the components of the given one.

Before leaving the subject of transformations, we consider the issue of generating (or deriving, synthesizing, predicting) as against analyzing (or describing, recognizing the structure of a sentence), which issue is commonly associated with transformations. First, the course of construction of a sentence suggests how a sentence can be considered to be derived from (expanded from) component sentences, with corresponding contributions of meaning to the source sentences. The transformational history of a sentence suggests derivation more strongly, because the derived sentence remains largely paraphrastic, hence 'the same sentence' in meaning; though in fact the 'derived' sentence is not derived in some general sense from its source, but merely contains the source (with expansions and shape changes). The well-known generative transformational theory of Noam Chomsky produces constituent components ('phrase structure') of the sentence and also its (later) transformations; the tree representation there could be considered a representation not so much of the sources of the sentence as of the ordered choices to be made in that system for producing the given sentence.

However, the difference between the analysis of a sentence and its generation is not substantive for the theory except in a limited but important sense (below), but rather is a matter of presentation. The analyzing of a sentence in structural linguistics allows both for a description which directly recognizes the structure, and alternatively for a grammar as a deductive system that synthesizes (generates) sentences (*Structural Linguistics*, pp. 365, 372; "Transfer Grammar," *International Journal of American Linguistics* 20 (1954) pp. 259–270), or for transformationally generating it as noted in the "Co-occurrence and Transformation" paper (sec. 5.6) cited above. In the latter case, the analytic statements of successively entering components of a sentence, or its decomposition, can be used almost directly to generate or predict sentences of that structure. In any case, analysis of the language precedes synthesis.

The difference between analysis and generation is rather that analysis has to identify as far as possible every regularity in speech or writing, and above all to recognize degeneracies, whereas generating can be done with just enough information about the language to distinguish in a general way every utterance from those not systematically identical with it (*Structural Linguistic* pp. 365–366). Analysis thus faces considerable additional difficulties. This lesser burden in generating becomes relevant when the informational features of grammar are distinguished from the non-informational ones (as in operator-grammar theory). For then, if all we want is to supply the information in a discourse, one method might be to generate an informational representation of its sentences, using the informational features alone (except insofar as some non-informational features are grammatically required or desirable in certain situations). The operator-argument theory below is in certain respects a generative theory with this capability.

We now consider the point about the metalanguage being in the language. First, as one analyzes the sentences of a language in more systematic detail one finds various evidences that metalinguistic sentences exist and operate in the grammar of a language. For example, the constraints on word choice in conjoined sentences (SCS) are such that generally the SCS is less immediately acceptable if there is no word that occurs in both component S. If nevertheless a given SCS is acceptable without this word repetition, it is found that there exists some sentence which would complete the repetition (by containing some word from each of the component S), creating an SCSCS which satisfies the condition. What creates the given SCS is that here the added S is zeroable (by the established low-information criterion for zeroing), either as being known to the hearer or as being a dictionary definition, or the like, known to all users of the language (*Mathematical Structures of Language* pp. 131–138). This shows the existence of metalinguistic sentences, giving the grammar and dictionary of the sentence to which they are adjoined.

Second, the explicit structure of statements in logic and mathematics had made it clear that the statements about this structure could not be expressed within this structure: the metalanguage of mathematics was outside mathematics. (See for example Alonzo Church, *Introduction to Mathematical Logic*, Princeton U. Press, 1956. While the term 'metalanguage' as used in the linguistic work is an extension of the use in Rudolf Carnap, *The Logical Syntax of Language*, it also satisfies the more stringent (finitary) condition for the term 'meta' in S. C. Kleene *Introduction to Metamathematics*.) The structure of the metalanguage had been left undescribed, the view being that it, or its metalanguage in turn in infinite regress, has to be undescribed and indeed not fully specifiable, simply given in natural language. This conforms to the common view in philosophy that natural language is amorphous, or in any case not fully specifiable.

However, as the analysis of natural language showed it to be specifiable in as great detail as we wish, with the unspecified residue being encapsulated as structurally secondary in respect to the main description, it became possible to specify the structure of the statements about natural language in comparison with the sentences that these sentences describe. In the first place, the metalinguistic statements are themselves sentences of natural language. In the second place, they are a structurally specifiable subset of these sentences and constitute a sublanguage in the sense given below ("Algebraic Operations in Language Structure," International Congress of Mathematicians, Moscow 1966; *Mathematical Structures of Language*, pp. 17, 125–128).

The motivation for studying the metalanguage of natural language was not only its different status from that of the metalanguage of mathematics, but also its value in formulating the syntax of natural language. Several important clarifications in syntax are achieved by specified relations between sentences of language and certain metalinguistic sentences adjoined to the sentences of which they speak. The most important is a single derivation for tense, which yields both 'absolute' and 'relative' tenses (i.e. tense in respect to time of speaking and tense in respect to neighboring sentences) and also non-time uses of tense (*Notes de Cours de Syntaxe*, Maurice Gross, tr. and ed., Editions du Seuil, 1976, pp. 158–181). Another is a derivation of reference from cross-reference, in a way that explains, for example, why the 'free' pronouns (e.g. *he*) have no fixed location for their antecedent (*A Grammar of English on Mathematical Principles*, Wiley 1982, pp. 87–97). More generally, the metalanguage makes the whole of a natural language self-contained; and each sentence in the language becomes self-contained when we adjoin to it the zeroable metalinguistic sentences which state the meaning and grammatical relations of each morpheme in it.

A crucial methodological contribution of the metalanguage is the following: since it is impossible to define the elementary entities and constraints of a language by recourse to its metalanguage (since the metalanguage is itself constructed from those entities by means of those constraints), it follows that the structure of language can be found only from the non-equiprobability of combinations of parts. This means that the description of a language is the description of contributory departures from equiprobability, and the least statement of such contributions (constraints) that is adequate to describe the sentences and discourses of the language is the most revealing.

Whereas the issues considered before this point were methods of analysis for language, the operator-argument construction suggests not only a method but also a theory. This may therefore be the place for a brief excursus about a theory in a field such as linguistics. Differently from most sciences, linguistics admits of an alternative to theory: an orderly catalog of the relevant data, sufficient to do most of the work that a theory is supposed to do. Both the knowledge of what is relevant in data and the possibility for orderly coverage are due to the recognition of a finite set of phonemic distinctions (hence, discrete phonemes) in each language, and also to the fact that only statable phoneme sequences (finite in number and length) constitute morphemes or words — the material from which syntax is directly made. Hence, the relevant information about a language can be given most completely and interestingly by a listing of each morpheme, each with a complete listing of the properties (its combinabilities with other morphemes, and its forms in those combinations): cf. the work being done by Maurice Gross and his associates (note *Structural Linguistics* pp. 376). Sophistication as to the properties that should be stated (grammatical class, selection, morphophonemics, transformations) may come from global investigation of regularities. But the coverage is assured by the listing, though one may fail to restore such properties as morpheme presence in zero shape, and though some properties may have such large and regular morphemic domain as to make wasteful a listing by individual morpheme.

Furthermore, given what we know about the status of 'truth' in logic and about the alternative descriptions of structure, a theory should not be thought of as presenting the final truth, but only as organizing the results of certain methods of analysis, 'true' as far as it goes.

Nevertheless, theoretical formulations present global results that are not (or not directly) represented in a catalogue of relevant data:

- The fuzziness of some domains.
- The essential relation among properties as it comes out in a deductive system.
- The relevant distinction of partially-ordered and linearly-ordered processes in language.
- The relating of forms and combinations to processes (some recursive) which create those forms and combinations.

- The relation of structure to change and then to the development of language.
- The basic relation of language structure, and language development, to expressing and transmitting information.

In the case of language, there is also a responsibility to formulate a theory based on self-organizing capacities: one that will present language as a system that can arise in a state in which language does not exist. This is so because of the unique status of language as a system which contains its own metalanguage. Any description we make of a language can only be stated in a language, if even only in order to state that some items of the description are properties of some other items (i.e. how to read the table). We cannot describe a language without knowing how our description can in turn be described. And the only way to avoid an infinite regress is to know a self-organizing description, which necessarily holds also for the language we are describing even if we do not use this fact in our description.

In addition to its service in analyzing sentences, transformational methods as used here had shown another way of characterizing a sentence: by the subset of sentences to which it belongs. This arose from the various sentence relations, more exactly sentence subset relations, and the mappings and partitions, in transformational analysis. The next question was naturally what other kinds of relevant and useful subsets of sentences might be found. The detailed study of the structure of language then showed that one can define within a natural language various sublanguages, such as the metalanguage, and the language use in many sciences (*Mathematical Structures of Language*, pp. 152–155). These were subsets of the sentences of the language which had the properties of sublanguages. It was not really a matter of subsets of the vocabulary: any subset of sentences or of discourses in a language would contain only a small part of the vocabulary of the language. What is special to sciences is that certain subclasses of words (and phrases) co-occur in a regular way to make certain specifiable sentence-types (as sentential combinations of word subclasses); and here, as the corpus of material being investigated grows, the set of sentence-types grows little if at all. If we take any two sentences of the subset and operate on them with various operators of the whole language, e.g. *and* or various transformations, we obtain again a sentence of the subset. Hence the subset is a sublanguage. The grammar of the sublanguage, however, can be shown to be not a subset of the grammar of the whole language; rather, it intersects, importantly, the latter grammar. The study of sublanguages was not influenced by any particular situation outside of linguistics, except for the general example of the existence of subsystems in mathematical systems. An example of a sublanguage is given in Harris, Z., Gottfried, M. Ryckman, T., Mattick, P., Daladier, A., Harris, T. N., Harris, S., *The Form of Information in Science: Analysis of an Immunology Sublanguage* (Kluwer Acad. Publ., Dordrecht, 1989).

There was finally a motivation that led out of transformations to an operator-argument theory of language. This came from two directions. First, for all that they contributed to linguistic theory, transformations were not general enough (their conditions were too specific, and the sequential applicability in deriving sentences was too limited), and not elementary enough (there were too many to constitute a reasonable set of primitives for a new ‘derivational’ dimension of sentence construction). Second, some of the more complex transformations (e.g. the English passive) were physically (morphemically) identical to successive application of particular added morphemes; and their domain restriction equalled the selection restrictions of just those morphemes (“The Elementary Transformations,” *Transformations and Discourse Analysis Papers* 54 (1964); “Transformational Theory,” *Language* 41 (1965) pp. 363–401). This led to defining a system of reductions in sentences such that most transformations are either a reduction or a successive application of reductions. It was then found that in most sentences the ultimate source sentence which was the starting point for the reductions had a simple subject-predicate or subject-verb-object structure (i.e. an operator-argument structure). The importance is not in this observation by itself, which is close to the popular understanding of language (and to logic from Aristotle and on), but in the ability to obtain other sentences from these simple predications by usually a priori statable reductions and recursively stated predications upon predications. Both the reductions and the predications upon predications were constrained to occur only in stated conditions. In the case of reductions, it was possible to say that they occurred when one participant word in an operator-argument structure had exceptional likelihood of occurring there in respect to the other participant word (hence the reductions were paraphrastic, contributing little or no information to the sentence at that point).

In line with the general ‘distributional’ program, this analysis was first used for sentences that involved restrictions, where the operator-argument source was found to be less restricted (because the domains of successive reductions are monotonic descending since each reduction can only be stated on all or a proper part of the set of words in the given operator-argument position). However, it was found that most of the remaining non-operator-argument sentences could be derived from operator-argument sentences by the same reductions and predications upon predications that had been used for the restricted sentence structures. The specific program to arrive at an operator-argument source was first used for the English comparative, in a way that incidentally explained Sapir's point that, e.g., *He is richer* does not imply: *He is rich* ("Grading: A Study in Semantics," *Philosophy of Science* 11 (1944) pp. 93–116; *Selected Writings of Edward Sapir*, D. G. Mandelbaum, ed. U. of Calif. Press 1958, pp. 122–149). The English comparative analysis is sketched in *Mathematical Structures of Language*, pp. 174–175; although this book was an expansion of a lecture given at the Courant Institute of Mathematical Sciences in 1961, the analysis of the comparative is later and was inserted shortly before publication of the book.

What came out finally was a system of predicates (operators) first on primitive arguments and then recursively on predicates, with reduction of words which had high likelihood in the given operator-argument relation. This created a partial order of words in each sentence, and in the language as a whole. It was constructive, not only in the partial order of entry of words into a sentence, but also in that the reductions took place in a word upon its entry, so that each sentence could be defined as a particular kind of semi-lattice of word-occurrences and reductions. All further events in forming a sentence are defined on resultants of the partial order construction.

This method went beyond transformations in two respects. First, transformations brought word-choice specification into grammar by accepting the unspecified word-choice in elementary sentences and then preserving it under transformation. Operator grammar uses likelihood information about word-choice both in the first-level operators that create the elementary sentences and in the similarly-working second-level operators that create from them the enlarged sentences. Second, the operator grammar gives a single system of word partial order for forming both elementary sentences and other sentences (some of the latter called transformational), with reduction in shape to form the remaining sentences.

An excursus in word-choice: traditional and structural linguistics found regularities of co-occurrence word classes, between one or another word of another set. Because almost every word was unique in its selection, i.e. in what individual words it occurred with most frequently, pre-transformational linguistics did not deal with the co-occurrence properties of individual words. In transformational analysis, it turns out that the undescribed relation has to be stated largely in the 'kernel' sentence alone, and is merely preserved in the transforms. In the operator-argument theory, the selection of individual words in respect to their operators or their arguments, in whatever detail determined, constitutes the basic data. Structure is then created by the stable distinction between zero and non-zero possibilities of co-occurrence in the operator-argument relation, which creates syntax, and by the somewhat less stable high probabilities of co-occurrence that characterize the meanings of individual words. Transformations are then found to be largely reductions of form in the highest-probability (lowest information) co-occurrences. And structure beyond single sentences (conjunctions, discourse, sublanguage) is made by various constraints in the preservation of word choice within operator-argument relations.

The operator grammar reveals a sharper relation between the structure of a sentence and its information (as had been sought by Carnap and the Vienna Positivists); this, by specifying and ordering each departure from equiprobability. Some of these departures (mostly universal ones) can be seen by their structure to be information bearing (in a sense related to that of mathematical information theory); others (mostly in particular languages or language families) create regularities and irregularities that are not substantively informational. By-products of the whole theory are the status of the operator-argument system as a mathematical object (a necessity for the stability of language structure), and the picture of language as a self-contained, self-organizing, and evolving system (*A Theory of Language and Information: A mathematical approach*, Oxford U. Press, 1991). All of these properties, including the lack of an external metalanguage, can be looked upon as being expectable, given the use (function) of language, and the fact that it was not created in any conscious plan.

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